

**October 9, 2006**  
**REDUCING THE RISKS OF HIGHLY ENRICHED URANIUM AT  
THE U.S. DEPARTMENT OF ENERGY'S Y-12 NATIONAL  
SECURITY COMPLEX**

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**Executive Summary and Recommendations**

The safe and secure storage of nuclear weapons materials in the United States remains a major unfinished task, which deserves priority attention by the federal government. In this regard, the U.S. Department of Energy's (DOE) Y-12 National Security Complex, in Oak Ridge Tennessee stores the largest amount of fissile material in the United States – approximately 400 metric tons of highly enriched uranium (HEU) – in deteriorated structures, long recognized as being vulnerable to fires and earthquakes. A large fraction of HEU which accumulated at the Y-12 site for more than 50 years is still in insecure and unstable forms – posing increased environmental, safety and health risks.

**Management Practices and Priorities**

In 2000 the Energy Department's Defense Nuclear Facility Safety Board (DNFSB) staff observed that DOE and contractors at Y-12 were conducting “*faith-based management*’ [premised] *on a deep-seated belief that there is no safety hazard associated with this operation.*” Since then significant progress has been made in changing this mindset – leading to increased safety. But, the management legacy of nuclear weapons production remains a major challenge. For more than a decade, the Energy department has not been able to reconcile competing objectives at the Y-12 site, such as the restart of old facilities, establishing new HEU storage and weapons facilities, stabilizing a large backlog of nuclear materials and downsizing. As a result, policies and guidance have been disjointed, costs have significantly increased and long-standing problems continue unresolved.

**The Backlog of Unstable HEU** – Over the past 50 years, the Y-12 site accumulated a large back-log of unstable HEU materials such as residues, metal pieces, oxides and solutions. Stabilizing these materials was identified in 1995 by the DNFSB staff as the “*mission most relevant to safety*” at the Y-12 Site. According to DOE they are stored in locations and numerous types of containers “*not designed for extended storage.*” Since comprehensive records were not maintained for HEU sent to Y-12, the exact content of numerous containers was not known, and many had never been opened. Over the past decade, there have been several fires and explosions, and criticality violations in uranium storage areas. DOE has sought to address this problem by attempting to restart HEU operations in Building 9212. After 12 years and restart costs in excess of \$400 million – more than three times the original estimate – the department has yet to achieve adequate

operational capacity to process this back-log, which has increased in the past ten years from other DOE sites.

**Vulnerable HEU Storage** -- In 1996, the Energy department concluded that the current main HEU storage building at Y-12, a wood-frame structure built in 1944, was vulnerable to a major fire causing it to collapse, and contaminate workers and the public with radioactive smoke and debris. None of the storage areas at the Y-12 complex comply with modern DOE design requirements. Energy decided in 1998 to design and build a modern HEU storage facility, after the Office of Environment, Safety and Health determined that a fire at the Y-12 wooden warehouse could occur within "*five years to end of facility-life.*" Completion of this important project is being impacted, however, because of design changes, uncertainties about the fate of in process materials, and quality assurance problems – such as inadequate concrete pouring. Its total estimated cost has increased over the past five years from \$120 million nearly \$500 million.

**New Weapons Production Capabilities** --The Department is seeking to replace HEU chemical conversion and foundry processes used since the 1950's for nuclear weapons production. The new Uranium Processing Facility is estimated to cost approximately \$1 billion, and is based on a design/build strategy dependant on further research and development. Saltless direct oxide reduction is being developed to replace the fluoride reduction process at Y-12, and microwave casting is to replace vacuum-induction melting. While a small prototype microwave caster has operated successfully, an explosion at the prototype facility for Saltless Oxide reduction in 2003 set back the project. An Independent Project Review, conducted in January 2006, prior to a Departmental decision to approve detailed design (Critical Decision 1) of the modernization project, raised several concerns regarding proposed cost and schedules, facility throughput and capability, and safety.

**Downsizing** -- Downsizing of the large antiquated infrastructure at Y-12 has proven to be elusive. About 70 percent of the Y-12 plant's structures were constructed in the 1940's . Several buildings have been shuttered for years, are seriously deteriorated, and contain vulnerable inventories of nuclear and non nuclear materials. Years of roof leaks have resulted in chronic safety problems such as standing water in fissile material storage areas and water accumulation near electric control panels. Furthermore, it appears that that size of the Y-12 complex for which the National Nuclear Security Administration is responsible has grown over the past 17 years from approximately 5.5 million square feet to more than 7.2 million square feet. Downsizing has proven daunting in part because DOE has simultaneously been trying to dispose of facilities, while building new ones at the same locations. The large expenses associated with maintaining this oversized infrastructure is reflected in the annual budgets for the Y-12 complex, which have doubled in the past ten years.

### **Environmental Safety and Health**

Hazards at the Y-12 complex stem from nuclear, radiological, and other materials unique to the site, and also include standard industrial hazards inherent with chemical and

metallurgical operations. To a large extent, these risks are associated with highly enriched (20 to >90% uranium-235) and other types of uranium stored and handled at the Y-12 Complex. In particular, fires, explosions and nuclear criticalities are dominant concerns. According to the DOE a fire involving tens of kilograms of HEU could result in significant doses to the public. The accidental release of chemicals, notably anhydrous fluoride, could result in public exposures some 30 times above lethal levels.

DOE has sought to address growing concerns over safety by eliminating the Office of Environment, Safety and Health, which was established in 1985 to formulate safety policy and centralize internal oversight and regulation.<sup>i</sup> Several functions have been moved to other offices, while safety and health regulation has been merged with safeguards and security oversight into new office. The National Nuclear Security Agency within DOE is also now seeking to eliminate federal oversight of safety and health requirements,<sup>ii</sup> as well as curtailing DOE investigations of accidents involving serious injury to workers at DOE nuclear weapons sites.<sup>iii</sup> Given the state-of-affairs at the Y-12 complex, these efforts are ill-advised.

**Accidents** -- Between 1992 and 2006 there have been at least 22 fires and explosions at the Y-12 complex involving nuclear and non-nuclear materials, and the site's aged electrical and coolant systems. (21 since 1997). A review of DOE operating experience, accident reports, and other DOE performance indicators suggests that since the end of the Cold War, 15 years ago, Y-12 has experienced the largest number of such events in the federal nuclear complex. Several resulted in worker injuries, radiological contamination and significant damage. Others were small but are of concern because of the potential for spreading due to deteriorated electric systems, and the collocation of combustible, pyrophoric and explosive materials.

**Risks of Fires** -- While some progress has been made, risks of fire remain a dominant concern for all processing and storage facilities due to problems of age and deterioration, exacerbated by the accumulation of pyrophoric uranium and combustibles, such as solvents. Reduction of fire risks is slow and equipment essential to fire protection has not been fully maintained, replaced or upgraded. Electrical systems pose potentially significant risks of fire because they are more than 50 years old and severely corroded. Since the late 1990's, there have been five high-voltage cable explosions – including one in 2001 which blew out all windows of a large building. A number of cable and cable splices were found to be under water. This year DOE has cut back funds for fire protection at Y-12 despite these unresolved problems.

**Nuclear Criticality Safety** -- Controls to avoid nuclear criticalities at the Y-12 site are of paramount importance. This is because the failures to control relatively small amounts of

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<sup>i</sup> U.S. Department of Energy, Energy Department Announces Creation of New Health, Safety and Security Office, Press Release, August 30, 2006.

<sup>ii</sup> U.S. Department of Energy, National Nuclear Security Administration, Memorandum for Edward L. Wilmot, Manager, Los Alamos Site Office, From: Linton Brooks, Administrator, (undated)

<sup>iii</sup> U.S. Department of Energy, National Nuclear Security Agency, Memorandum for Manager, Los Alamos Site Office, From: Thomas P.D. Agostino, Deputy Administrator for Defense Programs, July 10, 2006.

fissile materials have caused several accidents resulting in worker deaths and severe radiation exposures. Highly enriched uranium processing at the Y-12 complex was placed in a stand down in 1994, after the DNFSB reported “*widespread noncompliance*” of DOE criticality safety requirements. Progress was made to allow incremental restart of HEU processing beginning in 1998, but criticality safety problems have persisted. In the May 2006, an excessive amount of HEU accumulated in the filter system in the Y-12 metal casting operation, compelling the site contractor to declare a Category 1 safety violation, in which there were “*no valid controls to prevent a criticality accident.*”

Around the same time, the DNFSB reported that: “*many DOE site offices continue to be either unstaffed or understaffed in the area of NCS [nuclear criticality safety] oversight. Some of the problems with contractor NCS programs can be traced to ineffective NCS oversight by site offices.*”

**Seismic Risks** -- Because the major preponderance of facilities at Y-12 was constructed in the 1940's and 1950's, when nuclear safety design standards did not exist, impacts of earthquakes have become a source of growing concern. The inadequacy of seismic protection at Y-12 was first raised by the National Research Council in 1989, followed by the Office of Environment, Safety and Health in 1996, and more recently by the DNFSB. Finally, in 2005 DOE completed a structural analysis for the main HEU processing facility, which revealed seismic deficiencies, such as missing structural braces and glass process columns containing uranium liquids. DOE has not reconciled the large competing costs of seismic upgrading of old facilities and establishing new HEU processing capabilities for weapons.

**Worker Exposure** – Y-12 workers have the greatest risk of internal radiation exposure in the federal nuclear complex. Since 1993, Y-12 workers have absorbed about forty two percent of the total collective internal radiation dose for all DOE sites. A deep rooted problem at Y-12 is prevention of radiological exposures to workers from widespread historical contamination and the accumulated back-log of nuclear materials, as reflected in more than 20 years of critical appraisals.

## RECOMMENDATIONS

**New Nuclear Facilities** -- DOE's reliance on a design/build philosophy for new nuclear facilities has resulted in costly problems in which key safety features were not identified until after construction started. Too often conceptual bases are all that are used to justify Congressional funding for major projects. Critical decisions in the early stage of upgrading existing facilities or building new ones do not consistently involve rigorous safety or hazard analyses by current standards or equipment.

In this regard, DOE should refrain from concurrently designing and building industrial-scale deployment of Microwave Casting and Saltless Direct Oxide Reduction at the Y-12 complex. These technologies are still in a developmental stage, compounded by uncertainties in cost, throughput, and safety associated with a first-of-a-kind facility processing highly enriched uranium. Instead, the Energy department should establish a formal policy under the Code of Federal Regulations requiring safety assessments during

the early stages of procurement for new first-of-a-kind nuclear facilities. This would allow for a level of conservatism to bound uncertainties inherent with these projects; and reduce costly project disruptions after funding decisions are made.

**Existing DOE Facilities** -- Many DOE nuclear facilities, such as those at Y-12, are several decades old, one of a kind, and do not lend themselves easily to risk quantification. In fact it may not be cost effective for some facilities to meet current safety requirements. Although upgrading old facilities to meet new standards may not be cost effective, upgrading the qualifications and skills of the people who operate them should be mandatory.

The Energy department should establish such a policy under the Code of Federal Regulations, similar to that adopted by the Nuclear Regulatory Commission (NRC) for upgrading or “backfitting” older nuclear facilities (10CFR 50.109). This would provide a consistent and rational process to determine if mandatory improvements in safety are mandatory or not for aging nuclear facilities. Elements of such a policy include:

- Documented analyses which identifies specific objectives the proposed upgrade is supposed to achieve and description of the activity required by the department in order to complete the task;
- Potential changes in the risk and impacts to the public and workers;
- Installation and continuing costs associated with the upgrade;
- The relevancy and practicality of the upgrade.

Also, DOE should establish a formal process to address the competing demands between seismic and other upgrading of structures at the existing HEU foundry at Y-12, and the building of a new uranium processing facility. Both endeavors are costly, and the Department should define its priorities relative to feasibility, safety and need.

**Line Management Self-Assessment** -- With few exceptions, significant environmental, safety, health and project management problems at Y-12 have been brought to light by entities that are not part of line management responsible for the Y-12 Complex. The lack of critical self-assessment by federal and contractor managers is an institutional problem going back to the Cold War era. Despite various reforms in management, contractors lack incentives to report problems, which under current circumstances, may impact their award fees. Problems that are identified by contractors may not necessarily be acted upon or welcomed by federal managers seeking to free up funds.

The Energy department should establish formal policies and guidance which makes contractor self-assessment a key element of performance assessment. Contractors should be provided with incentives to self-identify safety and management problems, which are effectively discouraged under current contracting policies. This is a long-standing practice with a proven history of success by the Office of Naval Reactors, in the Energy department.

**Strengthening Nuclear Safety Oversight and Enforcement** – Oversight, enforcement and compliance within the Office of ES&H federal nuclear safety standards should be expanded to allow for a stronger and timely federal role. Currently the Nuclear Safety Oversight and Enforcement Office has a small professional staff and is highly dependant on contractor self-reporting. The number of federal professional staff should be increased along with achieving greater depth in specialized areas.

The DOE Facility Site Representative Program should be expanded to provide more effective oversight and coordination with contractors, DOE and the DNFSB. The Facility Representative program should increase its level of specialized knowledge in areas of importance, such as nuclear criticality and chemical safety.

The Defense Nuclear Facility Safety Board should provide the DOE with a hierarchy of safety risks and priorities at the Y-12 Complex, as well as guidance to address these risks. In carrying out these responsibilities the DNFSB staff should be increased.

**Highly Enriched Uranium Stabilization** -- The Department of Energy should establish a program for approval by the U.S. Congress (including a budget and schedule) for the stabilization, packaging and disposition of HEU, and other excess nuclear and non-nuclear materials at the Y-12 site. Near term actions which the DOE should undertake include:

- Excess materials containing less than one percent HEU should be declared as waste. These materials are estimated to consume 50 percent of the processing time at the Y-12 HEU foundry.
- The Department should convene an independent expert panel to determine if it is feasible and cost effective to process the backlog of HEU materials in at Building 9212, the HEU foundry, and to identify alternatives.

**The Highly Enriched Uranium Materials Facility** -- This project is of high national importance in terms of reducing unnecessary safety and security risks associated with the antiquated storage modes at the Y-12 Site. The DOE should establish a headquarters-based project management program, similar to that in department's Office of Science. This approach has been proven to work successfully and is endorsed by the National Research Council, in its review of DOE project management done for the U.S. Congress.

**Downsizing** -- The Energy department should develop a program with budget and schedule for approval by the U.S. Congress that would achieve a downsizing objective of 10 to 20 percent of current existing capacity at the Y-12 complex within a decade. Establishing new facilities and the reduction of the backlog of in process materials should be directly tied to a commensurate reduction in facilities that can be cleaned out, decontaminated and decommissioned.

## INTRODUCTION

In February 1996, the Energy department announced that the United States had produced 994 metric tons of highly enriched uranium (HEU).<sup>1</sup> While this information received a considerable amount of attention, a subsequent report about HEU storage conditions at DOE sites did not. This report, issued in December 1996, concluded that the Y-12 National Security Complex in Oak Ridge TN had the most numerous and significant environmental, safety and health vulnerabilities of all DOE sites.<sup>2</sup> (See Appendix A.)

At the time, the Y-12 complex was storing more than 189 metric tons of HEU comprised of 32,000 items in the forms of dismantled weapons parts, solutions, oxides, combustibles, and residues.<sup>3</sup> Risk of fire was a dominant concern because of the age and deterioration of buildings, most of which were constructed in the 1940's, combined with degraded or non-existent fire protection systems. The DOE assessment teams found a large back log of "*combustible in process materials*" which had accumulated in "*virtually every building [and] posed an unnecessary vulnerability with respect to fire loading.*" The likelihood of a fire at the site's primary HEU storage facility, a wooden structure built in 1944, was "*estimated to be five years to end of facility-life.*"<sup>4</sup>

According to the assessment, "*sixty percent of the drum-type storage containers at Y-12 have never been opened. Some are over 20 years old.*"<sup>5</sup> This raised questions about the accuracy and completeness of a physical inventory of HEU done by the Department in 1994. "*The Y- 12 Plant did not generate nor maintain comprehensive records on the storage configurations. Most containers were received at the Y-12 Plant and placed direct into storage without opening.*"<sup>6</sup>

Two years later, the DOE stopped reporting progress in correcting these problems in its environmental, safety and health performance indicator assessments.

To better understand these problems and what has been done to fix them, this author conducted a review of several official open source documents including those generated by the Department of Energy, National Research Council and the United States Congress, and non governmental organizations. Several knowledgeable experts with extensive experience in the Energy department were also interviewed. This task was made more difficult because in the past few years, important information regarding the safety and management of the Y-12 complex appears to have been removed by DOE from the public record. The DOE also now prevents public access to previously open information, regarding environmental, safety and health oversight, and accident investigations, based on a classification category known as "business sensitive." Despite the growing lack of transparency, the record is clear enough to show that the legacy of nuclear weapons production at the Y-12 site remains a fundamental challenge of national importance.

## A BRIEF DESCRIPTION AND HISTORY OF THE Y-12 FACILITY

Construction of the Y-12 complex began in 1942 in Bear Creek Valley nestled between the Great Smoky Mountains and the Cumberland Mountains, about 18 miles from

Knoxville, TN. (See Figure 1.) Its primary mission at the time was to produce sufficient quantities of Uranium 235 for the Hiroshima weapon. During this period some 40,000 people were employed to operate electromagnetic separations facilities (Calutrons),<sup>7</sup> designed by Ernest O. Lawrence and his team at the University of California. (See Figure 2) Between 1943 and 1947, large quantities of uranium oxides were converted into Uranium chloride (UCL<sub>4</sub>) and then were processed in two stages using calutrons housed in nine large structures.

*"By any scale, the operation there was mammoth."*<sup>8</sup> Two 500-tank calutron "race tracks" were installed *"each measuring four football fields long."*<sup>9</sup> By 1946, the mission to enrich uranium was shifted to the Oak Ridge K-25 Gaseous Diffusion Plant, sharply curtailing the calutron operations, which were used in subsequent decades to produce isotopes for research. Between 1944 and 1951, the Y-12 operation was focused on recovery and salvage of U-235 in calutron equipment and feed material. (See Figure 2)

**Figure 1 The Y-12 National Security Complex**



Source: BWTX- Y12

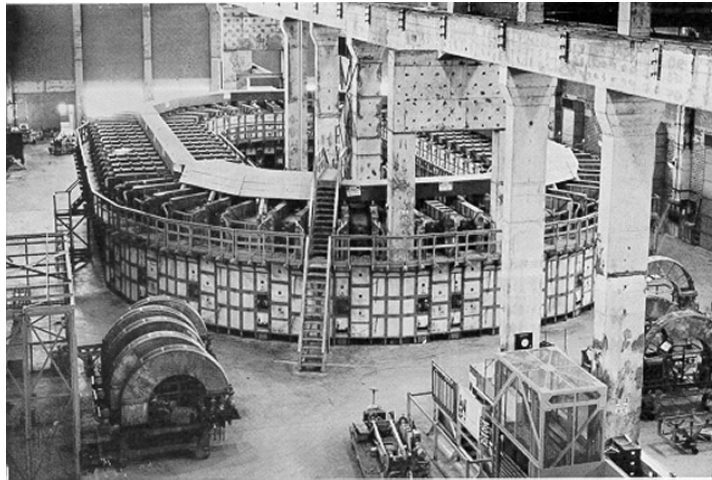
**Cold War Operations: 1949-1990.** By 1949, the Y-12 Plant began a significant transformation to process nuclear and other materials and to fabricate nuclear weapons components during the Cold War. This included foundry operations for highly enriched uranium and depleted uranium, lithium production for nuclear weapons, weapon component fabrication and dismantlement, and storage. Production of HEU-fueled fission weapons components began in the early 1950's, followed by the processing of weapons materials, and manufacture of other nuclear weapons components.<sup>10</sup> Weapons dismantlement activities began in the early 1950's.<sup>11</sup> Also Y-12 performed special work



such as reactor fuel fabrication, uranium-233 fabrication, and spent reactor fuel storage. After 1964, the U.S. ceased production of HEU from the gaseous diffusion plants for weapons and Y-12 relied on recycled uranium from weapons and from previously irradiated HEU separated from spent reactor fuel at the Savannah River Plant. During this period Y-12 Plant's activities encompassed:

- manufacturing fission nuclear warheads, <sup>12</sup>
- manufacturing nuclear weapons components, including primaries, and thermonuclear secondaries (canned subassemblies - CSA) <sup>13</sup> “special projects” such as reactor fuel production, <sup>14</sup> and processing of uranium-233, <sup>15</sup>
- disassembling fission nuclear warheads, <sup>16 17</sup> and
- storing weapons components, various highly-enriched uranium compounds, <sup>18</sup> small nuclear reactors, <sup>19</sup> fresh and spent reactor fuel, sealed sources and other materials containing actinides <sup>20 21</sup> and other nuclear materials. <sup>22</sup>

**Figure 2 Electromagnetic Separation Process Equipment at the Y-12 Plant (1943-1947)**



Source: <http://www.childrenofthemanhattanproject.org>

**Post Cold War Missions – (1992- present)** Soon after the end of the Cold War, the Y-12 Plant underwent a significant reduction and closure of production facilities, as the United States reduced its nuclear weapons stockpile. Y-12's primary functions now include:

- Receipt, storage and protection of highly enriched uranium (HEU).
- Nuclear weapons refurbishment and Life Extension Programs,
- Recycle/recovery of strategic materials,
- Dismantlement of nuclear weapons components,
- Environmental restoration and waste management.

## HEU Inventory

In 1996, The Energy Department declared that the United States had produced 994 metric tons of highly enriched uranium.<sup>23</sup> As of that year the Y-12 complex was storing more than 189 metric tons of HEU not including classified amounts from weapons activities. Since that time HEU from other sites have been sent to Y-12 for storage.<sup>24</sup> According to the Department of Energy (DOE), 2,836 nuclear weapons secondaries were disassembled at the Y-12 plant between 1988 and 1998.<sup>25</sup> Y-12 is currently estimated to be storing between 7,500 and 8,000 secondaries.<sup>26</sup> Shipments of HEU presumed to have occurred from Los Alamos National Laboratory and the Rocky Flats to Y-12 were reported as 6 and 2 MTU respectively.<sup>27</sup> As of 1996 more than 100 metric tons of materials with recoverable quantities of HEU remain to be processed.<sup>28</sup>

In November 2005, Energy Secretary Bodman announced that as much as 200 metric tons of HEU at Y-12 will be removed from weapons and be used for other purposes. Approximately 160 metric tons will be used as fuel for U.S. nuclear naval propulsion vessels, 20 metric tons to be blended down for commercial nuclear power fuel, and 20 metric tons for space and research reactors. Since 1999, approximately 45 metric tons of HEU were shipped from Y-12 to the U.S. Uranium Enrichment Corporation for down blending into power reactor fuel.<sup>29</sup>

In February 2006, the DOE released a report commissioned ten years earlier that accounts for the U.S. highly enriched uranium inventory.<sup>30</sup> Unlike the HEU vulnerability assessment of December 1996, the recent report contains less detailed information about site-specific inventories. Based on these and other data, Y-12 is estimated to currently store, approximately 400 metric tons of HEU.<sup>31 32</sup>

## DESCRIPTION OF Y-12 FACILITIES

The Y-12 Complex is responsible for HEU storage, weapons component fabrication, maintenance, surveillance and dismantlement and involving four major materials (See Table 1).

- Enriched Uranium;
- Special Weapons Materials, such as beryllium
- Depleted Uranium; and
- Lithium hydride/Deuteride for thermonuclear components.

**Table 1 Building Functions at the Y-12 Complex**

Building	Function
9720-5	long and Short-Term HEU Storage
9204-4	Quality Evaluation of Special Nuclear Material and Storage
9204-E	Assembly and Disassembly of Components
9212	Processing, Converting, Purifying, HEU, Casting and machining of HEU Metal
9998	Depleted Uranium Foundry
9215	Depleted Uranium Rolling and Milling

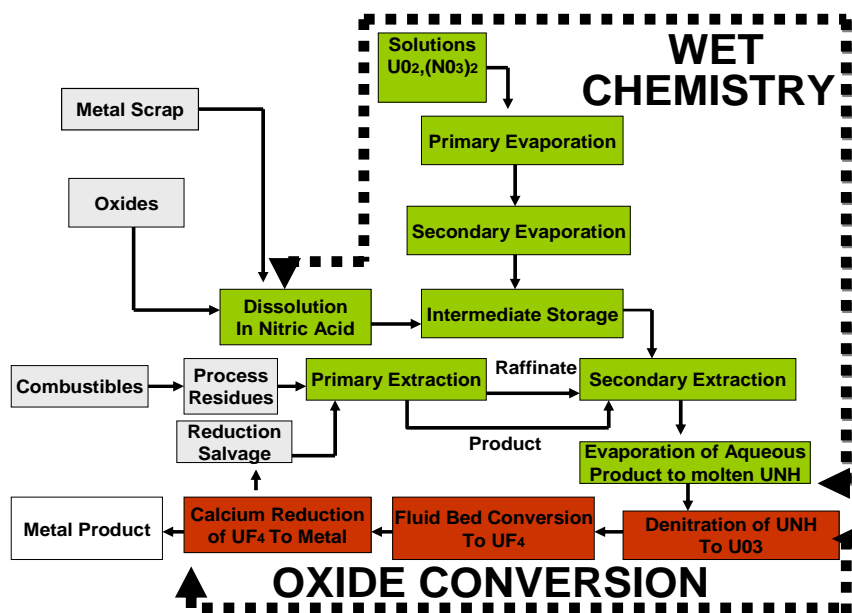
9201-5	Depleted Uranium Arc melting
9204-4	Weapons Component Assembly, Disassembly, and DU Pressing
9201-5N	DU production, plating, machining, and surface coating
9204-2, 9720-46, 9201-5	Special Material Operations including lithium hydride and deuteride, and lithium chloride processing
9292,9731,9203, 9996	Development Operations including 80 laboratories that focus research, development and oversight of Y-12 Complex activities.

There are nearly one hundred unit operations dedicated to processing, converting, purifying highly enriched uranium into a metal, and casting weapons components.<sup>33 34</sup> (See Figure 3). The primary processes are used on metals, oxides, residues and combustibles. Material forms that have been handled in this complex include enriched uranium billets, buttons, chips, scraps and solutions. These processes are described in the context of this report as:

- Wet Chemistry** – This process handles solutions, scraps, alloyed or impure metals that are mostly byproducts of the operations and some from other sites. These materials range from combustible and non combustible solids to aqueous to organic solutions. The basic approach is to convert HEU-bearing materials into a nitrate solution through dissolution, leach and other processes so they can be converted into pure metal. For instance, metal shapes are sheared into small pieces. Then they are heated to an oxide (U<sub>3</sub>O<sub>8</sub>) so as to be dissolved in nitric acid (uranyl hexahydrate – UNH) for purification through primary and secondary solvent extraction cycles. HEU contained in scrap and waste is also converted into uranyl nitrate.<sup>35</sup>
- Oxide Conversion** -- Once purified the UNH is denitrated in a stirred trough calciner into uranium trioxide powder (UO<sub>3</sub>). The UO<sub>3</sub> is then reduced in a fluid bed reactor to uranium oxide (UO<sub>2</sub>.) It is then transferred to a hydrofluorinator in which hydrogen fluoride gas introduced -- yielding uranium tetrafluoride UF<sub>4</sub> powder. The UF<sub>4</sub> is then sent to high-heat sintering furnaces used to convert the uranium oxide to a ceramic grade U<sub>3</sub>O<sub>8</sub>. Finally the UF<sub>4</sub> is reduced to metal in a “Bomb Reduction” process involving a thermite reaction where calcium and lithium are used as the reducing agent.
- Chip Processing:** This operation is for metals pure enough to be recycled directly to metal stock. These items are generated from machining operations as turnings. Then they are cleaned or degreased, dried and compressed into briquettes so as to be cast into metal feedstock. Because uranium chips are pyrophoric a continuous flow of argon gas is maintained in the drying process.<sup>36 37</sup>
- Metal Pickling** – According to the DOE, “pieces of oxidized or plated enriched uranium metal (e.g. rolling mill scrap, broken/sheared metal and broken buttons) are cleaned in the Metal Pickling System to prepare them for casting feedstock. The metal is cleaned in a nitric acid solution to remove oxide, grease and salts. After the pickling operation is complete, the material is transferred to storage for later use.”<sup>38</sup>
- Metal Casting** – Batches of reduction buttons, rolling mill scrap, and or/lugs removed from previous cast shapes are processed so they can be placed into a furnace and molded into shapes. After the melt is complete, it is removed from the furnace to be rolled for formed. Salt baths are used to anneal the metal plates. After annealing the plates are rinsed, then passed through a roller leveler unit to remove warp-

deformation. The plates are then heated and cut into pieces for pressing into desired shapes.<sup>39</sup>

**Figure 3 Enriched Uranium Process**



Source: Adapted from DOE/OR-895

- **Machining, Inspection and Certification** – Metal castings and plates of enriched uranium are then machined into their final shapes. The finished metal parts are the inspected and certified.

### Depleted Uranium Operations

Virgin metal, salvageable scrap, and reclaimed parts are cast into billets, ingots, and other shapes. Uranium and other metal billets are processed, using three different rolling operations.<sup>40</sup> An Arc Melt operation melts and casts DU-alloys containing niobium. Other processes include DU scrap metal processing, sawing, DU oxides and saw fines mixing, depolymerization and melting operations. Three large machine presses make rough depleted uranium shapes for machining, as well as heat treating furnaces, shears, torches, and other DU metal treatment processes. DU production machining, plating and surface coating for DU, DU alloys into finished weapons components. Inspections include dimensional, radiography, dye penetrant, ultrasonics, and other nondestructive testing processes.

### Special Material Operations

Salvage and recycle lithium, including wet chemistry processes, metal production, powder production, parts production, machining, and storage for weapon production. Lithium hydride and deuteride are processed through a series of chemical operations to recover purified lithium in the form of lithium chloride powder. Lithium hydride and

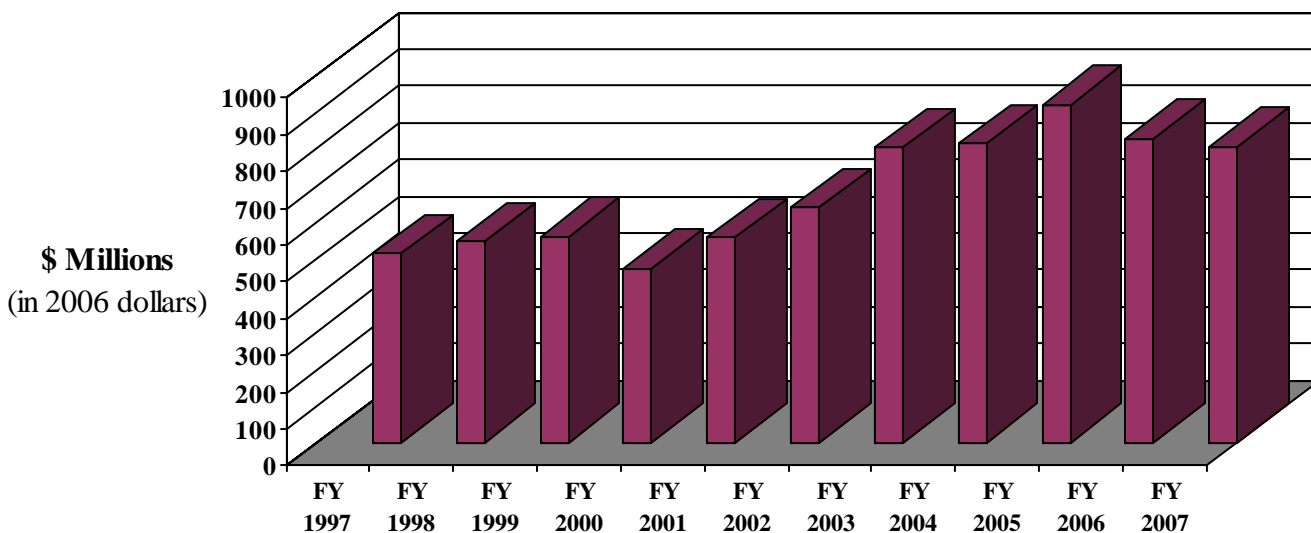
lithium deuteride components from retired weapons are run through a series of chemical operations to convert the lithium hydride and deuteride compounds into lithium chloride.

### Age and Deterioration

By the end of the Cold War, major production facilities were shuttered and Y-12 was left with a large, antiquated infrastructure. With 381 buildings, the Y-12 complex occupies 7,226, 655 square feet.<sup>41</sup> About 70 percent of the Y-12 plant's installed capacity was constructed in the 1940's<sup>42</sup>. Several years before the end of the Cold War, the Energy Department allowed the Y-12 weapons plant to deteriorate. By 1984, "*about 25 percent of the plant was rated as being in poor physical condition or as having inadequate technology.*"<sup>43</sup>

In 1999 it was reported that "*of the approximately 4000 weapons program personnel at the Y-12 plant, some 150 people work in buildings scheduled for abandonment and another 1000 work in obsolete buildings whose condition is rated as poor to fair.*"<sup>44</sup> For instance, Building 9705-5, the main storage facility for tens of tons of highly-enriched uranium weapons components and other special nuclear materials is a wood frame warehouse constructed in 1944.<sup>45</sup> Also, Y-12's primary highly enriched uranium processing building was constructed in the 1940's with additions made in the 1950's through 1970's.<sup>46</sup> Despite the end of new nuclear weapons production in 1991, the annual budget for the Y-12 complex has significantly increased (See Figure 4) In particular, deferred maintenance and repair costs have grown to the point where DOE has budgeted nearly \$750 million dollars between Fiscal Years 2005-2011.<sup>47</sup> In 1989, the National Research Council noted that Y-12 buildings constituted occupied approximately 5.5 million square feet.<sup>48</sup> Sixteen years later, it appears that the square footage which the National Nuclear Security Administration is responsible for has grown to more than 7.2 million square feet.<sup>49</sup>

**Figure 4 Annual Budgets for the Y-12 Site**



Source: DOE Budget Requests to the U.S. Congress

## HAZARDS OF THE Y-12 NATIONAL SECURITY COMPLEX

The hazards at the Y-12 complex stem from nuclear, radiological, and other chemicals present at the site, and also include standard industrial hazards associated with chemical and metallurgical operations. At the Y-12 complex the risks of fires, explosions, nuclear criticalities, acute and chronic exposure to ionizing radiations and non-radioactive substances to workers and the public are dominant concerns.

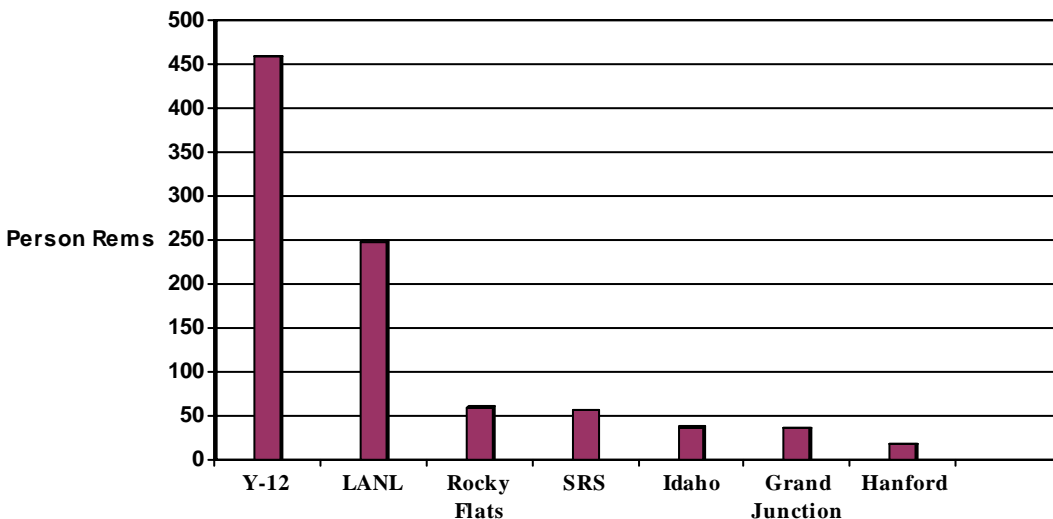
To a large extent, potential hazards are associated with large amounts of highly enriched (20 to >90% uranium-235) and other types of uranium containing stored and handled at the Y-12 Complex.<sup>50</sup> The Y-12 complex has other radioactive materials in lesser quantities that are of concern primarily to workers. They include: Tritium ( $^3\text{H}$ ), Strontium-90 ( $^{90}\text{Sr}$ ), Technetium-99 ( $^{99}\text{Tc}$ ), Thorium-228, ( $^{228}\text{Th}$ ), Thorium-232 ( $^{232}\text{Th}$ ), Plutonium-239 ( $^{239}\text{Pu}$ ), Plutonium-241 ( $^{241}\text{Pu}$ ), Neptium-237 ( $^{237}\text{Np}$ ) Uranium-233 ( $^{233}\text{U}$ ) and Americium-241 ( $^{241}\text{Am}$ ).<sup>51</sup>

Risks of internal radiation exposure are the highest at the Y-12 site than any other DOE site. (See Figure 5) More than forty percent of the total collective internal radiation dose received by workers in the DOE complex has occurred at the Y-12 Complex, since the early 1990's.<sup>52</sup> Contamination of the workplace and outside areas in the western portion of the Y-12 site from more than 60 years of production remains a problem. (See Appendix B)

Uranium reacts with nearly all non metals and is flammable and explosive when in contact with carbon dioxide, carbon tetrachloride, or nitric acid. Potentially flammable

**Figure 5**

### Internal Radiation Exposures to DOE Workers (Committed Effective Dose Equivalent)



Source: DOE REMS Data Base

and explosive uranium hydride is formed when exposed to water and can spontaneously ignite in open air.<sup>53</sup> Uranium is harmful to humans. Soluble forms of inhaled uranium (and a small fraction of less soluble forms) are absorbed into the blood, and deposit in the kidneys and skeletal bone.

Controls to avoid a nuclear criticality accident in storage and processing facilities are of paramount importance. A very small amount of fissile materials in solution could initiate a nuclear criticality accident due to the presence of water. The minimal amount of critical masses in uranium 233, uranium 235 and plutonium 239 in solution are about 0.5, 0.8 and 0.5 kilograms, respectively. Minimal amounts to achieve criticality in metallic form for these isotopes are 6, 20, and 5 kilograms respectively.<sup>54</sup>

This year the Defense Nuclear Facility Safety Board reported that: *many DOE site offices continue to be either unstaffed or understaffed in the area of NCS [nuclear criticality safety] oversight. Some of the problems with contractor NCS programs can be traced to ineffective NCS oversight by site offices.*<sup>55</sup>

Fires and chemical reactions/explosions involving the release of uranium to the environment are considered a dominant risk. The Energy Department has estimated that off-site exposures from a uranium fire releasing approximately 25 kilograms of oxide at Y-12 could result in an offsite doses ranging from 30<sup>56</sup> to 90 rem.<sup>57</sup> These risks have been enhanced by vulnerabilities associated with facility deterioration, and the accumulation of large amounts of unstable, and inadequately stored uranium materials.

According Y-12 site personnel in 1996, HEU accidents resulting in worker exposure and environmental releases at several other Y-12 buildings were estimated to likely occur within the life-span of the existing structures. A DOE Headquarters team determined in 1996 that the main HEU storage building, a wooden structure built in 1944, was *vulnerable to a wide-scale facility fire with ignition of the structure.*<sup>58</sup> A fire could start:

*“...due to any number of potential igniters (i.e. electrical lightening, human error) and the fire reaches the wood framing of the facility. As the fire burns, consuming the framing, the facility is weakened and begins to fall. Containers are exposed to the flames and potentially breached from falling debris. The fire continues and consumes some HEU in the facility. The resulting smoke is toxic and radioactive resulting in contamination to the worker, the Site and [with the potential to] carry beyond the site boundary resulting in contamination of the public.”*<sup>59</sup>

Activities at the Y-12 Plant also involve the processing, handling and storage of hazardous chemicals, (See Table 2)<sup>60</sup> which pose potentially serious occupational and public hazards. For instance:

- A major accident involving the release of hydrofluoric acid, used to process HEU, could result in air concentrations of 1,000 parts per million – more than 30 times greater than the level considered an immediate danger to human health.<sup>61</sup>

- Beryllium is a combustible and potentially explosive material which have been used and stored in large amounts. <sup>62</sup> It has also been demonstrated to cause beryllium disease), which cripples the lungs, and cancer in humans from chronic exposure. Approximately 5,000 Y-12 workers have been screened as a result of working in areas with beryllium. <sup>63</sup>
- Lithium is a highly reactive metal that reacts violently with water producing hydrogen. Types of lithium handled at Y-12 include lithium hydride, lithium deuteride, lithium metal, and lithium hydroxide. <sup>64</sup>
- Sodium Potassium metal (NaK) is an alkali metal which is very reactive with air and water. The heat generated by this reaction is sufficient in most cases to ignite the hydrogen gas (H<sub>2</sub>) that is evolved in the reaction. In December 1999 this reaction resulted in a powerful explosion which injured eleven workers at the Y-12 Plant. <sup>65</sup>
- Hundreds of thousands of gallons of an ignitable mixture of methanol/water coolant flows through several buildings at Y-12. Vapor ignition temperatures range between 75 degrees to 95 degrees Fahrenheit. In August 1998, a large coolant pump at the Y-12 Chiller building exploded, causing extensive damage to nearby equipment and structures, and injuring a worker in another room. According to DOE, “This occurrence was a very serious near miss, as anyone in the unprotected area near the pump could have been seriously or fatally injured.”<sup>66</sup> (See Figure 6.)

**Figure 6 Destruction Caused by Coolant Pump Explosion at the Y-12 Complex in August 1998**



Source: DOE/EH-0531(98Q2)

The recent accident history of the Y-12 Complex involving nuclear and non-nuclear materials does not inspire confidence in protective barriers. Between 1992 and 2006, a period when production activities were significantly curtailed, there were at least 22 fires and explosions involving electrical equipment, glove boxes, laboratory equipment, pumps, waste containers, and nuclear and other materials. Several fires resulted in the



injury of workers. A review of DOE operating experience, performance indicator, and accident reports suggest that Y-12 has experienced the largest number of fires and explosions over this time period.<sup>67 68 69 70</sup> Others were small but are significant because of the potential for spreading due to deteriorated equipment such as electric systems, and the collocation of combustible, pyrophoric and explosive materials. (See Table 3.)

## THE DIFFICULT PATH TO RESTART

After 12 years the Y-12 highly enriched uranium foundry in building 9212 has yet to achieve an adequate operational capacity. In 2004, restart costs were estimated by the DOE's Office of Inspector General to be in excess of \$400 million – more than three times the original estimate.<sup>71</sup> Since then, DOE has still not been able to fully restart the “wet chemistry,” and oxide conversion processes – necessary to stabilize the estimated 100 metric ton back-log of excess HEU materials. In February 2006, the DNFSB staff reported that for the past 14 months, *“equipment and safety basis issues continue to preclude these systems from achieving a sustained operational tempo [which] have resulted in a significant backlog of uranium solutions stored in facility tanks and safe bottles.. These solutions are nearing the solution storage capacity for the Enriched Uranium Operations .”*<sup>72</sup>

By May 2006, insufficient progress was being made to process the backlog of in process materials -- compelling the DOE to review all enriched uranium operations and requesting that BWXT, the Y-12 contractor, *“identify the underlying causes that are preventing sustainable manufacturing operations, both capability and capacity . . . .”*<sup>73</sup> Shipments of HEU from other sites over the past decade have increased this backlog.

DOE's restart effort was to occur in the following phases,

- Phase A1-2 included restart of accountability and casting processes, followed by rolling, forming and machining operations..
- Phase B was focused on restarting “Wet Chemistry” and oxide conversion operations for the processing of production by-products such as scraps, oxides and solutions

Restart of the HEU processing in Building 9212 have faced several obstacles, which include:

- **Fire Protection** --Equipment essential to fire protection has not been maintained or upgraded. This problem was first highlighted by the National Research Council in 1989.<sup>74</sup> Since that time numerous concerns about deficiencies in fire protection at Y-12 have been raised, mostly by the Defense Nuclear Facility Safety Board.<sup>75</sup>  
76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107

Electrical systems pose significant fire risks because they are more than 50 years old and severely corroded.<sup>108</sup> In 1996, DOE reported that Failure to repair and modernize fire protection equipment, *“could add to the likelihood that a fire would occur and also the severity of the fire.”*<sup>109</sup> There have been at least four

high-voltage cable explosions at the Y-12 site. A number of cable and cable splices were under water.<sup>110</sup><sup>111</sup> Deficient fire hazard analyses have been a persistent problem. Large amounts of combustible materials have been allowed to accumulate in process areas. Methanol Brine-- a coolant mixture of methanol and water (20-40 percent methanol) -- is present in large amounts ( ~ 400,000 gallons) throughout Y-12 process areas, including defunct facilities, where large leaks could go undetected. As mentioned, in 1998, a brine pump exploded as a result of negligent maintenance.<sup>112</sup> Two years after the explosion, the DNFSB staff found: *a 6" stalactite of gelatinous "mung" hanging off of a dripping chill water valve. We subsequently identified that the chill water system has not been sampled in five years!...sampling was stopped due to a lack of funding.*<sup>113</sup> In 2003, *a brine pump overheated to the point of burning up foam insulation. The pump had been running dry for several hours when it was discovered.*<sup>114</sup> Decades old fire suppression systems have not been replaced. As late as fiscal year 2006, funding for fire protection equipment upgrades and other corrective actions were *"significantly reduced and may impact additional corrective actions."*<sup>115</sup>

**Quality Assurance** – According to the Defense Nuclear Facility Safety Board staff in 2000, DOE's *"is practicing what can best be described as "faith-based management [based] on a deep-seated belief that there is no safety hazard associated with this operation."*<sup>116</sup> The year the board staff found, *"a number of unresolved safety issues ...many of which have been identified during previous staff reviews."*<sup>117</sup> In 2004 the DOE's Office of Inspector General reported that Department and its contractor had failed to implement an effective quality assurance program to ensure timely and cost-effective restart. In particular, *there was minimum oversight in the field. In fact the official reported that in almost all cases, quality assurance was not called on until after failures occurred."*<sup>118</sup>

**Nuclear Criticality Safety** – In 1994, the Y-12 HEU foundry was placed in a stand down mode because of *"widespread non-compliance"* of DOE nuclear criticality safety requirements. Some of these problems have persisted. For instance, despite the fact it was known that the ventilation duct system was significantly degraded for several years, it was only in 2004 that it was identified as a criticality safety risk.<sup>119</sup> Another concern is the lack of safe fissile materials containers, which meet DOE safety requirements. There are over 200 different types of fissile material containers used at Y-12, which are subject to a scattered and fragmented safety regime.<sup>120</sup> Moreover, as of 1996 about sixty percent of the drum-type storage containers had never been opened. Some are more than 30 years old.<sup>121</sup> <sup>122</sup> Lapses in criticality safety have been numerous and continuous to the present.<sup>123</sup> <sup>124</sup> <sup>125</sup> <sup>126</sup> <sup>127</sup> <sup>128</sup> <sup>129</sup> <sup>130</sup> <sup>131</sup> <sup>132</sup> <sup>133</sup> <sup>134</sup> <sup>135</sup> <sup>136</sup> <sup>137</sup> <sup>138</sup> <sup>139</sup> <sup>140</sup> In 2005, it was discovered that at the Y-12 main uranium storage area, *"numerous containers had been received and stored on separate occasions with contents exceeding criticality safety mass limits."*<sup>141</sup> As late as May of 2006 a Category 1 Criticality Safety Violation was declared which forced suspension of operations because there were *"no valid controls to prevent a criticality accident."*<sup>142</sup>

## STORAGE AND PRODUCTION MODERNIZATION

In 1998 the Energy department decided a new fissile material storage facility was needed to replace the aged and vulnerable Building 9502, and preceded with a preliminary conceptual design for Highly Enriched Uranium Material Facility (HEUMF). The following year, the HEUMF became part of the *Y-12 Site Integrated Modernization Plan* which also included:

- Support of nuclear weapons system returns and refurbishments for the next 20-30 years, including manufacture of weapon “secondaries” and radiation cases;
- Design and construction of a special material purification facility; and
- A new highly-enriched uranium processing facility to replace Building 9212 operations.

An Independent Project Review, conducted in January 2006, prior to a Departmental decision to approve detailed design (Critical Decision 1) of the modernization project, raised several concerns;

*“...the proposed cost and schedule ranges do not adequately reflect project uncertainties and risk. They also identified that the proposed design may not be consistent with current program requirements (e.g., facility throughput and capability). In addition, the team concluded that the Preliminary Hazard Analysis does not include sufficient analysis to identify a preliminary list of safety significant and safety class structures, systems and components.”<sup>143</sup>*

### Highly Enriched Uranium Material Facility

The original design and construction for the HEUMF was estimated at \$120 million.<sup>144</sup> The facility was envisioned as a concrete bunker covered by an earthen berm on the top and three sides of the facility. Its dimensions were approximately 230 x 500 ft, with the capacity to store 14,000 secondaries and 14,000 cans (metal and oxides) of HEU. The facility was also to be designed to accommodate International Atomic Energy Agency surveillance of HEU, as well as provide for receipt and disassembly of secondaries.<sup>145</sup>

In an effort to reduce costs, the DOE eliminated the IAEA inspection facility, and extra storage space to accommodate a “surge capacity” – reducing the size of the HEUMF by nearly 30 percent.<sup>146</sup> By April 2001 the DOE changed from a fixed price to a cost-plus procurement<sup>147</sup> and approved the recommendation of the new contractor, (BWTX) to remove the berm from the facility design. After various design revisions, design and construction costs for the non-berm facility had grown to \$253 million.<sup>148</sup> Currently, the projected cost for the HEUMF is estimated at approximately \$500 million.<sup>149</sup>

From the outset, several problems and concerns surfaced about the project. The DNFSB staff observed:

- “A systems engineering approach is not in place, integration amongst the designers, operations, and requirements owners (e.g., security, criticality safety) is extremely weak, and engineering formality is badly lacking.”<sup>150</sup>
- “DOE at Y-12 does not currently possess all the technical resources necessary to support its role in overseeing the Y-12 Modernization projects. More significantly, the totality of DOE’s technical responsibilities have not been compiled, recognized by management and converted into manpower requirements.”<sup>151</sup>

It is not clear what will be stored in the HEUMF. The Energy Department’s project plan limits storage in the new facility to uranium oxide and metal as well as nuclear weapons secondaries. But, DOE’s storage plans have included 13 different forms of uranium including, “hundreds of containers of solutions” This suggests that significant quantities of material placed in the new facility will not be in compliance with DOE standards for long-term storage.<sup>152</sup>

Finally, inadequate quality assurance resulted in led to construction mistakes, delays and cost overruns<sup>153 154 155 156 157</sup>

### **New Uranium Processing Facility.**

In February 2005, Energy Department’s Y-12 Support Office (YSO) approved the Uranium Processing Facility (UPF) Project Definition Plan, which subsequently was included in the DOE’s budget request to Congress for Fiscal Year 2007. The projected total project cost is \$1 billion and operations are expected to begin as early as FY 2013.<sup>158</sup> The new facility will rely on the development of new technologies to replace the chemical conversion and foundry processes used at Y-12 since the 1950’s. Specifically, the project is expected to deploy microwave casting and saltless direct oxide reduction.<sup>159</sup>

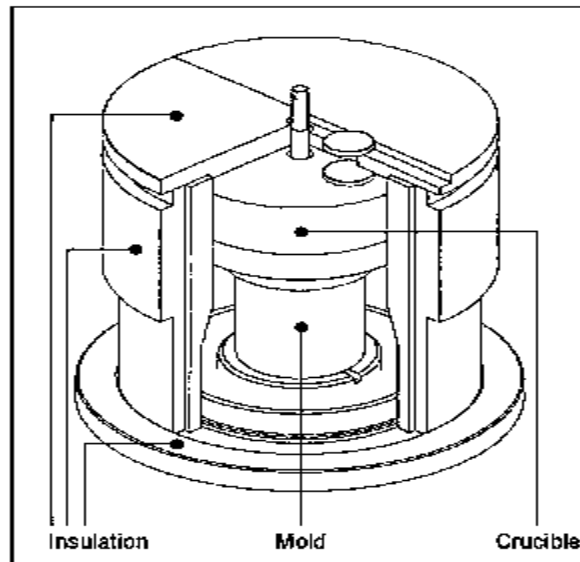
These technologies have been under development at the Y-12 plant for more than a decade. Production deployment for microwave casting and for the Saltless Direct Oxide were expected to be achievable by 2007 and 2008, respectively.<sup>160</sup> A small-scale microwave melter was installed in 2003 in Building 9212 and in January 2006, the conceptual design for the Uranium Processing Facility was being finalized. Facility detail design was expected to commence in mid-2006 following approval by the Energy department.<sup>161</sup>

**Microwave Casting** -- Microwave casting is considered to be safer, more energy efficient, and easy to maintain. “Among several advantages cited by BWXT [Y-12’s contractor] of microwave casting over the current casters in E-wing is that water cooling is not needed and a safety basis control to detect water is not required.”<sup>162</sup> According to researchers at Y-12, it produces high-quality metal with significantly fewer inclusions and carbon contamination versus vacuum-induction melting in existing furnaces. The Y-12 laboratory has demonstrated microwave melting and casting with steels, titanium, zirconium, uranium, copper, brass, bronze, aluminum, and other metals. Melt sizes range from a few pounds to more than 750 lb.<sup>163</sup>

Heating and melting bulk metals using microwaves rely on:

*“a multimode microwave cavity, a microwave-absorbing ceramic crucible and a thermally insulating casket that is microwave-transparent. The metal charge is placed in an open (no lid) ceramic crucible, and the insulating casket is positioned to completely cover the open crucible. The casket and crucible assembly are placed into a high-power multimode microwave cavity capable of uniformly heating the crucible to the desired temperature. Microwave energy applied to the cavity is strongly absorbed by the crucible. The metal charge in the crucible is quickly heated by means of radiation, conduction and convection with the heated crucible walls. The thermally insulating casket increases the energy efficiency of the microwave system by trapping the heat generated in the crucible. (See Figure.7).<sup>164</sup>*

**Figure 7 Microwave Crucible**



Source: Ripley and Oberhaus, Industrial Heating 2006

The deployment of the prototype microwave caster in Building 9212 has not been without problems. Prior to introducing uranium, copper was used for production runs. In late March 2005, a failure occurred because: *“molten copper was not introduced to the mold from the crucible due to complications from a loss of power to the microwave. ...Some of the issues under review by the [Readiness Assessment] team include content of the procedure, level of knowledge of operations personnel, and configuration of the microwave chamber pressure relief system.<sup>165</sup>* In May 2005, start-up of the microwave prototype commenced with enriched uranium. *“During the later portion of the heat-up, the power supply to the microwave failed. Initial troubleshooting found blown fuses in the power supply. Certain prior microwave runs with surrogate material have also had power supply problems.<sup>166</sup>* By June 2005, these problems were addressed and fifteen prototype test casts with enriched uranium were produced.<sup>167</sup>

**Saltless Direct Oxide Reduction (SDOR)** -- This technology converts uranium dioxide (UO<sub>2</sub>) to metal by direct reaction with calcium metal followed by leaching the calcium oxide (CaO) from the product. Uranium dioxide and calcium oxide are heated to a temperature of about 1,100 degrees C in a crucible. The metal filter cake is then dried and then converted into a “button” shape by melting.<sup>168 169</sup> SDOR is being developed to replace: (1) the fluoride reduction process at Y-12, which generates large amount of uranium-bearing waste salts and presents potentially serious occupational and public hazards due to significant amounts hydrogen fluoride used.<sup>170</sup>

The SDOR process also poses potential environmental, safety and health problems. For instance, direct reduction of metal oxides with calcium in solvent chloride salts also creates large volumes of salt residues that are difficult to process due to the corrosive nature of chloride solutions. Moreover, on April 18, 2003 a container exploded causing a fire in a glovebox that was part of a newly built Saltless Direct Oxide Reduction (SDOR) pilot facility. The explosion was caused by water reacting with calcium and depleted uranium that was in an unvented container inside the glovebox. According to the DOE: *The SDOR event resulted in gross container failure, loss of glovebox containment, a spread of radioactive contamination within the facility, and a minor unplanned radiological exposure to a worker...*<sup>171</sup> More than a year later, the event resulted in a Preliminary Notice of Violation by the Energy Department’s Price-Anderson Enforcement Office, which cited “*continuing violations of Y-12 Plant Safety Basis requirements.*”<sup>172</sup>

The accident compelled design changes, including a redesigned oxide dissolution system and the banning of sealed container. This has in turn led to a delay in the start-up for trial runs and a decision yet to be made by DOE whether or not to proceed with this technology.<sup>173</sup>

## **DOWNSIZING THE Y-12 COMPLEX**

Since the end of the Cold War the Energy Department announced various initiatives to significantly eliminate excess capacity at this site. However, downsizing has proven to be elusive. In 1996 the Department announced that “*By about the year 2003, the Y-12 facility would be approximately 10-20 percent the size of the existing plant.*”<sup>174</sup>

In 2002, however, the DOE Office of Inspector General reported that:

*At the Y-12 National Security Complex (Y-12) ... disposition plans appeared to conflict with requirements for new facilities. ... For example, Environmental Management's disposition plans were in conflict with Defense Programs' draft modernization plans for Y-12. Defense Programs' plans included construction of a new Enriched Uranium Manufacturing Facility as early as FY 2007 where an excess facility, Alpha-4 (9201-4), now stands. The Manufacturing Facility is critical to the Defense Programs national security mission and will replace current aging and oversized Enriched Uranium operations facilities.*

*Environmental Management was responsible for Alpha-4's disposition. However, there were no plans for demolition in the Environmental Management baseline.*<sup>175</sup>

Large excess capacity for HEU and depleted uranium processing remains in place, while defunct facilities with rotting roofs and beams continue to store unstable nuclear and other hazardous materials. Y-12's depleted uranium (DU) operations currently occupy more than 1 million square feet in four buildings. (See Appendix ...) The DU operations current produced needed weapons components, for a greatly reduced nuclear stockpile, and have not made components for new warheads since 1991. Efforts to downsize this function at the Y-12 Complex have been disjointed and have created difficulties with respect to the nuclear weapons stockpile maintenance.

In 2002, the DOE Office of Inspector General (OIG) reported that, *because Y-12 had not completed a previous consolidation effort... NNSA's ability to manufacture needed parts in the future may be in jeopardy.*<sup>176</sup> According to the OIG.

*“Our analysis of the condition status of this equipment suggests that NNSA's ability to manufacture needed parts in the future may be in jeopardy. We found, for example, that a 42-year old hydraulic press, used to forge virtually all parts manufactured at the facility, had significant damage and that this damage is so serious that it will ultimately lead to failure of the press. We were surprised to find that a replacement press, on site for well over a year, had not been installed because Y-12 had not budgeted for its installation.... If the depleted uranium process fails, NNSA may not be able to meet its weapons stockpile requirements. Furthermore, increased maintenance costs were being incurred and prior investments in new equipment were at risk.*<sup>177</sup>

About 75 percent of the depleted uranium stored in the DU processing five buildings, and outside “sea containers” was reported by the NNSA to have no further use.<sup>178</sup>

In 2005 a Department of Energy Task Force on the Nuclear Weapons Complex Infrastructure effectively recommended the closure of the Y-12 Complex. The Task Force’s primary focus was on modernization of the U.S. nuclear weapons stockpile through the design and production of a new the Reliable Replacement Warhead.

Citing the lack of “*modern-day production technology*” and DOE’s efforts to maintain the nuclear weapons stockpile while “*operating from World War II era facilities,*” the Task Force stressed that the Y-12, Los Alamos, and Pantex sites “*are sufficiently close to residential and commercial structures such that any partially successful terrorist attack on these sites may cause collateral damage to the surrounding civilian population.*”<sup>179</sup>

To accomplish the goal of prompt developing Reliable Replacement Warheads, the Task Force recommended that the National Nuclear Security Administration:

- “ *immediately begin site selection processes for building a modern set of production facilities with 21<sup>st</sup> century cutting-edge nuclear component production, manufacturing, and assembly technologies, all at one location.*” and
- consolidate the storage of all special nuclear material and weapon primary and secondary components to the same new weapons site.<sup>180</sup>

For the Y-12 Complex, HEU storage and weapons activities would end. The Energy department agrees on the need to develop a new Reliable Replacement Warhead but has rejected the Task Force recommendations on production and storage consolidation. Instead DOE has decided to proceed with its “*modernization in-place*” plan despite the objections of the Task Force.<sup>181</sup>



## APPENDIX A

### Material and Facility Vulnerabilities at the Y-12 Complex

For more than a decade, the stabilizing Y-12's large highly backlog of in process enriched uranium materials have been of primary importance to safety. In 1995, the Defense Nuclear facility Safety Board concluded:

*“The mission most relevant to safety is one of processing the backlog of in-process materials at Y-12. [Emphasis added.] In Building 9212, these materials occupy space in the hallways and operating corridors and some have been present for more than 40 years. The in-process materials do not meet the criteria for interim or long-term storage and no criteria for in-process storage have been developed. In-process materials form the largest portion of the "material at risk" considered in Building 9212 accident analyses and contribute significantly to the dose consequences of those accidents. These materials pose the greatest risk for spills, decomposition, or criticality safety infractions, make inventories difficult, and increase worker exposure risk due to their location in the workplace.”*<sup>182</sup>

In 1996, an Energy department followed up with an agency wide environmental, safety and health vulnerability assessment of the storage of highly enriched uranium. The assessment reported that the Y-12 Plant had the most significant vulnerabilities, both in number and degree of severity.<sup>183</sup>

At the time of the assessment, Y-12 facilities were storing 189 metric tons of excess HEU contained in 32,000 HEU items including dismantled weapons parts, solutions, oxides, combustibles stored in drums, and canned residues. (This estimate does not include classified quantities of HEU stored at the Y-12 Plant.) The preponderance of HEU assessed is in metal forms stored in carbon steel “shipping-like” drums. “Most containers have low concentration HEU, approximately 100 metric tons of bulk material forms. Surplus HEU from various DOE sites is expected to be shipped to Y-12 for future processing and storage.”<sup>184</sup> In Building 9206, a defunct processing facility used for storage, there were 2,600 batches of uranium-bearing material containing 3,200 kg of uranium-235.<sup>185</sup>

A total of 49 vulnerabilities (more than one third of the total DOE-wide) were identified at the Y-12 . Of those 19 related to facility conditions, 21 dealt with material/packaging and 9 were institutional. According to the 1996 assessment, major vulnerabilities included:

#### Facility Vulnerabilities

The assessment underscored the problem of the site's aged and deteriorated infrastructure noting structures were allowed to deteriorate, while containing with large quantities of HEU in numerous forms and packages.

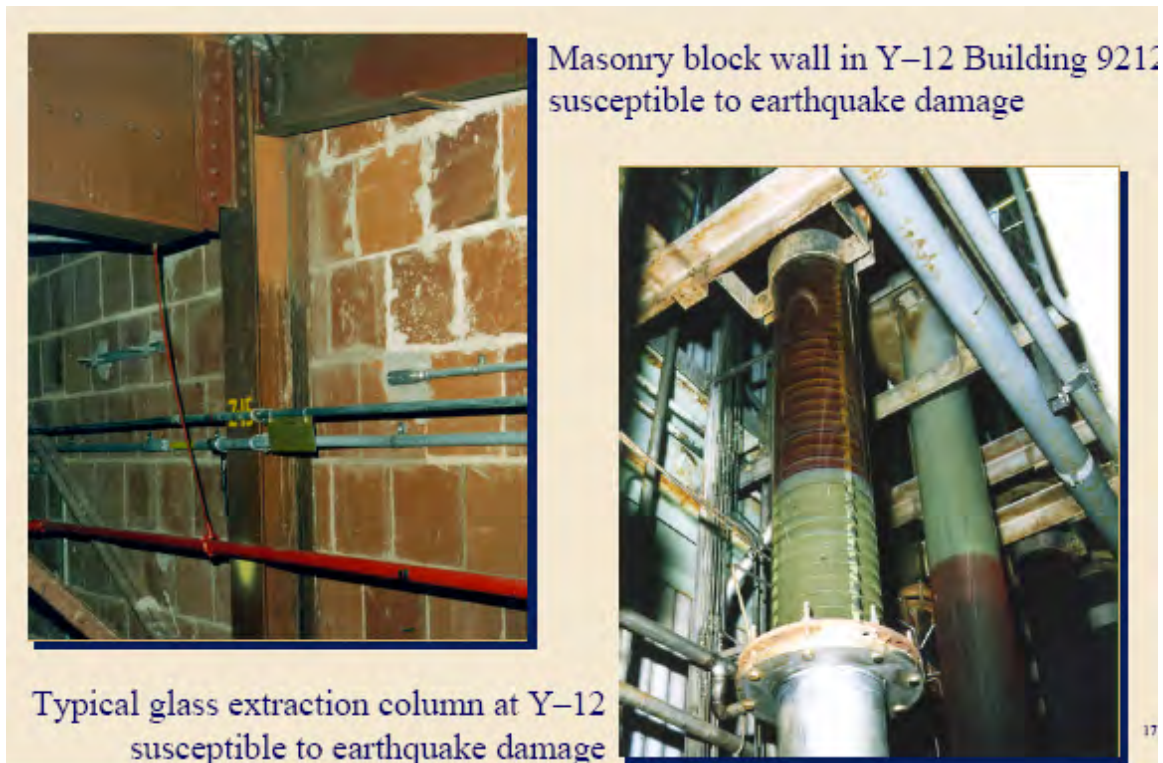
All building storing HEU were found to have vulnerabilities. For instance, The Energy Department Working Group found that in buildings 9206 and 9207-17, *HEU is stored in many forms, depending on where it is in the process or where it originated. .most of the...inventory will be stored for an undetermined period of years. ...The stated intention is to move all enriched uranium to Building 9212 for disposition. ... The long term storage will be severely impacted by the water intrusion from the leaking roof, liquids stored in process columns, and the condition of plastic bags and seals on containers... Waste to be incinerated remains in the incinerator feed system.*<sup>186</sup>

Building 9606, was described as” *an extremely old facility [that] has been shut down for several years and is receiving little maintenance or preservation.*<sup>187</sup> This multi-story structure was constructed in the early 1940s and ended production in 1993. An adjacent warehouse structure was added in the 1950’s (Building 9207-17) which is made of pre-fabricated metal siding atop a concrete grade, now used for storage of in-process HEU..

Deterioration has resulted in significant roof leaks and water intrusion in areas storing highly enriched and depleted uranium, as well as highly water-reactive chemicals such as lithium. In 2000 the DNFB staff reported: *“An indicator of the extent of physical deterioration at Y-12 is that the criticality safety organization is attempting to codify how much standing water is permissible in a fissile material storage array... it seems acquiescence to the status quo.*<sup>188</sup> In 2001, a fire hazard analysis performed by the contractor for one of these facilities concluded that *“the condition of the building is substandard ... at least three beams ... have rotted through. Portions of the roof deck have sustained previous water leakage-related damage. Interior wood posts have cracks due to age; one was observed to have termite damage.”*<sup>189</sup> In 2004, while inspecting Building 9212 the DNFSB and DOE staff *“observed a roof leak close to an electrical control panel. A waste drum used to catch the rainwater was full and overflowing. Despite this observation being noted to [DOE] and building management last week, the situation was found to be persisting this week by BWXT Manufacturing Division management.*<sup>190</sup>

Concerns about the ability of aged Y-12 facilities to withstand earthquakes and powerful weather events, first raised in 1989 by the National Research Council and then by the DOE’s Office of Environment, Safety and Health in 1996, have deepened.<sup>191 192</sup> However, it was only in 2005 that DOE completed a structural analysis for Building 9212 – the main HEU processing facility. (See Figure 8.)The results showed:

*“...numerous seismic deficiencies, including missing or loose bolts, missing or structurally inadequate braces, inadequate beam supports, and designs that are deficient when measured by current criteria. In these aging structures, glass sections in tall columns and sight glasses are vulnerable to breakage, cans on storage racks are not adequately secured, and horizontal and vertical tanks are not adequately supported.”*<sup>193</sup>

**Figure 8**

Source: DOE/EH-0515

### Material/Packaging Vulnerabilities

HEU solutions and solid residues are less stable chemically and were found to dominate material/ packaging vulnerabilities at the Y-12 plant. *“Large amounts of HEU materials are stored in Building 9212 in unsealed containers, both liquids and solids. Typically, solids in the form of chips and powder re contained in cans with slip-fit lids and liquids are stored in bottles with untightened caps...there is no barrier between HEU and the environment...there is no containment barrier between HEU material and workers. Moreover, there are few constant air monitors to warn workers.”*<sup>194</sup> (See Figure 9.)

Unlike, large metal shapes, finely divided metal pieces have the potential to react extensively with water. Given the absence of storage standards for in process materials, such as these, it is not clear if storage drums provide for necessary venting of hydrogen, to prevent over-pressurization and subsequent fires and explosions.<sup>195</sup> In addition the Working Group, *“observed an accumulation of combustible in process materials in virtually every building....the amount of combustible in process materials being stored in various buildings posed an unnecessary vulnerability with respect to fire loading.”*<sup>196</sup> Metal forms of HEU were considered less vulnerable (with certain exceptions such as small metal pieces and powder). *“Sixty percent of the drum-type storage containers at Y-12 have never been opened. Some are over 20 years old.”*<sup>197</sup> A complete physical inventory of HEU had not been done since 1994. *“The Y- 12 Plant did not generate nor maintain comprehensive records on the storage configurations. Most containers were*

received at the Y-12 Plant and placed direct into storage without opening.”<sup>198</sup> At the time of the assessment, Y-12 site personnel estimated that a container breach, possibly contaminating workers was likely to occur in five years. In October 2002, two uranium containers caught fire after workers attempted to remove them for processing. The “material had been stored in a glovebox for more than 10 years and adequate identification of the contents was not performed prior to removal for processing.”<sup>199</sup> Underscoring the potential risks associated with this vulnerability was the lack of storage standards for weapons components known as canned subassemblies (also called “secondaries”) and for in process material. Despite the many years of production and storage such standards were not adopted.<sup>200</sup> According to the DNFSB:

*Y-12 currently employs over 200 different types of fissile material containers... For certain containers, the Enriched Uranium organization (EUO) and the Non-EUO organizations utilize two different drawings for the same identical containers!... Each Y-12 nuclear facility has its own Criticality Safety Analysis (CSA) for the specific containers it uses....*<sup>201</sup>

By 2006, after the DNFSB raised concern about this problem in 2002, the contractor operating the Y-12 Complex (BWXT) has designed and manufactured prototype standardized containers now undergoing testing. It is expected that fabrication and use of the new containers will commence in 2007.<sup>202</sup>

The Energy department has been slow to fix the problems identified by the 1996 vulnerability assessment, despite efforts by the Defense Nuclear Facility Safety Board (DNFSB) to focus the department’s attention on his problem. In 2000, the DNFSB reported to DOE’s National Nuclear Security Agency that Building 9206 still contained large amounts of HEU “in many unstable forms, including uranyl nitrate solutions in glass columns and plastic bottles, pyrophoric compounds, hundreds of kilograms of unstabilized residues, and poorly characterized fissile material hold-up in ducting and other systems...The Board issued a letter to DOE in February 1998 noting that the lack of attention the building and materials were receiving was allowing its hazards and risks to increase...”<sup>203</sup> Subsequently, the DOE took action to stabilize the uranyl nitrate solutions and the expand the scope of facility activation. However, as of April 2006, a significant backlog of unstable HEU remains in Building 9206 – posing nuclear safety risks.<sup>204</sup>

Failure to maintain leaking roofs can cause water intrusion and possible collapse in HEU storage and processing areas. According to the Working Group: “maintenance problems such as in leakage of rain water and process liquid leaks were widely present. There was a substantial backlog of building and equipment maintenance tasks.....the large backlog of maintenance items contributed to a lower level of protection of HEU across the site....As a result, the potential for injury to workers operating facility equipment was higher, as was the potential for unexpected events leading to releases or having an impact on the environment...Little preventative maintenance has been conducted toward maintaining equipment operability...”<sup>205</sup>

**Figure 9**

Source: DOE/EH-0515

### **Institutional Vulnerabilities**

**Failure to Meet DOE Safety Requirements** -- At the time of the assessment the Y-12 Plant was in significant non-compliance with formal DOE safety requirements.<sup>206</sup> The working Group concluded, “*at Y-12, relevant safety evaluations are either incomplete or nonexistent.*”<sup>207</sup> The Y-12 plant was found to not have a complete and updated authorization basis that reflected, “*current missions, modes, status of operation, storage conditions, and combustible loadings, and that identify equipment needed to protect workers, the public and environment.*”<sup>208</sup> For instance, “*The authorization basis documentation often does not contain such fundamental information as the physical forms, storage configurations, or inventories of HEU assumed to be present in the facilities; and, therefore, were not evaluated for potential releases during major accident scenarios. This renders evaluation of ‘change in risk’ ...difficult and often meaningless.*”<sup>209</sup>

Nearly ten years later, DOE submitted a Documented Safety Analysis as required under statutory regulations (10 CFR 30) for Building 9212. However, the staff of the Defense Nuclear Facilities Safety Board (Board) conducted a review, which found “*weaknesses in the documents that have, resulted in improper classification of safety systems and unclear administrative controls... if uncorrected, [the noted weaknesses] could lead to an inadequate safety basis for the 9212 Complex and impede contractor implementation.*”<sup>210</sup>

Adding to the problem, age and deterioration of Y-12 storage facilities, combined with inadequate HEU packaging, makes it very difficult if not impossible for Y-12 to meet current DOE safety standards for the storage of HEU. “*No storage location currently in use meets the DOE Order 6430.1A General Design Criteria for new HEU Storage Facilities.*”<sup>211</sup> Much of the HEU at Y-12 “*is in containers and locations not designed for extended storage.*”<sup>212</sup>

**No Defined Plan to Stabilize Large Backlog of HEU** -- The Working group considered the lack of an integrated plan to process the large backlog of varied in process HEU materials to be a significant vulnerability. *The funding and schedule for processing this backlog of HEU has yet to be established.* <sup>213</sup> As mentioned much of these materials pose risks of combustion due to inherent flammability, chemical interactions and the collocation of large amounts of potentially flammable materials such as building coolant, plastics, and wooden items such as pallets. <sup>214</sup> *According to the 1996 assessment,, “some HEU materials at Y-12 have been in their present storage form for almost 40 years.* <sup>215</sup> *“Current plans address only the restart of the Y-12 Plant....”* <sup>216</sup>

In September 2002, the National Nuclear Security Agency acknowledged to the DNFSB that little progress had been made:

*Y-12 continues to compete for storage space with conflicting missions of infrastructure reduction and modernization of equipment and facilities. The bridging from current status to the modernized position is the challenge. As a result, Y-12 has considerable amounts of material stored in facilities that are described as deteriorated.* <sup>217</sup>

As if December 2003, DOE staff *“identified 17 material streams that have no defined use with three categories of material that have no clear disposition path. The preferred disposition option for most of the no-defined-use uranium materials is processing at a commercial vendor since the previous preferred option of canyon processing at the Savannah River Site is cost prohibitive. Discard limits continue to be reassessed to potentially allow for disposition of much of the low-equity uranium materials as waste. The staff and site rep. noted many nuclear material items stored in combustible containers.”* <sup>218</sup> A year later, efforts to establish Economic Discard Limits (EDLs) to allow for the disposition of the preponderance excess HEU materials continued at a slow pace. Despite the fact that about 50 percent of the processing time would be consumed for excess materials containing less than one percent uranium, DOE had yet to take action. <sup>219</sup>

More than a decade after this problem was first brought to light, the Energy department has yet to provide to the U.S. Congress with a budget and schedule to process this large backlog of unstable HEU materials.

**Maintenance Backlog** –A significant and large backlog of maintenance of facilities and equipment essential to the safe operation of Y-12 Plant was of major concern. Specifically, Y-12 was found to have a backlog of 18,000 maintenance items. <sup>220</sup> (See Figure 10.) For instance, the inability to properly maintain storage containers containing pyrophoric HEU materials can lead to leaks, fires and explosions. It also can translate into the malfunctioning of equipment leading to an accidental release of radioactivity, and contamination of onsite or offsite areas. The assessment noted an absence of preventative maintenance relative to fire sprinklers, which *“could add to the likelihood that a fire would occur and also the severity of the fire.”* <sup>221</sup>

**Figure 10**



Source: DOE/EH-015

At the Y-12 depleted uranium operations, DOE’s Office of Inspector General reported in 2002, that: *“Much of the production equipment presently in use has exceeded its useful life, has required significant maintenance, or was added as a substitute for the original equipment. Further, while some new equipment had been purchased, it had not been installed and had begun to degrade.<sup>222</sup> [Replacement] equipment [was] left inoperable for more than a decade, has degraded to the point that it must be replaced.<sup>223</sup>*

**TABLE 2 CHEMICALS AT THE Y-12 PLANT**

<u>Toxicants</u>	<u>Carcinogens</u>	<u>Acids</u>	<u>Oxidizers</u>	<u>Explosives</u>	<u>Generally Regarded As Safe</u>
Mercury	Uranium	Hydrochloric Acid	Calcium Hydroxide	Lithium	Dibutyl Carbitol
Cadmium	Uranium Hydride	Hydrogen Fluoride	Hydrogen Peroxide	Lithium Hydride/Lithium	Calcium
Acetonitrile	Beryllium	Nitric Acid		Lithium Hydroxide	
Methyl Chloroform	Other Radionuclides (i.e. Transuranics & Thorium)*	Sulfuric Acid		Deuteride	
Tributyl Phosphate					

Source: U.S. Department of Energy, National Nuclear Security Agency, Y-12 Area Office, Oversight of Chemical Safety, 2001

\* ORAUT-TKBS-0014-5, Rev. 01

**Table 3 EXPLOSIONS AND FIRES AT THE Y-12 COMPLEX  
(1992-2006)**

<b>1992 – Fire in a Uranium Oxide Vault</b>	As a result of the fire the vault could not be used and as of 2001, a significant amount of pyrophoric uranium chips were “being stored above ground in 55 gallon drums on wooden pallets in a metal shed with only a draped plastic curtain protecting the drums from the weather.” <sup>224</sup>
<b>July 2, 1997 – Waste drum Explosion</b>	Nitric acid in the drum caused the drum liner to fail and generate hydrogen. <sup>225</sup>
<b>July 30, 1997 –Waste Drum Explosion</b>	A container lid blew off due to pressure build-up associated with high temperatures within a warehouse. <sup>226</sup>
<b>August 7, 1997 – Explosion and fire in chemical reaction vessel.</b>	A wire-reinforced gasket breached explosively due to excess internal pressure causing a fire from a reaction vessel for hydriding lithium. <sup>227</sup>
<b>August 5, 1998 - Brine Pump Explosion</b>	“A 400 horsepower pump in Y-12 Building 9767-13 exploded due to operating for two hours with both inlet and outlet valves shut... A major contributor to the accident was determined to be due... to a severe lack of resources ... <sup>228</sup> The ...explosion moved the pump motor 8 feet from its foundation,... and shattered the glass window of a control room. One operator received minor cuts on the face and chest from flying glass.” <sup>229</sup>
<b>Late 1990’s - Four High Voltage Cable Explosions</b>	“In the late-1990s, there were four significant 13,800-volt cable faults resulting in explosions in the Area 5 distribution system at cable splice locations in manholes. The last failure occurred in May 1998... the staff noted that a number of the cables and the splices were underwater.” <sup>230</sup>
<b>March 31, 1999 – Lithium Explosion</b>	An explosion occurred in a salvage vat where a HEPA filter was submerged in water to dissolve trapped lithium materials. <sup>231</sup>
<b>December 8, 1999 Chemical Explosion in Building 92-1-5</b>	An explosion occurred in the depleted uranium building as a result of an impact with shock sensitive compound of sodium-potassium and mineral oil. Eleven workers were injured and three were hospitalized. <sup>232</sup>
<b>December 14, 1999 – Lithium Hydride (LiH)Fire</b>	a LiH fire occurred during a maintenance activity in a glovebox in Building 9204-2. While the glovebox had been vacuumed out, an adherent LiH film and crust piles remained and were ignited by a hot metal drilling chip.... <sup>233</sup>
<b>January 11, 2000 – Laboratory Explosion</b>	An uncontrolled reaction pressurized and shattered a bottle and a nearby beaker in the building 9995 analytical chemistry lab. Glass was thrown out of a hood. <sup>234</sup>
<b>October 19, 2001 – Electrical Explosion</b>	a 2,300-volt cable shorted out in an underground conduit connected to Building 9404-1 – causing an arc that super-heated and-rapidly expanded air in the conduit. The percussive impact blew out all windows in the building. The building was not occupied, as is normally the case, and no one was hurt. However, because of the possibility of personnel being inside the building and being



	<i>injured, the contractor reported this as a near miss.</i> <sup>235</sup>
<b>January 2002 Waste Drum Explosion</b>	<i>"...a worker was opening a 30-gallon waste drum in Building 9720-59 at the Oak Ridge Y-12 Site when the drum lid was suddenly propelled 4 to 5 feet into the air, missing the worker."</i> <sup>236</sup>
<b>October 2002 – Uranium Fire</b>	<i>Two containers of uranium caught fire - fueled by powdered forms of depleted uranium metal, reactive materials (e.g., lithium, magnesium, calcium), and polyethylene. The material had been stored in a glovebox for more than 10 years and adequate identification of the contents was not performed prior to removal for processing.</i> <sup>237</sup>
<b>April 15, 2003 Building 9202 - Glovebox Explosion/Fire.</b>	<i>a sealed glove exploded, generating a brief fire that exposed three workers to smoke and uranium. The explosion was caused by unreacted calcium, excess water and depleted uranium in an unvented container inside the glove box.</i> <sup>238 239</sup>
<b>Week of August 22, 2003 –Building 9202 Electrical Fire</b>	<i>"An unexpected electrical feeder bar for a furnace in the room above overheated and burned insulation and structural wood support material).</i> <sup>240</sup>
<b>November 13, 2003- Electrical Fire</b>	<i>An electrical fire occurred in a panel in Building 9212 due to overheating. Numerous electrical issues were identified including multiple loads connected to a circuit and loose fuses and connectors.</i> <sup>241</sup>
<b>April 22, 2004 Building 9995 Fire in Laboratory</b>	<i>a small fire was observed in a Building 9995 laboratory microwave oven. The fire had consumed a portion of a plastic carousel used for holding vials in the microwave. The Y-12 Fire Department was not notified until more than 1 hour after initial observation of the fire.</i> <sup>242</sup>
<b>November 22, 2005 –Fire In Special Materials Processing Building</b>	<i>Workers were performing maintenance on a crusher-grinder when finely divided material ignited – forcing 13 workers to evacuate the area. Lithium had been exposed to air for 6 weeks. One worker required medical attention.</i> <sup>243244</sup>
<b>March 16, 2006 Electric Motor Fire in the Special Material Processing Building</b>	<i>A small fire occurred in an air handling unit (containing an electrical motor and fan that supports ambient temperature control) in the Special Materials Processing building . The Y-12 fire department was called when smoke was seen coming from the unit's enclosure . Fire department personnel observed flames on the motor, a facility evacuation was ordered, and the fire was extinguished with a dry chemical extinguisher .</i> <sup>245</sup>

## APPENDIX B RADIOLOGICAL CONTROL

Between 1993 and 2005, more than forty percent of the total collective dose to workers from internal depositions of radioactive materials in the DOE complex occurred at the Y-12 site. (See Figure 9) A deep rooted problem at Y-12 is prevention of radiological exposures to workers from widespread historical contamination and the accumulated back-log of nuclear materials, as reflected in more than 20 years of appraisals.<sup>246 247 248</sup>  
<sup>249 250</sup> According to DOE:

*Prior to 1988 controls were in place for materials leaving the production area of the Y-12 plant. However, uranium contaminated items could be stored essentially anywhere within the western end of the plant. Uranium contaminated items could also be freely transported between production buildings without rigid controls to prevent the spread of uranium contamination. Because of these past practices, low-level alpha contamination exists in various places throughout the western end of the plant.*<sup>251</sup>

In 1996, nearly ten years after contamination control upgrades were made At Y-12, the Energy department reported that:

*“...a comprehensive survey [of site-wide radiological contamination] has not yet been completed. Workers can be at risk from contamination that is the result of nearly 50 years of nuclear weapons manufacturing in two ways. First, there is always some risk of a small radiation exposure through inhalation or ingestion of uranium contamination outside radiological control areas. Secondly, workers can be at risk from contamination, the large operating spaces that are contaminated require in facility workers to be ‘fully dressed out’ in anti contamination clothing and sometimes respiratory protection for extended periods of time. In addition, the presence of radiological controls in outdoor areas (e.g. rooftops) present a potential for spread of contamination due to precipitation or windblown vegetation.”*<sup>252</sup>

In more recent times, unexpected exposure from uranium contamination has resulted in significant personnel exposures. In September 1998, during a contamination incident

*“elevated levels of uranium were observed in bioassay data for one individual working in Building 9212 E-Wing casting operations...A total of 12 individuals are under radiological work restriction and about 60 operations and support personnel are being monitored for elevated levels. Possible causes under review include overall E-Wing contamination control and work practices in the casting knockout line and material handling areas in E-Wing”*<sup>253</sup>

Subsequently, the DNFSB reported that,

*bioassay (fecal) results for one E-Wing worker have exceeded the LMES administrative control level of 1000 mrem/year (i.e., 1124 mrem CEDE). He and three other workers who are approaching this limit have had their administrative control level increased to 1500 mrem.*<sup>254</sup>

In March 2000, the inability to remove contamination sources posing risks to workers persisted.

*“ In many of the unoccupied spaces around the Y-12 Plant, bulk waste containers and numerous bags have been accumulating (see item on 9212 E-Wing). Much of this waste is defective or obsolete hardware, renovation debris, or combustible trash, much of it potentially contaminated with uranium compounds..”*<sup>255</sup>

Slow progress in nuclear material stabilization and removal has been exacerbated by the risks of workers encountering unknown hazards. According to an inspection of Building 9505 which houses the depleted uranium operations by the Defense Nuclear Facility Safety Board staff in 2002:

*It is apparent that the very large inventory of deserted and abandoned materiel will be a challenge for future deactivation and decommissioning efforts. Of particular concern is the appropriate identification of hazards given the questionable control of previous shutdown activities.*<sup>256</sup>

That same year, the DOE Office of Inspector General reported:

*“...the risk of exposing plant workers to health and safety hazards remains at an increased level as long as depleted uranium operations continue in the old process buildings... Y-12 managers stated that: (1) process building ventilation systems average 50 percent availability, (2) half or less of the supply and exhaust fans work, (3) inlet screens were choked with debris, and (4) filters were completely plugged.”*<sup>257</sup>

As of 2005 the inability to remove and process potential sources of contamination continues to be a problem..

*Building 9204-4 personnel determined that seven drums containing machine chips were not vented. Some of these unvented drums have been loaded since 1990; several other drums containing depleted uranium chips are vented or have pressure relief devices. The chips are supposed to be in water but no drum inspections are known to have been performed and the water levels in the drums are not known.*<sup>258</sup>

## ENDNOTES

<sup>1</sup> U.S. Department of Energy, Record of decision for the Storage and Disposition of Weapons- Usable Fissile Materials Final Programmatic Environmental Impact Statement , Federal Register: January 21, 1997,(Volume 62, Number 13. <http://www.epa.gov/fedrgstr/EPA-IMPACT/1997/January/Day-21/i1355.htm>

<sup>2</sup> U.S. Department of Energy, Highly Enriched Uranium Working Group Report, on Environmental, Safety and Health Vulnerabilities Associated with the Storage of Highly Enriched Uranium, DOE/EH-0525, December 1996. (Hereafter known as DOE/EH-0525.)

<sup>3</sup> DOE/EH-0525, Report Summary

<sup>4</sup> DOE/EH-5050, Vulnerability Assessment Forms

<sup>5</sup> DOE/EH-0525, Report Summary, p. 10

<sup>6</sup> DOE/EH-0525, p. 7.

<sup>7</sup> A.P, Polednak , A.T. Keane, W. Beck, Estimation of radiation doses to the lungs of early uranium processing plant workers, Environ Res. 1982 Aug;28(2):313-28

<sup>8</sup> Gregg Herken, Brotherhood of the Bomb, Henry Holt and Company, New York, (2002), p 104)

<sup>9</sup> Ibid. *“Every pair of vacuum tanks required an individual operator seated at a console, continually adjusting the current to focus on the beam. An army of technicians was needed to monitor the orange uranium-oxide feed material for the beam and later scrape the errant green “gunk” -- uranium salts dissolved in carbon tetrachloride -- from the insides of each tank. An army of chemists would separate out the silvery white powder containing uranium-235 that was left in the receivers following each week-long run.”*

<sup>10</sup> T. Cochran et al, Nuclear Weapons Data Book, Nuclear Warhead Production, Vol. II, Ballinger Press (1987).

<sup>11</sup> Norris 2004

<sup>12</sup> Personal communication with Thomas B. Cochran, Director, Nuclear Program Natural Resources Defense Council, June 15, 2005.

<sup>13</sup> T. Cochran et al, Nuclear Weapons Data Book, Nuclear Warhead Production, Vol. II, Ballinger Press (1987).

<sup>14</sup> J.A. Klein, D.W. Turner, Issues Relating to Spent Nuclear Fuel Storage on the Oak Ridge Reservation, Oak Ridge National Laboratory, CONF-941207-20, December 13,-16, 1994 Hereafter Known as CONF-941207-20.)

<sup>15</sup> C.M. West, E. Rogers, Jr., Health physics experience during processing of U-233 in Y-12 Plant, Y-KB-19, September 12, 1962.

<sup>16</sup> Norris 2004

<sup>17</sup> Ibid.

<sup>18</sup> U.S. Department of Energy Working Group Report on Environmental, Safety and Health Vulnerabilities Associated with the Storage of Plutonium, Volume 2, Part 9, Oak Ridge Site Working Group Assessment Team Report, DOE/EH-0415, December 1996. (Hereafter Known as DOE/EH-0415.)

<sup>19</sup> CONF-941207-20

<sup>20</sup> DOE/EH-0415

<sup>21</sup> U.S. Department of Energy, Defense Nuclear Facilities Safety Board, Oak Ridge Site Representative Weekly Report, April 15, 2005 (hereafter known as DNFSB Weekly Staff Report.)

<sup>22</sup> DOE-EH-0525

<sup>23</sup> Op. Cit. Ref. 1.

<sup>24</sup> DOE/EH-0525, Site Assessment Summaries, p. 21.

<sup>25</sup> U.S. Department of Energy, Freedom of Information Request submission to the Natural Resources Defense Council, MS/FOIA OR99-0491, April 1998.

<sup>26</sup> Personal communication with R.S Norris, June 15, 2005.

<sup>27</sup> U.S. Department of Energy, Los Alamos National Laboratory, Actinide Research Quarterly, 2nd Quarter, 1998. <http://arq.lanl.gov/source/orgs/nmt/nmtdo/AQarchive/98summer/HEU.html>

<sup>28</sup> DOE/EH-0525, p. 18.

<sup>29</sup> BWXTimes, A newsletter for employees and friends of the Y-12 National Security Complex, November 2005, <http://www.y12.doe.gov/news/pdf/2005/Nov05Times.pdf#search=%22BWXT%20Y-12%20November%202005%22>

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<sup>30</sup> U.S. Department of Energy, Highly Enriched Uranium [HEU], Striking a Balance: A historical report on the United States highly enriched uranium production, acquisition, and utilization activities from 1945 through September 30, 1996

<sup>31</sup> D. Brian, Testimony before the U.S. House of Representatives Committee on Energy and Commerce, Subcommittee on Oversight and Investigations, March 18, 2005, <http://www.pogo.org/p/homeland/ht-050301-nuclearweapons.html> (Brian 2005.)

<sup>32</sup> Personal Communication with Thomas B. Cochran, Director, Nuclear Program Natural Resources Defense Council, September 14, 2006.

<sup>33</sup> Related structures include buildings 9809,9812,9215,9818,9815, 9980.

<sup>34</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board, Status of Highly Enriched Uranium Processing Capability At Building 9212 Oak Ridge Plant, Staff Issue Paper, Tech 9, December 8, 1995 (Hereafter known as DNFSB Tech 9).

<sup>35</sup> ORO 1997

<sup>36</sup> DNFSB Tech 9

<sup>37</sup> ORO 1997

<sup>38</sup> Ibid

<sup>39</sup> Ibid

<sup>40</sup> ORO 1997

<sup>41</sup> U.S. Department of Energy, Facilities Information Management System, Y-12 Site Office, National Nuclear Security Agency, Fiscal Year 2005 Summary. [http://fims.hr.doe.gov/doe\\_summary/y12.htm](http://fims.hr.doe.gov/doe_summary/y12.htm) (Hereafter known as FIMS 2005)

<sup>42</sup> U.S. Department of Energy, National Nuclear Security Agency, Infrastructure Plan for the NNSA Complex, April 2003, P. 14.

<sup>43</sup> National Research Council, Committee to Provide Interim Oversight of the DOE Nuclear Weapons Complex, National Academies Press, 1989, p. 249.(Hereafter known as NRC 1989).

<sup>44</sup> Report of the Commission On Maintaining United States Nuclear Weapons Expertise, *Report to the Congress and Secretary of Energy* Pursuant to the National Defense Authorization Acts of 1997 and 1998 March 1, 1999. p. 36, (Hereafter Known as Weapons Expertise Commission.)

<sup>45</sup> DOE/EH-041, Vol. 2, p. 11.

<sup>46</sup> DOE-EH-0525, p. 3-1.

<sup>47</sup> U.S. Department of Energy, FY 2007 Congressional Budget Request, NNSA.

<sup>48</sup> NRC 1989, Fig. 4.3, P.69

<sup>49</sup> FIMS 2005.

<sup>50</sup> . Types of uranium include: Natural uranium contains 0.7% uranium 235. Low enriched uranium used in power reactors contains 4 to 5 % uranium 235. Highly enriched uranium contains 20 to >90 % uranium 235. Depleted uranium contains 0.3 to 0.5% uranium 235., and Uranium-233 , which has been produced by the irradiation of Thorium-232.

<sup>51</sup> B.L. Rich, and M. Chew, M.H. 2005. *Technical Basis Document for the Y-12 National Security Complex – Occupational Internal Dose*, ORAUT-TKBS-0014-5, Rev. 01, Oak Ridge Associated Universities, Oak Ridge, Tennessee, May 10, 2005. <http://www.cdc.gov/niosh/ocas/pdfs/tbd/y1215c.pdf>

<sup>52</sup> U.S. Department of Energy, REMS data. Between 1993 and 2005, the collective Committed Effective Dose Equivalent (CEDE) for all DOE workers is 1,093,098 person millirems. The total CEDE for Y-12 is 459,202 person millirems.

<sup>53</sup> U.S. Occupational Safety and Health Administration, Occupational Safety and Health Guidelines for Uranium and Insoluble Compounds,

<sup>54</sup> DOE G 421.1-I.

<sup>55</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board, Letter to: the Honorable J. Cay Sell, Deputy Secretary, From: A. J. Greenberger, Chairman, June 28, 2006.

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<sup>56</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board, Integrated Safety Management: The Foundation for a Successful Safety Culture, Technical Report, December 2005, p.5-12.

<sup>76</sup> DOE/EH-5025, p 26.

<sup>58</sup> DOE/EH-0505, Vol. II. P.9.

<sup>59</sup> DOE/EH-0505, Vulnerability Assessment Sheet, Vulnerability # 9720-5/001.

<sup>60</sup> YGG-2001

<sup>61</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board, Memorandum For J. K. Fortenberry, Technical Director, From: W. White, Subject: Instrumentation and Control for Hydrogen Fluoride Supply System, March 10, 2000

<sup>62</sup> U.S. National Institute for Occupational Safety and Health, International Chemical Safety Card -0226, October 20, 1999. <http://www.cdc.gov/niosh/ipcsneng/neng0226.html>

<sup>63</sup> Oak Ridge Associated Universities, National Beryllium Medical Surveillance Program Cumulative through 1st Quarter Fiscal Year 2005. [http://www.ornl.gov/ce/BMSP\\_pro/1stQuarterReport.pdf](http://www.ornl.gov/ce/BMSP_pro/1stQuarterReport.pdf)

<sup>64</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board, Memorandum For J. K. Fortenberry, Technical Director, From: M. Helfrich, Subject: Material Storage Facilities, Oak Ridge Y-12 National Security Complex, May 3, 2001.

<sup>65</sup> DNFSB Weekly Staff Report, December 10, 1999.

<sup>66</sup> U.S. Department of Energy, Environmental, Safety and Health Performance Indicators, DOE/EH-0531(98Q2), December 1998. [http://www.eh.doe.gov/publications/performance\\_measures/98\\_q2\\_report.pdf](http://www.eh.doe.gov/publications/performance_measures/98_q2_report.pdf)

<sup>67</sup> U.S. Department of Energy, Performance Indicators for Environment, Safety and Health, Office of Environment, Safety and Health, DOE/EH-0531, Report Period: April- June 1995, March 1996, September 1996, March, 1997, March 1998, June 1998, September 1998, December 1998, March 1999, June 1999.

<sup>68</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board, Recommendations, Correspondence, Technical Reports, and weekly I site representative reports.

<sup>69</sup> U.S. Department of Energy, Office of Environment, Safety and Health, Unreviewed Safety Question Activity Reports, 2005-2006.

<sup>70</sup> U.S. Department of Energy, Office of Environment, Safety and Health, Annual Occupational Radiation Exposure Reports, 1992-2004.

<sup>71</sup> U.S. Department of Energy, Office of Inspector General, Audit Report, Reestablishment of Enriched Uranium Operations at the Y-12 National Security Complex, DOE/IG-0650, February 2004. p. 2 (Hereafter Known as DOE/IG-0650).

<sup>72</sup> DNFSB, Weekly Staff Report, February 17, 2006

<sup>73</sup> DNFSB, Weekly Staff Report, May 26, 2006

<sup>74</sup> NRC 1989, p.63. *Fire protection systems designed to mitigate the consequences of a fire are not comprehensively or uniformly covered by operational safety requirements (OSRs) throughout the weapons complex. OSRs are facility-specific procedural requirements covering many different systems. For some critical mechanical and electrical fire safety systems, they mandate that alternative compensatory actions be available if those systems become inoperable.... The applicability of OSRs to fire protection features at other sites within the complex varies considerably; indeed, at the Y-12 Plant we were informed that no fire protection systems are covered by OSRs.*

<sup>75</sup> DNFSB, Weekly Staff Report, October 16, 1998

<sup>76</sup> DOE/EH-0525

<sup>77</sup> DNFSB, Weekly Staff Report, November 20, 1998

<sup>78</sup> DNFSB, Weekly Staff Report, May 27, 1998

<sup>79</sup> DNFSB, Weekly Staff Report, December 11, 1998

<sup>80</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board, Weekly Staff Report, July 2, 1998. (hereafter known as DNFSB, Weekly Staff Report.)

<sup>81</sup> DNFSB, Weekly Staff Report, April 8, 1999

<sup>82</sup> DNFSB, Weekly Staff Report, April 15, 1998

<sup>83</sup> DNFSB, Weekly Staff Report, July 2, 1999

<sup>84</sup> DNFSB, Memorandum for G.W. Cunningham, Technical Director, From . M. Helfrich, Subject: Safety Basis for Defense Nuclear Facilities at Y-12 Plant, July 12, 1999

<sup>85</sup> DNFSB Weekly Staff Report, November 5, 1999

<sup>86</sup> DNFSB Weekly Staff Report, February 11, 2000

<sup>87</sup> DNFSB Weekly Staff Report, June 30, 2000

<sup>88</sup> NRC 1989, p.63

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<sup>89</sup> NRC 1989, p. 64

<sup>90</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board, Memorandum for J. K. Fortenberry, Technical Director, From: W. M. Shields, Subject: Review of Fire Protection Program, Y-12 Plant, July 19, 2000

<sup>91</sup> DNFSB Weekly Staff Report, September 1, 2000

<sup>92</sup> DNFSB Weekly Staff Report, October 20, 2000

<sup>93</sup> DNFSB Weekly Staff Report, December 15, 2000

<sup>94</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board, Memorandum For J. K. Fortenberry, Technical Director, From: F. Bamdad, Subject: Integrated Hazard Analysis Review, Oak Ridge Y-12 National Security Complex, March 19, 2001

<sup>95</sup> NRC 1989, p.63

<sup>96</sup> NRC 1989, p. 64

<sup>97</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board,, Memorandum For J. K. Fortenberry, Technical Director, From: M. Helfrich, Subject: Material Storage Facilities, Oak Ridge Y-12 National Security Complex, May 3, 2001

<sup>98</sup> DNFSB Weekly Staff Report, August 10, 2001

<sup>99</sup> DNFSB Weekly Staff Report, September 21, 2001

<sup>100</sup> DNFSB, Weekly Staff Report, March 8, 2002

<sup>101</sup> DNFSB, Weekly Staff Report, August 23, 2002

<sup>102</sup> DNFSB Weekly Staff Report, May 9, 2002

<sup>103</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board,, Memorandum For J. K. Fortenberry, Technical Director, From: R. Rauch, Subject: Y-12 Building 9212 Operational Safety Requirements, September 3, 2003

<sup>104</sup> U.S. Department of Energy, Memorandum for Distribution, From: John Evans, Facility Representative Program Manager, Subject: Facility Representative Program Performance Indicators Quarterly Report, December 12, 2003

<sup>105</sup> DNFSB, Weekly Staff Report, December 19, 2003

<sup>106</sup> DNFSB, Weekly Staff Report, February 13, 2004

<sup>107</sup> DNFSB, Weekly Staff Report, October 28, 2005

<sup>108</sup> U.S. Department of Energy, Defense Nuclear facility Safety Board, Memorandum for G.W. Cunningham, Technical Director, From: A.K. Gwal, Subject: Report of Trip to Y-12 Plant, December 7, 1993.

<sup>109</sup> DOE/EH-0525, p.38.

<sup>110</sup> Ibid

<sup>111</sup> Ibid

<sup>112</sup> DOE/EH-0525, Site Assessment Team Report, p. 2-23. (Buildings containing methanol brine include 9204-2, 9204-2E, 9212, and 9215.)

<sup>113</sup> DNFSB Weekly Staff Report, June 9, 2000

<sup>114</sup> U.S. Department of Energy, Operating Experience Summary, February 9, 2004.

<sup>115</sup>

<sup>116</sup> DNFSB Weekly Staff Report, July 28,2000

<sup>117</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board, Memorandum for J.K. Fortenberry, Technical Director, From: M. V. Helfrich, Subject: Readiness to Resume Reduction Process for Enriched Uranium Operations, August 25, 2000

<sup>118</sup> DOE/IG-0650, p.4.

<sup>119</sup> DNFSB Weekly Staff Report, July 30, 2004

<sup>120</sup> DNFSB Weekly Staff Report, January 14, 2000

<sup>121</sup> DOE/EH-0525, Report Summary, p. 10

<sup>122</sup> DNFSB, Weekly Staff Report, July 30, 2004

<sup>123</sup> DNFSB, Weekly Staff Report , December 18, 1998

<sup>124</sup> DNFSB, Weekly Staff Report, August 28, 1998

<sup>125</sup> DNFSB, Weekly Staff Report, May 27, 1998

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- <sup>126</sup> DNFSB, Weekly Staff Report, May 27, 1998
- <sup>127</sup> DNFSB Weekly Staff Report, September 3, 1999
- <sup>128</sup> DNFSB Weekly Staff Report, November 5, 1999
- <sup>129</sup> U.S. Department of Energy, Memorandum for Distribution, From: Joseph Arango, Facility Representative Program Manager, Subject: Facility Representative Program Performance Indicators Quarterly Report, November 20, 2000
- <sup>130</sup> DNFSB Weekly Staff Report, October 26, 2001
- <sup>131</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board., Sixteenth Annual Report to the Congress, February, 2006
- <sup>132</sup> DNFSB, Weekly Staff report, May 21, 2004 Two recent events have occurred where a criticality mass limit of 20 kg was violated, one in late April in Building 9212 E-Wing during break pressing of parts and one this week in Building 9215 during shearing of items. In the Building 9212 event, a container with 20.030 kg of material was stored after the break press operation; the event was discovered after several days when a material handler noted the mass that had been recorded on the batch card. A corrective action was to add more specific instructions to the procedure to ensure limit compliance. In the Building 9215 event, items being placed in the shear enclosure were not precisely being tracked for total mass (the operator was mentally adding masses) and 20.500 kg was placed in the enclosure (no corresponding specific instructions had been added in the Building 9215 procedure.
- <sup>133</sup> DNFSB Weekly Staff Report, June 25, 2004
- <sup>134</sup> DNFSB Weekly Staff Report, August 27, 2004
- <sup>135</sup> DNFSB Weekly Staff Report, September 24, 2004
- <sup>136</sup> DNFSB Weekly Staff Report, October 8, 2004
- <sup>137</sup> DNFSB Weekly Staff report, February 18, 2005.
- <sup>138</sup> DNFSB Weekly Staff Report, February 25, 2005
- <sup>139</sup> DNFSB Weekly Staff Report, March 18, 2005
- <sup>140</sup> DNFSB, Weekly Staff report August 19, 2005
- <sup>141</sup> U.S. Department of Energy (DOE) 1988. *Technical Safety Appraisal of Y-12 Plant 4/25/88 thru 5/6/88, Volume 1*, Oak Ridge Operations Office, Oak Ridge, Tennessee.
- <sup>142</sup> DNFSB, Weekly Staff Report , May 12, 2006
- <sup>143</sup> Ibid
- <sup>144</sup> U.S. Department of Energy, Congressional Budget Request for Fiscal Year 2001, Weapons Activities, Construction, P. 6. <http://www.mbe.doe.gov/budget/01budget/weapons/construc.pdf>
- <sup>145</sup> DNFSB, Memorandum for G. W. Cunningham, Technical Director, From: J. Blackman, Subject: Review of Conceptual Design of Highly Enriched Uranium Storage Facility at Y-12 Plant, March 28, 1999
- <sup>146</sup> DNFSB, Weekly Staff Report, May 10, 2002
- <sup>147</sup> DNFSB Weekly Staff Report, April 20, 2001
- <sup>148</sup> U.S. Department of Energy, Office of Inspector General, Audit Report: Design of the Uranium Storage Facility at the Y-12 National Security Complex, DOE/IG-0643, March 2004
- <sup>149</sup> Frank Munger, Nuclear storage estimate grows, Knoxville News, June 23, 2006.
- <sup>150</sup> DNFSB, Weekly staff Report, March 19, 1999,
- <sup>151</sup> DNFSB Weekly Staff Report, July 21, 2000,
- <sup>152</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board, Memorandum for G.W. Cunningham, Technical Director, From: F. Bamdad, Subject: Design and Safety Review of the Highly Enriched Uranium Materials Facility, December 2002. *The project plan allowed for only two forms of uranium – metal and oxide – as well as canned subassemblies, into long term storage* “.However, the DNFSB discovered that DOE was planning to store “13 different forms of uranium, “ including,” *hundreds of containers of solutions, unirradiated and irradiated reactor fuel elements.. a large portion of the material placed in the HEUMF will not be adequately containerized consistent with site standards for long-term storage.*”
- <sup>153</sup> DNFSB, Weekly Staff Report, January 13, 2006. “A project design engineer (working for BWXT) noted during a walkdown that the height of the reinforcing steel above the slab did not meet the BWXT steel reinforcement drawings of record. Specifically, the field lengths were found to be significantly less than drawing requirements. Initial



investigation by YSO and BWXT indicates that the length requirements in the BWXT drawings of record were incorrectly translated to construction contractor fabrication drawings.”

<sup>154</sup> DNFSB, Weekly Staff Report, February 1, 2006

<sup>155</sup> DNFSB Weekly Staff Report, February 24, 2006

<sup>156</sup> DNFSB, Weekly Staff report, February 17, 2006 Among the issues were :

- lack of comprehensive BWXT oversight of HEUMF construction and over-reliance on the construction contractor and its quality inspection function ;
- lack of experienced/knowledgeable BWXT personnel dedicated to HEUMF construction QA ;
- use of construction contractor (and subcontractor) fabrication drawings instead of BWXT design drawings of record for inspection/acceptance purposes ; and
- other HEUMF QA program deficiencies in inspection personnel training and performance, and in inspection processes .

<sup>157</sup> U.S. Department of Energy, Office of Environment, Safety and Health, Price Anderson Enforcement Office, Letter to: Mr. George Dials General Manager BWXT Y-12 National Security Complex, From: Stephen M. Sohinki Director Office of Price-Anderson Enforcement, June 15, 2006

<sup>158</sup> DNFSB, Weekly Staff Report, October 8, 2004

<sup>159</sup> DNFSB, Weekly Staff Report, February 2, 2005

<sup>160</sup> DNFSB, Weekly Staff Report, September 3, 2004

<sup>161</sup> DNFSB, Weekly Staff report January 6, 2006

<sup>162</sup> DNFSB Weekly Report, June 10, 2004

<sup>163</sup> Edward B. Ripley and Jason A. Oberhaus, Melting and Heat Treating Metals Using Microwave Heating, Industrial Heating, May 10, 2005,

[http://www.industrialheating.com/CDA/Archives/3948b31fb6cb7010VgnVCM100000f932a8c0\\_\\_\\_\\_\\_](http://www.industrialheating.com/CDA/Archives/3948b31fb6cb7010VgnVCM100000f932a8c0_____)

<sup>164</sup> Ibid. “*Three distinct methods used to heat treat metals using a microwave furnace are: molten salt-bath processing, granular susceping media and fluidized bed processing. **Molten salt-bath processing** traditionally has been used for such processes as hardening, annealing, carburizing and nitrocarburizing, wherein the workpiece to be heat treated is immersed into the molten salt bath. Traditional eutectic salts used for heat treating include nitrate salts, carbonate salts, cyanides, chloride salts and caustic salts. The type of heat treatment is determined by careful control of the time and temperature, and quenching of the workpiece sometimes follows the heat treatment. An advantage of using traditional salt baths is that they quickly and uniformly heat the workpiece by conduction. Various surface properties can be imparted to the workpiece by controlling the composition of the salt....*

- **Granular susceping media.** *A part can be quickly and efficiently heated by placing it into a granular material that directly absorbs microwave energy. When metal items are placed into a microwave field, the energy tends to concentrate at edges and points, locations where stresses could initiate a crack and provide a failure mechanism. The use of a granular susceping media helps to normalize and diminish any nonuniformity in the microwave field, resulting in an evenly heated part. A variety of processing atmospheres can also be used. This processing method provides good thermal conduction and results in an easily controlled process.*
- **Fluidized-bed processing** *is a heat treating process in which particles are suspended in a gaseous stream, and the suspended particles behave like a liquid. A variety of processing gases, such as argon, LPG, natural gas, ammonia and nitrogen, can be used to provide the fluidization and to produce the desired surface properties on the treated metal parts. The atmosphere within the furnace can also be varied easily and quickly, according to the heat treatment required. Heat treated parts can be quenched to achieve required properties.”*

<sup>165</sup> DNFSB, Weekly Staff Report, April 1, 2005

<sup>166</sup> DNFSB Weekly Staff Report, May 20, 2005

<sup>167</sup> DNFSB, Weekly Staff Report, June 17, 2005

<sup>168</sup> W. K. Duerksen, Photochemical Reduction of Uranyl Nitrate, Chemistry and Chemical Technology Department Development Division, Lockheed Martin Energy Systems Y-12, October 20, 1993

<sup>169</sup> Christopher P. Boring, Cermet Crucible for Metallurgical Processing, Martin Marietta Energy Systems, (undated)

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<sup>170</sup> U.S. Department of Energy, Office of Defense Programs, Integrated Contractors Waste Minimization Program Accomplishments, Fiscal Years 1990, 91, &92, p. 11. <http://www.p2pays.org/ref/26/25659.pdf>

<sup>171</sup> U.S. Department of Energy, DOE/NNSA Cites BWXT Y-12 for Price-Anderson Violations at the Y- 12 Plant, June 10, 2004)

<sup>172</sup> Ibid.

<sup>173</sup> DNFSB, Weekly Staff Report, November 24, 2004

<sup>174</sup> U.S. Department of Energy, Press Release, R-96-181, 19 December 1996.

<sup>175</sup> U.S. Department of Energy, Office of Inspector General, Audit Report on Disposition of the Department's Excess Facilities, April 3, 2002

<sup>176</sup> Memorandum for the Secretary, From: Gregory H. Friedman, Inspector General, Subject: Audit Report on "Depleted Uranium Operations at the Y-12 National Security Complex," September 25, 2002

<sup>177</sup> Ibid.

<sup>178</sup> NNSA 2002, p.7.

<sup>179</sup> U.S. Department of Energy, Report of the Nuclear Weapons Complex Infrastructure Task Force, Recommendations for the Nuclear Weapons Complex of the Future, July 13, 2005, Final Report Secretary of Energy Advisory Board, U.S. Department of Energy p. 1 (Hereafter, known as SEAB 2005.)

<sup>180</sup> SEAB 2005, p. vii.

<sup>181</sup> SEAB 2005, p.1, " The Task Force found the production side of the Complex operating from World War II era facilities, lacking in modern-day production technology and striving to optimize performance with antiquated equipment and facilities. The production staff is aging and is a fraction of what it once was. A DOE modernization plan is in place, but it provides for a mix of many old sites (some 80 years old by 2030) and a few dispersed modern facilities, rather than a modern and more cost-effective state-of-the-art production center...."

<sup>182</sup> DNFSB Tech 9, December 8, 1995.

<sup>183</sup> DOE/EH-0525, December 1996.

<sup>184</sup> DOE/EH-0525, Report Summary, p. vi

<sup>185</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board, Tenth Annual Report to Congress, February 200, P. 88.

<sup>186</sup> DOE/EH-0525, Vol. II No. 1..pp-27-28.

<sup>187</sup> DOE/EH-0525, p. 27.

<sup>188</sup> DNFSB Weekly Staff Report, April 28, 2000

<sup>189</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board, Letter to Brigadier General Thomas F. Gioconda, Acting Deputy Administrator for Defense Programs, Department of Energy, From John Conway, Chairman, May 29, 2001

<sup>190</sup> DNFSB Weekly Staff Report, October 22, 2004

<sup>191</sup> NRC 1989, pp.68-70 *The Department of Energy should develop improved guidelines for seismic review of older structures housing hazardous facilities*

<sup>192</sup> DOE/EN-0525, Vol. II, P.9. "Incomplete Natural Phenomena Evaluation to be an institutional vulnerability applicable to all Y-12 Plant HEU facilities... The [Y-12 site personnel] identified potential earthquake-caused fire vulnerabilities and cited 'manual fire fighting capability on-site 24/hours/ day' as compensator measures. However, given that an earthquake and fire are simultaneous events that would affect other areas of the plant and the fact that the water tanks are not seismically qualified, using the fire department as a mitigating factor is not valid.

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- <sup>193</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board, 16<sup>th</sup> Annual Report to Congress, February 2006, P. 23.
- <sup>194</sup> DOE/EH-0525, Vol. II, Vulnerability #Y-12/Gen/WGAT/005
- <sup>195</sup> DOE/EH-0525, Vol. II. P. 17..
- <sup>196</sup> DOE/EH-0525, Vol. II, Vol. II. P. 19
- <sup>197</sup> DOE/EH-0525, Report Summary, p. 10
- <sup>198</sup> DOE/EH-0525, p. 7.
- <sup>199</sup> DNFSB, Weekly Staff Report, October 11, 2002
- <sup>200</sup> DOE/EH-0525, Vol. II, Vol. II. P. 15.
- <sup>201</sup> DNFSB Weekly Staff Report, January 14, 2000
- <sup>202</sup> DNFSB, Weekly Staff Report, January 23, 2006
- <sup>203</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board, Memorandum for J. K. Fortenberry, Technical Director, From: T.L. Hunt, Subject: Review of Building 9206 Deactivation and Risk Reduction Activities at Oak Ridge Y-12 Plant, October 17, 2000
- <sup>204</sup> DNFSB Weekly Staff Report, April 7, 2006.
- <sup>205</sup> DOE/EH-0525, Working Group Assessment Team Report, p. ES-1.
- <sup>206</sup> DOE/EH-0525, Report Summary, p. 10. The Working Group found that the Y-12 Plant had 17 institutional vulnerabilities. Of high concern was the lack of adequate safety documentation. According to the HEU vulnerability assessment report, *“The goal of the safety analysis program is to ensure that hazardous materials and conditions are identified and adequately controlled by facility engineered features or administrative controls. These barriers protect workers and the public from exposure and the environment from contamination by radioactive materials. Authorization basis documents (e.g. safety analyses, operational safety requirements, technical safety requirements, safety and operational limits) define the necessary administrative controls for a safe operation of a facility.”*
- <sup>207</sup> DOE/EH-0525, Vol. II, P 44. The Working group found an *“absence of rigorous and comprehensive hazard analyses, resulting in a poorly defined safety envelope, and a poor technical basis for OSRs [Operational Safety Requirements]....As a result, the OSRs.. did not include safety systems or components [SSCs] designed for the protection of the worker, either in-facility or co-located in an adjacent building. Additionally the OSRs may not capture all of the administrative controls being relied upon to prevent or mitigate all accident scenarios...”* In particular the Y-12 plant was found to not have a complete and updated authorization basis that reflected, *“current missions, modes, status of operation, storage conditions, and combustible loadings, and that identify equipment needed to protect workers, the public and environment.”* For instance, *“The authorization basis documentation often does not contain such fundamental information as the physical forms, storage configurations, or inventories of HEU assumed to be present in the facilities; and, therefore, were not evaluated for potential releases during major accident scenarios. This renders evaluation of ‘change in risk’ ...difficult and often meaningless.”*
- <sup>208</sup> Ibid.
- <sup>209</sup> Ibid..
- <sup>210</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board, Letter to the Honorable Linton Brooks, Administrator, National Nuclear Security Administration, From: A. J.Eggenberger, Chairman, February 28, 2006.
- <sup>211</sup> DOE/EH-0525, Vol. II, p. 45.
- <sup>212</sup> DOE/EH-0525, Report Summary, p. 1.
- <sup>213</sup> Ibid.
- <sup>214</sup> DOE/EH-0525, Report Summary, p. 19.
- <sup>215</sup> DOE/EH-0525, Report Summary, p. 10.
- <sup>216</sup> DOE/EH-0525, Vol. II, p. 45.
- <sup>216</sup> DOE/EH-0525, Report Summary, p. 24.
- <sup>217</sup> U.S. Department of Energy, National Nuclear Security Agency, Response to Defense Nuclear Facilities Safety Board May 20,2002, Letter on Inactive Actinide Materials ,September 17,2002. p 13 (Hereafter Known as NNSA 2002).
- <sup>218</sup> DNFSB, Weekly Staff Report, December 19, 2003.
- <sup>219</sup> DNFSB, Weekly Staff Report, December 23, 2004
- <sup>220</sup> DOE/EH-0525, Report Summary, p. 11.
- <sup>221</sup> DOE/EH-0525, Working Group Assessment Team Report, p.38.

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- <sup>222</sup> U.S. Department of Energy, Office of Inspector General, Audit Report: Depleted Uranium Operations at the Y-12 National Security Complex, DOE/IG-0570, September 2002, P.
- <sup>223</sup> DOE/IG-0570, pp.2-3.
- <sup>224</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board, Memorandum For J. K. Fortenberry, Technical Director, From: M. Helfrich, Subject: Material Storage Facilities, Oak Ridge Y-12 National Security Complex, May 3, 2001
- <sup>225</sup> U.S. Department of Energy, Type B Accident Investigation Board Report on the Drum Explosion at the Paducah Gaseous Diffusion Plant, Final Report, DOE/ORO/2061, November 1997, p.6.
- <sup>226</sup> U.S. Department of Energy, Office of Environment, Safety and Health, Memorandum From: R. Sastry, Chemical Safety Concerns / Search of Occurrence Reporting and Processing System, August 11, 1997
- <sup>227</sup> U.S. Department of Energy, Office of Environment, Safety and Health, Memorandum From: R. Sastry, Chemical Safety Concerns / Search of Occurrence Reporting and Processing System, September 15, 1997.
- <sup>228</sup> DNFSB Weekly Staff Report, April 21, 2000
- <sup>229</sup> U.S. Department of Energy, Operating Experience Summary, February 9, 2004.
- <sup>230</sup> Ibid
- <sup>231</sup> DNFSB, Weekly Staff Report, April 9, 1999
- <sup>232</sup> U.S. Department of Energy, Office of Environment, Safety and Health, Type A Accident Investigation of December 8, 1999, Multiple Injury Accident Resulting from the Sodium-Potassium Explosion in Building 9210-5 at the Y-12 Plant, February 2000.
- <sup>233</sup> DNFSB, Weekly Staff Report, December 17, 1999
- <sup>234</sup> DNFSB Weekly Staff Report, January 14, 2000
- <sup>235</sup> U.S. Department of Energy, Office of Environment, Safety and Health, Operating Experience Summary, February 11, 2002
- <sup>236</sup> U.S. Department of Energy, Office of Environment, Safety and Health, Operating Experience Summary, March 25, 2002
- <sup>237</sup> DNFSB, Weekly Staff Report, October 11, 2002
- <sup>238</sup> DNFSB Weekly Staff Report, April 18, 2003,
- <sup>239</sup> Frank Munger, Knoxville News Sentinel, October 10, 2005
- <sup>240</sup> DNFSB Weekly Staff Report, August 22, 2003.
- <sup>241</sup> U.S. Department of Energy, Defense Nuclear Facility Safety Board, Memorandum For J. K. Fortenberry, Technical Director, From: A. K. Gwal, Subject: Electrical Systems at the Y-12 National Security Complex, June 9, 2005
- <sup>242</sup> DNFSB, Weekly Staff Report, April 23, 2004
- <sup>243</sup> U.S. Department of Energy, Operating Experience Summary, Issue No. 2006-03.
- <sup>244</sup> DNFSB, Weekly Staff Report, November 23, 2005
- <sup>245</sup> DNFSB, Weekly Staff Report, March 17, 2006
- <sup>148</sup> U.S. Department of Energy (DOE) 1984. *Health Physics Appraisal of Y-12 Plant, Oak Ridge, Tennessee, FY 1984*, Oak Ridge Operations Office, Oak Ridge, Tennessee.
- <sup>247</sup> DOE-EH-0525
- <sup>248</sup> U.S. Department of Energy (DOE) 1988. Technical Safety Appraisal of Y-12 Plant 4/25/88 thru 5/6/88, Volume 1, Oak Ridge Operations Office, Oak Ridge, Tennessee.
- <sup>249</sup> Tech 9, December 8, 1995.
- <sup>250</sup> DNFSB Weekly Staff Report, October, 2, 1998.
- <sup>251</sup> DOE-EH-0525. p. 3-1
- <sup>252</sup> Ibid.
- <sup>253</sup> DNFSB Weekly Staff Report, October, 2, 1998.
- <sup>254</sup> DNFSB Weekly Staff Report, October, 30, 1998.

<sup>255</sup> DNFSB Weekly Staff Report, March 10, 2000.

<sup>256</sup> DNFSB Weekly Staff Report, February 1, 2002.

<sup>257</sup> U.S. DOE Office of Inspector General, Depleted Uranium Operations at the Y-12 National Security Complex, Audit Report, DOE/OIG-0570, September 2002.

<sup>258</sup> DNFSB Weekly Staff Report, March 22, 2005.