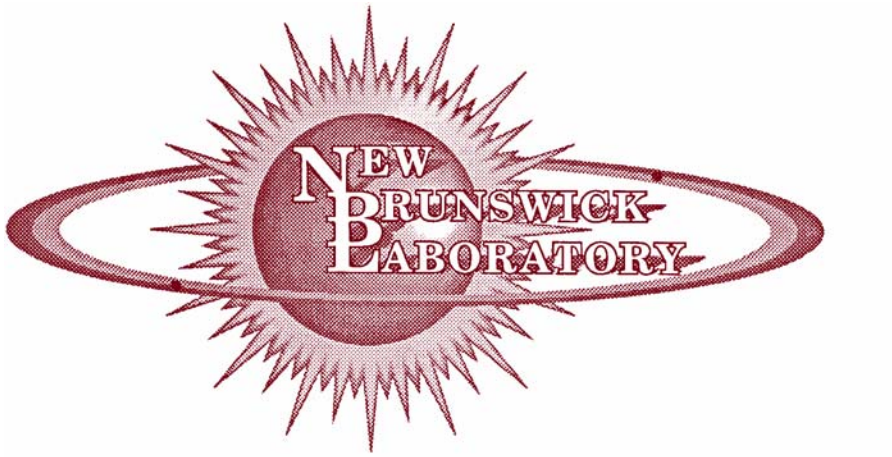
NBL-372
JUNE 2003

SAFEGUARDS MEASUREMENT EVALUATION PROGRAM

URANIUM SAMPLE EXCHANGE

PLUTONIUM SAMPLE EXCHANGE



FISCAL YEAR 2002

Jay M. Thompson and David T. Baran

U.S. DEPARTMENT OF ENERGY · CHICAGO OPERATIONS OFFICE · ARGONNE, ILLINOIS

NBL-372

U.S. DEPARTMENT OF ENERGY

SAFEGUARDS MEASUREMENT EVALUATION PROGRAM

URANIUM SAMPLE EXCHANGE

PLUTONIUM SAMPLE EXCHANGE

NUCLEAR MATERIALS MEASUREMENT DATA
CONSOLIDATED REPORT
FISCAL YEAR 2002

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DOE AND NBL BACKGROUND AND MISSION

OWNERSHIP

New Brunswick Laboratory (NBL) is owned and operated by the U.S. Department of Energy (DOE). Its primary sponsor is the Office of Plutonium, Uranium, and Special Materials Inventory (SO-62) in the DOE Office of Security.

DOE MISSION

DOE is entrusted to contribute to the welfare of the nation by providing the scientific foundation, technology, policy, and institutional leadership necessary to achieve efficiency in energy use, diversity in energy sources, a more productive and competitive economy, improved environmental quality, and a secure national defense.

NBL MISSION

NBL serves as the U.S. government central authority for nuclear materials measurements and measurement evaluation. It is also the U.S. government certifying authority for nuclear reference materials. These functions assure that the United States maintains an accurate and reliable nuclear safeguards program, particularly in the area of nuclear materials accountability. NBL program and technical capabilities not only enhance domestic nuclear security but also support international nonproliferation efforts. Its nuclear material measurements and measurement evaluation roles allow the federal government to perform independent technical audits and validate nuclear material measurements made by contractors. NBL also has the technical capability for the independent resolution of measurement and safeguards anomalies that may arise from nuclear operations and the transfer of materials between sites.

NBL HISTORY

NBL was established by the Atomic Energy Commission in New Brunswick, NJ in 1949. It was initially staffed by scientists from the National Bureau of Standards who had contributed to the science of measuring nuclear materials for the Manhattan Project. At first, the NBL mission was to provide the federal government with the capability to assay uranium-containing materials for the nation's developing atomic energy program. Over the years, NBL expanded its capabilities, improving methods and procedures, developing new ones, and certifying additional reference materials for use around the world. It incorporated the capability to make plutonium measurements in 1959. During the period from 1975 to 1977, NBL was relocated from New Jersey to the current site at Argonne, Illinois.

Since its beginning, NBL has been a center of excellence in analytical chemistry and the science of measuring nuclear materials. In this role, NBL continues to make state-of-the-art measurements of elemental and isotopic composition for a wide range of nuclear materials.

ACKNOWLEDGEMENTS

This program is administered by New Brunswick Laboratory under the auspices of the U.S. Department of Energy, Office of Plutonium, Uranium, and Special Materials Inventory (SO-62) in the DOE Office of Security.

ABSTRACT

New Brunswick Laboratory has been tasked by the U.S. Department of Energy Office of Security to assess and evaluate the adequacy of measurement technology as applied to materials accounting in U.S. Department of Energy nuclear facilities. The Safeguards Measurement Evaluation Program was developed as a means to monitor and evaluate the quality and effectiveness of nuclear materials accounting destructive measurements by site.

With the approval of the Department of Energy Office of Security, the first international participant, the Safeguards Analytical Laboratory in Tokai, Japan was added to the Program in Fiscal Year 1997, on a cost-recovery basis. This laboratory is currently performing measurements for uranium assay and enrichment, and plutonium assay and isotopics.

This report presents and statistically analyzes nuclear materials measurement data generated by participants of the Safeguards Measurement Evaluation Program on uranium and plutonium assay and isotopic test materials during Fiscal Year 2002.

INTRODUCTION

New Brunswick Laboratory (NBL) operates the U.S. Government Nuclear Material Standards and Measurements Laboratory as an essential technical element in the fulfillment of the Department of Energy (DOE) statutory responsibility to assure the safeguarding of nuclear materials. The mission of the Laboratory includes serving as a technical extension of the Department of Energy Office of Security in the area of nuclear material control and accountability (MC&A), and providing Federal assessment and oversight of the implementation of MC&A policies and programs for safeguarding nuclear materials.

As part of the assessment of MC&A programs, NBL administers the Safeguards Measurement Evaluation (SME) Program to evaluate the quality and adequacy of destructive safeguards measurements, as performed by DOE contractor facilities. Participation by these DOE facility laboratories enables the fulfillment of a requirement of DOE Manual 474.1-1A, issued in November 2000, which states, "Each facility's measurement control program must include participation in appropriate interlaboratory control programs to provide independent verification of internal analytical quality control." [Chapter II.4.e.(7)]

Five U.S. Nuclear Regulatory Commission (NRC) licensees began full participation in the Program in Fiscal Year 1996, under a cooperative agreement between NBL and the NRC, with the approval of the DOE Office of Security; a sixth licensee was added in Fiscal Year 1997. In addition, oversight for both Paducah and Portsmouth Gaseous Diffusion Plants was transferred from DOE to the NRC in Fiscal Year 1997; their participation in the Program continued under the NRC. Licensee participation in the program allows more timely and cost-effective monitoring of measurement performance, compared with the previous practice of analyzing inventory verification samples taken by NRC personnel during on-site inspections. The NRC discontinued its role under the cooperative agreement during Fiscal Year 2001; licensees may continue participation on an individual basis.

With the approval of the DOE Office of Security, the first international participant, the Safeguards Analytical Laboratory in Tokai, Japan was added to the Program in Fiscal Year 1997, on a cost-recovery basis. This laboratory analyzed low-enriched uranium dioxide pellets for both uranium concentration and enrichment, and plutonium for isotopic abundances.

The effectiveness of the DOE and international nuclear industry to carry out their respective responsibilities for nuclear safeguards primarily depends on their abilities to account for the

quantities and isotopic composition of nuclear materials being stored, handled, processed, or transported.

Defensible accountancy data must be continuously generated to provide the final evidence that other aspects of nuclear safeguards, such as physical security and materials control, have been effective. Furthermore, accountancy measurements must be accurate, precise, and compatible with the national measurement base.

Within a given laboratory, these requirements are met through the concurrent analysis of reference materials and samples. These reference materials have well-known values; the ability to reproduce the reference values provides assurance that accurate results are being obtained during sample analysis. It is still possible, however, to experience undetected analytical problems: for example, during the preparation of the reference material for analysis.

Thus, compatibility with the national reference base requires more than the internal use of reference materials for quality control. It requires that measurement results obtained on a given material by a given method and analyst agree, within the statistical uncertainties of the methods, with results obtained by different methods or analysts at different facilities. A sample exchange program can validate the effectiveness of internal quality control, as well serve as a means of intercomparison of analytical performance by all participating laboratories.

CONDUCT OF THE PROGRAM

The Safeguards Measurement Evaluation Program provides external monitoring of the quality and adequacy of destructive safeguards measurements through the distribution of characterized materials traceable to the national measurement base for periodic analysis at participating facilities. Reported measurements are subjected to statistical evaluation. Table 1 contains a list of laboratories participating in the uranium portion of the Program for the Fiscal Year 2002 reporting period. Table 2 contains a list of laboratories participating in the plutonium isotopic portion of the Program.

TABLE 1

URANIUM SAMPLE EXCHANGE PARTICIPATING FACILITIES
ARGONNE NATIONAL LABORATORY–WEST
LOS ALAMOS NATIONAL LABORATORY
NEW BRUNSWICK LABORATORY
SAVANNAH RIVER SITE
TOKAI SAFEGUARDS ANALYTICAL LABORATORY
Y-12 NATIONAL SECURITY COMPLEX

TABLE 2

PLUTONIUM ISOTOPIC EXCHANGE PARTICIPATING FACILITIES
NEW BRUNSWICK LABORATORY
TOKAI SAFEGUARDS ANALYTICAL LABORATORY

Measurement Methods and Laboratory Participation

During Fiscal Year 2002, SME Program participants used five different methods to perform uranium concentration measurements on three different materials, and one measurement method to perform isotopic measurements on both low- and high-enriched uranium materials. Additionally, plutonium samples were analyzed for elemental amount by isotope dilution mass spectrometry and isotopic abundances by thermal ionization mass spectrometry. Table 3 illustrates the various materials analyzed and measurement methods used by participating laboratories (identified by laboratory code only).

TABLE 3
LABORATORY PARTICIPATION FOR FISCAL YEAR 2002
BY MATERIAL AND MEASUREMENT METHOD

Table Entries are Facility Codes with the Number of Times Participated in Fiscal Year 2002

UPPER Portion of this Table Shows Methods and Materials for Assay Measurements
LOWER Portion of this Table Shows Methods and Materials for Isotopic Measurements

Method	UNH Solutions	UO_2 Pellets	UO_3 Powder	UF_6	Pu Sulfate
Dichromate Titration	B4 F2	F1 T2	F1		
Ceric Titration	G4				
U IDMS	A3 J1		A4		
X-Ray Fluorescence	A3		A8		
Pu IDMS					F1
TIMS LEU	A1	F1 T2	F1	F1	
HEU	A3 F1 J1				
Pu					F1 T2

Characterization of Test Materials

Characterization measurements were performed at NBL on each of the test materials as packaged for use in the Program, in accordance with a specific characterization plan designed by the NBL Numerical Analysis Group. The plan specified the number of randomly-selected samples to be analyzed to provide the characterized value, and the specific measurement method to be used. A requirement for concurrent validation of measurements with Certified Reference Materials was incorporated into every characterization protocol. This requirement also provided traceability to the national measurement base. As a participant in the Program, NBL periodically reanalyzes all the materials distributed for analysis both for evaluation of NBL's performance and as a check on the integrity of the materials.

Distribution of Materials and Analysis Requirements

The characterized materials were distributed to the participating facilities with instructions on handling and analysis. For uranium measurements, whenever possible, participants were asked to analyze each of the two samples specified for the measurement period in duplicate on each of two days, producing a total of eight results. This maximized the information available for statistical evaluation while minimizing analytical effort. For plutonium isotopic measurements, only duplicate analyses were requested on each of the samples.

Statistical Analysis and Reporting

During Fiscal Year 1995, a database application for the statistical evaluation of submitted results was developed to facilitate statistical analysis and reporting. This application streamlines the entire process of statistical evaluation, from data entry to report and graphics generation. Starting in Fiscal Year 1996, all uranium data were processed using the new application. In Fiscal Year 1999, the database was upgraded to become Y2K compliant. The application has been adapted to process plutonium data.

All data were reviewed for handling, analysis, and reporting problems before statistical analysis. If necessary, the submitting laboratory was contacted for any necessary clarifications or corrections. For each set of data submitted, individual data evaluation reports were prepared and distributed to the reporting facility and to the cognizant DOE Operations Office, if appropriate. These reports were distributed within three weeks of receipt of raw data, whenever possible, to provide rapid feedback to the participant. In order for this feedback to be most meaningful, timely submission of data to the Program is very important. Several sites submitted data via email in FY2002, and data evaluation reports from NBL were distributed to participants electronically (in Adobe© Portable Document File). These initiatives have enhanced the timeliness of the reports.

In order to normalize the data for reporting, the percent relative difference (%RD), from the reference value, defined as

%RD = [(observed value - reference value)/reference value](100%),

was calculated for each reported measurement value.

Outlier tests were performed on each set of data submitted by each participant; further statistical analyses were performed on the data after elimination of statistically significant outliers. Both the mean of the %RDs and the mean of the absolute %RDs were calculated. A 95% confidence limit (C.L.) was calculated for the mean of the %RDs. This C.L. consisted of an estimate of standard uncertainty of the mean multiplied by a coverage factor, i.e.

95% C.L. = standard uncertainty * coverage factor

If the C.L. did not include zero, a bias was reported.

Both within-day variation and variation due to day of analysis were calculated. Comparison of the between-day variation with the within-day variation was accomplished using standard one-factor analysis of variance (ANOVA), with analysis day as the factor. If the ANOVA results indicated no significant excess variation due to analysis day, the standard uncertainty estimate used was the standard error, which is the standard deviation of the mean. This is the simple standard deviation divided by the square root of *n*, where *n* is the number of observations. The coverage factor used was the 95% Student's "t" factor with *n*-1 degrees of freedom.

If the ANOVA results indicated significant excess variation due to analysis day, the standard uncertainty estimate used was the square root of the mean square for the "model" quantity from the ANOVA results. The coverage factor used was the 95% Student's "t" factor with k-1 degrees of freedom, where k was the number of days over which the analyses were performed; since analyses were usually performed over two days, the Student's "t" factor for one degree of freedom was used in the calculations.

Two uranium sample reports are shown in Figures 1 and 2. In Figure 1, the ANOVA results indicate that the data contained no significant excess variation due to analysis day. The 95% C.L. does not include zero, indicating that the mean is significantly biased. Note in Figure 2 that the statistical significance of the between-day standard deviation is more than 95%, indicating that significant excess variation due to analysis day was present. Therefore the 95% C.L. is calculated using the Student's "t" factor for one degree of freedom (for two analysis days). This number is approximately 12.7; the 95% C.L. of the mean then becomes very large. Detecting a statistically significant bias becomes very difficult in this circumstance.

Figure 1

SAMPLE DATA EVALUATION REPORT

No significant excess difference due to analysis day

U.S. Department of Energy
New Brunswick Laboratory
Safeguards Measurement Evaluation Program
Data Evaluation Report

Day to Day ANOVA analysis

Report for Laboratory: XX

U02 Pellet – U Concentration

Davies-Gray Titration

Date of Report: July 30, 2002

Sample Number	Aliquant Number	Analysis Date	Reported %U	% Relative Difference	Analyst Code
95EU0079-1	1	06/25/02	88.126	-0.0034	XXX
95EU0079-1	2	06/25/02	87.990	-0.1577	XXX
95EU0079-2	1	06/25/02	88.031	-0.1112	XXX
95EU0079-2	2	06/25/02	87.892	-0.2689	XXX
95EU0079-1	3	06/26/02	88.030	-0.1123	XXX
95EU0079-1	4	06/26/02	87.950	-0.2031	XXX
95EU0079-2	3	06/26/02	87.922	-0.2349	XXX
95EU0079-2	4	06/26/02	88.002	-0.1441	XXX

Number of Results Analyzed	8
Mean % Difference	-0.154
Mean Absolute % Difference	0.154
95% C.L. of Mean (df = 7)	0.070
Standard Deviation	0.083
Between-Day Standard Deviation (df = 1)	0.054
Within-Day Standard Deviation (df = 6)	0.087
Statistical Significance of Between-Day Standard Deviation	44.3%

Figure 2

SAMPLE DATA EVALUATION REPORT

Significant excess difference due to analysis day

U.S. Department of Energy
New Brunswick Laboratory
Safeguards Measurement Evaluation Program
Data Evaluation Report

Day to Day ANOVA analysis

Report for Laboratory: XX

UNH Solution – U Concentration

IDMS

Date of Report: May 8, 2002

Sample Number	Aliquant Number	Analysis Date	Reported %U	% Relative Difference	Analyst Code
94NU0021-023	1	04/11/02	1.0000	-0.0590	XXX
94NU0021-023	2	04/11/02	1.0003	-0.0290	XXX
94NU0023-079	1	04/11/02	0.9991	-0.0080	XXX
94NU0023-079	2	04/11/02	0.9996	-0.2582	XXX
94NU0021-023	3	04/15/02	1.0022	0.1609	XXX
94NU0021-023	4	04/15/02	1.0004	-0.0190	XXX
94NU0023-079	3	04/15/02	1.0004	0.1221	XXX
94NU0023-079	4	04/15/02	1.0013	0.2122	XXX

Number of Results Analyzed	8
Mean % Difference	0.015
Mean Absolute % Difference	0.109
95% C.L. of Mean (df = 1)	1.319
Standard Deviation	0.149
Between-Day Standard Deviation (df = 1)	0.294
Within-Day Standard Deviation (df = 6)	0.107
Statistical Significance of Between-Day Standard Deviation	96.6%

Annual Reporting

Data sets from each of the participating facilities are consolidated in this report, and presented with comparisons among facilities. The presentation and discussion of submitted data are organized in this report according to the material analyzed. All data are referenced to facility codes to maintain anonymity of the participants.

New International Target Values (ITVs) were published in 2000[1] by the International Atomic Energy Agency, and adopted by the Program in 2001. These target values are intended to be realistic goals for the performance of the methods used. The 2000 ITVs are displayed on most of the comparative graphs in this report.

Two types of graphical formats are used to display the interlaboratory comparisons. The Material-Measurement Skeletal Graphs (Figures 3, 5, 7, 9, 11, 13, 15, and 17) permit a simplified comparison of measurement capabilities by laboratory. The diamond on the vertical line indicates the location of the mean value of the %RDs. The vertical line depicts the standard deviation of the mean %RD. If the mean %RD is between the bias target limit lines, that target value has been met. Laboratory codes are located across the base of the plot; the number of analyses is located across the top of the plot.

The Material-Measurement Line Graphs (Figures 4, 6, 8, 10, 12, 14, 16, and 18) emphasize the precision of the data. The diamond on the vertical line represents absolute value of the mean %RD. If the diamond is near the zero end of the line, the data are unbiased. The height of the line represents the percent relative standard deviation (%RSD), defined as the standard deviation of the mean %RD. If the %RSD is below the precision target limit line, that target value has been met.

Following the interlaboratory comparisons by material, Material-Measurement Skeletal Graphs for all uranium measurements are displayed for each laboratory (Figures 19 through 34). Three years of data are plotted on these graphs, so that longer-term performance may be evaluated.

A complete listing of all data submitted to the Program, sorted by material and laboratory, is included in the Appendix of this report.

[1] Deron, S. et al, "International Target Values 2000 for Measurement Uncertainties in Safeguarding Nuclear Materials", Journal of Nuclear Materials Management XXX, No. 2 (2002).

EVALUATION OF MEASUREMENT PERFORMANCE BY MATERIAL

URANYL NITRATE SOLUTIONS

The analysis of pure uranyl nitrate solutions represents the most direct test of measurement systems for uranium elemental concentration. The first such solution to be analyzed within the Program was donated by the Y-12 Plant, and was used to help resolve a shipper-receiver difference. The solution was intended to be representative of actual material being shipped, which was approximately 50% enriched in ^{235}U. This solution, plus samples from a suite of three high-enriched (approximately 90% ^{235}U) solutions were analyzed by three facilities utilizing isotope dilution mass spectrometry (IDMS) to determine uranium concentration. A suite of three uranyl nitrate solutions of normal enrichment is analyzed by most other Program participants. The use of normal enrichment enables participation by facilities restricted from receiving shipments of enriched materials. These three normal solutions differ from one another in elemental concentration by approximately 0.2%; the ability to differentiate among them demonstrates good analytical capabilities.

Preparation and Packaging for Shipment

The uranyl nitrate solutions are packaged in flame-sealed glass ampules with a break-off tip. Before shipping, the ampules are sealed in plastic, wrapped in absorbent cushioning, sealed in plastic again, and packaged in secondary containers (screw-cap fiberboard cans). The uranium concentrations range from approximately 7 to 10 mg U/g solution.

Reference Value and Uncertainties

The reference values for the 50%-enriched solution and the 90%-enriched solutions were determined by analyzing subsamples taken from ampulated samples. The NBL-modified Davies and Gray titration procedure was used to perform the characterization measurements.

All of the normal enrichment uranium solutions were prepared from NBL dingot metal, the source of Certified Reference Material (CRM) 112-A, Uranium Metal Assay Standard. Because of the possibility of evaporation during the ampulation process, the original suite of normal uranium solutions was characterized after ampulation using the NBL-modified Davies and Gray titration procedure. The characterized values were then used as the reference values in the Program. In all cases, agreement between prepared and characterized values was within a few hundredths of a percent. Because of this good agreement, the characterized values of the new suite of normal uranium solutions were based on prepared values; a more limited number of measurements were

performed to confirm the prepared values. This resulted in a significant savings in analytical effort and in the overall cost of the ampules.

The 95% confidence limit (C.L.) for the 50% enriched solution is ±0.1% of the reference value. The 95% C.L. for each of the high-enriched solutions is approximately ±0.02%. The 95% C.L. for each of the normal enrichment solutions currently in use in the program ranges from ±0.02% to ±0.05%. Although characterized values for the new suite of normal enrichment solutions were based on prepared values, the uncertainties were calculated using measurement data, to produce more conservative uncertainty estimates.

Evaluation of Performance

For Figures 3 and 4, the data are arranged by methods and their target values. Laboratories G, B, and F measure uranium concentration by titration. Laboratories A* and J* measure uranium concentration by IDMS. Facility A** uses x-ray fluorescence (XRF). International Target Values are used for titration and IDMS. There are no specific 2000 International Target Values for XRF, so DOE target values[2] from 1993 are used. Target values for bias are 0.1% for titration and IDMS, and 0.5% for XRF. Target values for precision are 0.1% for titration, 0.15% for IDMS, and 0.5% for XRF. Target values for bias are plotted in Figure 3. Target values for precision are plotted in Figure 4.

As seen in Figure 3, all laboratories except J* met the target limits for bias in Fiscal Year 2002. Laboratory J* just barely exceeded the target value for bias. As seen in Figure 4, Laboratory B did not meet the target limit for precision. The results from laboratories G, A*, A**, and F demonstrate very good accuracy and precision in the measurement of uranyl nitrate solutions. Table 4 presents the numerical values of the plotted data.

[2] U.S. DOE Office of Security Affairs/Office of Safeguards and Security, *Measurement Control Guide* and *Measurement Improvement Plan*, 1993.

Table 4
Interlaboratory Performance Summary
UNH - Percent U

Method	Lab code	Mean	Standard deviation	N
Ceric Titration	G	-0.006	0.048	32
Davies-Gray Titration	B	-0.014	0.174	37
	F	-0.016	0.037	32
IDMS	A*	0.025	0.094	24
	J*	-0.118	0.058	18
X-Ray Fluorescence	A**	0.147	0.319	24

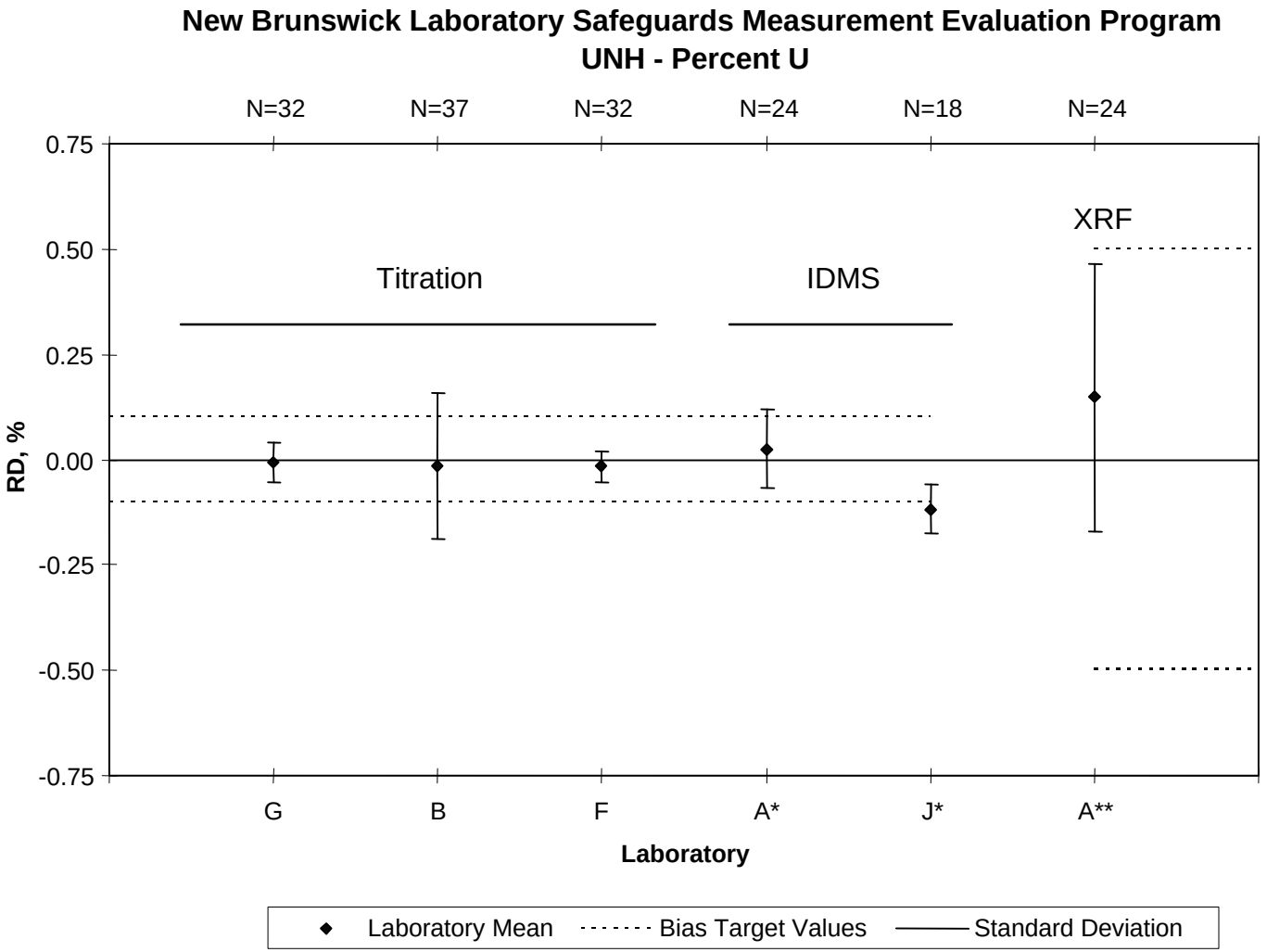
New Brunswick Laboratory Safeguards Measurement Evaluation Program
UNH - Percent U
N=32
N=37
N=32
N=24
N=18
N=24
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
RD, %
Titration
IDMS
XRF
G
B
F
A*
J*
A**
Laboratory
Laboratory Mean
Bias Target Values
Standard Deviation

Figure 3

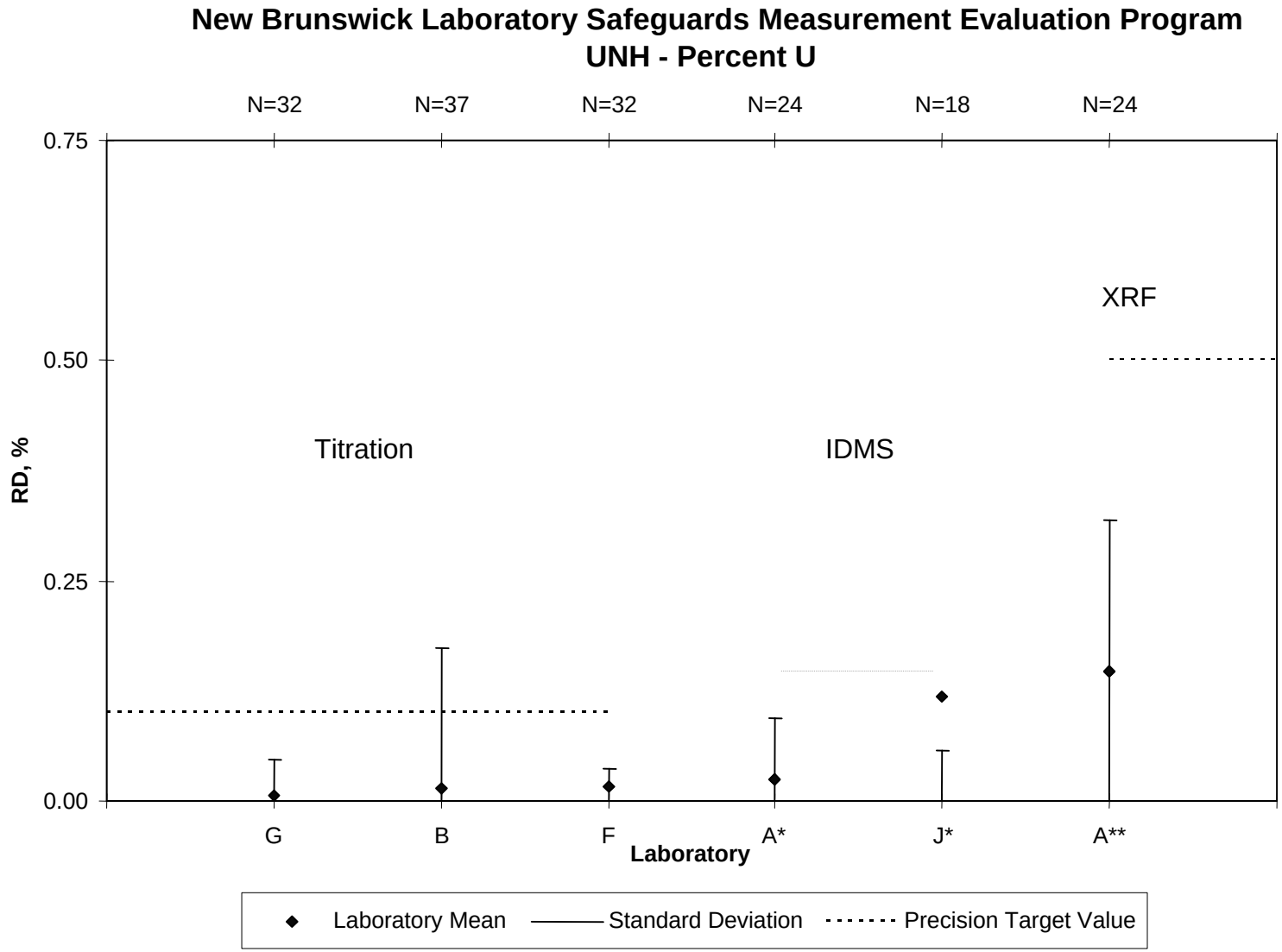
New Brunswick Laboratory Safeguards Measurement Evaluation Program
UNH - Percent U
N=32
N=37
N=32
N=24
N=18
N=24
0.75
0.50
0.25
0.00
RD, %
Titration
IDMS
XRF
G
B
F
A*
J*
A**
Laboratory
Laboratory Mean
Standard Deviation
Precision Target Value

Figure 4

ENRICHED URANIUM DIOXIDE PELLET

As a collaborative effort between DOE and the NRC, NBL has packaged and certified a uranium dioxide pellet material to serve as both a Certified Reference Material (CRM 125-A) and a test material in this Program. Westinghouse Commercial Nuclear Fuel Division, an NRC licensee, supplied the NBL with the base material, a single production batch of UO_2 pellets. These pellets were sintered at 1700°C for 20 hours in a reducing atmosphere in order to produce a ceramic-like material that is resistant to moisture uptake and is stable when exposed to air.

Preparation and Packaging for Shipment

The UO_2 pellets are packaged in a snap-cap glass bottle with a low-lint tissue for cushioning to prevent chipping. The glass bottle is sealed in plastic, and packaged in a cardboard tube.

Reference Value Uncertainties

Uranium elemental concentration measurements were performed using the NBL high-precision titration. NBL CRM 112-A, Uranium Metal Assay Standard, was used for quality control. The 95% C.L. is less than ±0.02% of the reference value. Uncertainties assigned to the isotopic abundance values are discussed in the Uranium Enrichment section.

Evaluation of Performance

For Figures 5 and 6, the data are arranged by methods and target values. Laboratories F and T use modified Davies and Gray titration. The 2000 International Target Values for titration are 0.1% for both bias and precision. Data from both laboratories are within their applicable target limits. Table 5 presents the numerical values of the plotted data.

Table 5
Interlaboratory Performance Summary
UO_2 Pellets - Percent U

Method	Lab code	Mean	Standard deviation	N
Davies-Gray Titration	F	-0.046	0.031	29
	T	-0.046	0.098	16

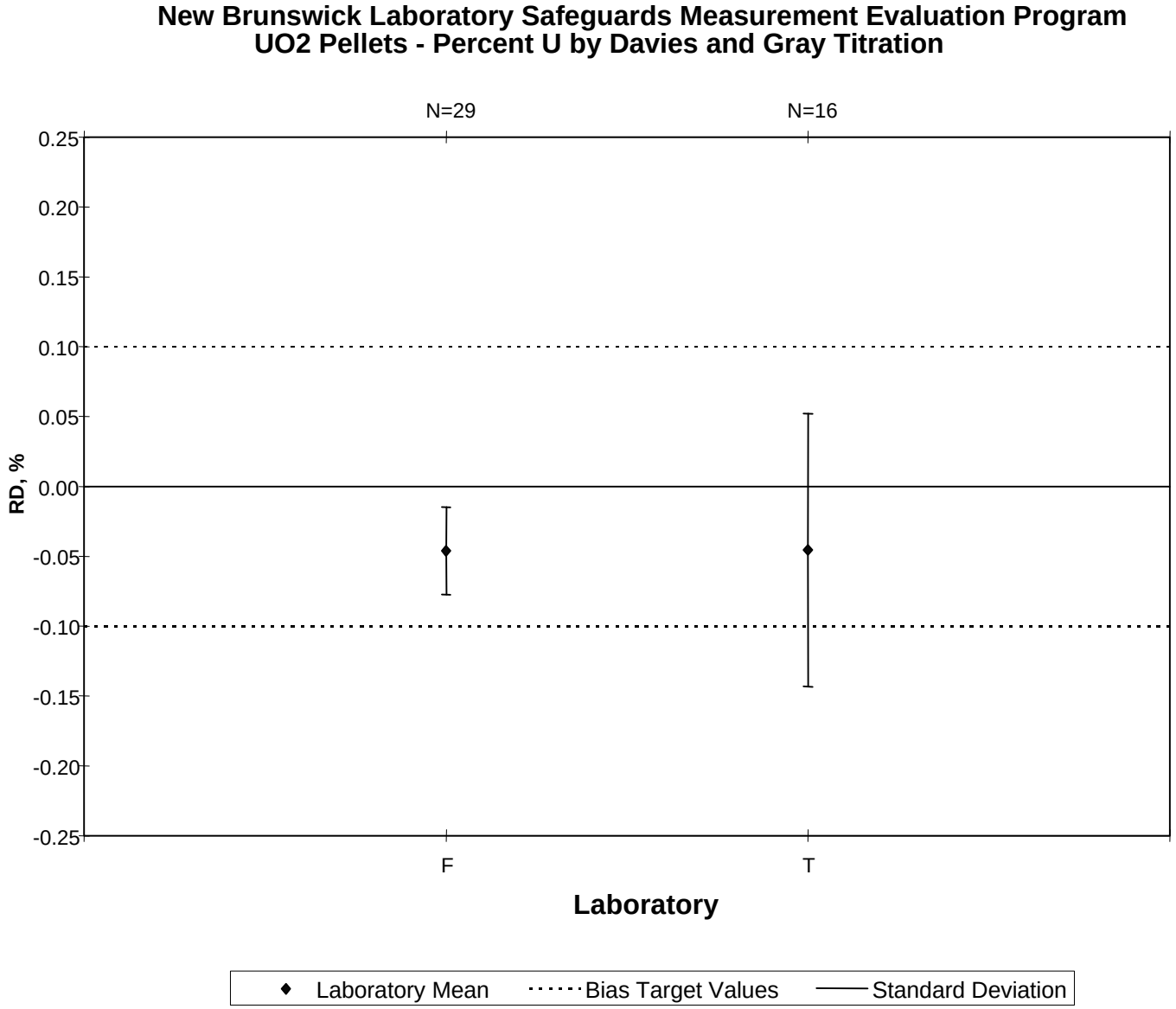
New Brunswick Laboratory Safeguards Measurement Evaluation Program
UO2 Pellets - Percent U by Davies and Gray Titration
N=29
N=16
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
RD, %
F
T
Laboratory
Laboratory Mean
Bias Target Values
Standard Deviation

Figure 5

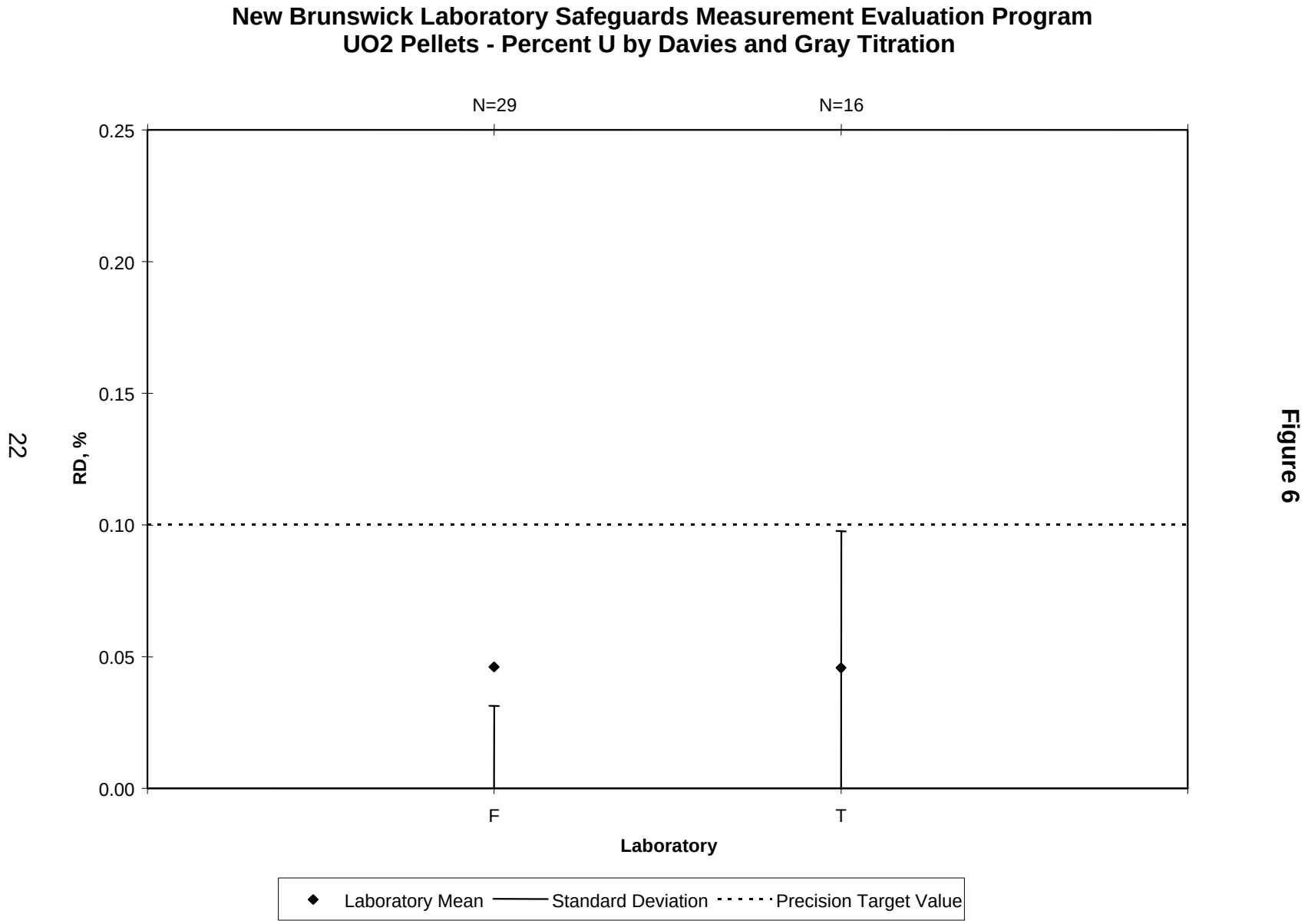
New Brunswick Laboratory Safeguards Measurement Evaluation Program
UO2 Pellets - Percent U by Davies and Gray Titration
N=29
N=16
0.25
0.20
0.15
0.10
0.05
0.00
RD, %
F
T
Laboratory
Laboratory Mean
Standard Deviation
Precision Target Value

Figure 6

URANIUM HEXAFLUORIDE

Portsmouth Gaseous Diffusion Plant donated two sampling manifolds to NBL, to be used to transfer the UF_6 material from 2S cylinders to P-10 tubes for shipment and analysis. One manifold is dedicated to uranium with normal enrichment; the other is being reserved for enriched uranium. With Portsmouth technical assistance and after extensive safety review at the NBL, normal-enrichment UF_6 was added to the Program as a continuing material for analysis in Fiscal Year 1993.

In Fiscal Year 1996, plans were made to add a UF_6 test material characterized for both uranium concentration and ^{235}U enrichment. Because CRM 113, Uranium (Enriched) Hexafluoride, is sold out, the decision was made to certify an appropriate material for use in both the SME and the Reference Material Programs. An enrichment level of approximately 4.5% was chosen for the new CRM because it represents the enrichment level of material supplied to fuel fabrication licensees for pellet production, and also because it is near the enrichment level of Russian downblended UF_6 material shipped to the U.S. During 1998, certification for both uranium concentration and isotopic abundances was completed. The primary users identified for this CRM are the two GDPs. These facilities were converted from DOE contractor sites to NRC licensees in March 1997. Because of the change in their status, this CRM was certified with joint funding from both DOE OSS and the NRC. This CRM (CRM 113-B) was added as a test material to the SME Program in Fiscal Year 2001.

Preparation and Packaging for Shipment

The normal enrichment material is packaged in P-10 tubes under dry nitrogen with each tube containing from 7 to 12 g UF_6. The tubes are heat-sealed in plastic and packaged in secondary containers (produce cans) before shipping. CRM 113-B is currently packaged in 2S cylinders.

Reference Value Uncertainty

Uranium elemental concentration measurements of CRM 113-B were performed using the NBL high-precision titration method. NBL CRM 112-A, Uranium Metal Assay Standard, was used for quality control. Samples of SME Program normal-enrichment UF_6 were analyzed concurrently to provide a check on the extensive handling required to prepare samples for analysis. The 95% C.L. of the uranium concentration of CRM 113-B is 0.033%. Uncertainties assigned to the isotopic values are discussed in the Uranium Enrichment section.

URANIUM OXIDE (UO_3) POWDER

NBL was requested by a DOE Safeguards Measurement Evaluation Program participant to reintroduce a UO_3 powder test material into the Program. This material was previously used in the Program to test the ability of the participating laboratories to handle a hygroscopic material; its use had been discontinued because of lack of interest. The laboratory requesting the reintroduction planned to use three different methods to analyze the material: x-ray fluorescence (XRF) in solid form, XRF in liquid form, and isotope dilution mass spectrometry.

Preparation and Packaging for Shipment

UO_3 powder is packaged under dry nitrogen in pharmaceutical vials closed with Teflon-lined stoppers under a crimped seal. The vial is sealed in plastic, and packaged in a cardboard tube.

Reference Value Uncertainty

The test materials originally had been packaged over five years ago. Since the packaging might have been compromised over such a long period of time, allowing moisture adsorption by the test material, it was necessary to recharacterize the uranium content of the material.

If the material had adsorbed moisture over the time since packaging, it was also necessary to ensure that the packaged material was still sufficiently uniform from unit-to-unit to be a suitable test material. Eight vials were selected for verification analysis. Uranium elemental concentration measurements were performed using the NBL-Modified Davies and Gray Titration. NBL CRM 112-A, Uranium Metal Assay Standard, was used for quality control. The final uranium concentration value differed from the original measured value by -0.064%, with a 95% confidence level of 0.012% of the value. The material was reintroduced to the Program using the updated characterized value.

Evaluation of Performance

For Figures 7 and 8, the data are arranged by methods and their target values. Laboratory F measures uranium concentration by Davies and Gray titration. Facility A measures uranium concentration by three different methods: IDMS (A), XRF – liquid (A*), and XRF – solid (A**). International Target Values are used for titration and IDMS. As noted in the section on uranyl nitrate solutions, there are no specific 2000 International Target Values for XRF, so DOE target values from 1993 are used. Target values for bias are 0.1% for titration and IDMS, and 0.5% for the XRF methods. Target values for precision are 0.1% for titration, 0.15% for IDMS, and 0.5%

for the XRF methods. All laboratories met the target limits for bias and precision. Table 6 presents the numerical values of the plotted data.

Table 6
Interlaboratory Performance Summary
UO_3 - Percent U

Method	Lab code	Mean	Standard deviation	N
Davies-Gray Titration	F	-0.042	0.032	16
IDMS	A	-0.016	0.126	32
X-Ray Fluorescence Liquid	A*	-0.179	0.368	32
X-Ray Fluorescence Solid	A**	-0.007	0.258	32

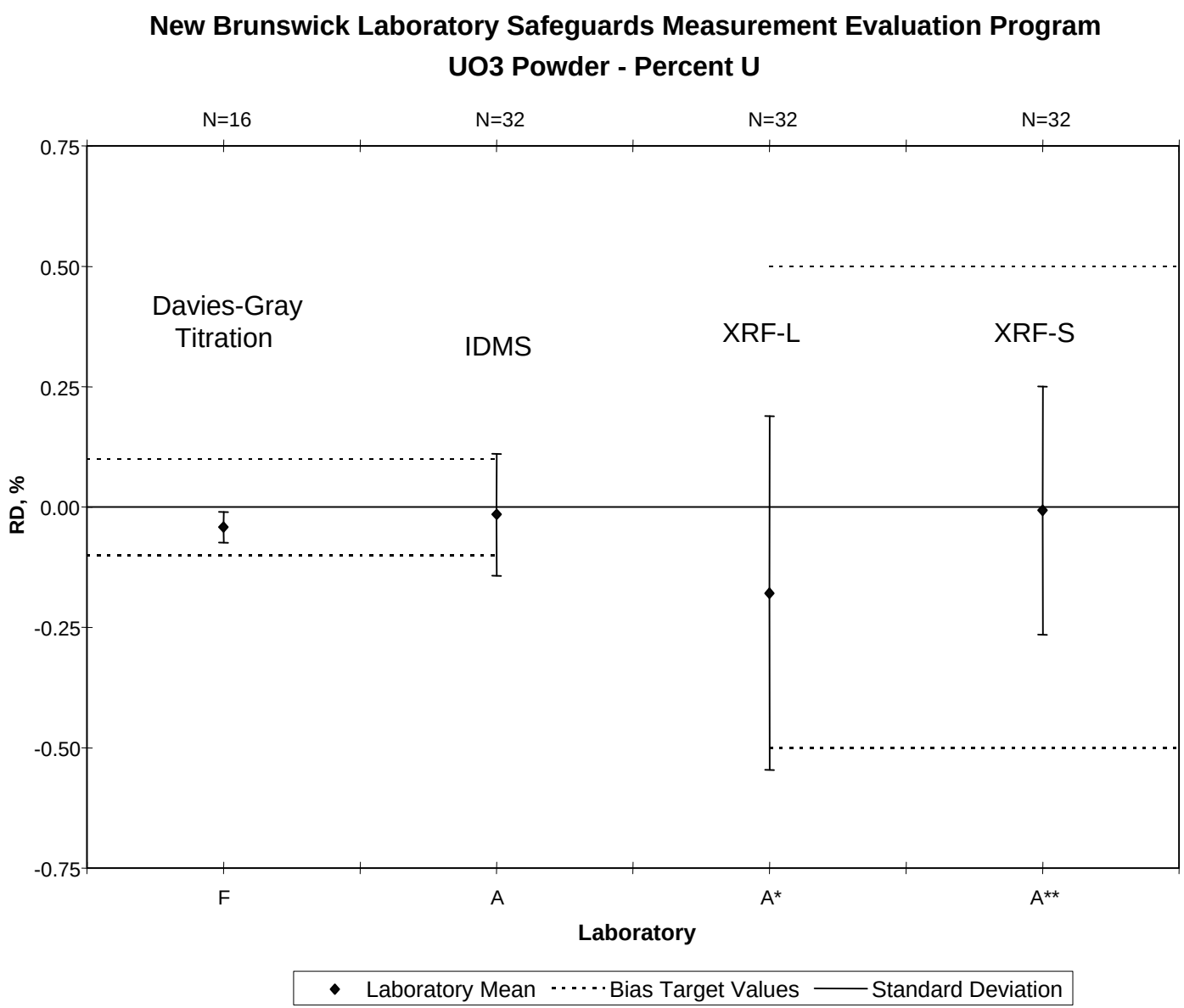
New Brunswick Laboratory Safeguards Measurement Evaluation Program
UO3 Powder - Percent U
N=16
N=32
N=32
N=32
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
RD, %
Davies-Gray Titration
IDMS
XRF-L
XRF-S
F
A
A*
A**
Laboratory
Laboratory Mean
Bias Target Values
Standard Deviation

Figure 7

New Brunswick Laboratory Safeguards Measurement Evaluation Program
UO3 Powder - Percent U

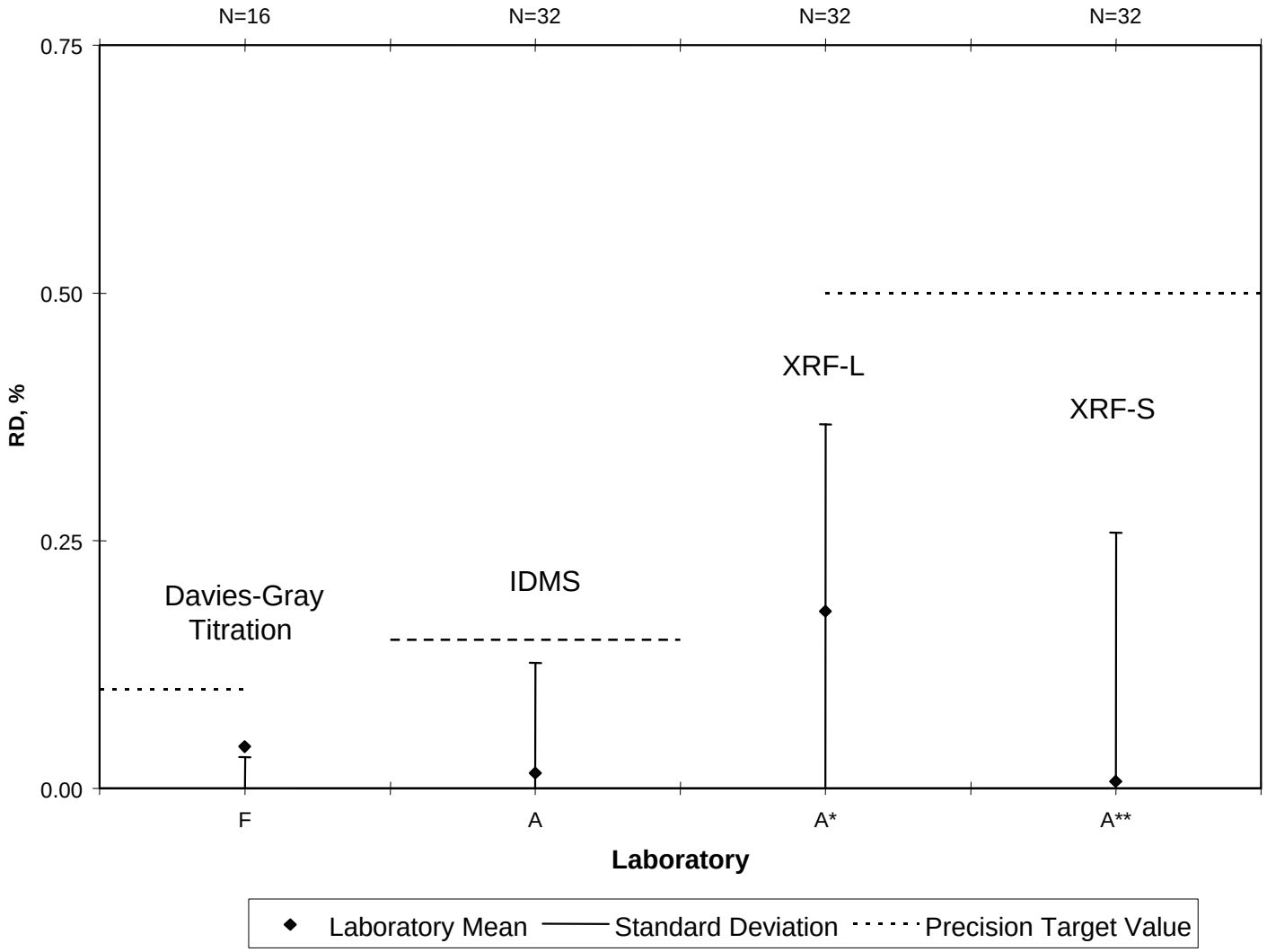

Figure 8

URANIUM-235 ENRICHMENT

Five test materials in the form of uranyl nitrate solutions are available for the measurement of uranium enrichment. These test materials include a suite of three solutions prepared from uranium enriched to approximately the 90% level, a solution prepared from uranium enriched to approximately 50%, and a solution prepared from uranium enriched to approximately 4%. NBL and the NRC fuel fabrication licensees are also analyzing the UO_2 pellet (described in another section) for enrichment (approximately 4%), as well as for uranium concentration. The certification of CRM 113-B, 4.5% enriched UF_6, was recently completed. This material was added to the Program in FY2001 to evaluate the performance of gas mass spectrometry at Portsmouth and Paducah Gaseous Diffusion Plants.

Preparation and Packaging for Shipment

The uranyl nitrate solutions are packaged in flame-sealed glass ampules with a break-off tip, and have an elemental concentration ranging from 5-10 mg U/g solution. Before shipping, the ampules are sealed in plastic, wrapped in absorbent cushioning, sealed in plastic again, and packaged in cardboard tubes. The UO_2 pellets are packaged in a snap-cap glass bottle with a low-lint tissue for cushioning to prevent chipping. The glass bottles are sealed in plastic, and packaged in a cardboard tube. CRM 113-B UF_6 material is currently packaged in 2S cylinders.

Reference Value Uncertainties

All isotopic abundance reference values were obtained using thermal ionization mass spectrometry (TIMS). NBL CRMs of approximately equivalent enrichments were used to determine the mass bias correction. The 95% C.L.s of the reference values of the uranyl nitrate solution test materials were determined without propagating the uncertainty on the $^{235}U/^{238}U$ ratio of the CRMs. The assigned C.L.s, which include only analytical variation, are 0.02% for the 4% solution, and less than 0.01% for the 50% and 90% solutions.

Following International Standards Organization guidelines, the C.L.s for all of the isotopic abundance values for the UO_2 pellet (CRM 125-A) were recalculated in Fiscal Year 1997 including the uncertainty on the $^{235}U/^{238}U$ ratio of the CRM used to determine the mass bias correction. The updated 95% C.L. for the ^{235}U enrichment value of the pellet is 0.07%.

The isotopic abundances of CRM 113-B UF_6 were certified using thermal ionization mass spectrometry. The $^{235}U/^{238}U$ ratio was verified by gas mass spectrometry. As with CRM 125-A

above, the uncertainty was included in the 95% C.L. assigned to the ^{235}U enrichment value. The 95% C.L. is 0.053% of the value.

Besides being characterized for isotopic abundances, the 90% enriched solutions and the 50% enriched solution were also characterized for elemental concentration by the NBL-modified Davies and Gray titration. This enables these solutions to be used as test materials for the analysis of uranium concentration by isotope dilution mass spectrometry, as well as for uranium enrichment. As noted in the Enriched Uranium Dioxide Pellet section, the 4% enriched pellet was also certified for elemental concentration by the NBL high-precision titration.

Evaluation of Performance

Laboratories A, F, J, and T, used TIMS for their analytical method.

For display, results from the 50% and the 90% enriched solutions were combined on Figures 9 and 10, as these results were generally comparable. The 2000 International Target Values for the analysis of highly-enriched uranium (0.05% for both precision and bias) are displayed on the comparative graphs. All participating facilities are well within the limits for precision and bias for the high-enriched material. Table 7 presents the numerical values of the plotted data.

Table 7
Interlaboratory Performance Summary
^{235}U Enrichment - HEU

Method	Lab code	Mean	Standard deviation	N
TIMS	A	-0.003	0.023	16
TIMS	F	0.002	0.003	18
TIMS	J	0.001	0.007	18

The 2000 International Target Values for the analysis of low-enriched material by TIMS are 0.1% for both precision and bias. These ITVs are displayed on the LEU comparative graphs (Figures 11 and 12). All participating facilities are within the limits for bias and precision. Table 8 presents the numerical values of the plotted data.

Although statistical evaluation was performed only on the ^{235}U abundance, the test materials are characterized for all isotopic abundances. Reports returned by the NBL to the facility include calculations of %RDs for the other isotopic abundances, for diagnostic purposes.

Table 8
Interlaboratory Performance Summary
^{235}U Enrichment - LEU

Method	Lab code	Mean	Standard deviation	N
TIMS	A	-0.029	0.039	4
TIMS	F	-0.020	0.025	49
TIMS	T	0.060	0.028	16

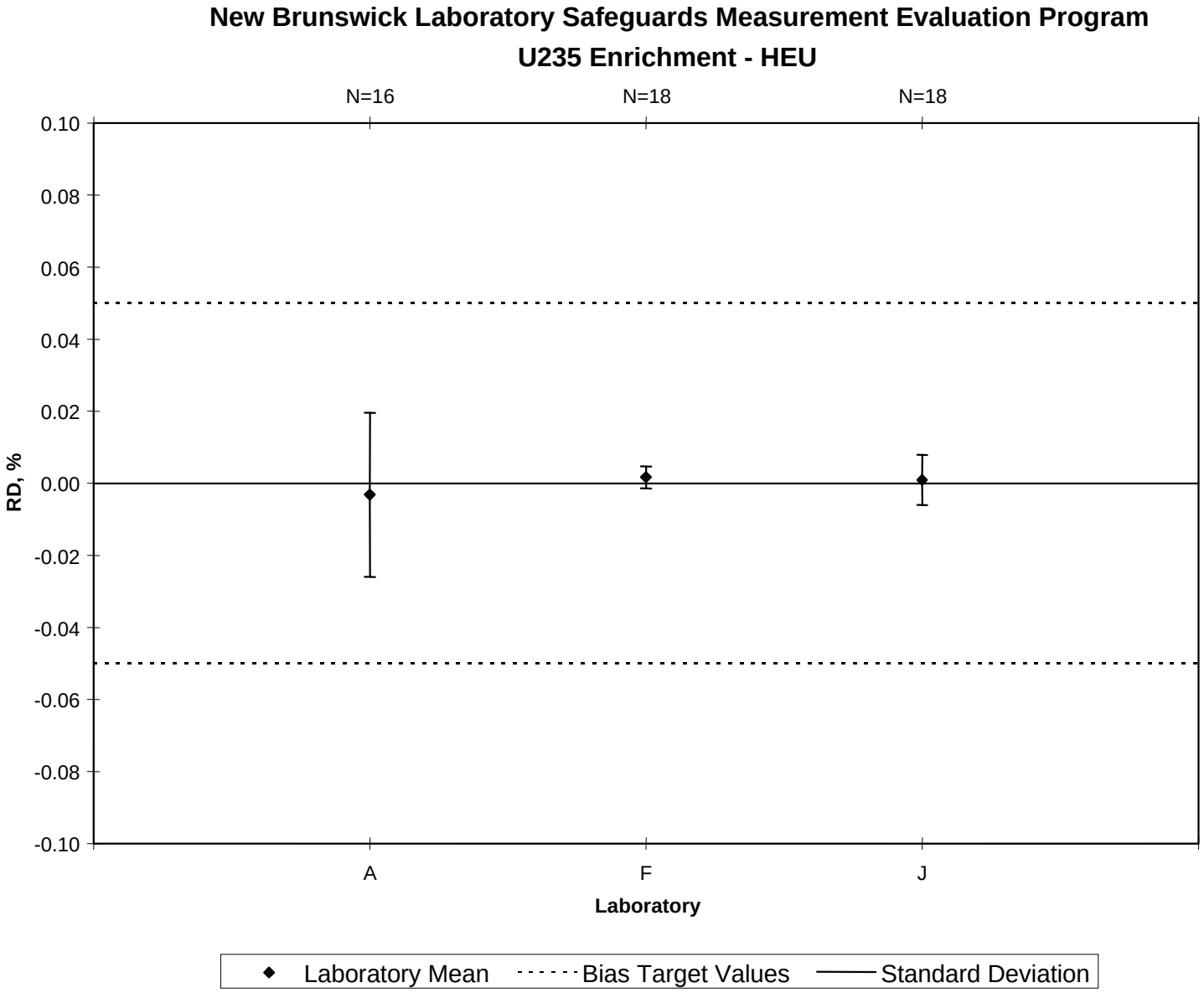
New Brunswick Laboratory Safeguards Measurement Evaluation Program
U235 Enrichment - HEU
N=16
N=18
N=18
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
RD, %
A
F
J
Laboratory
Laboratory Mean
Bias Target Values
Standard Deviation

Figure 9

New Brunswick Laboratory Safeguards Measurement Evaluation Program
U235 Enrichment - HEU

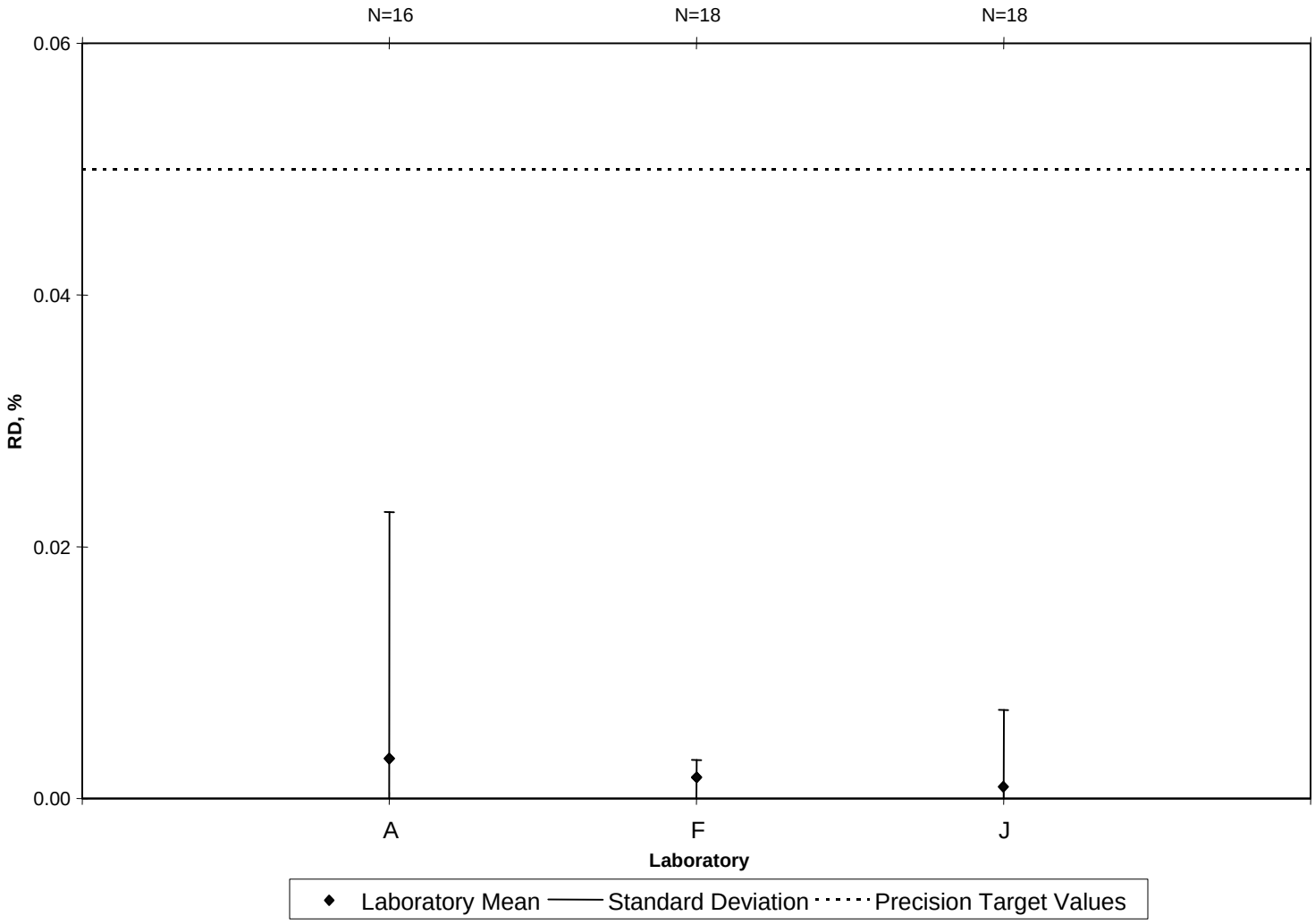

Figure 10

New Brunswick Laboratory Safeguards Measurement Evaluation Program

U235 Enrichment - LEU

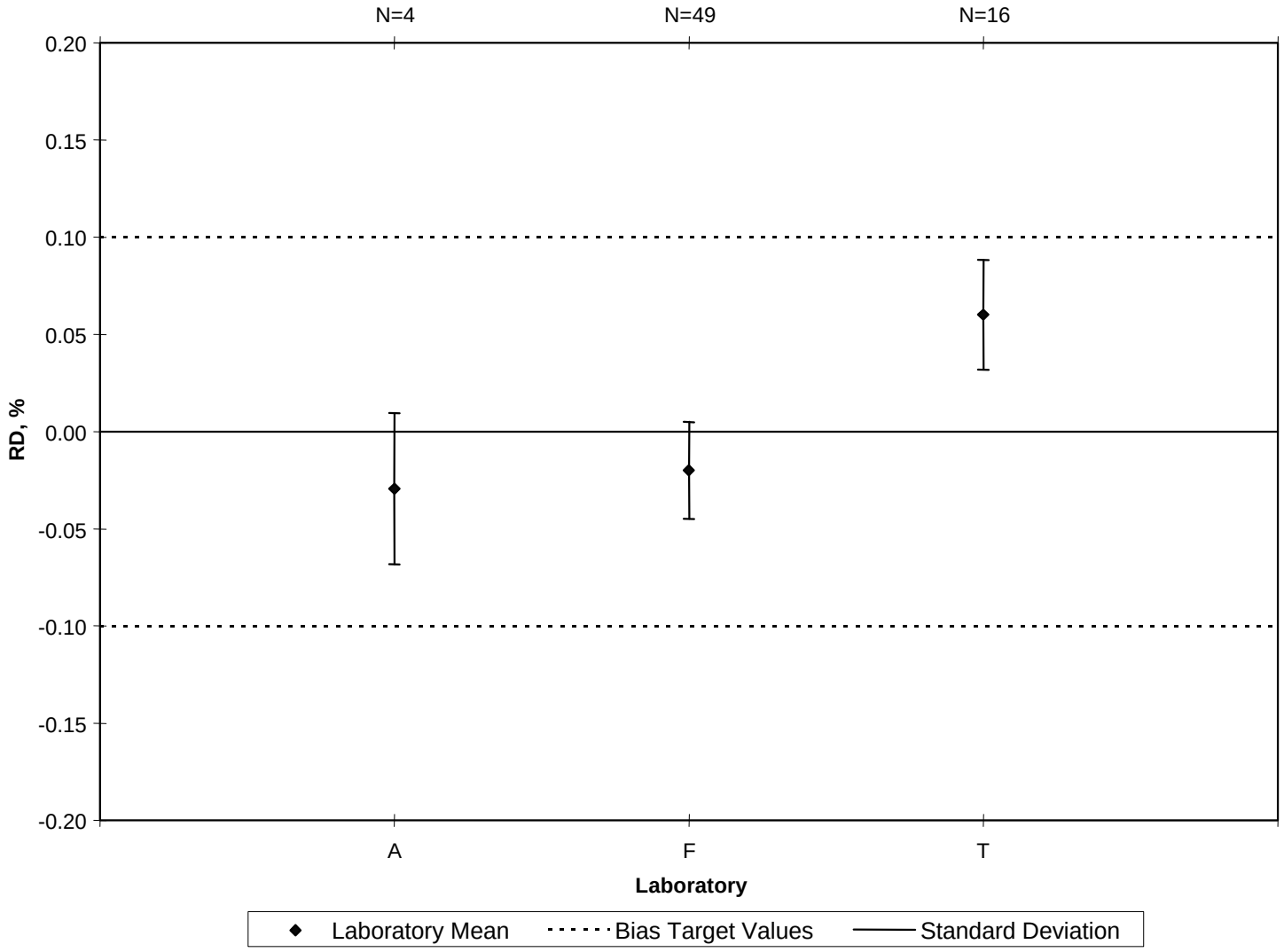

Figure 11

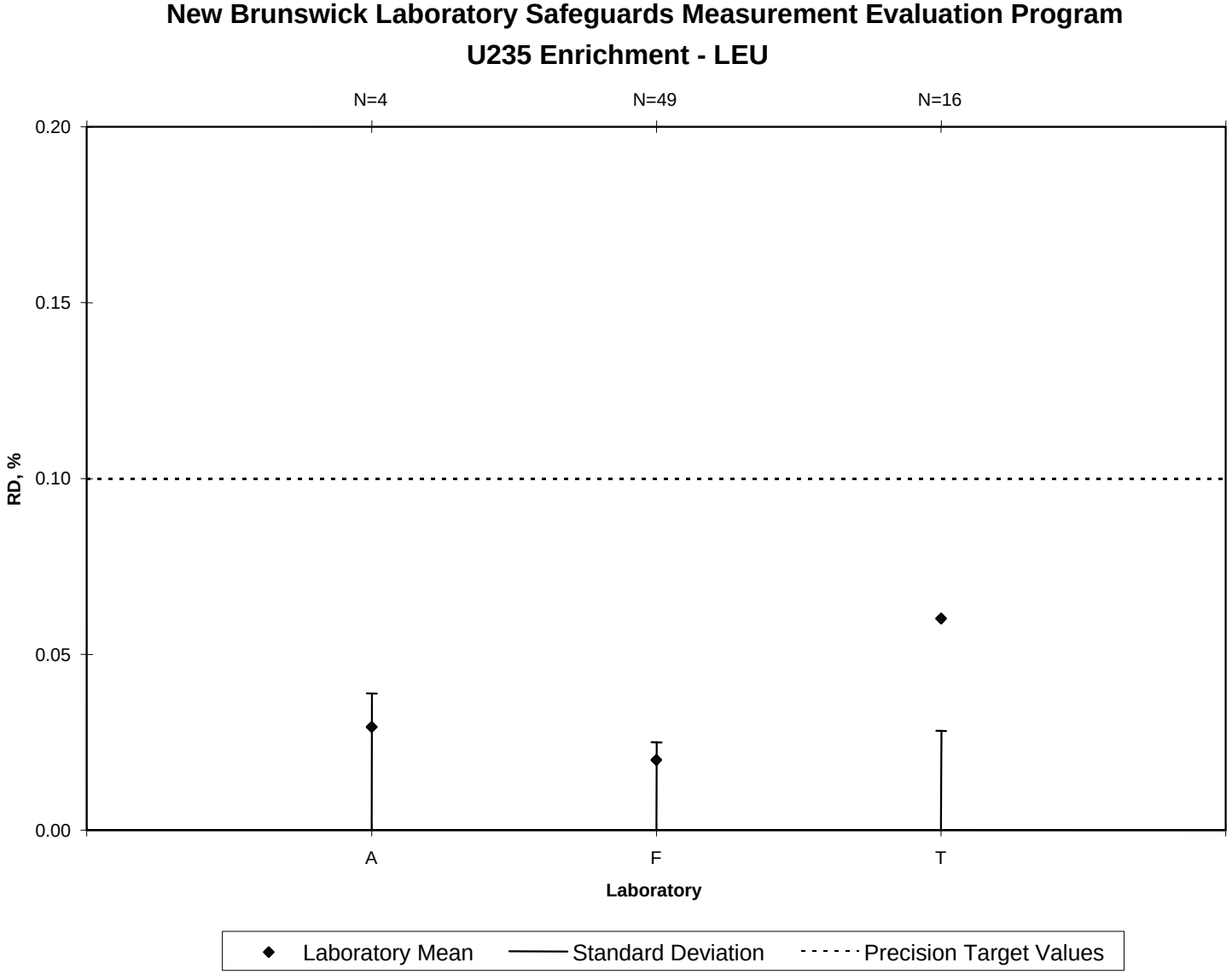
New Brunswick Laboratory Safeguards Measurement Evaluation Program
U235 Enrichment - LEU
N=4
N=49
N=16
0.20
0.15
0.10
0.05
0.00
RD, %
A
F
T
Laboratory
Laboratory Mean
Standard Deviation
Precision Target Values

Figure 12

PLUTONIUM ASSAY AND ISOTOPIC ABUNDANCES

The test materials distributed and analyzed for assay of plutonium elemental composition were prepared from CRM 126, Plutonium Metal (Plutonium Assay and Isotopic Standard) and CRM 122, Plutonium Oxide in Powder Form (Plutonium Assay and Isotopic Standard). The CRMs were dissolved, diluted to an appropriate concentration with 8 *M* HNO_3 and aliquants of approximately 20 or 40 µg were placed in glass bottles and fumed to dryness as a sulfate. These samples were specifically intended to be analyzed by isotope dilution mass spectrometry (IDMS).

The test materials for isotopic analysis were prepared from CRM 122 oxide, and CRM 136 and 137, Plutonium Isotopic Standards in the form of plutonium sulfate tetrahydrate. The CRMs were dissolved in 8 *M* HNO_3 and aliquants of approximately 1 mg were placed in glass bottles and fumed to dryness as the sulfate. No purification was performed on the master solutions; due to the age of the CRMs, americium ingrowth is very significant.

Preparation and Packaging for Shipment

The size of the glass bottles chosen to contain the samples for assay analysis was selected to enable the addition of the participant's IDMS spike and the performance of oxidation-reduction reactions for isotopic equilibration directly within the sample container. The glass bottles containing either the assay or the isotopic samples were heat-sealed in plastic twice, and packaged in secondary containers (produce cans) before shipping.

Reference Value Uncertainties

For CRM 126, the uncertainty on the plutonium concentration is approximately 0.02%, expressed as the 95% confidence interval of the mean. For CRM 122, the uncertainty on the plutonium concentration is approximately 0.04%, expressed as the 95% confidence interval of the mean. For the isotopic materials, the abundances of ^{238}Pu range from approximately 0.05% to 0.25%; the ^{239}Pu abundances from 78% to 88%; the ^{240}Pu abundances from 12% to 19%; the ^{241}Pu abundances from 0.05% to 1.3%, and ^{242}Pu abundances from 0.2% to 1.2%. The uncertainties are stated on the CRM certificates; for CRM 122, all uncertainties are expressed as the 95% confidence interval of the mean; for CRMs 136 and 137, all uncertainties are expressed as the 95% confidence interval of a single determination (approximately two sigma).

Evaluation of Performance

As with the uranium materials, all results are reported as percent relative differences. Facilities used IDMS to determine plutonium elemental mass and TIMS to determine isotopic abundances. Only data for the abundances of ^{239}Pu and ^{240}Pu are presented graphically in this report since they are the plutonium isotopes of major concern. Data for ^{238}Pu, ^{241}Pu, and ^{242}Pu were analyzed in individual reports and included in the data listing at the end of this report.

Pu Mass by IDMS

The target values for Pu elemental amount by IDMS are 0.15% for precision and 0.1% for bias. As shown in Figure 13, laboratory F was not within the target values for bias. Laboratory F was within the target value for precision, as shown in Figure 14. Table 9 presents the numerical values of the plotted data.

Table 9
Interlaboratory Performance Summary
Pu sulfate –Pu Mass

Method	Lab code	Mean	Standard deviation	N
IDMS	F	0.150	0.050	4

^{239}Pu Abundance

Because of the small number of submitted results, results from high- and low-burnup plutonium samples have been combined. However, the 2000 ITVs are different for the two burnup levels. For ^{239}Pu, the target values displayed in Figures 15 and 16 correspond to those for low-burnup plutonium (0.01% for both precision and bias), which are more limiting than the ITVs for ^{239}Pu in high-burnup material (0.06% for precision and 0.04% for bias). As can be seen in Figures 15 and 16, all laboratories were within the low-burnup target values for both bias and precision. Table 10 presents the numerical values of the plotted data.

Table 10
Interlaboratory Performance Summary
^{239}Pu Abundance

Method	Lab code	Mean	Standard deviation	N
TIMS	F	0.007	0.005	12
TIMS	T	0.005	0.006	16

^{240}Pu Abundance

Because of the small number of submitted results, results from high- and low-burnup plutonium samples have been combined. The 2000 ITVs are different for the two burnup levels. For ^{240}Pu, the target values displayed in Figures 20 and 21 correspond to those for high-burnup plutonium (0.12% for precision and 0.07% for bias), which are more limiting than the ITVs for ^{240}Pu in low-burnup material (0.15% for precision and 0.10% for bias). As can be seen in Figures 20 and 21, all laboratories were within the high-burnup target values for both bias and precision. Table 11 presents the numerical values of the plotted data.

Table 11
Interlaboratory Performance Summary
^{240}Pu Abundance

Method	Lab code	Mean	Standard deviation	N
TIMS	F	-0.026	0.019	12
TIMS	T	-0.029	0.027	16

New Brunswick Laboratory Safeguards Measurement Evaluation Program
Pu Sulfate - Percent Pu

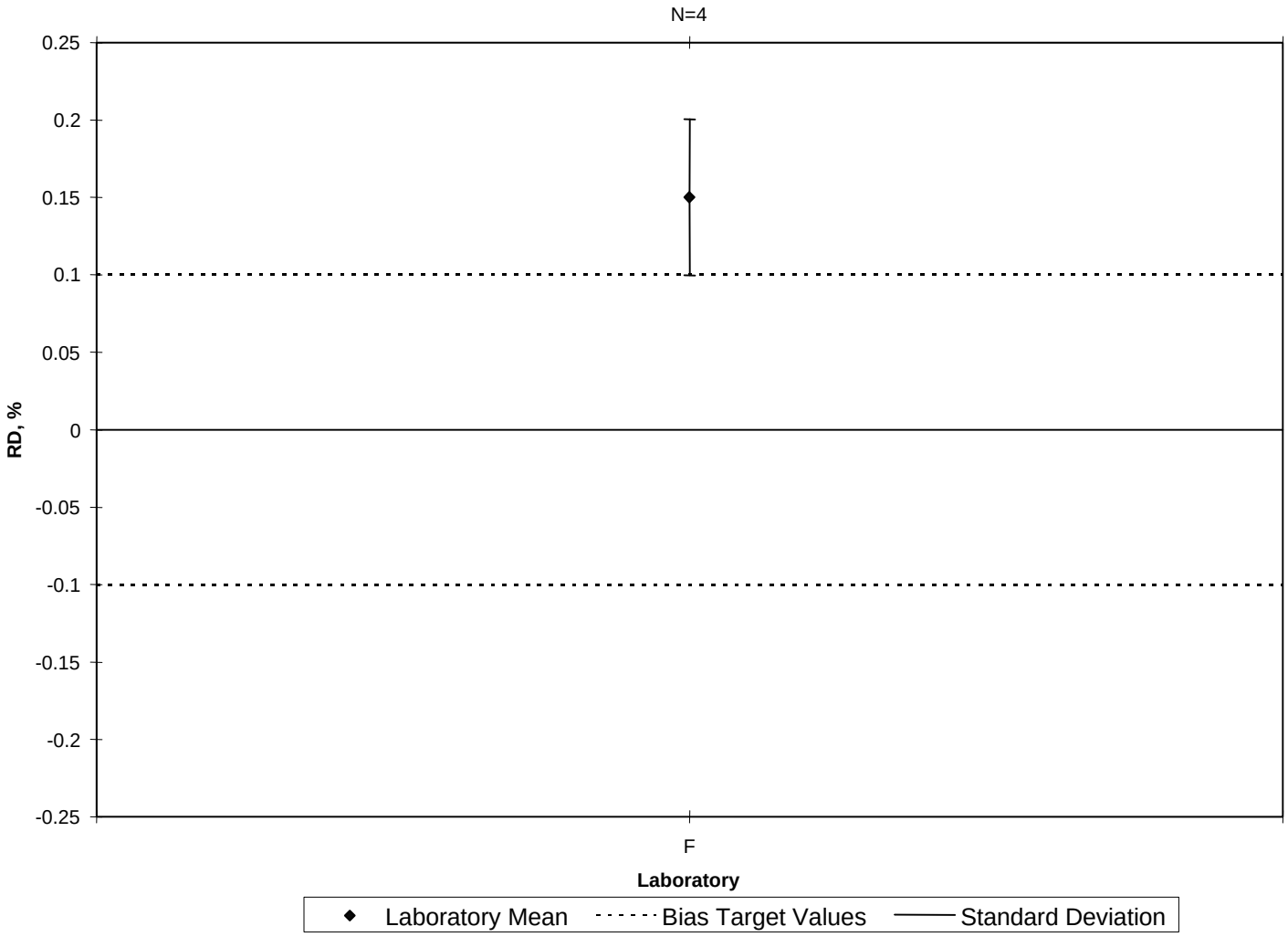

Figure 13

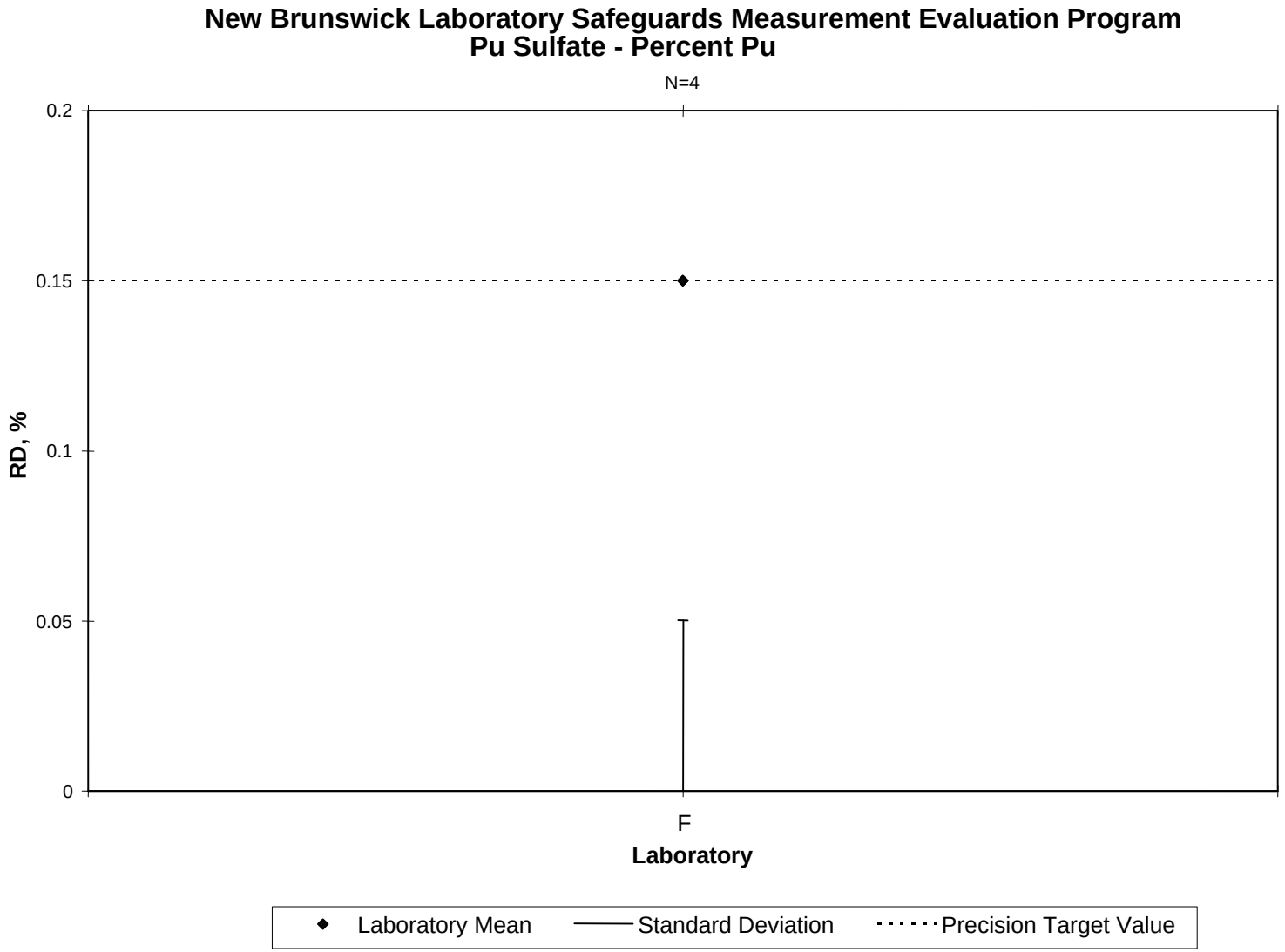
New Brunswick Laboratory Safeguards Measurement Evaluation Program
Pu Sulfate - Percent Pu
N=4
0.2
0.15
0.1
0.05
0
RD, %
F
Laboratory
Laboratory Mean
Standard Deviation
Precision Target Value

Figure 14

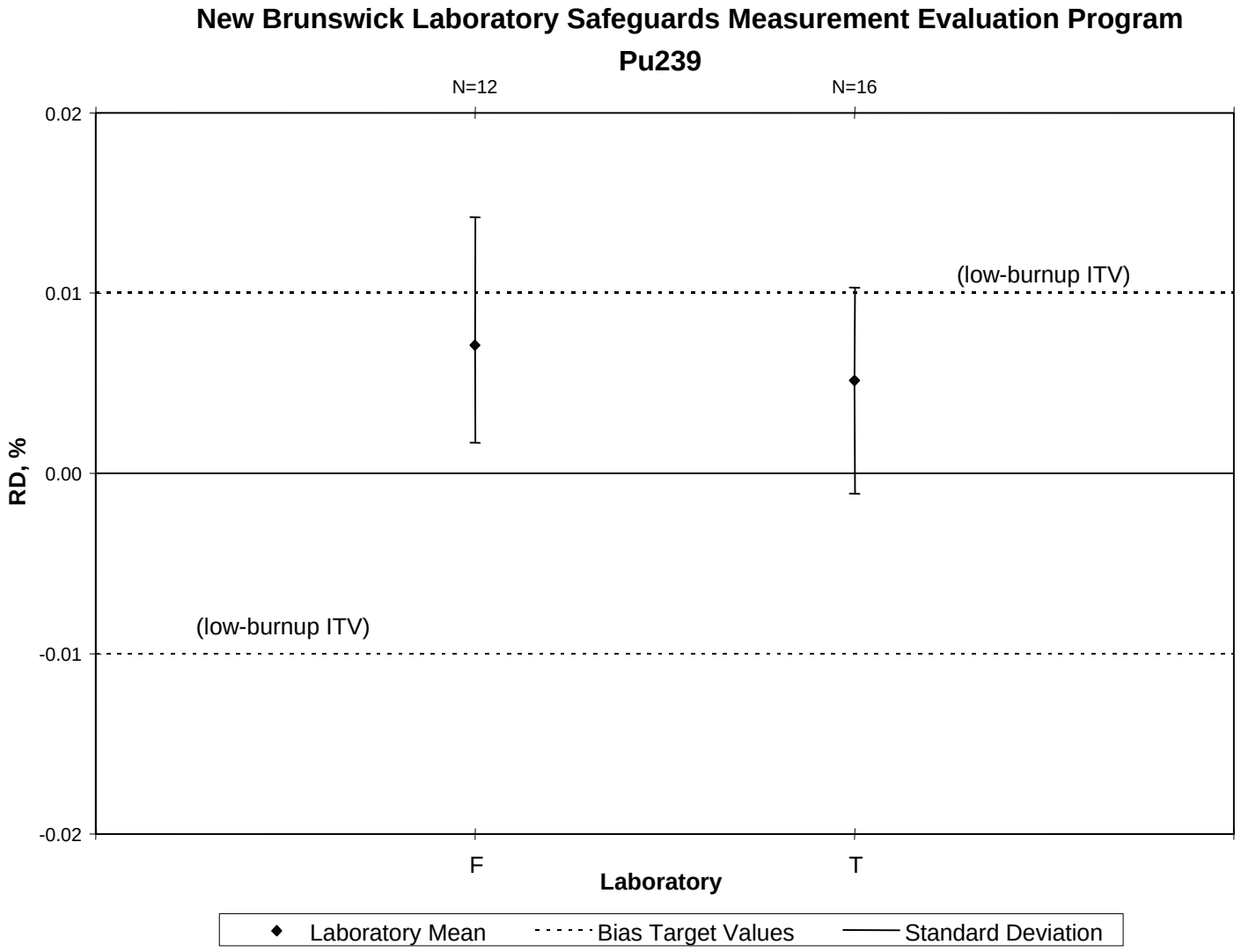
New Brunswick Laboratory Safeguards Measurement Evaluation Program
Pu239
N=12
N=16
0.02
0.01
0.00
-0.01
-0.02
RD, %
(low-burnup ITV)
(low-burnup ITV)
F
T
Laboratory
Laboratory Mean
Bias Target Values
Standard Deviation

Figure 15

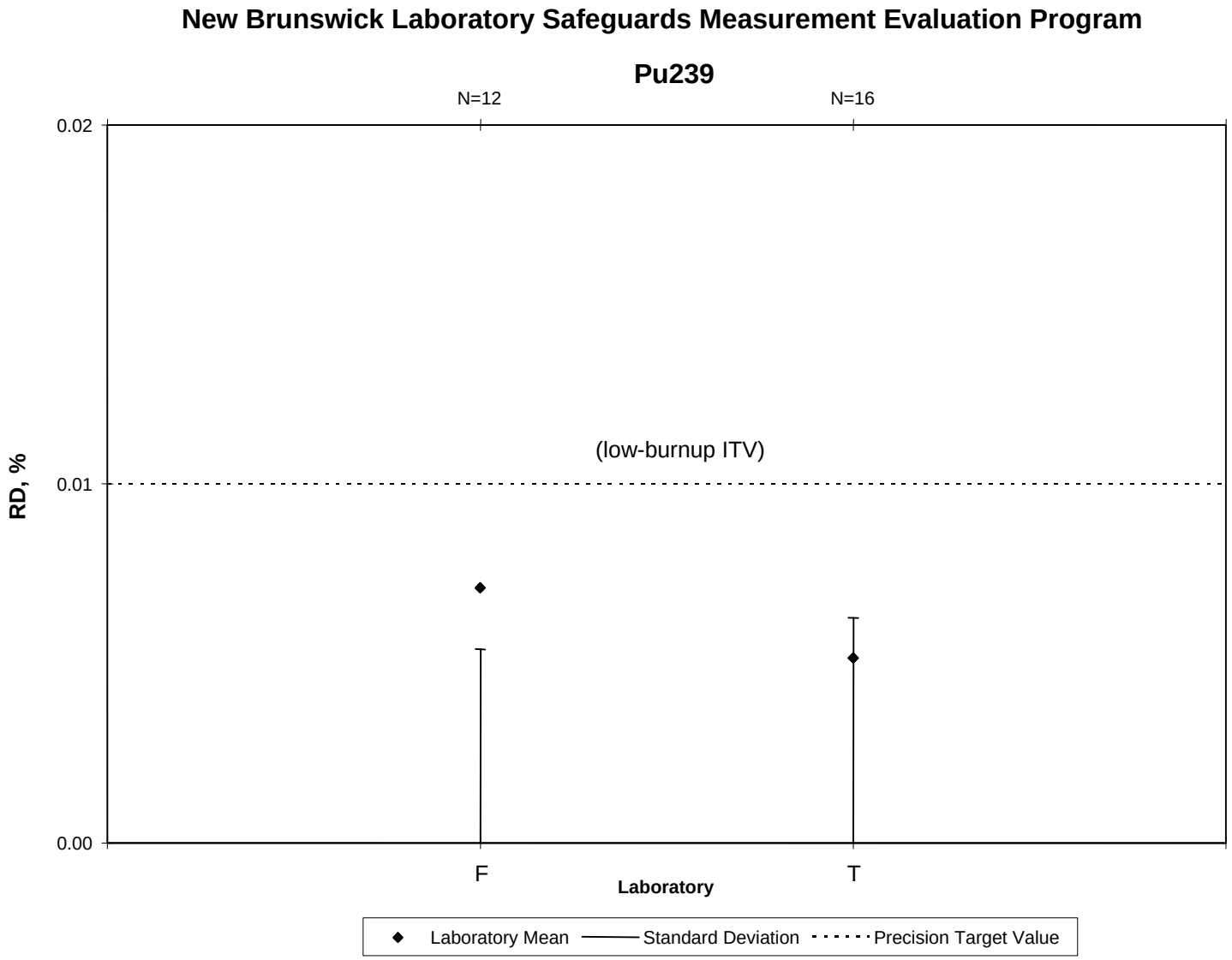
New Brunswick Laboratory Safeguards Measurement Evaluation Program
Pu239
N=12
N=16
0.02
0.01
0.00
RD, %
(low-burnup ITV)
F
T
Laboratory
Laboratory Mean
Standard Deviation
Precision Target Value

Figure 16

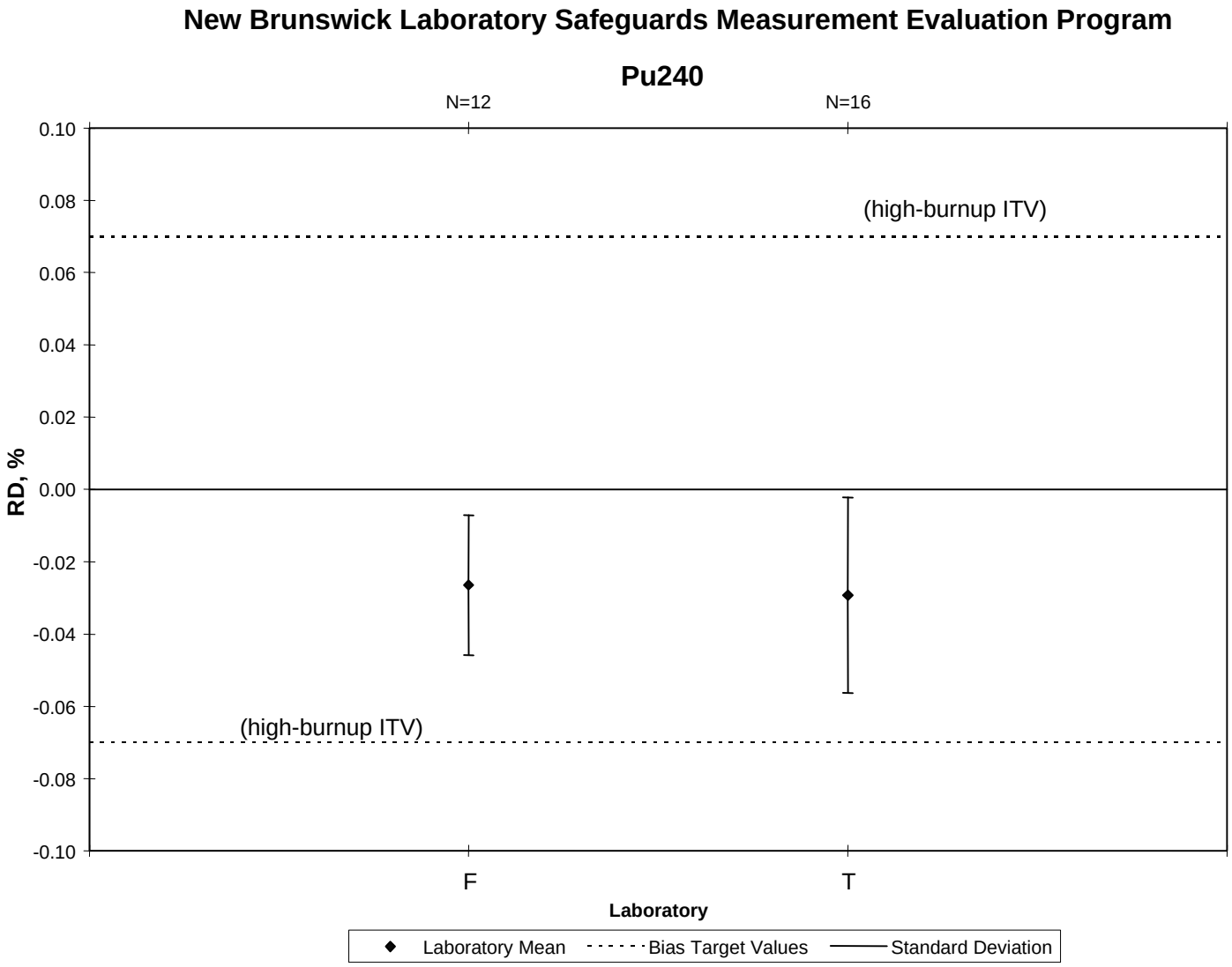
New Brunswick Laboratory Safeguards Measurement Evaluation Program
Pu240
N=12
N=16
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
RD, %
(high-burnup ITV)
(high-burnup ITV)
F
T
Laboratory
Laboratory Mean
Bias Target Values
Standard Deviation

Figure 17

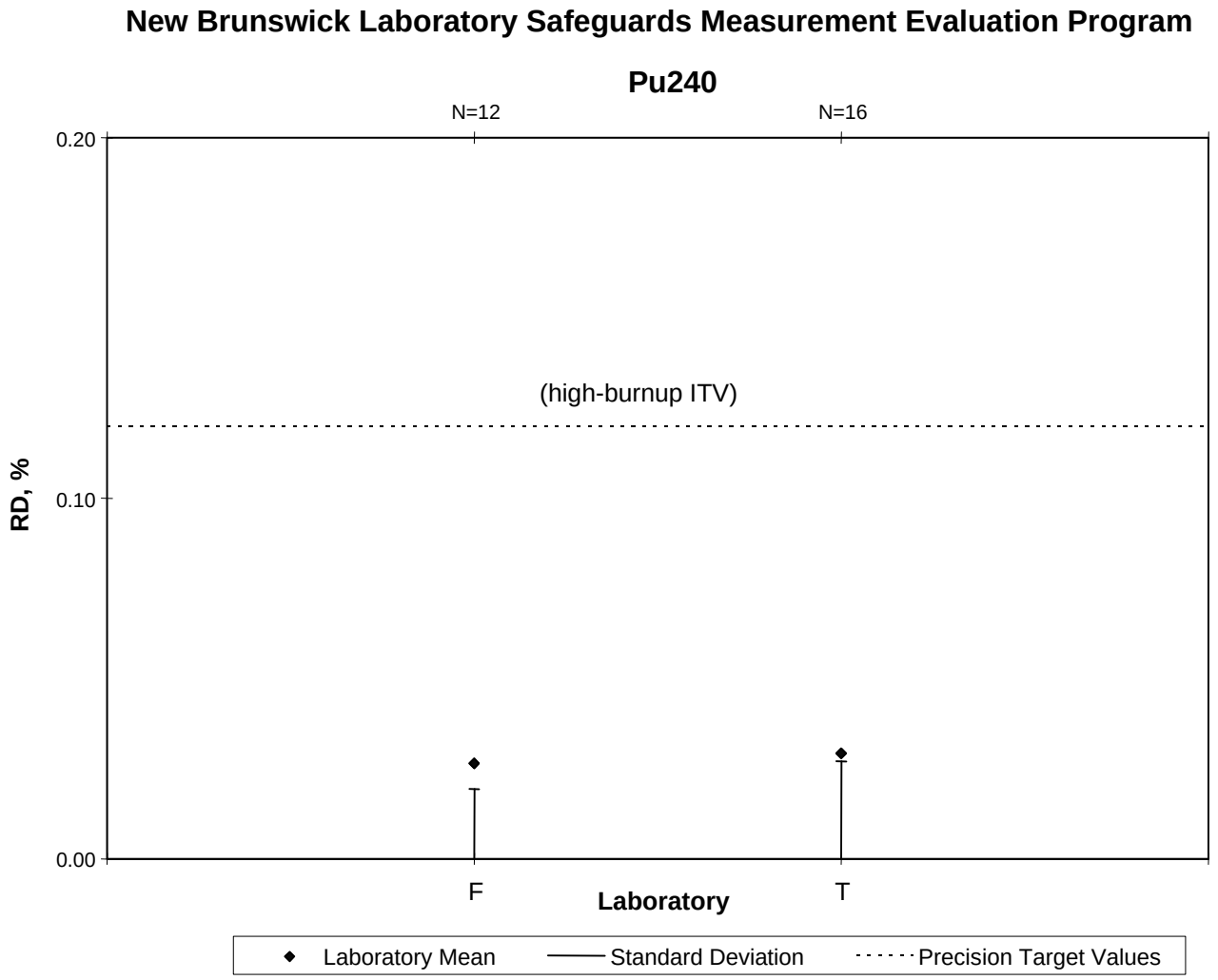
New Brunswick Laboratory Safeguards Measurement Evaluation Program
Pu240
N=12
N=16
0.20
0.10
0.00
RD, %
(high-burnup ITV)
F
T
Laboratory
Laboratory Mean
Standard Deviation
Precision Target Values

Figure 18

INDIVIDUAL LABORATORY

URANIUM MATERIAL-MEASUREMENT SKELETAL GRAPHS

FISCAL YEARS 2000 - 2002

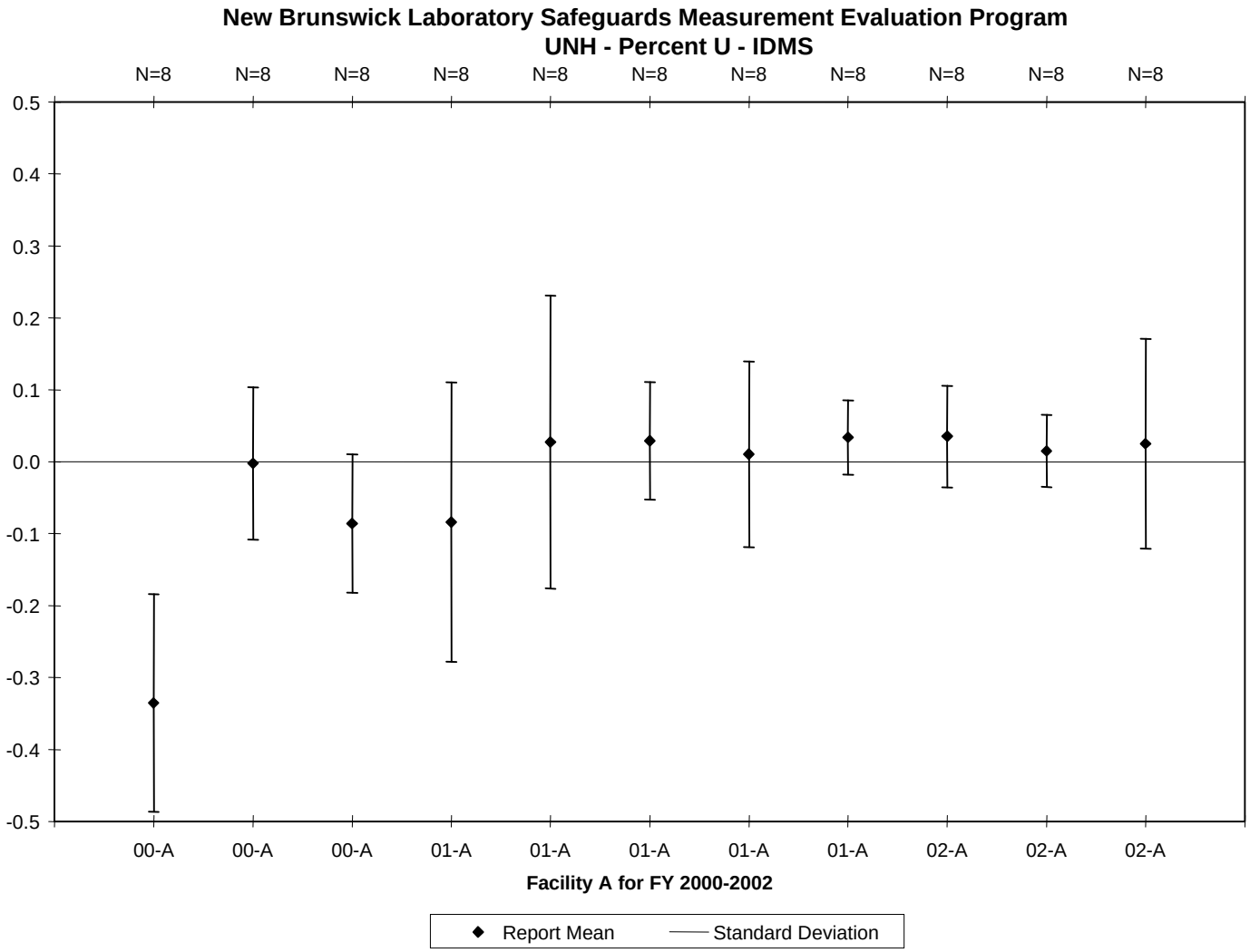
New Brunswick Laboratory Safeguards Measurement Evaluation Program
UNH - Percent U - IDMS
N=8
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
00-A
01-A
02-A
Facility A for FY 2000-2002
Report Mean
Standard Deviation

Figure 19

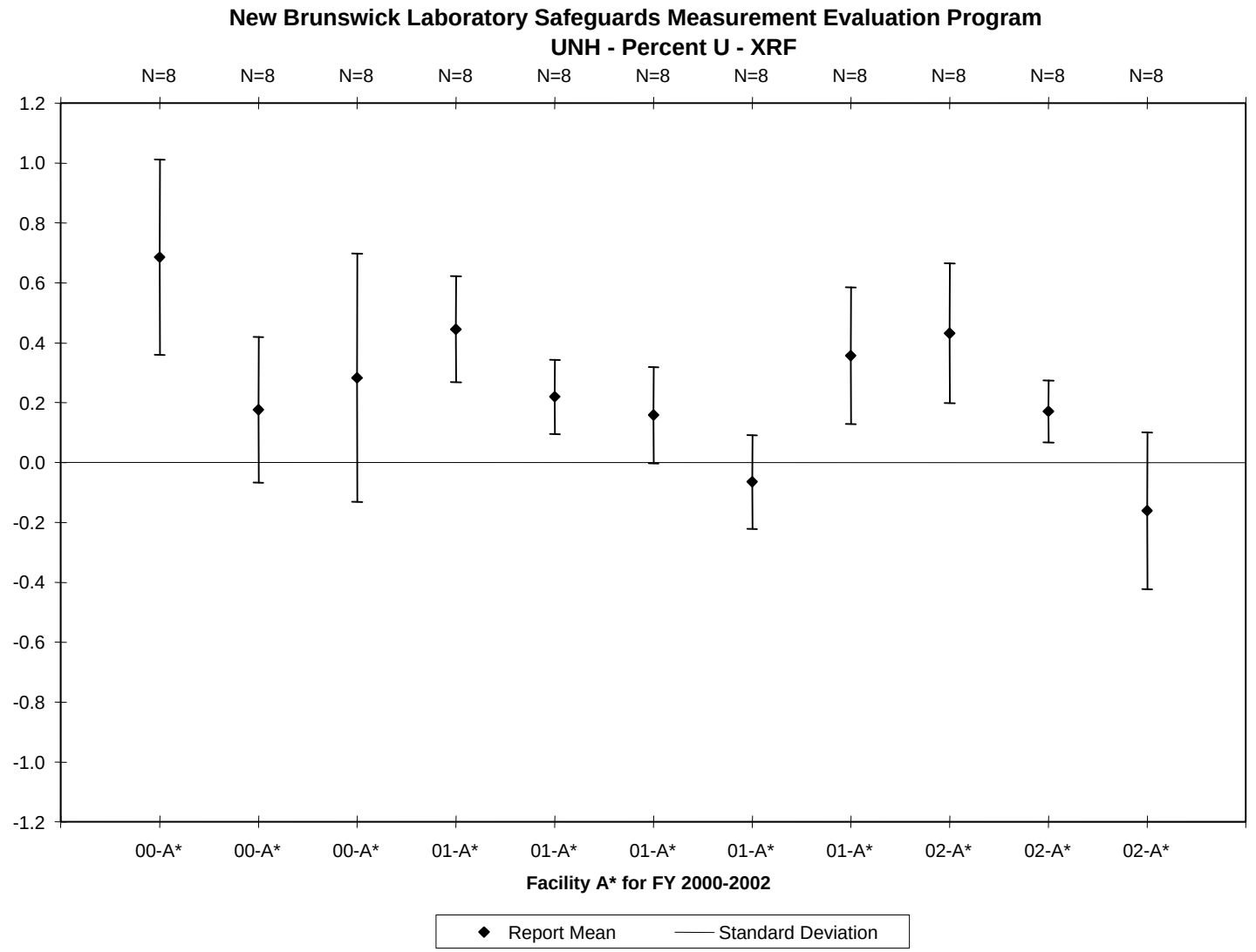
New Brunswick Laboratory Safeguards Measurement Evaluation Program
UNH - Percent U - XRF
N=8
N=8
N=8
N=8
N=8
N=8
N=8
N=8
N=8
N=8
N=8
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
00-A*
00-A*
00-A*
01-A*
01-A*
01-A*
01-A*
01-A*
02-A*
02-A*
02-A*
Facility A* for FY 2000-2002
Report Mean
Standard Deviation

Figure 20

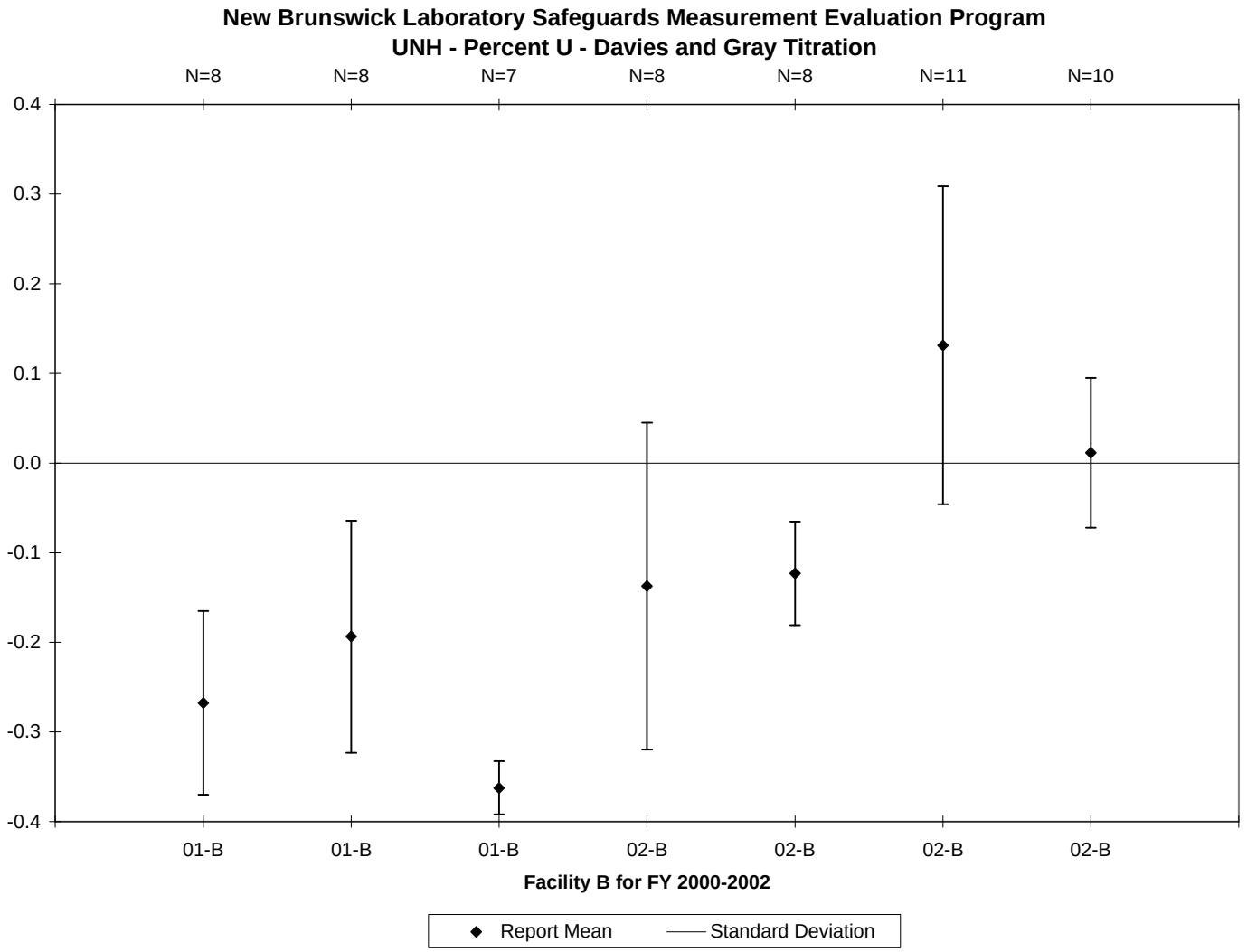
New Brunswick Laboratory Safeguards Measurement Evaluation Program
UNH - Percent U - Davies and Gray Titration
N=8
N=8
N=7
N=8
N=8
N=11
N=10
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
01-B
01-B
01-B
02-B
02-B
02-B
02-B
Facility B for FY 2000-2002
Report Mean
Standard Deviation

Figure 21

New Brunswick Laboratory Safeguards Measurement Evaluation Program

UNH - Percent U

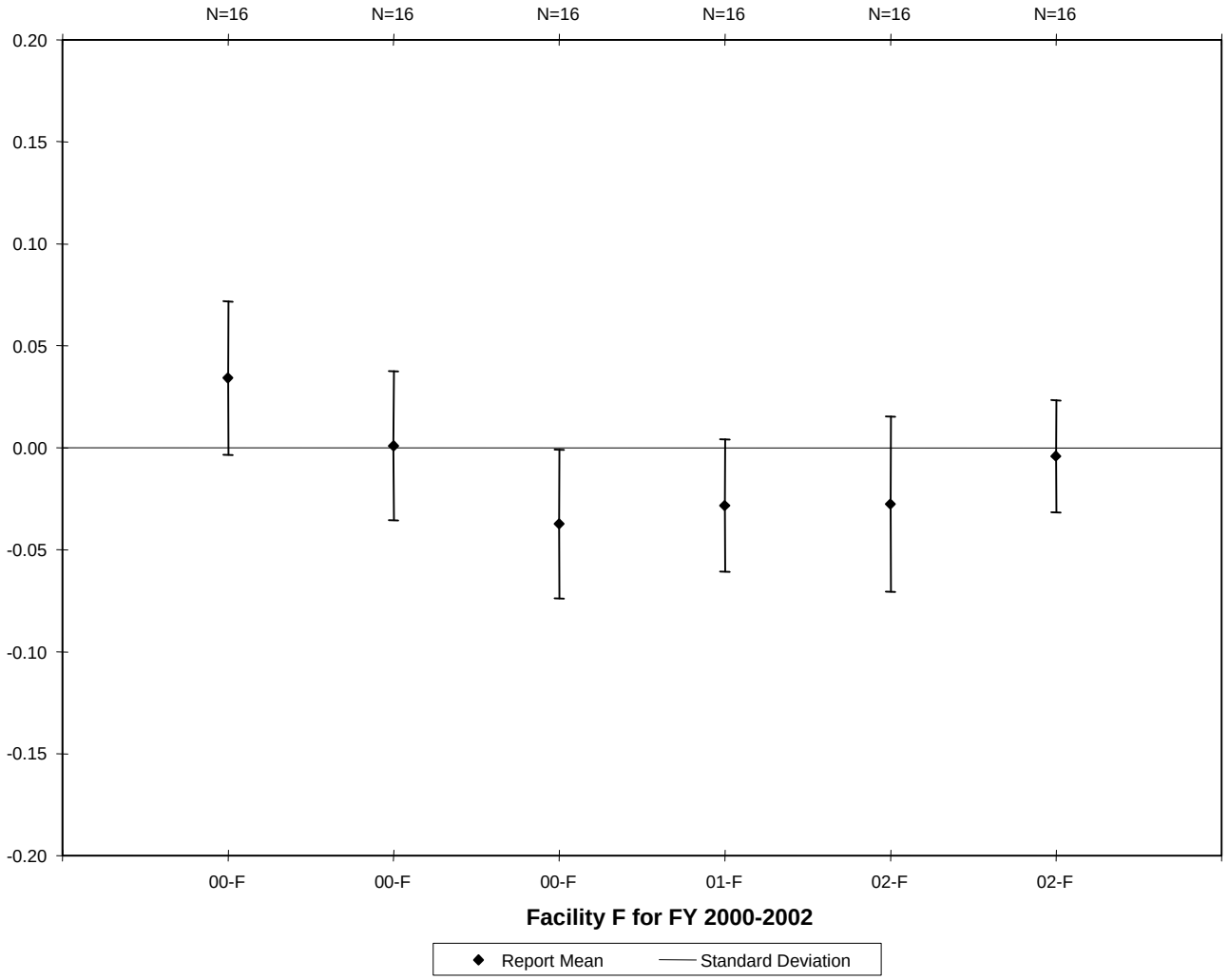

Figure 22

New Brunswick Laboratory Safeguards Measurement Evaluation Program

UNH - Percent U

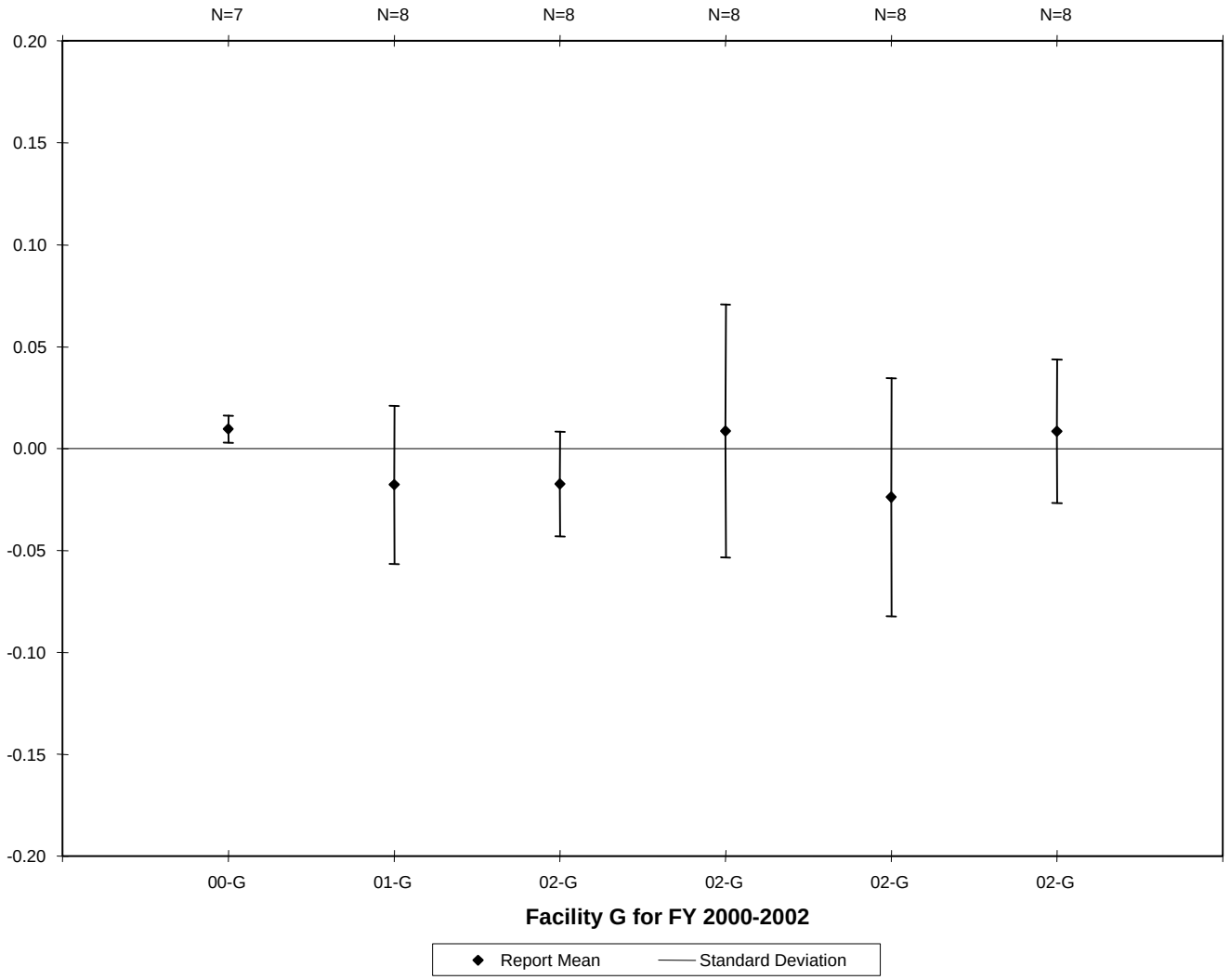

Figure 23

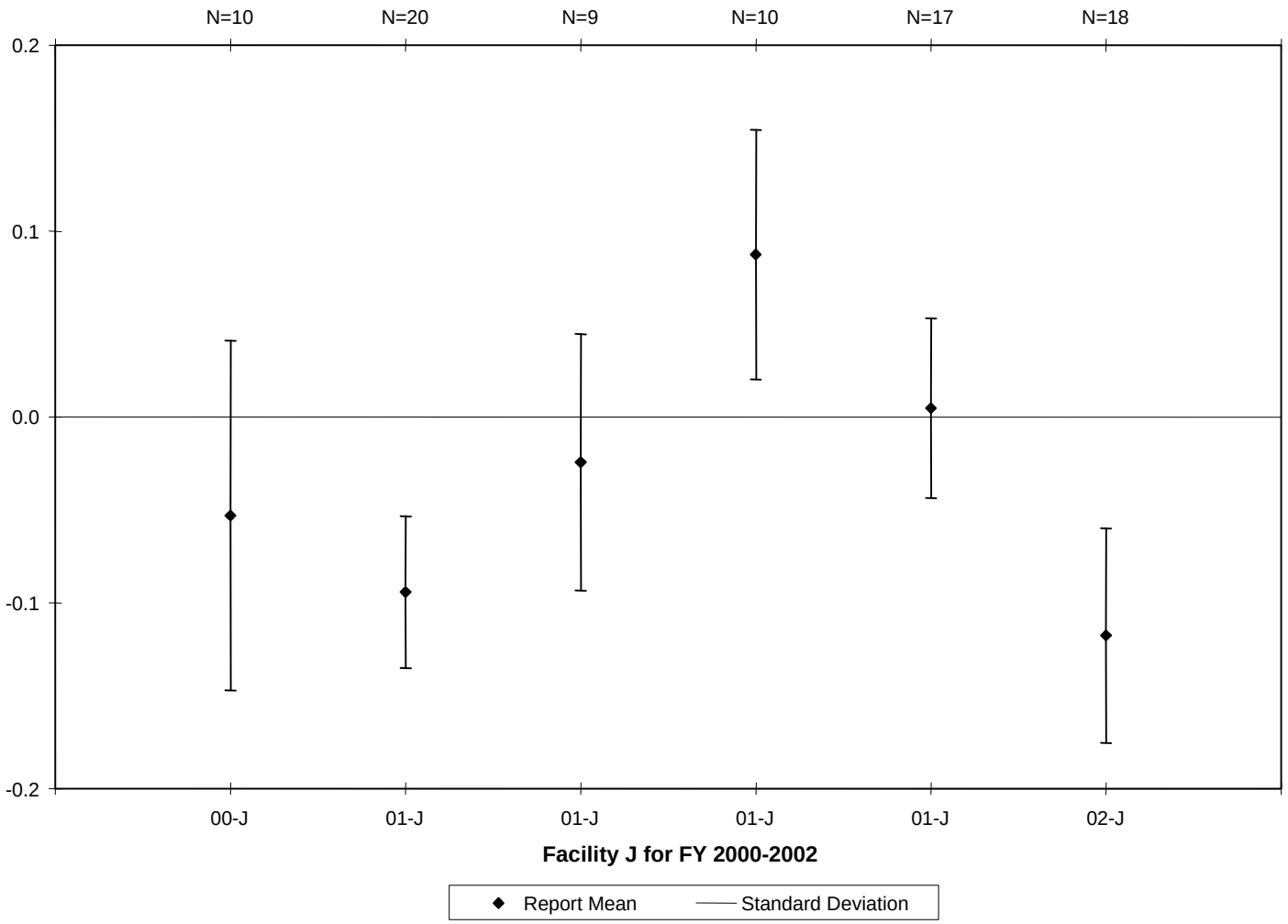
New Brunswick Laboratory Safeguards Measurement Evaluation Program
UNH - Percent U - IDMS
N=10
N=20
N=9
N=10
N=17
N=18
0.2
0.1
0.0
-0.1
-0.2
00-J
01-J
01-J
01-J
01-J
02-J
Facility J for FY 2000-2002
Report Mean
Standard Deviation

Figure 24

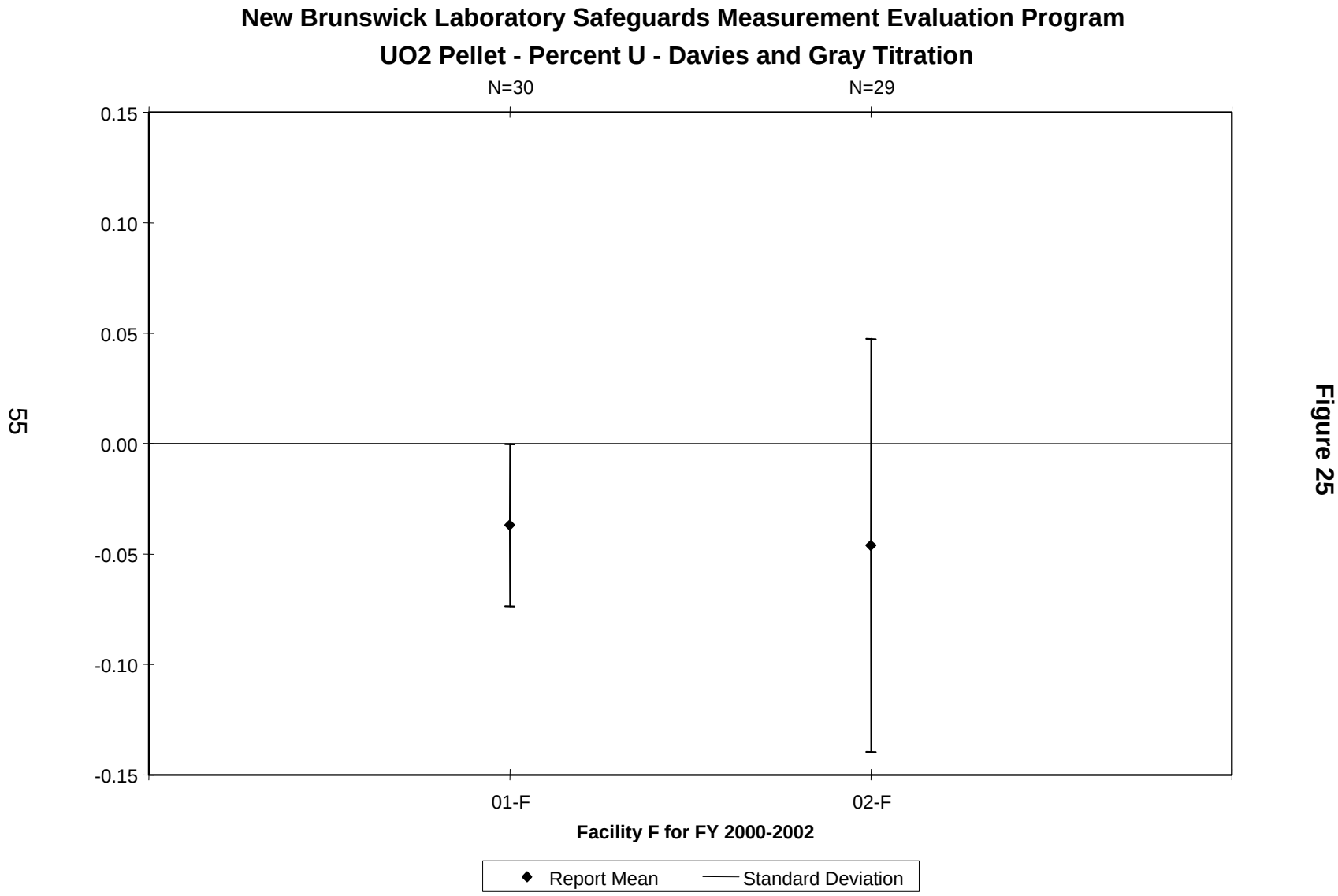
New Brunswick Laboratory Safeguards Measurement Evaluation Program
UO2 Pellet - Percent U - Davies and Gray Titration
N=30
N=29
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
01-F
02-F
Facility F for FY 2000-2002
Report Mean
Standard Deviation

Figure 25

New Brunswick Laboratory Safeguards Measurement Evaluation Program

UO2 Pellet - Percent U by Titration

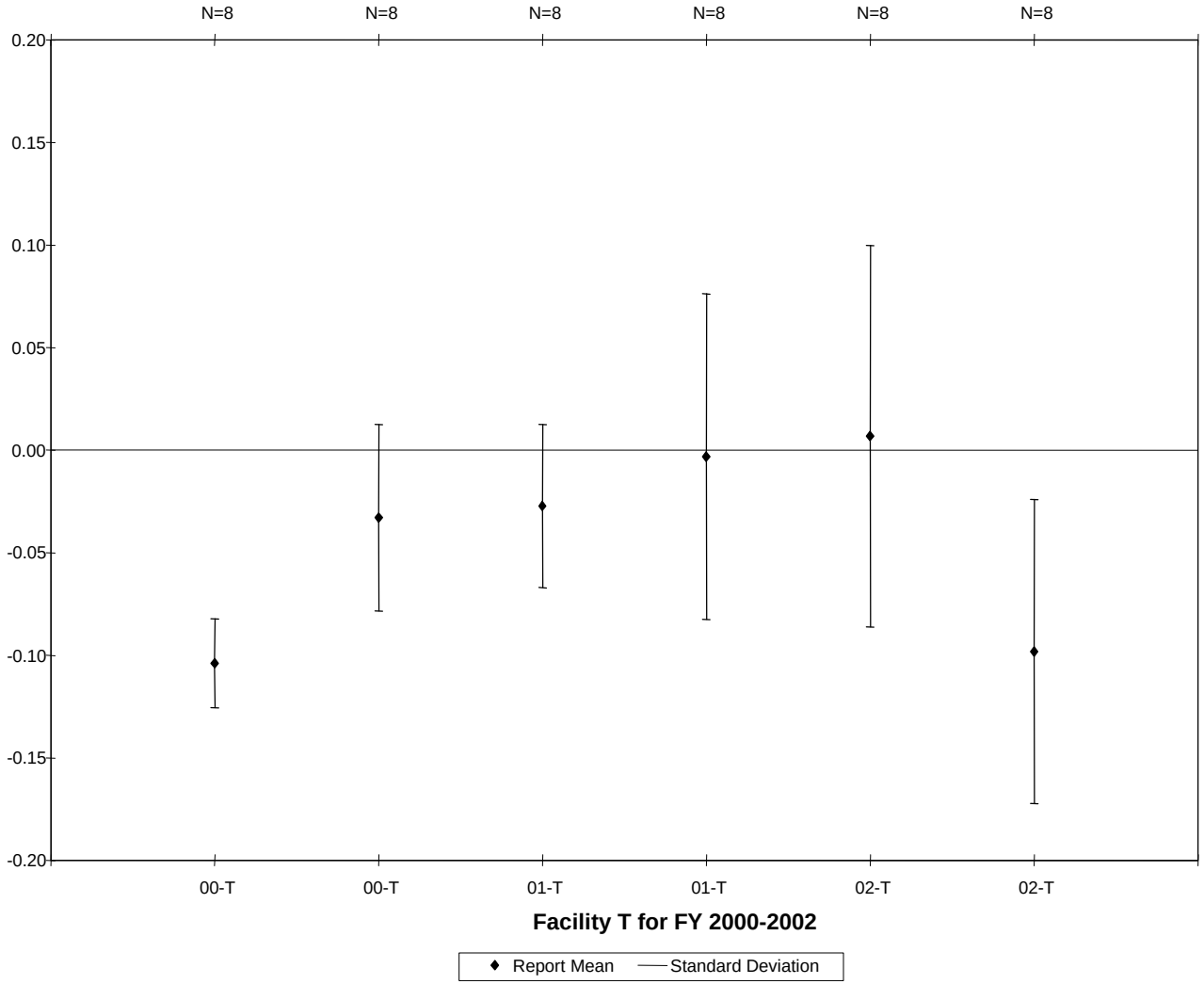

Figure 26

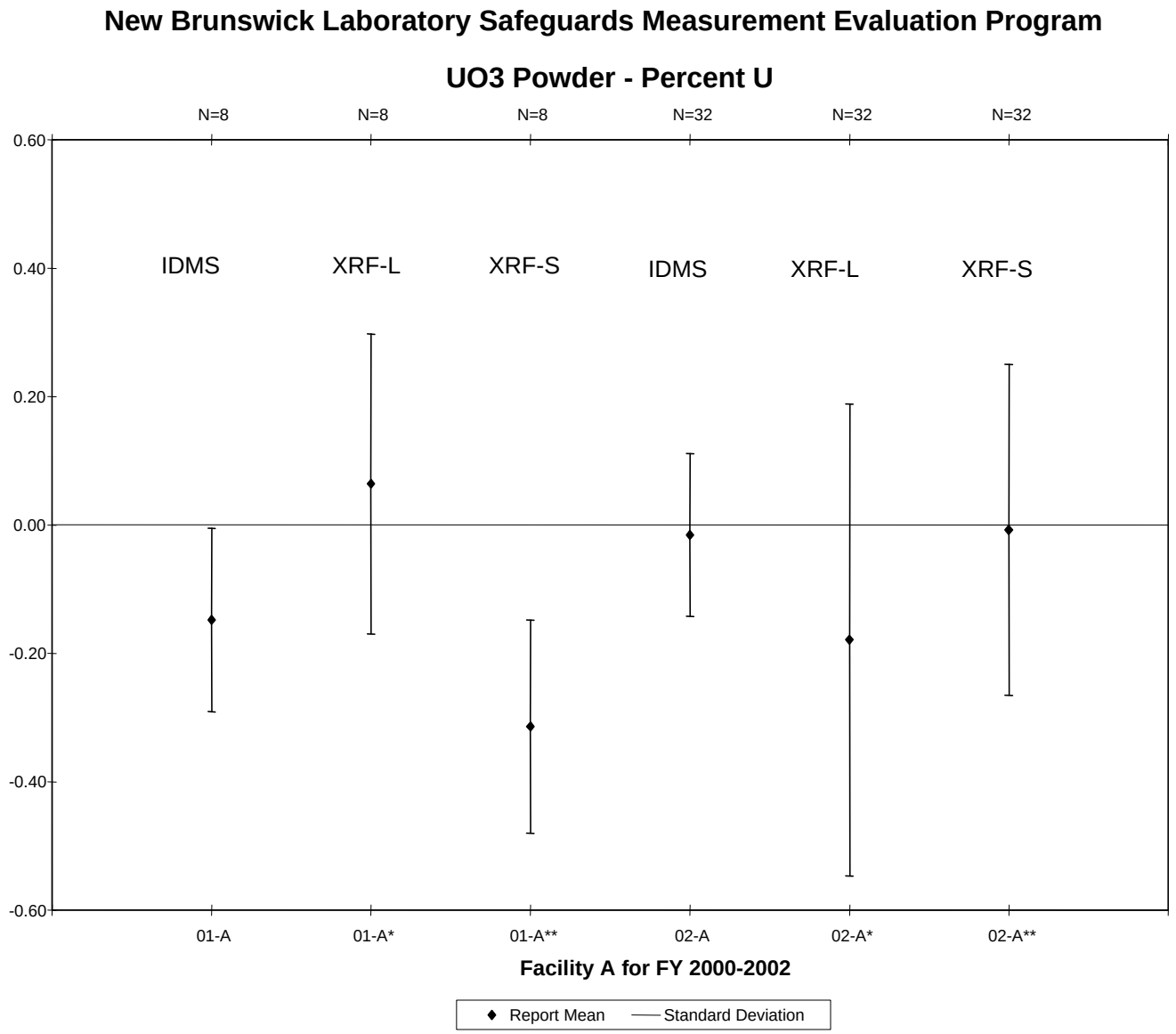
New Brunswick Laboratory Safeguards Measurement Evaluation Program
UO3 Powder - Percent U
N=8
N=8
N=8
N=32
N=32
N=32
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
IDMS
XRF-L
XRF-S
IDMS
XRF-L
XRF-S
01-A
01-A*
01-A**
02-A
02-A*
02-A**
Facility A for FY 2000-2002
Report Mean
Standard Deviation

Figure 27

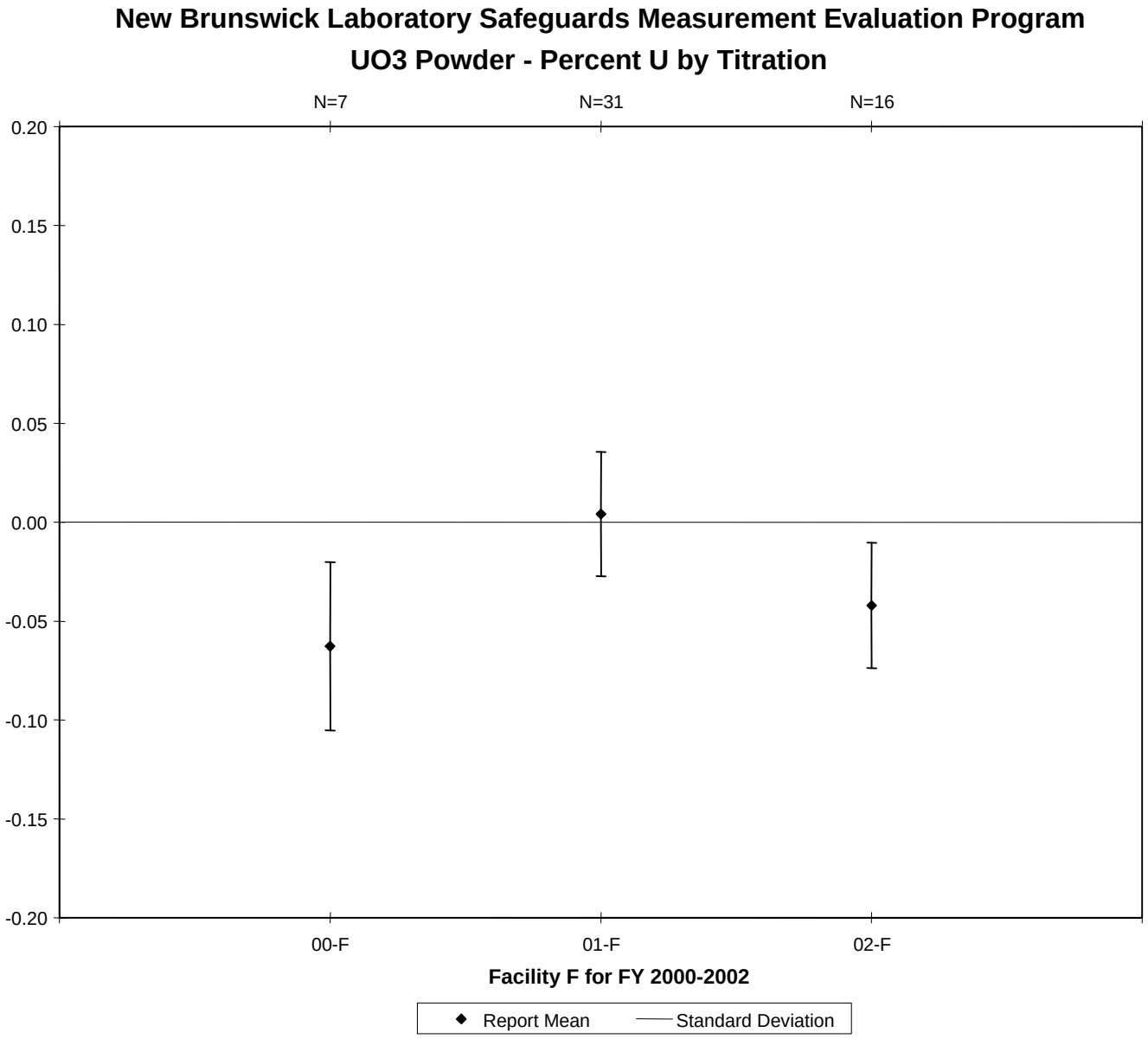
New Brunswick Laboratory Safeguards Measurement Evaluation Program
UO3 Powder - Percent U by Titration
N=7
N=31
N=16
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
00-F
01-F
02-F
Facility F for FY 2000-2002
Report Mean
Standard Deviation

Figure 28

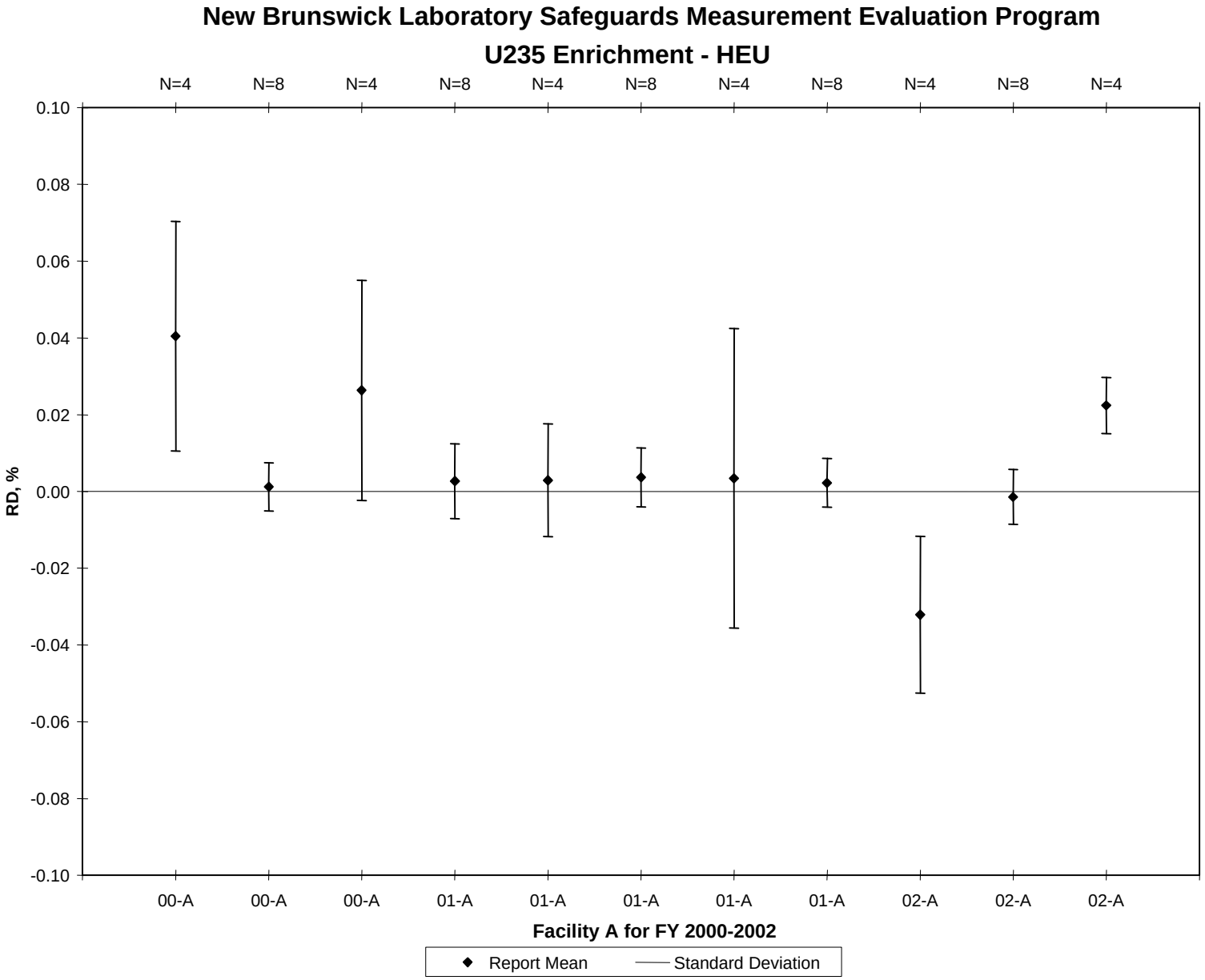
New Brunswick Laboratory Safeguards Measurement Evaluation Program
U235 Enrichment - HEU
N=4
N=8
N=4
N=8
N=4
N=8
N=4
N=8
N=4
N=8
N=4
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
RD, %
00-A
00-A
00-A
01-A
01-A
01-A
01-A
01-A
02-A
02-A
02-A
Facility A for FY 2000-2002
Report Mean
Standard Deviation

Figure 29

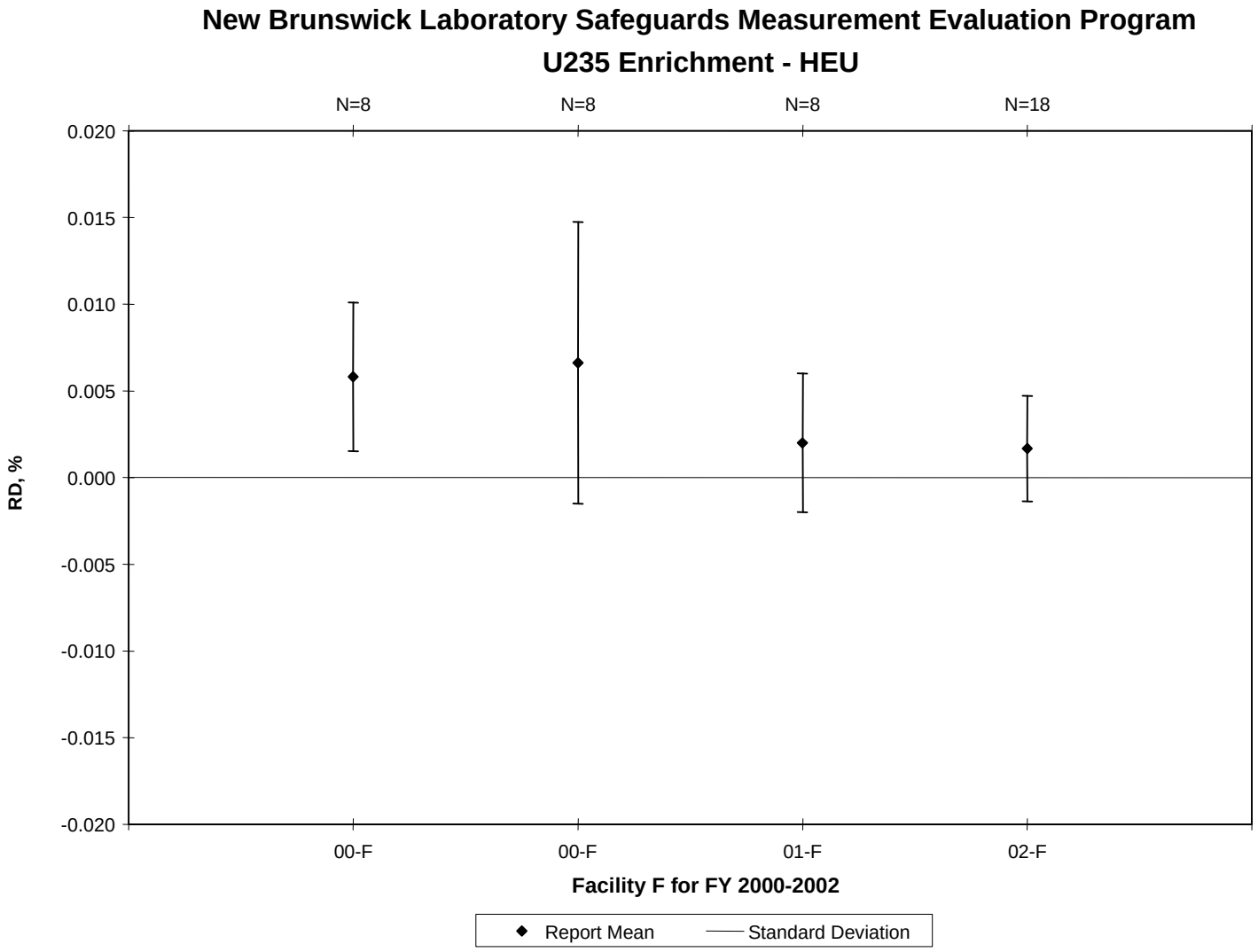
New Brunswick Laboratory Safeguards Measurement Evaluation Program
U235 Enrichment - HEU
N=8
N=8
N=8
N=18
0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
RD, %
00-F
00-F
01-F
02-F
Facility F for FY 2000-2002
Report Mean
Standard Deviation

Figure 30

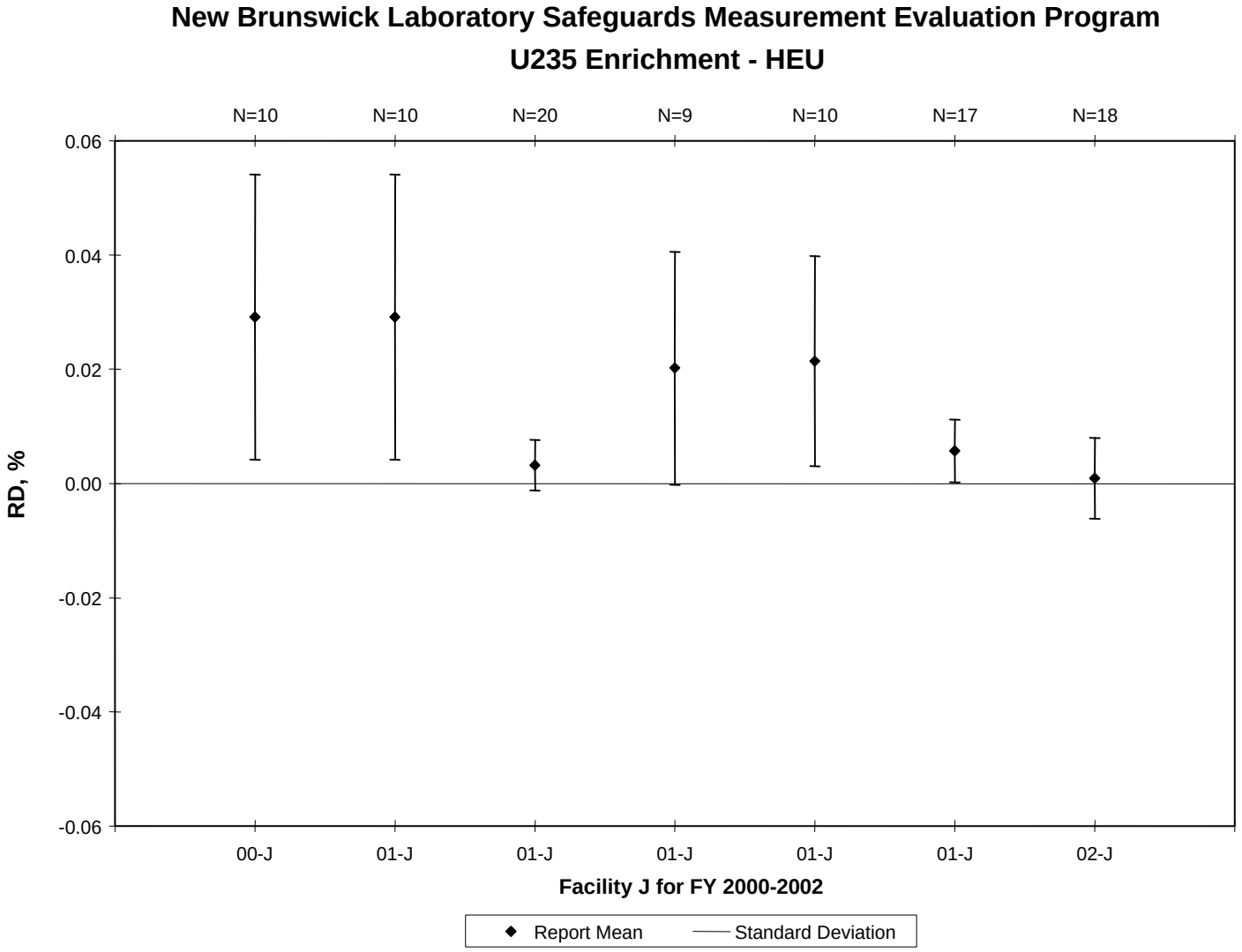
New Brunswick Laboratory Safeguards Measurement Evaluation Program
U235 Enrichment - HEU
N=10
N=10
N=20
N=9
N=10
N=17
N=18
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
RD, %
00-J
01-J
01-J
01-J
01-J
01-J
02-J
Facility J for FY 2000-2002
Report Mean
Standard Deviation

Figure 31

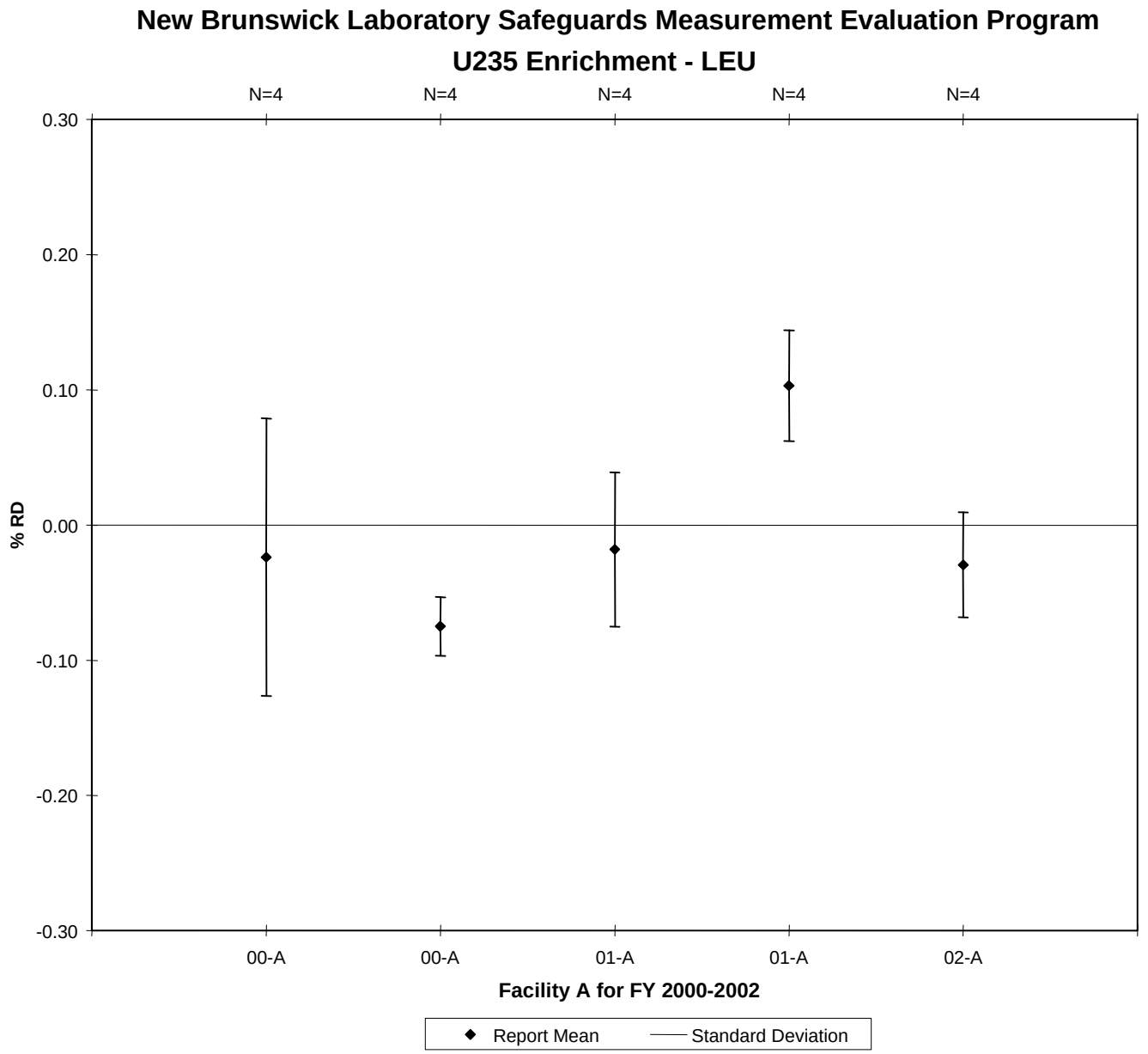
New Brunswick Laboratory Safeguards Measurement Evaluation Program
U235 Enrichment - LEU
N=4
N=4
N=4
N=4
N=4
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
% RD
00-A
00-A
01-A
01-A
02-A
Facility A for FY 2000-2002
Report Mean
Standard Deviation

Figure 32

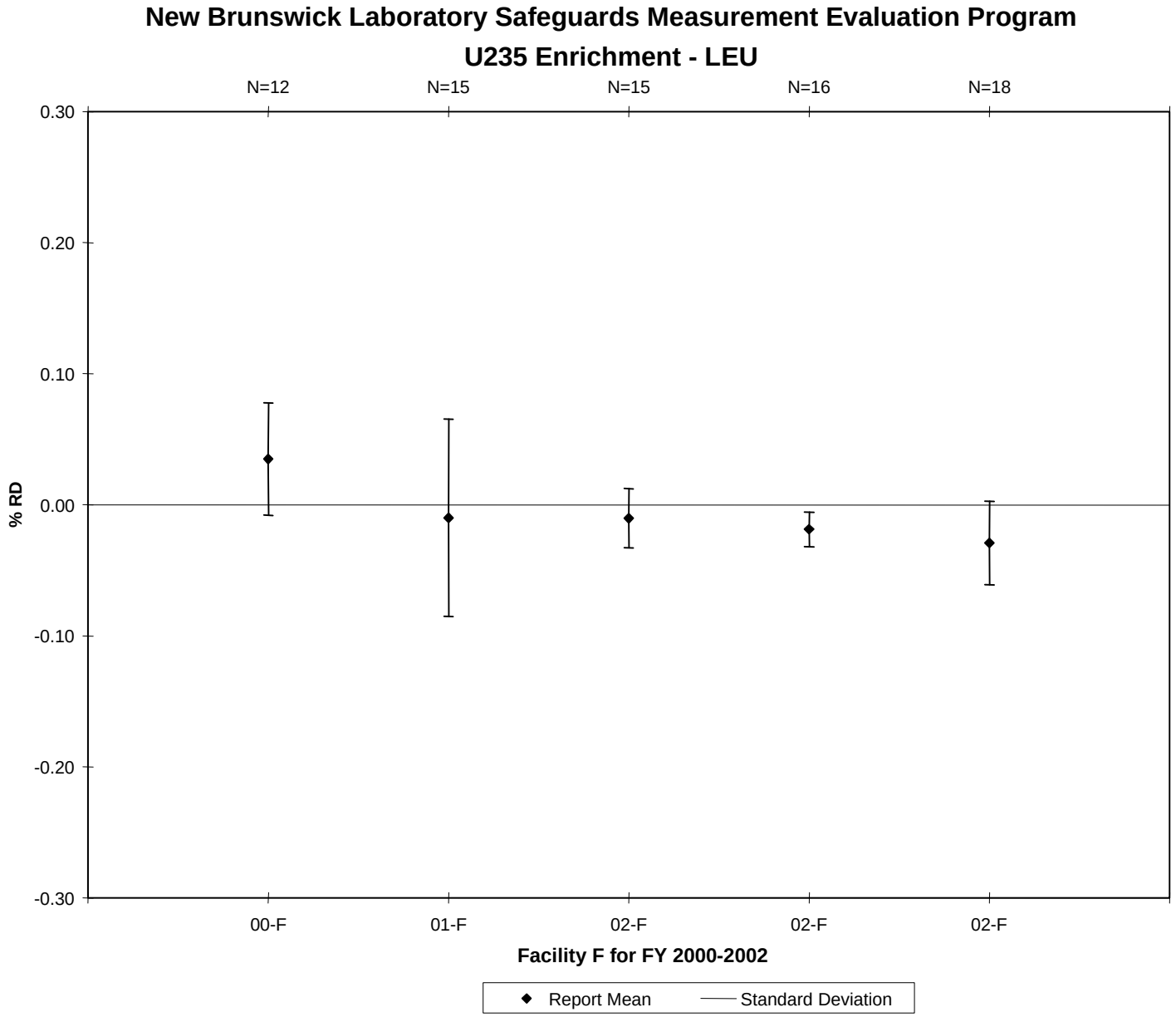
New Brunswick Laboratory Safeguards Measurement Evaluation Program
U235 Enrichment - LEU
N=12
N=15
N=15
N=16
N=18
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
% RD
00-F
01-F
02-F
02-F
02-F
Facility F for FY 2000-2002
Report Mean
Standard Deviation

Figure 33

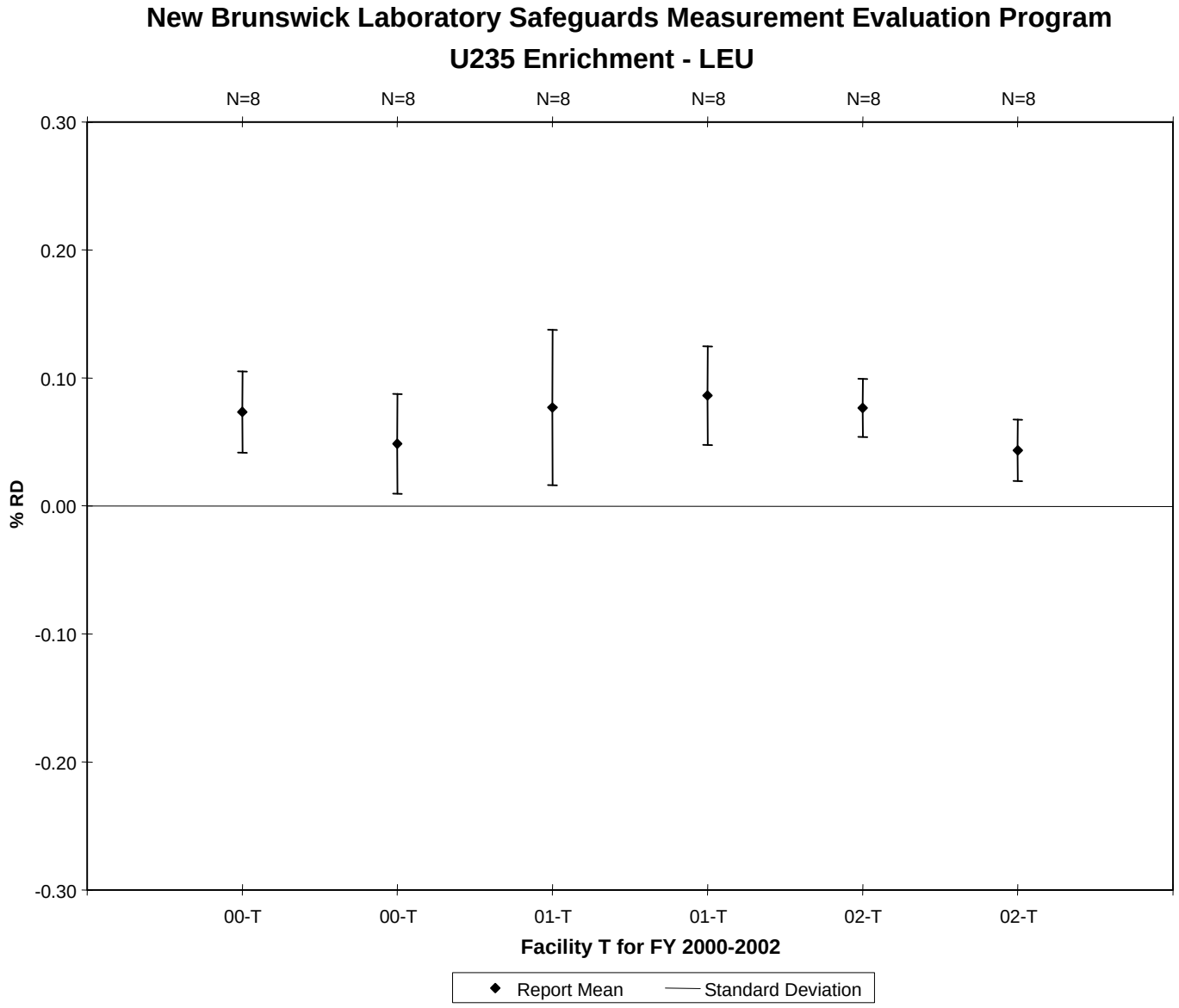
New Brunswick Laboratory Safeguards Measurement Evaluation Program
U235 Enrichment - LEU
N=8
N=8
N=8
N=8
N=8
N=8
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
% RD
00-T
00-T
01-T
01-T
02-T
02-T
Facility T for FY 2000-2002
Report Mean
Standard Deviation

Figure 34

APPENDIX

INDIVIDUAL LABORATORY RESULTS

RESULTS BY MATERIAL/LABORATORY

Material Type Symbols

UNH = Uranyl Nitrate Solution
UO2 = Uranium Dioxide Pellet
UO3 = Uranium Trioxide Powder
HEU = Uranium Enrichment (High)
LEU = Uranium Enrichment (Low)
PU = Dried Pu Sulfate
PUXXX = Plutonium Isotope

Method Type Symbols

IDMS = Isotope Dilution Mass Spectrometry
XRFL = X-Ray Fluorescence - Liquid
XRFS = X-Ray Fluorescence – Solid
DG = Davies and Gray Titration
Ceric = Ceric Titration
TIMS = Thermal Ionization Mass Spectrometry

Material	Facility	Method	Analysis Date	Reported Result	% RD	Analyst
UNH	A*	IDMS	2/1/02	1.0039	-0.011952	MJH
UNH	A*	IDMS	2/1/02	1.005	0.097608	MJH
UNH	A*	IDMS	2/1/02	1.0029	0.059862	MJH
UNH	A*	IDMS	2/1/02	1.0025	0.019954	MJH
UNH	A*	IDMS	2/4/02	1.0036	-0.041832	MJH
UNH	A*	IDMS	2/4/02	1.0038	-0.021912	MJH
UNH	A*	IDMS	2/4/02	1.0024	0.009977	MJH
UNH	A*	IDMS	2/4/02	1.004	0.169610	MJH
UNH	A*	IDMS	4/19/02	1.0045	0.047808	MJH
UNH	A*	IDMS	4/19/02	1.0052	0.117528	MJH
UNH	A*	IDMS	4/19/02	1.0007	0.014992	MJH
UNH	A*	IDMS	4/19/02	1.0004	-0.014992	MJH
UNH	A*	IDMS	4/23/02	1.0043	0.027888	MJH
UNH	A*	IDMS	4/23/02	1.0039	-0.011952	MJH
UNH	A*	IDMS	4/23/02	1.0002	-0.034981	MJH
UNH	A*	IDMS	4/23/02	1.0003	-0.024986	MJH
UNH	A*	IDMS	8/6/02	1.0018	-0.049885	MJH
UNH	A*	IDMS	8/6/02	1.0012	-0.109748	MJH
UNH	A*	IDMS	8/6/02	1.003	0.244865	MJH
UNH	A*	IDMS	8/6/02	1.003	0.244865	MJH
UNH	A*	IDMS	8/7/02	1.0019	-0.039908	MJH
UNH	A*	IDMS	8/7/02	1.003	0.069839	MJH
UNH	A*	IDMS	8/8/02	0.9998	-0.074959	MJH
UNH	A*	IDMS	8/8/02	0.9997	-0.084953	MJH
UNH	A**	XRFL	1/14/02	1.004	0.169610	ACB/RDB
UNH	A**	XRFL	1/14/02	1.004	0.169610	ACB/RDB
UNH	A**	XRFL	1/14/02	1.004	0.344810	ACB/RDB
UNH	A**	XRFL	1/14/02	1.003	0.244865	ACB/RDB
UNH	A**	XRFL	1/17/02	1.007	0.468921	ACB/RDB
UNH	A**	XRFL	1/17/02	1.009	0.668463	ACB/RDB
UNH	A**	XRFL	1/17/02	1.007	0.644645	ACB/RDB
UNH	A**	XRFL	1/17/02	1.008	0.744590	ACB/RDB
UNH	A**	XRFL	4/8/02	1.005	0.097608	ACB/RBD
UNH	A**	XRFL	4/8/02	1.005	0.097608	ACB/RBD
UNH	A**	XRFL	4/8/02	1.002	0.144920	ACB/RBD

Material	Facility	Method	Analysis Date	Reported Result	% RD	Analyst
UNH	A**	XRFL	4/8/02	1.001	0.044975	ACB/RBD
UNH	A**	XRFL	4/10/02	1.006	0.197207	ACB/RBD
UNH	A**	XRFL	4/10/02	1.007	0.296807	ACB/RBD
UNH	A**	XRFL	4/10/02	1.002	0.144920	ACB/RBD
UNH	A**	XRFL	4/10/02	1.004	0.344810	ACB/RBD
UNH	A**	XRFL	7/25/02	0.9971	-0.518807	ACB/RBD
UNH	A**	XRFL	7/25/02	1.002	-0.029931	ACB/RBD
UNH	A**	XRFL	7/25/02	0.9993	-0.124931	ACB/RBD
UNH	A**	XRFL	7/25/02	0.9952	-0.534706	ACB/RBD
UNH	A**	XRFL	7/31/02	1.001	-0.129702	ACB/RBD
UNH	A**	XRFL	7/31/02	1.005	0.269380	ACB/RBD
UNH	A**	XRFL	7/31/02	0.9996	-0.094948	ACB/RBD
UNH	A**	XRFL	7/31/02	0.9993	-0.124931	ACB/RBD
UNH	B	DG	12/8/01	0.9981	-0.419036	L.B.
UNH	B	DG	12/9/01	0.9987	-0.184898	L.B.
UNH	B	DG	12/10/01	1.0021	-0.019954	J.P.
UNH	B	DG	12/10/01	0.9985	-0.204887	J.P.
UNH	B	DG	12/10/01	1.0001	-0.044975	J.P.
UNH	B	DG	12/11/01	0.9996	-0.269380	L.B.
UNH	B	DG	12/20/01	1.0042	0.189564	L.B.
UNH	B	DG	12/20/01	0.9991	-0.144920	L.B.
UNH	B	DG	3/24/02	1.0023	-0.171311	J.P.
UNH	B	DG	3/24/02	1.0008	-0.149656	J.P.
UNH	B	DG	3/25/02	1.0027	-0.131471	J.P.
UNH	B	DG	3/25/02	1.0027	-0.131471	L.B.
UNH	B	DG	3/25/02	1.0012	-0.109748	L.B.
UNH	B	DG	3/25/02	1.001	-0.129702	J.P.
UNH	B	DG	3/28/02	1.0023	-0.171311	L.B.
UNH	B	DG	3/28/02	1.0024	0.009977	J.P.
UNH	B	DG	6/22/02	1.0085	0.446206	J.P.
UNH	B	DG	6/22/02	1.006	0.197207	J.P.
UNH	B	DG	6/22/02	1.0015	0.094948	J.P.
UNH	B	DG	6/22/02	0.9984	-0.214882	J.P.
UNH	B	DG	6/22/02	1.0008	0.024986	J.P.
UNH	B	DG	6/23/02	1.0047	0.067728	J.P.
UNH	B	DG	6/23/02	1.0071	0.306767	J.P.
UNH	B	DG	6/23/02	1.0051	0.107568	J.P.
UNH	B	DG	6/23/02	1.0036	0.304832	J.P.
UNH	B	DG	6/23/02	1.0008	0.024986	J.P.
UNH	B	DG	6/23/02	1.0014	0.084953	J.P.
UNH	B	DG	9/18/02	1.0035	0.119725	M.H.
UNH	B	DG	9/18/02	1.0019	0.134926	M.H.
UNH	B	DG	9/19/02	1.0019	-0.039908	M.H.
UNH	B	DG	9/19/02	1.0024	0.009977	M.H.
UNH	B	DG	9/19/02	0.9995	-0.104942	M.H.
UNH	B	DG	9/19/02	1.0002	-0.034981	M.H.
UNH	B	DG	9/26/02	1.0022	-0.009977	M.H.
UNH	B	DG	9/26/02	1.0035	0.119725	M.H.
UNH	B	DG	9/26/02	1.0002	-0.034981	M.H.
UNH	B	DG	9/26/02	1.0001	-0.044975	M.H.
UNH	F	DG	12/19/01	1.00384	-0.017928	164

Material	Facility	Method	Analysis Date	Reported Result	% RD	Analyst
UNH	F	DG	12/19/01	1.0035	-0.051792	164
UNH	F	DG	12/19/01	0.99947	-0.107941	164
UNH	F	DG	12/19/01	0.99948	-0.106941	164
UNH	F	DG	12/20/01	1.00362	-0.039840	164
UNH	F	DG	12/20/01	1.0037	-0.031872	164
UNH	F	DG	12/20/01	1.0001	-0.044975	164
UNH	F	DG	12/20/01	0.99999	-0.055969	164
UNH	F	DG	12/21/01	1.00408	0.005976	237
UNH	F	DG	12/21/01	1.00424	0.021912	237
UNH	F	DG	12/21/01	1.00055	0.000000	237
UNH	F	DG	12/21/01	0.99999	-0.055969	237
UNH	F	DG	12/27/01	1.00433	0.030876	237
UNH	F	DG	12/27/01	1.00427	0.024900	237
UNH	F	DG	12/27/01	1.00069	0.013992	237
UNH	F	DG	12/27/01	1.0003	-0.024986	237
UNH	F	DG	9/24/02	1.00192	-0.037913	164
UNH	F	DG	9/24/02	1.00202	-0.027936	164
UNH	F	DG	9/24/02	1.00023	-0.031982	164
UNH	F	DG	9/24/02	1.00034	-0.020988	164
UNH	F	DG	9/26/02	1.00221	-0.008979	164
UNH	F	DG	9/26/02	1.00196	-0.033922	164
UNH	F	DG	9/26/02	1.00065	0.009995	164
UNH	F	DG	9/26/02	1.00022	-0.032982	164
UNH	F	DG	10/3/02	1.0025	0.019954	237
UNH	F	DG	10/3/02	1.00262	0.031927	237
UNH	F	DG	10/3/02	1.00067	0.011993	237
UNH	F	DG	10/3/02	1.0003	-0.024986	237
UNH	F	DG	10/11/02	1.00282	0.051881	237
UNH	F	DG	10/11/02	1.00247	0.016961	237
UNH	F	DG	10/11/02	1.00073	0.017990	237
UNH	F	DG	10/11/02	1.00047	-0.007996	237
UNH	G	Ceric	1/9/02	1.00374	-0.027888	
UNH	G	Ceric	1/9/02	1.00395	-0.006972	
UNH	G	Ceric	1/9/02	1.00085	0.029984	
UNH	G	Ceric	1/9/02	1.00059	0.003998	
UNH	G	Ceric	1/10/02	1.00471	0.068724	
UNH	G	Ceric	1/10/02	1.00389	-0.012948	
UNH	G	Ceric	1/10/02	1.00026	-0.028984	
UNH	G	Ceric	1/10/02	1.00097	0.041977	
UNH	G	Ceric	4/18/02	1.00349	-0.052788	
UNH	G	Ceric	4/18/02	1.00376	-0.025896	
UNH	G	Ceric	4/18/02	1.0021	-0.019954	
UNH	G	Ceric	4/18/02	1.00244	0.013968	
UNH	G	Ceric	4/22/02	1.00352	-0.049800	
UNH	G	Ceric	4/22/02	1.00385	-0.016932	
UNH	G	Ceric	4/22/02	1.00245	0.014966	
UNH	G	Ceric	4/22/02	1.00227	-0.002993	
UNH	G	Ceric	7/17/02	1.00333	-0.068724	
UNH	G	Ceric	7/17/02	1.00462	0.059760	
UNH	G	Ceric	7/17/02	1.00092	0.036980	
UNH	G	Ceric	7/17/02	1.00026	-0.028984	

Material	Facility	Method	Analysis Date	Reported Result	% RD	Analyst
UNH	G	Ceric	7/18/02	1.00372	-0.029880	
UNH	G	Ceric	7/18/02	1.00495	0.092628	
UNH	G	Ceric	7/18/02	1.0012	0.064964	
UNH	G	Ceric	7/18/02	0.99997	-0.057968	
UNH	G	Ceric	10/22/02	0.99976	-0.078957	
UNH	G	Ceric	10/22/02	1.00139	0.083954	
UNH	G	Ceric	10/22/02	1.00136	-0.093784	
UNH	G	Ceric	10/22/02	1.0017	-0.059862	
UNH	G	Ceric	10/23/02	1.00082	0.026985	
UNH	G	Ceric	10/23/02	1.00015	-0.039978	
UNH	G	Ceric	10/23/02	1.00222	-0.007982	
UNH	G	Ceric	10/23/02	1.00209	-0.020952	
UNH	J	IDMS	5/23/02	0.46993	-0.040415	U814
UNH	J	IDMS	5/23/02	0.46966	-0.097847	U815
UNH	J	IDMS	5/23/02	0.46283	-0.028080	U816
UNH	J	IDMS	5/23/02	0.46265	-0.066960	U817
UNH	J	IDMS	5/30/02	0.46986	-0.055305	U814
UNH	J	IDMS	5/30/02	0.46958	-0.114864	U815
UNH	J	IDMS	5/30/02	0.46243	-0.114481	U817
UNH	J	IDMS	6/3/02	0.46914	-0.208457	U814
UNH	J	IDMS	6/3/02	0.46956	-0.119119	U815
UNH	J	IDMS	6/3/02	0.46224	-0.155521	U816
UNH	J	IDMS	6/3/02	0.46249	-0.101521	U817
UNH	J	IDMS	10/3/02	0.46909	-0.219093	U814
UNH	J	IDMS	10/3/02	0.46905	-0.227601	U815
UNH	J	IDMS	10/3/02	0.46245	-0.110161	U816
UNH	J	IDMS	10/3/02	0.4626	-0.077760	U817
UNH	J	IDMS	10/7/02	0.46968	-0.093593	U815
UNH	J	IDMS	10/7/02	0.46232	-0.138241	U816
UNH	J	IDMS	10/7/02	0.46228	-0.146881	U817
UO2	F	DG	8/22/02	88.0456	-0.094634	237
UO2	F	DG	8/22/02	88.1308	0.002042	237
UO2	F	DG	8/22/02	88.0954	-0.038126	237
UO2	F	DG	8/22/02	88.0858	-0.049019	237
UO2	F	DG	8/22/02	88.0571	-0.081585	237
UO2	F	DG	8/22/02	88.1	-0.032906	237
UO2	F	DG	8/22/02	88.0872	-0.047430	237
UO2	F	DG	8/30/02	88.1259	-0.003518	164
UO2	F	DG	8/30/02	88.1325	0.003971	164
UO2	F	DG	8/30/02	88.0585	-0.079996	237
UO2	F	DG	8/30/02	88.0884	-0.046069	237
UO2	F	DG	8/30/02	88.0975	-0.035743	164
UO2	F	DG	8/30/02	88.0522	-0.087145	164
UO2	F	DG	8/30/02	88.0876	-0.046977	237
UO2	F	DG	8/30/02	88.0912	-0.042892	164
UO2	F	DG	8/30/02	88.0502	-0.089414	164
UO2	F	DG	8/30/02	88.0758	-0.060366	237
UO2	F	DG	8/30/02	88.0549	-0.084081	237
UO2	F	DG	8/30/02	88.1095	-0.022127	164
UO2	F	DG	8/30/02	88.0734	-0.063089	164
UO2	F	DG	8/30/02	88.1081	-0.023715	237

Material	Facility	Method	Analysis Date	Reported Result	% RD	Analyst
UO2	F	DG	8/30/02	88.0748	-0.061501	237
UO2	F	DG	9/3/02	88.1358	0.007716	164
UO2	F	DG	9/3/02	88.1031	-0.029389	164
UO2	F	DG	9/3/02	88.1051	-0.027119	164
UO2	F	DG	9/3/02	88.0532	-0.086010	164
UO2	F	DG	9/3/02	88.0645	-0.073188	164
UO2	F	DG	9/3/02	88.1366	0.008624	164
UO2	F	DG	9/3/02	88.0807	-0.054806	164
UO2	T	DG	12/17/01	87.97	-0.180417	
UO2	T	DG	12/17/01	88.21	0.091911	
UO2	T	DG	12/17/01	88.1	-0.032906	
UO2	T	DG	12/17/01	88.12	-0.010212	
UO2	T	DG	3/18/02	88.17	0.046523	
UO2	T	DG	3/18/02	88.22	0.103258	
UO2	T	DG	3/18/02	88.1	-0.032906	
UO2	T	DG	3/18/02	88.19	0.069217	
UO2	T	DG	6/3/02	88	-0.146376	
UO2	T	DG	6/3/02	88.04	-0.100988	
UO2	T	DG	6/3/02	88.02	-0.123682	
UO2	T	DG	6/3/02	88.14	0.012482	
UO2	T	DG	9/24/02	88	-0.146376	
UO2	T	DG	9/24/02	88.14	0.012482	
UO2	T	DG	9/24/02	88.04	-0.100988	
UO2	T	DG	9/24/02	87.96	-0.191764	
UO3	A	IDMS	10/11/01	82.57	-0.122171	JLW
UO3	A	IDMS	10/11/01	82.8	0.156040	JLW
UO3	A	IDMS	10/11/01	82.77	0.119752	JLW
UO3	A	IDMS	10/11/01	82.53	-0.170556	JLW
UO3	A	IDMS	10/16/01	82.54	-0.158459	MJH
UO3	A	IDMS	10/16/01	82.75	0.095560	MJH
UO3	A	IDMS	10/16/01	82.56	-0.134267	MJH
UO3	A	IDMS	10/16/01	82.54	-0.158459	MJH
UO3	A	IDMS	2/1/02	82.56	-0.134267	MJH
UO3	A	IDMS	2/1/02	82.68	0.010887	MJH
UO3	A	IDMS	2/1/02	82.81	0.168136	MJH
UO3	A	IDMS	2/1/02	82.63	-0.049594	MJH
UO3	A	IDMS	2/4/02	82.76	0.107656	MJH
UO3	A	IDMS	2/4/02	82.58	-0.110075	MJH
UO3	A	IDMS	2/4/02	82.57	-0.122171	MJH
UO3	A	IDMS	2/4/02	82.59	-0.097979	MJH
UO3	A	IDMS	4/25/02	82.78	0.131848	MJH
UO3	A	IDMS	4/25/02	82.6	-0.085883	MJH
UO3	A	IDMS	4/25/02	82.76	0.107656	MJH
UO3	A	IDMS	4/25/02	82.66	-0.013306	MJH
UO3	A	IDMS	4/29/02	82.63	-0.049594	MJH
UO3	A	IDMS	4/29/02	82.72	0.059271	MJH
UO3	A	IDMS	4/29/02	82.69	0.022983	MJH
UO3	A	IDMS	4/29/02	82.59	-0.097979	MJH
UO3	A	IDMS	8/8/02	82.7	0.035079	MJH
UO3	A	IDMS	8/8/02	82.82	0.180232	MJH
UO3	A	IDMS	8/8/02	82.52	-0.182652	MJH

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UO3	A	IDMS	8/8/02	82.82	0.180232	MJH
UO3	A	IDMS	8/9/02	82.67	-0.001210	DLB
UO3	A	IDMS	8/9/02	82.68	0.010887	DLB
UO3	A	IDMS	8/9/02	82.75	0.095560	DLB
UO3	A	IDMS	8/9/02	82.43	-0.291517	DLB
UO3	A*	XRFL	10/26/01	83	0.397963	ACB/RBD
UO3	A*	XRFL	10/26/01	83.07	0.482636	ACB/RBD
UO3	A*	XRFL	10/26/01	82.92	0.301194	ACB/RBD
UO3	A*	XRFL	10/26/01	82.98	0.373771	ACB/RBD
UO3	A*	XRFL	11/2/01	82.82	0.180232	ACB/RBD
UO3	A*	XRFL	11/2/01	82.84	0.204425	ACB/RBD
UO3	A*	XRFL	11/2/01	82.59	-0.097979	ACB/RBD
UO3	A*	XRFL	11/2/01	82.73	0.071367	ACB/RBD
UO3	A*	XRFL	1/14/02	82.63	-0.049594	ACB/RDB
UO3	A*	XRFL	1/14/02	82.77	0.119752	ACB/RDB
UO3	A*	XRFL	1/14/02	82.74	0.083463	ACB/RDB
UO3	A*	XRFL	1/14/02	82.58	-0.110075	ACB/RDB
UO3	A*	XRFL	1/17/02	82.68	0.010887	ACB/RDB
UO3	A*	XRFL	1/17/02	82.54	-0.158459	ACB/RDB
UO3	A*	XRFL	1/17/02	82.55	-0.146363	ACB/RDB
UO3	A*	XRFL	1/17/02	82.66	-0.013306	ACB/RDB
UO3	A*	XRFL	4/4/02	82.63	-0.049594	ACB/RDB
UO3	A*	XRFL	4/4/02	82.38	-0.351998	ACB/RDB
UO3	A*	XRFL	4/4/02	82.43	-0.291517	ACB/RDB
UO3	A*	XRFL	4/4/02	82.51	-0.194748	ACB/RDB
UO3	A*	XRFL	4/8/02	82.58	-0.110075	ACB/RDB
UO3	A*	XRFL	4/8/02	82.44	-0.279421	ACB/RDB
UO3	A*	XRFL	4/8/02	82.39	-0.339902	ACB/RDB
UO3	A*	XRFL	4/8/02	82.4	-0.327805	ACB/RDB
UO3	A*	XRFL	7/25/02	82.05	-0.751170	ACB/RBD
UO3	A*	XRFL	7/25/02	82.2	-0.569728	ACB/RBD
UO3	A*	XRFL	7/25/02	82.04	-0.763266	ACB/RBD
UO3	A*	XRFL	7/25/02	81.91	-0.920516	ACB/RBD
UO3	A*	XRFL	7/31/02	82.2	-0.569728	ACB/RBD
UO3	A*	XRFL	7/31/02	82.01	-0.799555	ACB/RBD
UO3	A*	XRFL	7/31/02	82.16	-0.618113	ACB/RBD
UO3	A*	XRFL	7/31/02	82.31	-0.436671	ACB/RBD
UO3	A**	XRFS	10/30/01	82.87	0.240713	ACB/RBD
UO3	A**	XRFS	10/30/01	82.63	-0.049594	ACB/RBD
UO3	A**	XRFS	10/30/01	83.04	0.446348	ACB/RBD
UO3	A**	XRFS	10/30/01	82.82	0.180232	ACB/RBD
UO3	A**	XRFS	11/2/01	82.5	-0.206844	ACB/RBD
UO3	A**	XRFS	11/2/01	82.8	0.156040	ACB/RBD
UO3	A**	XRFS	11/2/01	82.8	0.156040	ACB/RBD
UO3	A**	XRFS	11/2/01	82.55	-0.146363	ACB/RBD
UO3	A**	XRFS	1/14/02	82.64	-0.037498	ACB/RDB
UO3	A**	XRFS	1/14/02	82.75	0.095560	ACB/RDB
UO3	A**	XRFS	1/14/02	82.88	0.252809	ACB/RDB
UO3	A**	XRFS	1/14/02	82.48	-0.231036	ACB/RDB
UO3	A**	XRFS	1/16/02	82.49	-0.218940	ACB/RDB
UO3	A**	XRFS	1/16/02	82.52	-0.182652	ACB/RDB

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UO3	A**	XRFS	1/16/02	82.38	-0.351998	ACB/RDB
UO3	A**	XRFS	1/16/02	82.39	-0.339902	ACB/RDB
UO3	A**	XRFS	4/3/02	82.66	-0.013306	ACB/RDB
UO3	A**	XRFS	4/3/02	82.94	0.325386	ACB/RDB
UO3	A**	XRFS	4/3/02	82.65	-0.025402	ACB/RDB
UO3	A**	XRFS	4/3/02	82.94	0.325386	ACB/RDB
UO3	A**	XRFS	4/4/02	82.96	0.349578	ACB/RDB
UO3	A**	XRFS	4/4/02	82.88	0.252809	ACB/RDB
UO3	A**	XRFS	4/4/02	82.78	0.131848	ACB/RDB
UO3	A**	XRFS	4/4/02	82.83	0.192329	ACB/RDB
UO3	A**	XRFS	7/25/02	82.51	-0.194748	ACB/RBD
UO3	A**	XRFS	7/25/02	82.71	0.047175	ACB/RBD
UO3	A**	XRFS	7/25/02	82.66	-0.013306	ACB/RBD
UO3	A**	XRFS	7/25/02	82.8	0.156040	ACB/RBD
UO3	A**	XRFS	8/1/02	82.32	-0.424575	ACB/RBD
UO3	A**	XRFS	8/1/02	82.15	-0.630209	ACB/RBD
UO3	A**	XRFS	8/1/02	82.44	-0.279421	ACB/RBD
UO3	A**	XRFS	8/1/02	82.51	-0.194748	ACB/RBD
UO3	F	DG	1/22/02	82.612	-0.071367	237
UO3	F	DG	1/22/02	82.6088	-0.075238	237
UO3	F	DG	1/22/02	82.6219	-0.059392	237
UO3	F	DG	1/22/02	82.64	-0.037498	237
UO3	F	DG	1/23/02	82.6312	-0.048143	237
UO3	F	DG	1/23/02	82.6217	-0.059634	237
UO3	F	DG	1/23/02	82.5906	-0.097253	237
UO3	F	DG	1/23/02	82.6029	-0.082375	237
UO3	F	DG	2/6/02	82.6519	-0.023104	164
UO3	F	DG	2/6/02	82.6936	0.027337	164
UO3	F	DG	2/6/02	82.649	-0.026612	164
UO3	F	DG	2/6/02	82.6421	-0.034958	164
UO3	F	DG	2/7/02	82.6683	-0.003266	164
UO3	F	DG	2/7/02	82.6499	-0.025523	164
UO3	F	DG	2/7/02	82.6544	-0.020080	164
UO3	F	DG	2/7/02	82.6416	-0.035563	164
HEU	A	TIMS	2/11/02	51.321	-0.006819	MJH
HEU	A	TIMS	2/11/02	51.299	-0.049684	MJH
HEU	A	TIMS	2/13/02	51.312	-0.024355	MJH
HEU	A	TIMS	2/13/02	51.3	-0.047735	MJH
HEU	A	TIMS	4/19/02	90.329	-0.009055	MJH
HEU	A	TIMS	4/19/02	90.339	0.002015	MJH
HEU	A	TIMS	4/19/02	89.891	-0.000156	MJH
HEU	A	TIMS	4/19/02	89.884	-0.007943	MJH
HEU	A	TIMS	4/22/02	90.331	-0.006841	MJH
HEU	A	TIMS	4/22/02	90.349	0.013084	MJH
HEU	A	TIMS	4/22/02	89.891	-0.000156	MJH
HEU	A	TIMS	4/22/02	89.889	-0.002381	MJH
HEU	A	TIMS	8/6/02	51.336	0.022406	MJH
HEU	A	TIMS	8/6/02	51.341	0.032148	MJH
HEU	A	TIMS	8/15/02	51.335	0.020458	MJH
HEU	A	TIMS	8/15/02	51.332	0.014613	MJH
HEU	F	TIMS	10/10/02	89.8934	0.002514	247

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HEU	F	TIMS	10/10/02	89.8913	0.000178	247
HEU	F	TIMS	10/10/02	90.3383	0.001240	247
HEU	F	TIMS	10/10/02	90.3412	0.004450	247
HEU	F	TIMS	10/10/02	90.3405	0.003675	247
HEU	F	TIMS	10/10/02	90.3382	0.001129	247
HEU	F	TIMS	10/11/02	89.8931	0.002180	247
HEU	F	TIMS	10/11/02	89.8956	0.004962	247
HEU	F	TIMS	10/11/02	89.8936	0.002737	247
HEU	F	TIMS	10/11/02	89.8939	0.003070	247
HEU	F	TIMS	10/11/02	90.3402	0.003343	247
HEU	F	TIMS	10/11/02	90.3399	0.003011	247
HEU	F	TIMS	10/15/02	89.8918	0.000734	247
HEU	F	TIMS	10/15/02	89.8904	-0.000823	247
HEU	F	TIMS	10/15/02	89.8927	0.001735	247
HEU	F	TIMS	10/15/02	90.3388	0.001793	247
HEU	F	TIMS	10/15/02	90.3401	0.003232	247
HEU	F	TIMS	10/15/02	90.329	-0.009055	247
HEU	J	TIMS	5/23/02	89.6677	-0.012400	U814
HEU	J	TIMS	5/23/02	89.6748	-0.004483	U815
HEU	J	TIMS	5/23/02	89.8871	-0.004494	U816
HEU	J	TIMS	5/23/02	89.8906	-0.000601	U817
HEU	J	TIMS	5/30/02	89.6699	-0.009947	U814
HEU	J	TIMS	5/30/02	89.6772	-0.001806	U815
HEU	J	TIMS	5/30/02	89.8954	0.004739	U817
HEU	J	TIMS	6/3/02	89.6849	0.006780	U814
HEU	J	TIMS	6/3/02	89.6741	-0.005263	U815
HEU	J	TIMS	6/3/02	89.8998	0.009634	U816
HEU	J	TIMS	6/3/02	89.893	0.002069	U817
HEU	J	TIMS	10/3/02	89.6858	0.007783	U814
HEU	J	TIMS	10/3/02	89.6897	0.012132	U815
HEU	J	TIMS	10/3/02	89.8942	0.003404	U816
HEU	J	TIMS	10/3/02	89.8914	0.000289	U817
HEU	J	TIMS	10/7/02	89.6735	-0.005932	U815
HEU	J	TIMS	10/7/02	89.8981	0.007743	U816
HEU	J	TIMS	10/7/02	89.8975	0.007075	U817
LEU	A	TIMS	2/1/02	4.388	-0.080610	MJH
LEU	A	TIMS	2/1/02	4.392	0.010475	MJH
LEU	A	TIMS	2/13/02	4.39	-0.035067	MJH
LEU	A	TIMS	2/13/02	4.391	-0.012296	MJH
LEU	F	TIMS	5/2/02	4.4613	0.020178	247
LEU	F	TIMS	5/2/02	4.4615	0.024661	247
LEU	F	TIMS	5/2/02	4.4603	-0.002242	247
LEU	F	TIMS	5/2/02	4.4593	-0.024661	247
LEU	F	TIMS	5/2/02	4.4596	-0.017936	247
LEU	F	TIMS	5/2/02	4.4617	0.029145	247
LEU	F	TIMS	5/2/02	4.4606	0.004484	247
LEU	F	TIMS	5/2/02	4.4579	-0.056049	247
LEU	F	TIMS	5/3/02	4.4598	-0.013452	247
LEU	F	TIMS	5/3/02	4.4592	-0.026903	247
LEU	F	TIMS	5/3/02	4.4595	-0.020178	247
LEU	F	TIMS	5/3/02	4.4601	-0.006726	247

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LEU	F	TIMS	5/3/02	4.4596	-0.017936	247
LEU	F	TIMS	5/3/02	4.4595	-0.020178	247
LEU	F	TIMS	5/3/02	4.4592	-0.026903	247
LEU	F	TIMS	8/15/02	4.3911	-0.010019	247
LEU	F	TIMS	8/15/02	4.3907	-0.019128	247
LEU	F	TIMS	8/15/02	4.3897	-0.041899	247
LEU	F	TIMS	8/15/02	4.3907	-0.019128	247
LEU	F	TIMS	8/15/02	4.3907	-0.019128	247
LEU	F	TIMS	8/15/02	4.391	-0.012296	247
LEU	F	TIMS	8/15/02	4.3897	-0.041899	247
LEU	F	TIMS	8/15/02	4.3897	-0.041899	247
LEU	F	TIMS	8/15/02	4.4596	-0.004485	247
LEU	F	TIMS	8/15/02	4.46	0.004485	247
LEU	F	TIMS	8/15/02	4.459	-0.017938	247
LEU	F	TIMS	8/15/02	4.4589	-0.020180	247
LEU	F	TIMS	8/15/02	4.4591	-0.015696	247
LEU	F	TIMS	8/15/02	4.4593	-0.011211	247
LEU	F	TIMS	8/15/02	4.4593	-0.011211	247
LEU	F	TIMS	8/15/02	4.459	-0.017938	247
LEU	F	TIMS	8/23/02	4.0066	-0.039918	247
LEU	F	TIMS	8/23/02	4.004	-0.104785	247
LEU	F	TIMS	8/23/02	4.007	-0.029939	247
LEU	F	TIMS	8/23/02	4.0089	0.017464	247
LEU	F	TIMS	8/23/02	4.0089	0.017464	247
LEU	F	TIMS	8/23/02	4.0071	-0.027444	247
LEU	F	TIMS	8/26/02	4.0075	-0.017464	247
LEU	F	TIMS	8/26/02	4.0062	-0.049898	247
LEU	F	TIMS	8/26/02	4.0093	0.027444	247
LEU	F	TIMS	8/26/02	4.0064	-0.044908	247
LEU	F	TIMS	8/26/02	4.0082	0.000000	247
LEU	F	TIMS	8/26/02	4.0075	-0.017464	247
LEU	F	TIMS	8/27/02	4.0063	-0.047403	247
LEU	F	TIMS	8/27/02	4.0066	-0.039918	247
LEU	F	TIMS	8/27/02	4.0066	-0.039918	247
LEU	F	TIMS	8/27/02	4.0075	-0.017464	247
LEU	F	TIMS	8/27/02	4.0062	-0.049898	247
LEU	F	TIMS	8/27/02	4.0058	-0.059877	247
LEU	T	TIMS	12/20/01	4.0108	0.064867	
LEU	T	TIMS	12/20/01	4.0118	0.089816	
LEU	T	TIMS	12/20/01	4.0128	0.114765	
LEU	T	TIMS	12/20/01	4.0108	0.064867	
LEU	T	TIMS	3/18/02	4.0117	0.087321	
LEU	T	TIMS	3/18/02	4.0098	0.039918	
LEU	T	TIMS	3/18/02	4.0108	0.064867	
LEU	T	TIMS	3/18/02	4.0117	0.087321	
LEU	T	TIMS	6/5/02	4.00977	0.039170	
LEU	T	TIMS	6/5/02	4.0099	0.042413	
LEU	T	TIMS	6/5/02	4.0098	0.039918	
LEU	T	TIMS	6/5/02	4.0098	0.039918	
LEU	T	TIMS	9/27/02	4.0108	0.064867	
LEU	T	TIMS	9/27/02	4.0079	-0.007485	

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LEU	T	TIMS	9/27/02	4.0108	0.064867	
LEU	T	TIMS	9/27/02	4.0108	0.064867	
PU	F	IDMS	3/12/02	43.1287	0.159940	201
PU	F	IDMS	3/12/02	43.1482	0.205226	201
PU	F	IDMS	3/12/02	44.1978	0.083445	201
PU	F	IDMS	3/12/02	44.2278	0.151378	201
PU239	F	TIMS	3/5/02	0.857801	0.002709	201
PU239	F	TIMS	3/5/02	0.857818	0.007489	201
PU239	F	TIMS	3/5/02	0.857789	0.004108	201
PU239	F	TIMS	3/5/02	0.784477	0.010185	201
PU239	F	TIMS	3/5/02	0.784528	0.016687	201
PU239	F	TIMS	3/5/02	0.784453	0.007125	201
PU239	F	TIMS	3/8/02	0.85783	0.008488	201
PU239	F	TIMS	3/8/02	0.857823	0.007672	201
PU239	F	TIMS	3/8/02	0.857777	0.002310	201
PU239	F	TIMS	3/8/02	0.784472	0.009547	201
PU239	F	TIMS	3/8/02	0.784503	0.013039	201
PU239	F	TIMS	3/8/02	0.784369	-0.004044	201
PU239	T	TIMS	12/18/01	0.784374	0.008934	
PU239	T	TIMS	12/18/01	0.784353	0.006257	
PU239	T	TIMS	12/18/01	0.877306	0.000751	
PU239	T	TIMS	12/18/01	0.877305	0.000637	
PU239	T	TIMS	3/26/02	0.857799	0.002476	
PU239	T	TIMS	3/26/02	0.857831	0.006207	
PU239	T	TIMS	3/26/02	0.877385	0.004103	
PU239	T	TIMS	3/26/02	0.877346	-0.000342	
PU239	T	TIMS	6/20/02	0.85794	0.007528	
PU239	T	TIMS	6/20/02	0.85794	0.007528	
PU239	T	TIMS	6/20/02	0.784657	0.016806	
PU239	T	TIMS	6/20/02	0.784659	0.017061	
PU239	T	TIMS	9/30/02	0.877416	-0.003017	
PU239	T	TIMS	9/30/02	0.877387	-0.006322	
PU239	T	TIMS	9/30/02	0.784704	0.007435	
PU239	T	TIMS	9/30/02	0.784696	0.006416	
PU240	F	TIMS	3/5/02	0.124721	-0.033464	201
PU240	F	TIMS	3/5/02	0.124703	-0.045535	201
PU240	F	TIMS	3/5/02	0.124725	-0.027902	201
PU240	F	TIMS	3/5/02	0.189821	-0.024612	201
PU240	F	TIMS	3/5/02	0.189784	-0.044099	201
PU240	F	TIMS	3/5/02	0.189841	-0.014078	201
PU240	F	TIMS	3/8/02	0.124707	-0.042666	201
PU240	F	TIMS	3/8/02	0.124707	-0.042666	201
PU240	F	TIMS	3/8/02	0.124742	-0.014612	201
PU240	F	TIMS	3/8/02	0.189825	-0.022505	201
PU240	F	TIMS	3/8/02	0.189813	-0.029225	201
PU240	F	TIMS	3/8/02	0.189914	0.023969	201
PU240	T	TIMS	12/18/01	0.189808	-0.021201	
PU240	T	TIMS	12/18/01	0.189818	-0.015934	
PU240	T	TIMS	12/18/01	0.116293	0.002597	
PU240	T	TIMS	12/18/01	0.116294	0.003457	
PU240	T	TIMS	3/26/02	0.124689	-0.059112	

Material	Facility	Method	Analysis Date	Reported Result	% RD	Analyst
PU240	T	TIMS	3/26/02	0.124666	-0.077547	
PU240	T	TIMS	3/26/02	0.116254	-0.034525	
PU240	T	TIMS	3/26/02	0.116273	-0.018187	
PU240	T	TIMS	6/20/02	0.124708	-0.053448	
PU240	T	TIMS	6/20/02	0.124718	-0.045434	
PU240	T	TIMS	6/20/02	0.189796	-0.051845	
PU240	T	TIMS	6/20/02	0.189784	-0.058164	
PU240	T	TIMS	9/30/02	0.116314	0.010370	
PU240	T	TIMS	9/30/02	0.116313	0.009510	
PU240	T	TIMS	9/30/02	0.18986	-0.031350	
PU240	T	TIMS	9/30/02	0.189868	-0.027138	