A NEW APPROACH FOR SAFEGUARDING ENRICHED URANIUM HEXAFLUORIDE BULK TRANSFERS
L. W. Doher Chairman, ANSI N15.8
Rockwell International
Rocky Flats Plant
P. O. Box 464
Golden Colorado 80401
and
P. E. Pontius Consultant, ANSI N15.8
and J. R. Whetstone
Center for Mechanical Engineering and Process Technology
U. S. National Bureau of Standards (NBS), Washington D. C. 20234

Abstract
The unique concepts of American National Standard ANSI N15.18-1975 "Mass Calibration Techniques for Nuclear Material Control" are discussed in regard to the establishment and maintenance of control of mass measurement of Uranium Hexafluoride (UF₆) both within and between facilities. Emphasis is placed on the role of control of the measurements between facilities, and thus establish decision points for detection of measurement problems and making safeguards judgments.

The unique concepts include the use of artifacts of UF₆ packaging cylinders, calibrated by a central authority, to introduce the mass unit into all of the industries' weighing processes. These are called Replicate Mass Standards (RMS). This feat is accomplished by comparing the RMS to each facility's In-House Standards (IHS), also artifacts, and thence the usage of these IHS to quantify the systematic and random errors of each UF₆ mass measurement process.

A recent demonstration, which exchanged UF₆ cylinders between two facilities, who used ANSI N15.18-1975 concepts and procedures is discussed. The discussion includes methodology and treatment of data for use in detection of measurement and safeguards problems.

The discussion incorporates the methodology for data treatment and judgments concerning (1) the common base (2) measurement process offsets (3) measurement process precision and (4) shipper-receiver bulk measurement differences.

From the evidence gained in the demonstration, conclusions are reached as to the usefulness of the realistic criteria for detection of mass measurement problems upon acceptance of the concepts of ANSI N15.18-1975.

LIST OF TABLES
Table I - Provisional NBS Values for UF₆ RMS
Table II - In-House Standards Calibration
Table III - Typical In-House Standard Data for Process Offset (F₁ + b₁) & (E₁ + b₁)
Table IV - Typical In-House Standard Data for Process Precision (F₂ + c₁)
Table V - Between Facility Comparison of Product Cylinder Weights (A - B)

LIST OF FIGURES
Figure 1 - Process Offset and Precision
Figure 2 - 48X Empty Product Cylinder Comparisons (S/R Diff) by Date
Figure 3 - 48X Full Product Cylinder Comparisons (S/R Diff) by Date

NOTICE
This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.
DISCLAIMER

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

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.
Introduction

In 1970 American National Standards Institute (ANSI) Committee N15 (Nuclear Materials Control), with The Institute of Nuclear Materials Management (INMM) as secretariat, formed subcommittee INMM-8 (Calibration Techniques). One of the tasks was the creation of a standard for calibration and control of weighing systems within the unique confines and rigorous requirements of the nuclear industry for measurement of nuclear materials for control and safeguards. The responsible writing group was designated INMM 8.1.

In 1972, the membership of INMM 8.1 conducted a study which included visits to some nuclear facilities which expressed concern with mass measurements. The most productive visits were those to the portions of the industry that weigh massive cylinders of uranium hexafluoride (UF₆). It was discovered that one area of mass measurement, that which controls the interchange of material between various facilities, is of greatest concern to the nuclear industry. INMM 8.1 addressed this problem and published ANSI N15.18-1975 "Mass Calibration Techniques for Nuclear Materials Control." This document provides guidelines for establishing and maintaining adequate mass measurement processes for nuclear material control both within a facility and for transfer of material between facilities. Specific guidelines include: (1) Selecting weighing instruments and mass standards; (2) Evaluating performance of mass measurement processes, which includes determining the magnitude of random errors, systematic errors, and error limits; (3) Assigning mass values to test objects; (4) Initiating and maintaining a program using replica mass standards of large cylinders of uranium hexafluoride, (UF₆) and (5) Establishing and maintaining control of mass measurement both within and between facilities.

This paper addresses the implementation of these guidelines particularly those relating to UF₆ Replica Mass Standards (RMS) and the demonstration of realistic uncertainties to be used to maintain control of shipper/receiver differences in mass measurement of UF₆ cylinders.

ANSI N15.18-1975 describes in detail the concepts of the mass measurement process and makes recommendations relative to the mass measurements involved in the transfer of uranium hexafluoride (UF₆). These recommendations are based on the assumption that a regulatory function will (1) accept the uncertainty limits as demonstrated and monitored by the various facilities as adequate evidence of facility process control; (2) monitor the exchange of material from one facility to another by a review of shipper/receiver measurement data relative to the uncertainty statement of the facilities involved and (3) test the system on occasion by requiring each facility to furnish measurement data on selected objects circulated to all of the facilities within the system. The Standard details characterization of the mass measurement process to include error limit evaluation, test data, process parameter determination and updating together with demonstration of process control. Assignment of mass values to test objects and the uncertainty determination associated with those values is discussed in detail. These discussions rely heavily on the work of Pontius [2-3].

In 1975 two decisions were mutually made by INMM 8.1 and the U. S. Nuclear Regulatory Commission (NRC). They were: (1) the inauguration of a pilot Measurement Assurance Program (MAP) involving a select group of facilities who routinely measure UF₆, and (2) an overview of how the
concepts of ANSI N15.18-1975 could be incorporated in a nuclear materials control system. It was emphasized that a large portion of ANSI N15.18-1975 had been directed toward establishing realistic, as to opposed to historically arbitrary, uncertainties of the mass measurement processes concerned with the transfer of UF6.

A status report by Doher and Pontius[4] of the first portion of the UF6 pilot MAP was presented at the 18th Annual Meeting of the INMM in June of 1977. Key portions of that report have been included in this paper for clarity and continuity.

The UF6 Measurement Assurance Demonstration

There are two aspects of the UF6 measurement assurance demonstration. One aspect is concerned with the performance of the weighing processes within a given facility, as discussed in detail in ANSI 15.18-1975. The other is concerned with the agreement between facilities, which is also the concern of those interested in safeguards. In the discussion that follows, the latter aspect is treated first.

There are three essential elements for realistic evaluation of the agreement of the results between measurements made on the same object by two different measurement processes. First, the measurements must be referred to a common base. This is not to say that all facilities must use this common base routinely but rather that they must be able to establish the offset between the basis for the results in each facility with reference to a common base. The second and third elements are facility measurement offset (relative to the common base) and process precision. These are closely related. There must be evidence that each measurement process involved is indeed operating in a state of control, and there must be an index of precision for that portion of the measurement process which produced the results which are to be compared.

The Common Base

A common base for stating the mass values is established through the use of artifacts which are replicate UF6 cylinders. The two reasons for choosing replicate cylinders are: (1) the ease of handling by the facilities as compared to the conventional summations of mass standards classically used to calibrate and (2) the minimization of bias associated with apparent mass values assigned to product cylinders relative to the summations of mass standards maintained above. These artifacts are the Replica Mass Standards (RMS), owned by the NRC. They are stainless steel facsimiles (two each) of the Models 30B, 48X, and 48Y as specified in ANSI N14.1-1971[5]. One cylinder of each size has been filled to provide an RMS at two mass levels, full and empty.

The RMS artifacts have been calibrated by the National Bureau of Standards (NBS). The results of this work are shown in Table I. Detailed accounting of the buoyant effect was done in the initial calibration so that the values assigned are true mass values. Since the displacement values of the artifacts are essentially the same as that of the product cylinders, the bias introduced by the buoyant effect of the atmosphere has been minimized.

The common base is introduced into each facility by In-House Standards (IHS) which are also facsimiles of UF6 cylinders.

For each model cylinder, each participating facility has four "In-House-Standards," (IHS), i.e. two "Full" and two "Empty." There are two
reasons for using pairs of IHS's: (1) to permit the facility to monitor the constancy of one with respect to the other, and (2) to permit greater flexibility in the use of these cylinders to control the product weighing process.

Each facility is responsible for establishing the mass values for its set of IHS. These values are established relative to those assigned to the RMS, following the carefully prescribed procedures of ANSI N15.18-1975 which incorporates a weighing design and substitution measurement methods. In this work, the various weighing devices are used as comparators. Therefore, the uncertainty associated with the mass values assigned to the IHS artifacts is only a function of random variability. Since all IHS artifacts in the system are calibrated relative to the RMS artifacts, the uncertainty associated with the values assigned to the RMS by NBS are common to the entire system and need not be accounted for in comparing results. Table II summarizes the results of this effort.

The use of two "full" and two "empty" IHS artifacts at each facility provides a means of monitoring the constancy of the artifacts, one relative to the other. The results of this comparison at the beginning and at the end of the demonstration for one facility proved to show constancy (less than one lb. difference). Such comparisons can be made at any time and if the results are not in order, the RMS artifacts can be requested for the purpose of establishing new values for the IHS artifacts.

Facility Offset Relative to the Common Base

Two IHS artifacts in each facility, designated $F_i$ and $E_i$ (full and empty) were used in "calibration" or to determine the offsets of the processes involved. Two summations were used ($F_i + b_i$) and ($E_i + b_i$), where $b_i$ are known small weights used for incremental changes over a range of approximately 200 lbs. With the mass values of the summation known, the process offset ($O S_i$) of full and empty is defined as:

$$O S_i = W_i - (F_i + b_i) \quad \text{and} \quad O S_i = W_i - (E_i + b_i),$$

respectively, (Eq 1)

Where: $W_i$ is the observed weight for the various summations. Several sequences of measurements were made during the course of the demonstration, with the average of the total collection, $O S_i$, defined as the process offset. Typical data relating to process offset are shown in Table III and the offsets for the various processes are superimposed on precision data in Figure 1.

Factors which contribute to the magnitude of the offsets shown are related to the methods and procedures used in each facility, the largest being associated with the air buoyancy and essentially eliminated as discussed before. These are on the order of 8 lb. for the empty and 5 lb. for the full 48X cylinders. Other elements include the methods in which the scale calibration results were used and procedural differences. By referring all measurements to a common base by the method discussed, the effect of between facility procedural differences is eliminated from the results which are to be compared, provided that the measurement processes are performing in a stable manner. Conversely, within each facility confidence in the measurement results depends on explanation of the offsets exhibited. Such studies are the other aspects of the UF6 measurement assurance demonstration.
### TABLE I
Provisional N.B.S. Values for UF₆ RMS

<table>
<thead>
<tr>
<th>Cylinder Designation</th>
<th>Value</th>
<th>Uncertainty</th>
<th>Displacement Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMS-1</td>
<td>1296.238 (lb)</td>
<td>± .127 (lb)</td>
<td>29.63 (ft³)</td>
</tr>
<tr>
<td>RMS-2</td>
<td>6355.999</td>
<td>± .127</td>
<td>29.89</td>
</tr>
<tr>
<td>RMS-3</td>
<td>4463.810</td>
<td>± .127</td>
<td>120.75</td>
</tr>
<tr>
<td>RMS-4</td>
<td>25332.076</td>
<td>± .127</td>
<td>121.08</td>
</tr>
<tr>
<td>RMS-5</td>
<td>5284.925</td>
<td>± .127</td>
<td>154.67</td>
</tr>
<tr>
<td>RMS-6</td>
<td>32507.424</td>
<td>± .127</td>
<td>154.67</td>
</tr>
</tbody>
</table>

### TABLE II
In-House Standards Calibration

<table>
<thead>
<tr>
<th>Facility</th>
<th>30B Mass</th>
<th>Provisional Mass</th>
<th>Unc</th>
<th>48X Mass</th>
<th>Unc</th>
<th>48Y Mass</th>
<th>Unc</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F₁</td>
<td>----</td>
<td>F₁ 25327.62</td>
<td>± .92</td>
<td>F₁ 32497.46</td>
<td>±1.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F₂</td>
<td>----</td>
<td>F₂ 25370.79</td>
<td>± .92</td>
<td>F₂ 32488.67</td>
<td>±1.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E₁</td>
<td>----</td>
<td>E₁ 4428.81</td>
<td>± .92</td>
<td>E₁ 5287.27</td>
<td>±1.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E₂</td>
<td>----</td>
<td>E₂ 4419.06</td>
<td>± .92</td>
<td>E₂ 5289.20</td>
<td>±1.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F₁</td>
<td>6341.52</td>
<td>F₁ 25322.73</td>
<td>± .42</td>
<td>F₁ 32497.27</td>
<td>± .42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F₂</td>
<td>6348.50</td>
<td>F₂ 25338.42</td>
<td>± .42</td>
<td>F₂ 32493.80</td>
<td>± .42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E₁</td>
<td>1553.15</td>
<td>E₁ 4474.29</td>
<td>± .48</td>
<td>E₁ ------</td>
<td>------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E₂</td>
<td>1555.18</td>
<td>E₂ 4460.33</td>
<td>± .48</td>
<td>E₂ ------</td>
<td>------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F₁</td>
<td>6356.74</td>
<td>F₁ ------</td>
<td></td>
<td>F₁ ------</td>
<td>------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F₂</td>
<td>6357.35</td>
<td>F₂ ------</td>
<td></td>
<td>F₂ ------</td>
<td>------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E₁</td>
<td>1396.23</td>
<td>E₁ ------</td>
<td></td>
<td>E₁ ------</td>
<td>------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E₂</td>
<td>1396.23</td>
<td>E₂ ------</td>
<td></td>
<td>E₂ ------</td>
<td>------</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Where F = Full Cylinder  
E = Empty Cylinder

*NOTE: Facility C was unable to participate in any further aspects of the demonstration.*
Process Precision and State of Control

Most regulatory agencies require each facility to generate data which will exhibit the state of control of the various product weighing processes on a continuous basis. As a rule, these data are also used to determine an estimate of the process precision. A study of a number of sequences of such data raised some doubts as to the validity of the use of the precision index for the product weighing process, i.e., the data appears to be truncated to satisfy arbitrarily established bounds for variability. A second pair of IHS artifacts, designated F2 and E2 (empty and full), provide a vehicle for evaluating the precision of the product weighing process. Once again, summations of known weights, (F2 + c1) and (E2 + c1) are made, c1 again being known small weights. In this case, each summation is weighed frequently, in exactly the same manner as the product cylinders. The collection of observed weights for these summations, normalized by the known value of the added weights, define a collection of numbers. If the process is operating in a state of control, this collection of numbers will have a distribution which reflects the precision of the process. Each new value in the collection provides information about the state of control, either "in control" with respect to past performance, or "out of control." "In control" data reinforces the precision estimate i.e., it lies within the bounds of the previous distribution. "Out of control" data signals possible process change. Table IV shows typical data for (F2 + c1) when the summation has been weighed by the same procedures used to weigh product cylinders. It should be noted that this collection of values is also a measure of the process offset previously discussed. Figure 1 summarizes the precision estimates of the processes numbers in the demonstration.

The top left hand control chart of Figure 1 shows the data generated to comply with the requirements of a regulatory agency in facility A. The top right hand chart, superimposed over the process offset data, reflects the performance of the measurement process when the IHS (E2 + c1) is treated as a product cylinder. Likewise, the treatment of (F2 + c1) is shown in Figure 1, for both the full and empty cylinders. These support the suspicion that the data shown on the left of Figure 1 may be truncated. The two outliers in the 48X full data are marginally in control relative to the computed precision.

Facility B elected to treat the appropriate IHS's in the same manner used to satisfy the regulatory agency's requirements. Therefore, it can be postulated that the limits associated with these measurements do not properly describe the product weighing process. The "blank" chart of Figure 1 indicates the imposed limits.

The last part of the demonstration was the actual exchange of sets of full and empty product cylinders between facilities A and B. Figure 1 also shows the time intervals where product cylinder weighings were made.

Between Facility Comparisons

The results of the comparisons are summarized in Table V where the differences shown, Facility A-Facility B, are computed as follows:

\[(A - B) = (W_A + OS_A) - (W_B + OS_B)\]  \hspace{1cm} (Eq 2)

Where: \(W_A\) and \(W_B\) are the observed weights for each cylinder, at facilities A and B and \(OS_A\), \(OS_B\) are the respective process offsets.
### TABLE III

Typical In-House Standard Data For Process Offset

\[(F_3 + b_3) \quad \text{and} \quad (E_3 + b_3)\]

<table>
<thead>
<tr>
<th>(b_3)</th>
<th>(F_3 + b_3)</th>
<th>(W_1)</th>
<th>(O_1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>25,371</td>
<td>25,364*</td>
<td>-7</td>
</tr>
<tr>
<td>30</td>
<td>25,401</td>
<td>25,395</td>
<td>-6</td>
</tr>
<tr>
<td>65</td>
<td>25,436</td>
<td>25,430</td>
<td>-6</td>
</tr>
<tr>
<td>95</td>
<td>25,466</td>
<td>25,460</td>
<td>-6</td>
</tr>
</tbody>
</table>

### TABLE IV

Typical In-House Standard Data for Process Precision

\[(F_2 + c_4)\]

<table>
<thead>
<tr>
<th>Date</th>
<th>Added Weight of (c_4) in lbs.</th>
<th>(F_2 + c_4) lbs.</th>
<th>Observation (W_1) lbs.</th>
<th>Difference (O_1) lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 7, 1978</td>
<td>55</td>
<td>25,413</td>
<td>25,407</td>
<td>-6</td>
</tr>
<tr>
<td>April 11, 1978</td>
<td>28</td>
<td>25,386</td>
<td>25,381</td>
<td>-5</td>
</tr>
<tr>
<td>April 12, 1978</td>
<td>45</td>
<td>25,403</td>
<td>25,398</td>
<td>-5</td>
</tr>
<tr>
<td>April 13, 1978</td>
<td>45</td>
<td>25,403</td>
<td>25,393</td>
<td>-10</td>
</tr>
<tr>
<td>April 14, 1978</td>
<td>45</td>
<td>25,403</td>
<td>25,398</td>
<td>-5</td>
</tr>
<tr>
<td>April 17, 1978</td>
<td>59</td>
<td>25,411</td>
<td>25,414</td>
<td>-3</td>
</tr>
<tr>
<td>April 20, 1978</td>
<td>74</td>
<td>25,432</td>
<td>25,427</td>
<td>-5</td>
</tr>
<tr>
<td>April 25, 1978</td>
<td>53</td>
<td>25,411</td>
<td>25,404</td>
<td>-7</td>
</tr>
<tr>
<td>April 26, 1978</td>
<td>64</td>
<td>25,422</td>
<td>25,416</td>
<td>-6</td>
</tr>
<tr>
<td>April 28, 1978</td>
<td>17</td>
<td>25,375</td>
<td>25,372</td>
<td>-7</td>
</tr>
<tr>
<td>May 8, 1978</td>
<td>30</td>
<td>25,388</td>
<td>25,318</td>
<td>-7</td>
</tr>
</tbody>
</table>

*Scale zero was checked and adjusted, as necessary, prior to obtaining this weight.
Diagnostic analysis of the above set of differences is the basis for the second aspect of the UF₆ measurement assurance demonstration; i.e. the evaluation of the within facility process performance. From the parameters developed in the demonstration for each facility, the expected error bounds for the differences from both the "full" and "empty" product cylinders, in pounds, are:

\[
EB = \pm 3\sqrt{(s.d.\text{ }_A)^2 + (s.d.\text{ }_B)^2 + (SE_A + SE_B)} \tag{Eq. 3}
\]

\[
EEB = \pm 3\sqrt{(1.5)^2 + (0.68)^2 + (0.92 + 0.42)}
\]
\[
= \pm 3(1.64) + (1.34) \text{ lb} = \pm 5.04 + (1.34) \text{ lb}
\]

And Similarly

\[
FEB = \pm 3\sqrt{(1.6)^2 + (0.94)^2 + (0.92 + 0.42)}
\]
\[
= \pm 3(1.84) + (1.34) = \pm 1.52 + (1.34) \text{ lb}
\]

Where:

- \(EB\) = Total error bounds
- \(EEB\) = Total error bounds of empty weights
- \(FEB\) = Total error bounds of full weights
- \(s.d.\text{ }_A\) = Standard deviation of facility A process
- \(s.d.\text{ }_B\) = Standard deviation of facility B process
- \(SE_A\) = Systematic error of A process
- \(SE_B\) = Systematic error of B process

In Figure 2 the differences, \((A - B)\), between the exchanged 48X Empty Cylinders are plotted by the date the measurements were made in each facility. Both processes appear to be stable over the time intervals shown, with a standard deviation (s.d.) = 1.54 lb which compares favorably with the expected s.d. of 1.64 lb. The offset, \(X = -1.5\) lb, indicates that the values obtained from the empty cylinders in facility A are lower than obtained in facility B somewhat in excess of the expected limits for offset of facility A with respect to B, 1.34 lb. It is important to note that the expected offset may be either + or - and of any magnitude equal to or less than the propagated error bounds of A and B.

In Figure 3 the differences, \((A - B)\) for the 48X Full Cylinders are plotted in the same manner. Here there is clear evidence of grouping, particularly in facility B where multiple weighings were made on each of four days. The range of the values exceed the expected \(\pm 3\) s.d. limit \((\pm 5.5 \text{ lb})\), thus it must be concluded that the two extremes are probably out of control. The nature of the plot suggests that the source of this difficulty is with facility B.

In order to support the tentative conclusions stated above, refer again to Figure 1. In the case of the 48X empty process at facility A, it is clear that the \((E_2 + c_e)\) simulated product cylinder weights are offset by \(-1.8\) lb from the \((E_1 + b)\) weighings used to determine the process offset. For the 48X full cylinders at facility B, the two sets of data used to determine the offset show that the process on scale B = 1 changed over the time interval shown in the direction and by an amount...
which would remove the out of control differences in the full cylinder data. In both cases, the data used to determine the process offsets was generated by the procedures now in use to "calibrate" the various scales. The offset for scale B - 2 at facility B, used initially to establish the values of the IHS relative to the RMS and recently overhauled, was established by 10 independent weighings of \( F_2 + c_e \). The differences for the product cylinders weighed on this scale reflect the expected agreement between the two facilities.

Conclusions and Future Plans

This demonstration proved that the minimum detection level was a function of the combined error bounds for the two facilities involved, and thus is an example of the technique's practicability for safeguarding the transfer of UF₆.

Therefore, a data base, formulated from ANSI N15.18 guidance, for UF₆ transfer participants, provides a realistic safeguards tool for detection of loss as opposed to arbitrary criteria used in the past. Given real time data processing for maintenance of data bases, a mass value difference greater than the accepted uncertainties for the two measurement processes alerts the system to the spurious nature of a transfer. Thus, the system is able to react in a timely fashion and investigate the "out of control condition" be it safeguards problems, equipment and/or operator error, or other assignable causes.

Such a data base also provides an inspection agency with the ability to verify the mass measurement of UF₆ cylinders within a facility. For example, the inspector can require demonstration of the realism and accuracy of uncertainty statements for mass measurements by a set of witnessed weighings of the IHS and comparisons of the value obtained relative to the currently accepted uncertainties associated with that facility. This method provides the tool to verify the realism of the facility's mass measurement statements and to estimate the reliability of the facility's inventory.

Recent funding from NRC has provided the UF₆ MAP with an interim administrator. The data base from the recent demonstration will be delegated to this administrator for expansion. The task thus far accomplished has shown that the methodology and philosophy of the MAP detects problems in the mass measurement of UF₆ cylinders. That is, a UF₆ shipper-receiver mass difference greater than the propagated measurement uncertainties of the shipper and the receiver raises safeguards questions, while a weighing of the IHS resulting in a value outside the measurement process limits detects internal measurement problems.

Therefore, with the use of real time communication and computing equipment, the MAP administrator can immediately (1) update the data base, and thus (2) detect possible safeguards problems and (3) detect internal mass measurement problems. All of these actions and judgments can then be communicated to the shipper-receiver facilities and/or regulatory bodies for immediate action.
### TABLE V

Between Facility Comparison of Product Cylinder Weights (A - B)

<table>
<thead>
<tr>
<th>Cyl.</th>
<th>48X Empty (A - B) lb.</th>
<th>48X Full (A - B) lb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - E</td>
<td>.5</td>
<td>1 - F</td>
</tr>
<tr>
<td>2 - E</td>
<td>-3.5</td>
<td>2 - F</td>
</tr>
<tr>
<td>3 - E</td>
<td>-.5</td>
<td>3 - F</td>
</tr>
<tr>
<td>4 - E</td>
<td>-1.5</td>
<td>4 - F</td>
</tr>
<tr>
<td>5 - E</td>
<td>-1.5</td>
<td>5 - F*</td>
</tr>
<tr>
<td>6 - E</td>
<td>-4.5</td>
<td>6 - F*</td>
</tr>
<tr>
<td>7 - E</td>
<td>-1.5</td>
<td>7 - F*</td>
</tr>
<tr>
<td>8 - E</td>
<td>-3.5</td>
<td>8 - F*</td>
</tr>
<tr>
<td>9 - E</td>
<td>-.5</td>
<td>9 - F*</td>
</tr>
<tr>
<td>10 - E</td>
<td>-1.5</td>
<td>10 - F*</td>
</tr>
<tr>
<td>11 - E</td>
<td>+.5</td>
<td>11 - F*</td>
</tr>
<tr>
<td>12 - E</td>
<td>-.5</td>
<td>12 - F</td>
</tr>
<tr>
<td>13 - E</td>
<td>-3.5</td>
<td>13 - F</td>
</tr>
<tr>
<td>14 - E</td>
<td>-2.5</td>
<td>14 - F</td>
</tr>
<tr>
<td>15 - E</td>
<td>-1.5</td>
<td>15 - F</td>
</tr>
<tr>
<td>16 - E</td>
<td>+.5</td>
<td>16 - F</td>
</tr>
<tr>
<td>17 - E</td>
<td>-.5</td>
<td>17 - F</td>
</tr>
<tr>
<td>18 - E</td>
<td>-.5</td>
<td>18 - F</td>
</tr>
<tr>
<td>19 - E</td>
<td>-3.5</td>
<td>19 - F</td>
</tr>
</tbody>
</table>

*48X Full weighings for these cylinders were made on Scale B - 2.

All other weighings were made on Scales A - 1 and B - 1 respectively.
REFERENCES


PROCESS OFFSET AND PRECISION
FACILITY A

OFFSET

48X FULL SCALE A-1

PROCESS CONTROL
\( X \bullet = -1.8 \text{ lbs} \)
\( \text{s.d. } \circ = 1.5 \text{ lbs} \)

OFFSET

48X EMPTY SCALE A-1

PROCESS CONTROL
\( X \bullet = -0.9 \text{ lbs} \)
\( \text{s.d. } \circ = 1.6 \text{ lbs} \)

Figure 1.
PROCESS OFFSET AND PRECISION

FACILITY B

OFFSET

JUN 77  JULY  AUG  SEPT  OCT

POUNDS

+4
+2

-2

-4

OFFSET

FEB 78  MAR  APR  MAY  JUN

48X EMPTY
SCALE B-1

Imposed
Limits ±2 lbs

PROCESS CONTROL
(All points not shown)

Product
Cylinder
Weighing

\[ \bar{x} = +0.3 \text{ lbs} \]
\[ \text{s.d.} = 0.68 \text{ lbs} \]

48X FULL
SCALE B-2

OFFSET

PRODUCT

Cylinder
Weighing

This Date

\[ \bar{x} = -0.5 \text{ lbs} \]
\[ \text{s.d.} = 0.94 \text{ lbs} \]

PROCESS CONTROL
(All points not shown)

Imposed
Limits

Figure 1 (cont.)
Figure 2.
48X FULL PRODUCT CYLINDER COMPARISONS (S/R Diff) BY DATE

(A-B) by A Date

(A-B) by B Date

Figure 3.