A DISCUSSION OF INVENTORY DIFFERENCE,

ITS ORIGIN AND EFFECT

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Compiled for the
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Safeguards and Security Program Support

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DISCUSSION OF INVENTORY DIFFERENCES

I. WHAT IS AN ID?

A. TECHNICAL

An inventory difference (ID) occurs when the book value (BV) is different from the values observed during the conduct of a physical inventory (PI). In terms of a mathematical model, it is:

$$ID = BV - PI$$

or:

$$ID = (BI + R - S + A) - EI$$

In this equation the book value is composed of the terms BI, R, S, and A; while the physical inventory is the term EI:

where:

- ID = Inventory Difference [formerly material unaccounted for (MUF)].
- BI = Beginning Inventory, or material on hand at the beginning of an accounting cycle.
- R = Receipts, or material received from outside the accounting group.
- S = Shipments, or material removed to another accounting group or off site location.
- A = Adjustments, documented changes to the book value and can be either a positive or negative adjustment.
- EI = Ending inventory, or material on hand at the end of an accounting cycle.

B. PRACTICAL

In simple terms, an ID can be described as the difference between what you think you should have (book value) and what you actually have (inventory).

II. WHAT MAKES UP AN ID?

An ID is usually composed of several components. These components range from the intuitively obvious to the very subtle. Several of the components to the ID for a nuclear material account will be discussed briefly in this section. Figure 1 is a schematic of a typical "campaign process." This is a process where material is fed into the process at a measured value, then processed to measured product and waste. At the end of the nuclear material accounting period the process is stopped, equipment is cleaned, and a physical inventory is taken. The residual material that cannot be cleaned out is called process holdup.

Process holdup is "the amount of nuclear material remaining in process equipment and facilities after the in-process material, stored materials, and product have been removed."[1] The material left behind can be very difficult to evaluate or measure. A discussion of some the mechanisms for creating process holdup in different processing environments follows.

Figure 2 is a drawing of a typical processing line from the glovebox to the pre-filter system. This arrangement is significantly simplified from what would be found in a processing plant. The typical

1 *Safeguards and Security Definitions Guide,* U. S. Department of Energy, Office of Safeguards and Security, Office of Security Affairs, December 20, 1993, page 46.

system would consist of many of these systems intertwined into a processing network. It can be seen that the accurate and precise measurement of the holdup in even such a simple system can be very complex when combined with many such systems in the same room.

A. PROCESS HOLDUP

The amount of material that is ultimately held up in, and on, the equipment varies significantly. Table 1 lists the types and amounts of material that one can expect to find held up in equipment. For example, Building 771 has several miles of pipes and ducts and numerous furnaces, gloveboxes, blenders, tanks, grinders, and calciners. An examination of Table 1 shows that the magnitude of holdup could be significant. This subject is discussed numerically later in this paper. The major exception to the values listed in Table 1 are that Rocky Flats Environmental Technology Site (RFETS) ducts, prior to cleaning and remediation, have typically contained 2 to 3 grams per meter which is in the lower range shown in Table 1.[2]

Figure 3 is a data plot of the holdup of uranium oxide in a calciner as a function of throughput as determined during a controlled holdup experiment. This figure is an example of the leveling out of holdup at a steady-state value after an initial buildup. At a point in the operating history, the holdup increased when the furnace temperature was changed, resulting in another buildup. When plutonium is processed, the same mechanisms exist to create holdup. The buildup curves would be the same. Figure 4 is a plot of the relative ID for the RFETS plutonium ID (relative) with the same general curve as in Figure 3 superimposed on the actual data.

Machining Operations:

When plutonium is machined, there are chips and turnings like those present during the machining operations involving steel or other metals. These chips and turnings from plutonium machining are gathered up and reprocessed much as you would capture the residues from a steel machining process. The amount of material and the degree of cleanup is relative to the value and hazards associated with the material. The cleanup of a plutonium machining process might be better compared to a gold or platinum operation than to the machining of steel or iron. Great care is taken to ensure as much of the recoverable material as possible finds its way into the recycle stream and a minimum amount finds its way into waste streams. Invariably, some material does not immediately find its way into either the product or waste stream; instead it becomes fixed to the machinery or temporarily contained in such items as machine coolant.

Foundry Operations:

In foundry (melting and casting) operations, material remains on the casting molds and in the melting and casting furnaces. Great care is taken to remove all of this material, but some small amount remains behind. Additionally, some material is left in equipment used to remove the material from the molds and some is held up in the containment equipment. Most of this material is periodically cleaned up as well is possible and eventually finds its way into the recycle or waste streams. The actual path depends on the concentration, chemical and physical form, and the economics of recycle.

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2 Communication (about 5/10/94) with F. W. Lamb, Technical Lead for the Safeguards Measurements Holdup Measurement Team, EG&G, Rocky Flats, Inc.

Thermal Stabilization:

This is an operation where the material is in the form of an "unstable oxide." The term unstable is a relative term and only describes material that must be completely oxidized prior to storage. Plutonium oxide must be in a "stable state" prior to storage to avoid pressurization of the containment vessel. When oxides are heated to the temperature required to complete the oxidation process, the material becomes very dry, and its physical characteristics resemble that of talcum powder. This results in light "dusting" of the environment in which the operation is contained. Efforts to clean up this material are very successful and no additional safety hazard is present when the next batch of material is introduced into the process.

Recovery (Recycle) Operations:

Recovery operations can involve any of the foregoing processes but can also include a dissolution and precipitation phase(s). During this process, material can be held up in processing equipment in a manner similar to that discussed previously.

Filter Media:

When material is processed in a glovebox, varying degrees of material become airborne and are introduced into the glovebox ventilation system. It must be remembered that the ventilation system for glovebox operations is separate from the ventilation systems for worker environmental control. At the RFETS, the amount of material measured on first stage filters has ranged from a few grams to several hundred grams. Other stages of filtration have basically been only contaminated, with very little measurable material.

B. MEASUREMENT UNCERTAINTIES

When nuclear material is processed and it comes time to perform a physical inventory, all material must be measured to arrive at a good physical inventory value. One of the most difficult and important concepts involved in this process is the effect of the measurement uncertainties associated with the physical inventory. The concept of measurement uncertainties can be as difficult to grasp as to evaluate. The primary constituents of measurement uncertainties are the precision and accuracy of the measurements being made. A simple analogy can be seen by considering the use of a bathroom scale every morning to weigh yourself. If you weigh yourself ten times in close succession each morning, you will probably get more than one reading on your scale; this is a measure of the precision with which you have determined your weight. However, it only indicates what you would expect the scale readings to average if you were to weigh yourself ten more times. The accuracy of your scale is the determination of how close the reading on the scale is to your actual weight.

In the measurement of nuclear material, both holdup and product measurements, the degree of precision needs to be known as well as a measure of the accuracy of the measurement. A highly accurate measurement that has poor precision is of little value since the uncertainty in your weight, as displayed by the scale, would be very large. On the other hand, a reading that is very precise, but lacks accuracy, is also of little value. For any system used to measure nuclear materials at the RFETS, great care is taken to determine both the accuracy and precision of a measurement method. The statements of accuracy and precision are forwarded to the DOE/RFFO for approval prior to implementation of the measurement method. Typical values for the accuracy and precision of various NDA techniques used for measuring plutonium and uranium are shown in Table 2A and Table 2B. The values in these two tables are industry accepted

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C. INSTRUMENTS FOR NONDESTRUCTIVE MEASUREMENT

Gamma Spectroscopy

Figure 5 is a schematic of a typical segmented gamma scanning instrument. This instrument, with minor modifications, is the backbone of gamma measurement systems. Instruments using multiple transmission sources, scintillation crystals, single and multiple high resolution solid state detectors, rotating/helical sample tables, and other variations are used for measurement of nuclear materials. The material to be measured can be packaged in a variety of containers with a widely varying matrix composition. This particular instrument is widely used throughout the nuclear industry for measuring materials with low density matrices. The precision and accuracy of this instrument are dependent to a large extent on knowledge of the matrix in which the material to be measured is found.

Neutron Counting

Figure 6 is a cross sectional view of a typical neutron coincidence counter for measuring plutonium in small containers. Instruments of this type have a more flexible measurement capability with respect to the matrix. When properly calibrated, instruments of this type can be used to measure a wide range and concentration of nuclear materials. The instruments can be used in either a passive or active mode. When used in the passive mode, the neutrons given off by the material in question are measured directly with a correction applied for the neutrons generated by the interaction of the alpha particles given off by the plutonium and the material matrix. In the active mode, the material is excited with neutrons from an external source and the neutrons that are generated from the fission of the material assist in determination of the amount of nuclear material present. This instrument can also be used in other configurations to measure nuclear material. This instrument is almost identical in operation to the passive/active drum and crate counters in use at the RFETS. The primary difference between these instruments is the shape of the sample cavity, number of helium-3 tubes, and the amount of neutron moderator. The passive/active counters have sample cavities capable of measuring 55-gallon drums and 4'x4'x7' wooden crates. The primary limitation of this class of instruments is the correction for self-multiplication and high neutron generation rates caused by the alpha/neutron interactions. A relatively new technique, called neutron multiplicity counting, is being examined at the Los Alamos National Laboratory (LANL). This technique will make it easier to evaluate the amount of plutonium present and to make necessary corrections for self-multiplication in the material being analyzed.

Calorimetric Assay

Figure 7 is a cross sectional view of an isothermal twin cell calorimeter. There are many variations of this instrument in use for the measurement of nuclear materials. For intuitive reasons some of the systems are called water bath calorimeters, and some air bath calorimeters. The calorimeter measures the thermal energy emitted by an item. The heat generation is directly proportional to the energy of the radioactive decay products of the item being measured. When coupled with a high resolution gamma spectroscopy system, the isotopic composition of the plutonium can be derived. From the isotopic distribution of the plutonium and americium, the specific heat of the sample can be determined. Using the specific heat and the thermal energy output of the item the mass of plutonium can be calculated. This is one of the most accurate and precise methods for determining the amounts of nuclear material contained in an item. The major drawback for this nondestructive assay

(NDA) technique is the time required to make an analysis. This timing and the handling of some of the samples present a personnel radiation exposure concern.

Holdup Measurements

Figure 8 is a view of a typical setup for the measurement of plutonium in ducts. There are numerous variations in how this system is actually applied. The preferred method is referred to as far field measurements. Far field measurements require that the distance from the centerline of the duct to the detector face be approximately three times the diameter of the duct. From Figure 8 this means that R must be three times D. For a duct that is 36 inches (3 feet) in diameter, R must be 108 inches (9 feet). Even for an 18-inch (1.5 feet) duct, the distance R must be 54 inches (4.5 feet). Due to the "stand-off" requirement, this method has not been as useful at the RFETS as it has at some other facilities. At the RFETS, there has frequently not been sufficient clearance to allow this method to be employed. When the distance between the detector and the duct being measured increases, in many cases so does the background radiation. This phenomenon reduces the precision of the measurement and increases personnel exposures. The personnel exposures are increased because the time to obtain a measurement is significantly increased and thus the radiation exposure of the employees is increased. At the RFETS, most of the measurements were made using a contact measurement method. This method was co-developed with the LANL. The method was peer reviewed by staff members of the Defense Nuclear Facility Safety Board (DNFSB) and others to validate the model. Several hundred feet of ductwork in Building 707 were measured, both before and after remediation. The material removed from the ductwork during remediation was measured and the value compared to the difference in the measurements made before and after remediation. On several occasions where the physical arrangement allowed both contact and far field measurements, the results were compared and found to be in excellent agreement and within the measurement uncertainties of the methods. These two checks showed that the method employed for ductwork measurements was very accurate and precise.

The RFETS has used several techniques for the measurement of holdup material. A portable system similar to the one shown in Figure 8 was used where the detector was a Bismuth Germinate scintillation crystal (BGO). This system, when coupled to a multi-channel analyzer and a portable computer, has been used to perform the bulk of the measurements. A similar system employing a high resolution, solid-state detector has been used for the confirmation of isotopic distributions.

III. INSTRUMENTATION/MEASUREMENT HISTORY

A. Initial Instrument Development and Implementation

The development and implementation of improved nuclear material measurement equipment, to define the quantities of material present in product, intermediate forms, residues, and wastes has been an ongoing process. A brief synopsis of the history of the measurements and equipment used at the RFETS is contained in Table 3. An examination of this table shows that significant and constant improvements have been made to the measurement capability at the RFETS. The earliest values were not as accurate, or as precise, as the measurements that were made starting in the late 1960s, but they were the best that technology offered at the time.

B. Present Measurement Capability

The present capabilities of the measurement systems for nuclear material and waste are listed in Table 4. The instruments currently employed at the RFETS are adequate for the measurements to be made. The accuracy and precision of the systems exceed the level that was in place during the late 1970s to mid 1980s. The instruments are approaching the end of their useful life cycles and will need to be replaced with more current technology as funding becomes available. The instruments that are currently in service have adequate capacity for several more years, but will begin to significantly exceed the design capacity before the year 2000. The change in capacity is expected to occur from two sources, increased decontamination and decommissioning and the increase in efforts to stabilize the materials prior to long-term storage. As materials are entered into processes in preparation for repackaging, shipping, or storage they will be remeasured using current technology. It is anticipated that this operation will significantly reduce the cumulative RFETS ID.

C. PROPOSED/FUTURE RFETS MEASUREMENTS AND MEASUREMENT SYSTEMS

Significant planning has been ongoing at the RFETS on the development and implementation of new and updated systems. The lack of funding and resources have been a continuing problem in the updating of measurement practices and measurement systems. Significant progress has been made in the past year toward the purchase of additional operating equipment.

A radiographic scanner for performing real-time radiography (RTR) has been purchased and is being installed. This system will allow the site to better evaluate environmental compliance for waste materials placed in a drum. It will further assist NDA personnel in ensuring that the contents, or the matrix materials, of a drum are consistent with the stated content. This allows for a more accurate assay and assignment of values to the drums and crates. These more accurate and precise values will reduce the amount of uncertainty associated with the nuclear material inventory and the ID.

During fiscal years 1994 and 1995 the present passive/active crate counter will be upgraded. The upgrade will improve the reliability of the system as well as increase the analytical capability of the equipment. The upgrade will result in increased accuracy and precision, thus allowing for better definition of low-level waste (LLW) versus higher level transuranic (TRU) waste, and increase the ability to distinguish between these two levels of waste.

During fiscal years 1995 and 1996, additional NDA equipment will be added to the existing equipment to support better measurements. As shown in Table 5, there will be a new low specific activity counter (LOSAC), a new passive/active drum counter (PADC), and new air bath calorimeters added to the equipment available for measurements. Also in fiscal years 1996 and 1997, a new passive/active crate counter will be added. The addition of these systems will improve the accuracy and precision of the measurements by the application of more up-to-date technology.

IV. MEASUREMENT CRITERIA

Through the years, measurement criteria have changed significantly to meet new demands and standards, but primarily because the technology has allowed for many changes and improvements in measurement accuracy and precision. The one factor that has remained constant throughout the development and implementation of new technology has been the fact that some materials have always been easier to measure more accurately and precisely than others. The ability to measure waste streams and some residues was practically nonexistent in the 1960s and 1970s. However, the ability to weigh pure metal parts and ingots have always been quite good. Oxides were usually measured following complete stabilization; thus the stoichiometric values were accurate enough to obtain very good values. In fact they approached the accuracy and precision that one would expect for the weight of metal parts and ingots. Therefor, even in the early days, and still true today, the more attractive a material, the better the measured values that have been assigned to the material.

An additional factor that has influenced the development of more accurate and precise measurements has been the development of measurement control programs. These programs are, in essence, a measurement quality assurance program. The quality of any measurement is only as good as the controls placed on the instruments used, the training of operators, and the surveillance and audit of the operations. The RFETS has developed and monitored the performance of its NDA instruments for many years, and the results have been verified by many agencies who have audited the NDA measurement systems.

V. A DISCUSSION OF THE PLUTONIUM INVENTORY DIFFERENCES AT THE RFETS

A. GENERAL DISCUSSION

The preceding sections of this document have attempted to explain the mechanism and problems associated with measured values. These problems manifest themselves in many ways, but the one of concern for this document is how they affect nuclear safety and nuclear material control and accountability. Specifically, how do these problems interact with the ID at the RFETS?

Inventory differences are, and always have been, taken very seriously at the RFETS. Procedures have been established for many years governing how to deal with IDs. These procedures have required that each ID be evaluated against specific statistical and operational history criteria to determine its significance. If the ID is determined to be statistically significant, it is analyzed and an explanation forwarded to the DOE-RFFO (or its predecessors) for their evaluation. During the course of operations of the plant, several IDs have received very careful scrutiny and evaluation of their significance. One of the criterion has always been the potential effect of the health and safety of the general public as well as the impacts to the workers. The evaluation of IDs is a tedious, time consuming, and necessary function of any nuclear material control and accountability system. The real problem is deciding which, if any, of the inventory differences are significant. To paraphrase a common saying; "The significance is often in the eye of the beholder." As an illustration of the significance of an ID, let us look at a simple example. Suppose that we have two separate operations, each of which has a reported inventory difference at the end of an inventory cycle of 200 grams.

The first process to be evaluated is the incineration of rags. This process is no longer used at the RFETS but serves as a good example. Suppose this process generates 400 cans of "rag ash" in the current inventory period. Then assume a loading of approximately 1 kilogram of ash in each can with a plutonium content of 50 grams each. The cans generated are then measured using a gamma ray spectroscopy system similar to the one shown in Figure 5 or a neutron coincidence counter similar to the one shown in Figure 6. The combined uncertainty for this matrix and instruments is on the order of 10 to 15%. The amount of material at the end of the inventory cycle is 20 kilograms (400 cans, with 50 grams per can). The total combined uncertainty in the value is between 2 and 3 kilograms. Therefore, in performing a material balance one would assume that if the book value when compared to the measured value is within 2 to 3 kilograms, the difference is not statistically significant. Therefore, an inventory difference of 200 grams would not be considered statistically significant. This ID would be evaluated for consistency with operational history before being considered closed.

Let us now consider a different process that produces metal parts with a bulk weight of 50 grams each and a plutonium content of 99.5% (49.75 grams). When these parts are analyzed using "wet chemistry" for plutonium content, the assay uncertainty when coupled with the weighing and sampling uncertainty is about 0.4%. If 400 of these parts are produced in an inventory period the inventory would be 19.9 kilograms. The uncertainty in this value is approximately 80 grams. Then an ID of 200 grams would be considered statistically significant, and evaluated for probable causes and possible safety implications. It would also be reported to Nuclear Criticality Safety for evaluation of any impacts on worker and criticality safety. In all likelihood, the process would be terminated until this matter was resolved to the satisfaction of the EG&G, Rocky Flats Inc. (EG&G) safety, safeguards and security organizations, and the DOE-RFFO.

Thus, it is shown that the amount of any ID must be evaluated against many related facts to determine its significance. In the first case it is shown that the ID does not necessarily involve "missing material," but only involves the uncertainty presented by measurement properties. The second case would indicate that there is a probability of "missing material" and would need to be scrutinized very carefully to determine the major components of the ID.

B. THE RFETS INVENTORY DIFFERENCE

On June 27, 1994, Secretary of Energy Hazel O'Leary reported to the public that since Rocky Flats began operations there has been an inventory difference of 1,191 kilograms of plutonium. At first glance this number can appear quite alarming. However, when this value is carefully examined and evaluated, several causal factors stand out. These factors are discussed in the following section of this paper.

Figure 3 shows the expected value of ID due to process holdup as it would appear in a processing facility. This figure is for a single, highly controlled experimental process. However, if this type of buildup is combined for several processes with varying throughput patterns, the resulting curve would not be particularly different in its shape. Thus, one would expect that the buildup of inventory difference at the RFETS would follow a similar pattern. Figure 4 shows the buildup of the inventory difference at Rocky Flats. While there are differences in the actual versus the predicted curve, they can be explained. The actual differences are discussed in the following section of this paper. It should be pointed out that it was during this time that new processes were being introduced and the amount of material being processed was increased. Therefore, a buildup of ID that was faster than a theoretical curve would predict is understandable. The rate of growth of the ID was not considered unusual and did not provide a positive indication that material was being "lost" or stolen.

After examining the data, it can be seen that the cumulative ID, and hence the periodic ID, has been fairly stable since about 1965. This coincides with the time frame when breakthroughs in measurement technology allowed for better measurements of waste and intermediate products allowing for better values to be established. It also corresponds to a time when most of the processes were installed and operations were fairly stable. As a result of this situation, the overall

ID did not accumulate as fast as in the first several years of operation when new processes were being introduced and throughput for the existing processes began to stabilize.

C. IS THERE MATERIAL MISSING FROM ROCKY FLATS?

Waste Shipped Offsite:

An independent study of the amount of plutonium shipped from Rocky Flats to the Idaho National Engineering Laboratory (INEL) has been conducted by INEL personnel, Rocky Flats contractor personnel, and DOE personnel. It has been estimated that the inventory of the waste drums shipped to INEL for burial is understated. The actual amount of the understatement has been estimated at 600 to 800 kilograms of plutonium. This is a large number and represents shipments made in the 1953 to 1971 time frame. During this period, only very crude estimates of the amount of plutonium were able to be made due to technological limitations. Table 3 shows the time development of instrumentation and the range of accuracy and precision. As the technology was developed and became available, Rocky Flats either built or purchased the latest instrumentation technology to determine the nuclear material content of items as accurately and precisely as possible. During the 1970's, there were significant advances in the development of nuclear material measurement system, and computer-aided tools to assist in the analysis of nuclear material counting data.

Material Measurements Onsite:

During the same time frame as the waste was being shipped to INEL for burial, Rocky Flats was generating residues, sometimes referred to as scrap. Residues differ from waste in that it was determined that the plutonium in residues was economically feasible to recover. The material was set aside for eventual recycling. The recycling process was unable to keep up with the generation of new residues and created what is now commonly referred to as the "backlog." This material was no easier to measure than the wastes described earlier. Hence the measurement uncertainties associated with this material range from 10 to 50%, most of which is estimated to be an understatement of the plutonium content of the material. EG&G has committed to DOE-RFFO that all of these materials will be remeasured prior to their being introduced into any process. It is anticipated that this remeasurement will add another 200 to 300 kilograms to the nuclear material inventory and reduce the stated ID by the same amount.

Equipment and Process Holdup

In addition to the material shipped to INEL and the material in the residues, it is estimated that another 200 to 300 kilograms of plutonium is held up in process and duct systems. While this estimate sounds quite high at first, an examination of the data in Table 1 when applied to some operational conditions at the RFETS reveals some insight into the magnitude of potential holdup, and eventual cleanup of material.

Process Piping

It has been estimated there is approximately nine miles (14,350 meters) of ½- to ¾-inch process piping in Building 371.[3] This piping was used to move solutions between various phases of processing. Using the value from Table 1, this would result in about 4.3 kilograms of holdup after the pipes have been thoroughly cleaned out. Prior to cleaning, the pipes could easily contain three to five times this amount of material. While this facility represents the building with the most process piping, the amount of holdup could easily approach this same level for Building 771.

Gloveboxes

It has been estimated that there are approximately 190 gloveboxes in Building 771,[4] it has been further estimated that the other major processing buildings have a similar number of gloveboxes.[5] This adds up to about 1,000 gloveboxes. When one applies the values for holdup in gloveboxes from Table 1, clearly there could be as much as 50 kilograms of holdup in the gloveboxes. Following decommissioning and decontamination these gloveboxes could be expected to have less than 10 kilograms of holdup following destructive cleaning. The difference of about 40 kilograms would be added to the inventory and reduce the ID by that amount.

Process Ductwork

It has been estimated that there are about 16,000 feet of process ductwork in the processing buildings at Rocky Flats.[6] The breakdown by building is given in Table 6. These ducts range from about 3 inches to 48 inches in diameter. If an average diameter of 16 inches is assumed, then the surface area is about 6,225 square meters. Experience has shown that the ductwork at the RFETS usually contains from 0 to 3 grams of plutonium per foot of unremediated ductwork. Thus, the value would more realistically be about 20 to 30 kilograms. Following destructive cleaning and complete remediation, the value could be as low as 2 to 3 kilograms. As discussed earlier, this difference would be added to the inventory value and the ID reduced by 15 to 25 kilograms.

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3 Communication (8/3/94) with T. Kearns, SAIC and formerly with the DOE PRMP Program Office, and confirmed as reasonable by D. Kusel, Nuclear Material Safeguards (8/4/94), EG&G, Rocky Flats, Inc.

4 Communication (8/4/94) with D. Bailey of the Building 771 Operations Group, EG&G, Rocky Flats, Inc.

5 Based on an estimate and confirmed with D. Heath (8/4/94) of the Nuclear Materials Control Group of Nuclear Materials Safeguards, EG&G, Rocky Flats, Inc.

6 Communication (8/4/94) with F. W. Lamb, Technical Lead for the Safeguards Measurements Holdup Measurement Team, EG&G, Rocky Flats, Inc.

Process Tanks

There are approximately 190 process solution storage tanks in Building 771.[7] Data in Table 1 shows that when all of the tanks are emptied and rinsed, the resulting material could be as high as 95 kilograms, but would more realistically be about 30 to 40 kilograms.

Process Equipment

The amount of process equipment is very difficult to evaluate since it ranges from items as large as rolling mills to items as small as a spatula. However, looking at Table 1, it can be seen that a small number of furnaces, grinders, blenders, and other miscellaneous equipment could very easily add up to many more kilograms, maybe as much as 100 kilograms, of material that will be recovered during the decontamination and decommissioning of processing equipment.

When the foregoing data are examined, it can be stated that cleanup and decommissioning could easily result in the 200 to 300 kilograms of material being either left as nonremovable or removed from process systems and equipment by the end of decommissioning and decontamination of the facilities. It should be pointed out that in cases where equipment is decommissioned, a value can be assigned to the equipment by measurement, even though the material may not be removable. These measurements when made with the best technology available may still have high uncertainties associated with the assigned values. However, these values can still be very useful in evaluating the final RFETS ID.

D. Is There a Hazard Associated with the Inventory Difference at the RFETS?

There are three major categories of possible hazards associated with the accumulation of plutonium or any other fissile or fertile isotope. These three areas are hazard to the public, hazard to the worker, and a risk of a criticality accident. Each of these three is very complex to analyze. Some of the analyses of the hazards and the actions taken to mitigate the hazards related to each will be discussed briefly.

Public Hazard

The major source of hazard to the public is an uncontrolled release of material to the environment by some sort of accident or through the theft or diversion of such material. In the case of the material being discussed here, most of the ID results from the accumulation of measurement uncertainties for material either being stored at the INEL or at the RFETS. The material at the INEL is stored in sealed drums and is under the control of INEL personnel who are well aware of the amount of the understatement of material shipped to the INEL. The status and safety of this material is covered in reports to the public by the INEL and the DOE Idaho Operations Office.

Where measurement uncertainties are the source of ID for material stored at the RFETS, there is adequate protection from a release to the environment. The material in process

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7 Communication (8/4/94) with D. Bailey of the Building 771 Operations Group, EG&G, Rocky Flats, Inc.

holdup is contained within the building containment systems and is also protected from release to the environment.

During her press conference on June 27, 1994, Secretary of Energy Hazel O'Leary made the following statement relative to the theft and diversion of special nuclear material in relation to the ID.[8]

> Stringent security measures have made theft or diversion unlikely. Physical security will respond to design-basis threats based upon specific events and intelligence assessments. These threats include terrorists, nuclear weapon proliferants, and criminals. These threats, in addition to those related to malevolent insiders, have been drivers behind the type and level of safeguards and security measures in place at Departmental nuclear facilities today. These measures prevent, deter, detect, and respond to losses of nuclear material. Prevention measures include barriers and protective forces.
>
> Deterrence and detection are achieved through a combination of personnel security, material access controls, materials accountability, and physical security. Response capabilities exist to interrupt or stop malevolent acts such as diversion/theft of nuclear materials that have negative consequences on national security. These safeguards and security measures give us high confidence that no plutonium and highly enriched uranium were stolen or diverted and that if these acts were attempted or had occurred, they would have been detected.

Worker Hazard

The primary source of hazard to the worker is associated with working in areas where there is holdup of radioactive materials in the processing equipment. The primary hazard from this material is the increased radiation exposure that would be received during the course of performing necessary work in the vicinity of this equipment. As new operations are planned and procedures are developed, the radiation exposure to individual employees is reviewed and evaluated in accordance with an established program for reducing radiation exposures to workers. This program is called the ALARA program. ALARA is an acronym for As Low As Reasonably Achievable, and dictates that all work must be performed within the guidelines of this program. As the name implies, the program is designed to ensure that a worker's radiation exposure is maintained at as low a level as is reasonably achievable.

Another source of hazard to the worker is an uncontrolled release of material to the workplace from an accident. Should nuclear material escape the primary confinement systems (gloveboxes or tanks), workers are protected by a workplace airborne sampling system that sets off alarms requiring evacuation of the immediate area. Appropriate respiratory protection is used during the cleanup of any contamination.

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8 O'Leary, Hazel, Openness Press Conference Fact Sheets, June 27, 1994, Page 116.

Criticality Hazard

The potential for a criticality event from holdup material has been analyzed in several studies. The results will be discussed briefly below; however, for a more technical and detailed explanation, the original documentation should be reviewed.

The initial hazard examined was the problem with plutonium in the glovebox ventilation system. This hazard, real or perceived, has been well characterized in many public reports. The essence is that as long as there are fewer than 400 grams of plutonium in a duct, there is no possibility of a critical mass being assembled as a result of some operational or natural phenomenon. Prior to the resumption of any processing a careful evaluation is performed.

The second hazard that was evaluated concerned plutonium holdup in equipment throughout the plant. An evaluation of potential holdup areas in the processing equipment and processing lines in Building 707 was performed. The evaluation resulted in a worst case of 166 grams of plutonium per square foot. This is not typical and should not be considered typical. All of the equipment evaluated had been cleaned for inventory, but was not cleaned to the level required for decontamination and decommissioning. Even when this "hot spot" is considered, it was concluded that there was no significant problem. The results are document in an internal report from Nuclear Safety Engineering[9]

It is therefore concluded that the current state of the inventory difference has a minimal effect on criticality safety.

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9 Memorandum to FPM Duct Remediation from Nuclear Saety Engineering, "Critiality Assessment Report for the Plutonium Holdup in Untoward Areas Project," July 23, 1993, (DGS-346-93)

FIGURES

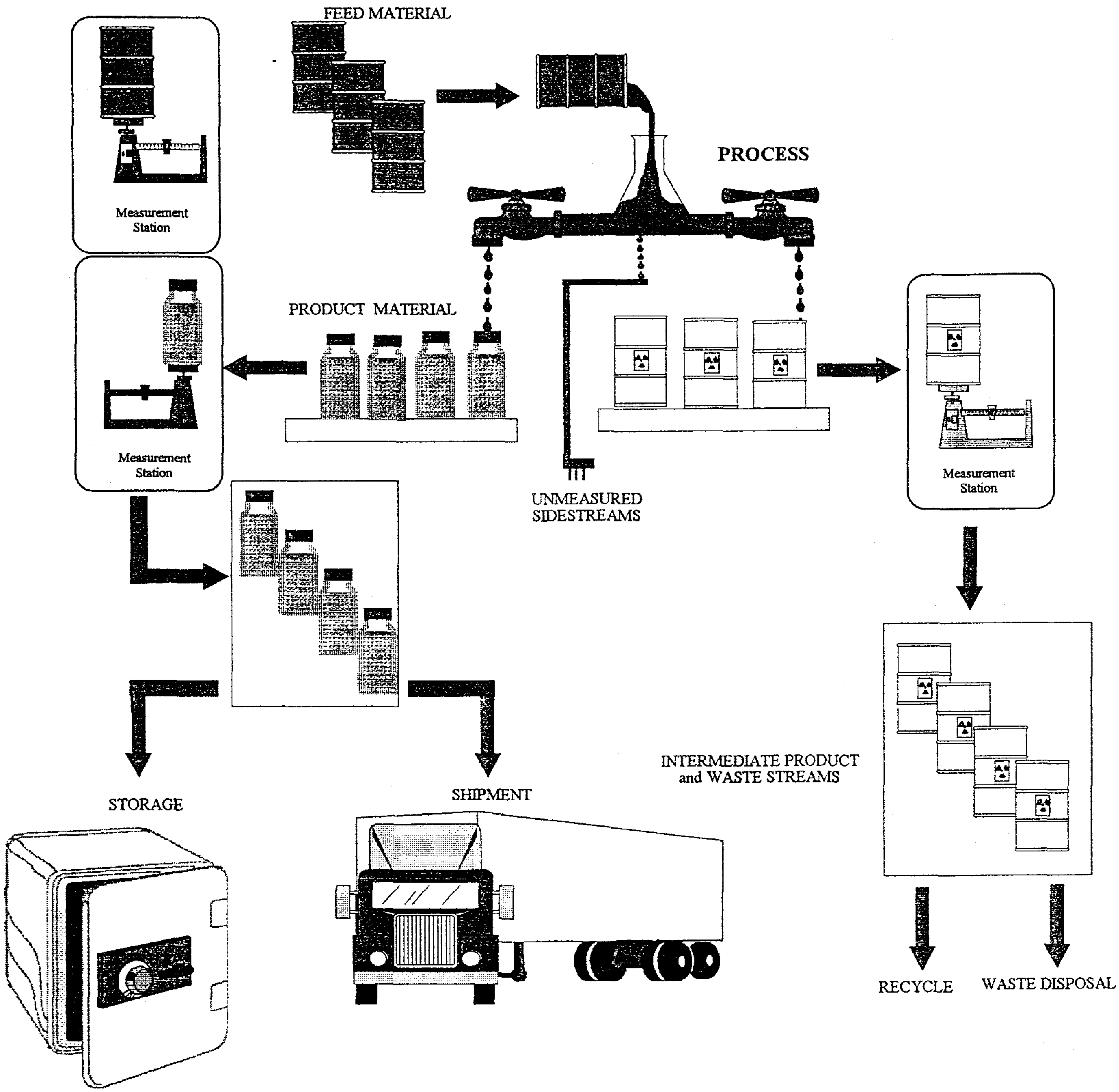

FIGURE 1: TYPICAL PROCESSING/MEASUREMENT SCHEME FOR A CAMPAIGN PROCESS

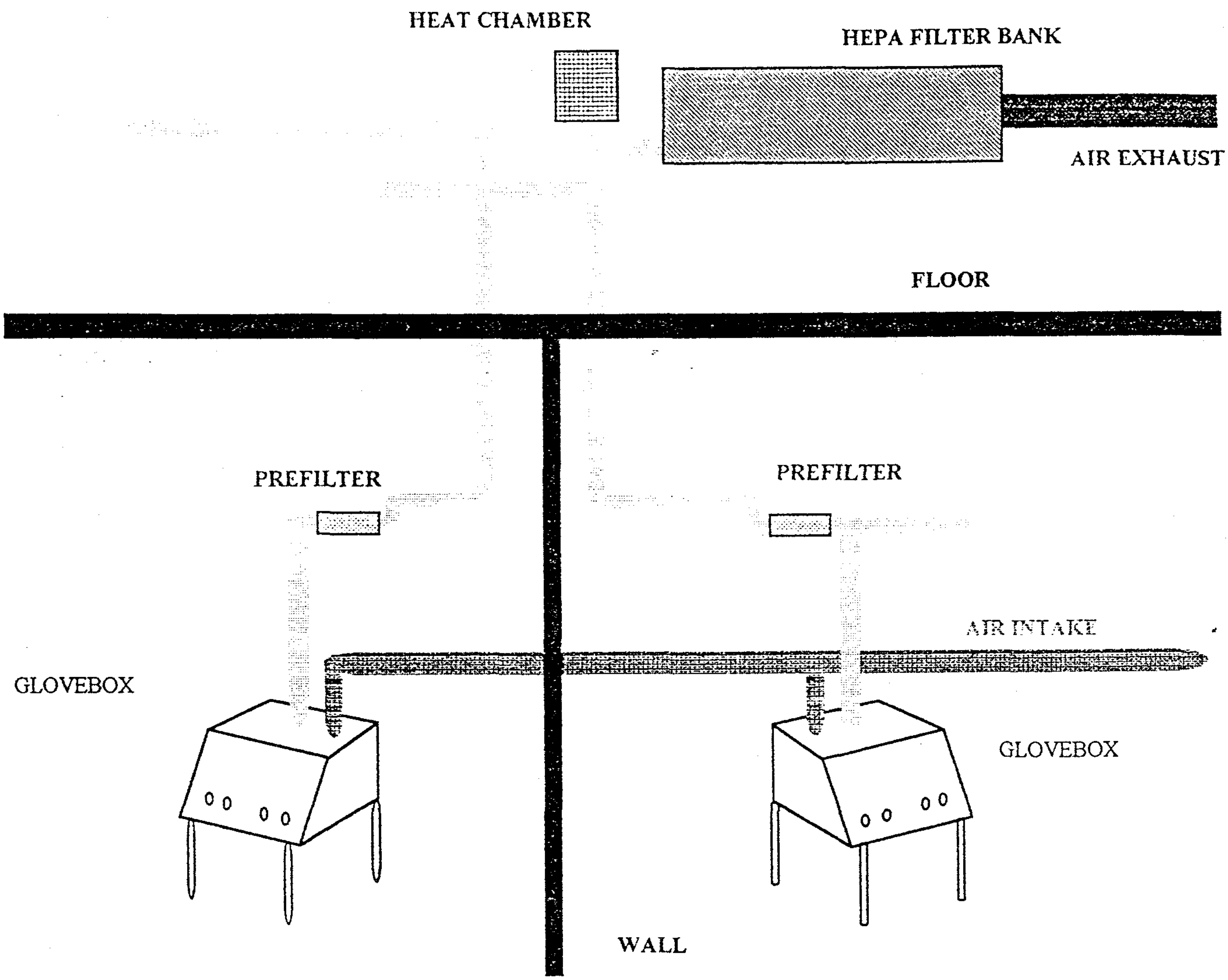

FIGURE 2: TYPICAL PROCESS EQUIPMENT LAYOUT

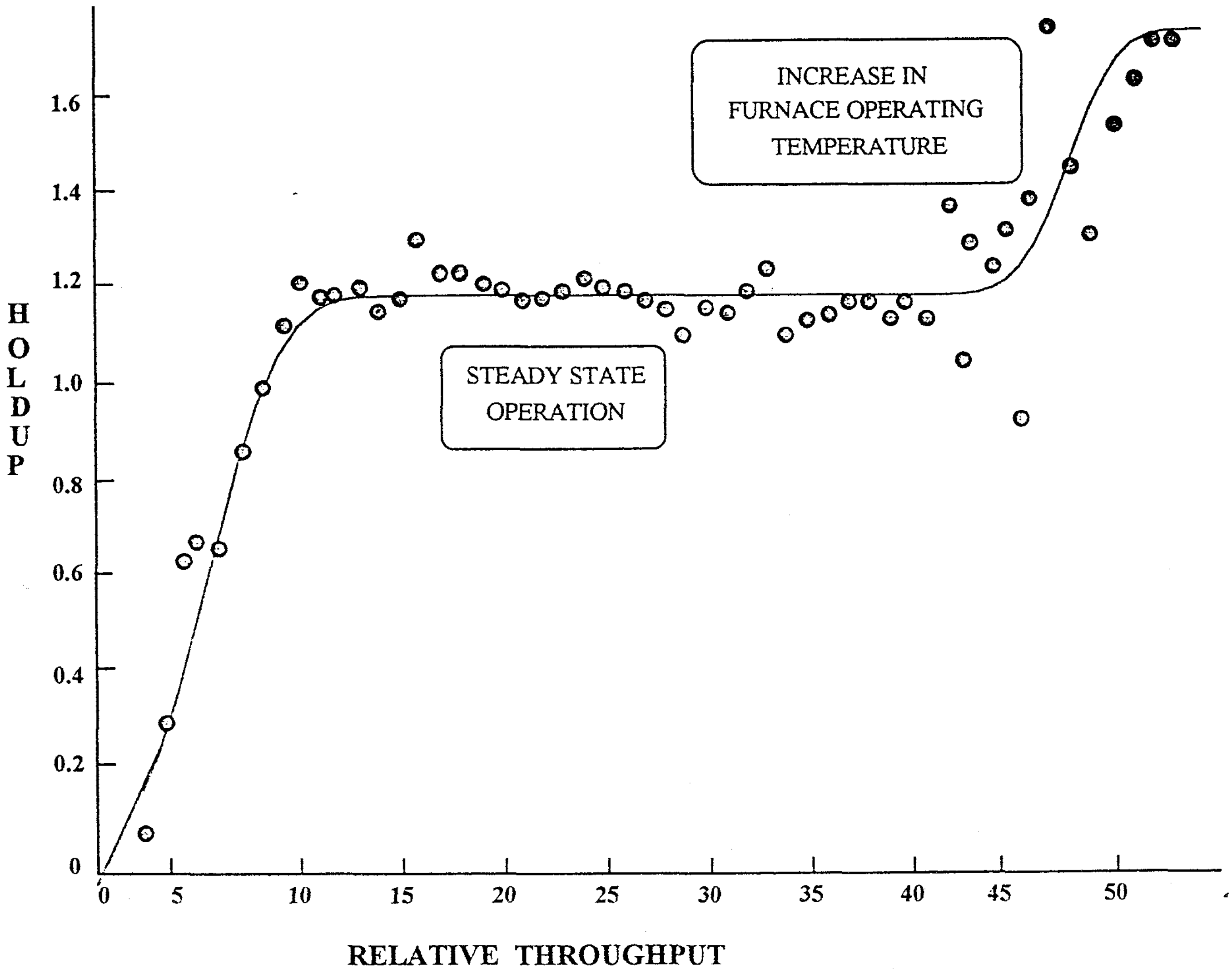

FIGURE 3: HOLDUP OF URANIUM OXIDE IN A CALCINER[10]

10 Reilly, Doug, et al, *Passive Nondestructive Assay of Nuclear Materials,* U. S. Government Printing Office, LA-UR-90-732, NUREG/CR-5550, March, 1991 (Adapted from Figure 20.4, Page 601) (Often referred to as the PANDA Manual)

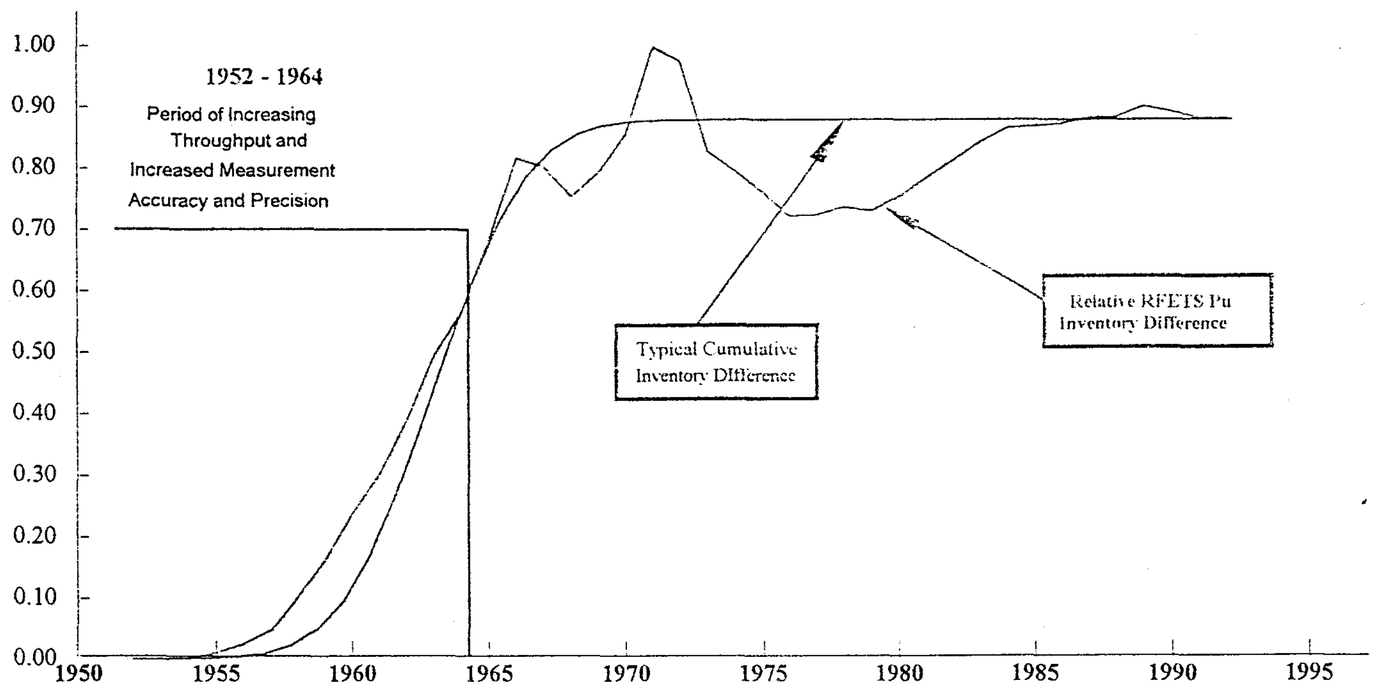

FIGURE 4: ACTUAL ID HISTORY COMPARED TO THEORETICAL/EXPECTED BUILDUP