Session Objectives

SESSION 23: ASSIGNMENT OF ELEMENT AND ISOTOPE FACTORS

Session 23 describes the use of uranium element and U-235 isotope factors in the model plant materials accounting system.

After the session, participants will be able to understand the basis for the use of element and isotope factors and how they are used in the computer-based accounting system.

INTERNATIONAL TRAINING COURSE ON IMPLEMENTATION
OF STATE SYSTEMS OF ACCOUNTING FOR
AND CONTROL OF NUCLEAR MATERIALS

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SESSION 23: ASSIGNMENT OF ELEMENT AND ISOTOPE FACTORS

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I. INTRODUCTION

As discussed previously by Tony Kraft and Dan Noss, element and isotope factors are assigned in the NICS internal accounting system on the basis of coded information included on the material transfer documents. This section will explain more fully the manner in which NICS assigns these factors.

A. Factor Tables

Chart 1 shows a sample NICS element and isotope factor table relating to the model plant. The isotope factor table consists of three columns. The first column is a listing of numerical project accounts. Each project account corresponds to a nuclear reactor reload. The second column lists the nominal enrichments associated with each project account. As explained previously, nuclear materials accounting is based on a project enrichment account, or an account with a given project code and nominal enrichment. For each such account, a specific isotope factor (third column) is used by NICS to assign all isotope weights.

The element factor table also consists of three columns. The first column is a listing of the last two letters of all the material composition codes used in the plant. As an example, for full cylinders of UF_6 gas, the material composition code is UUF, but only the letters UF appear in the factor table. The second column consists of a binary valued factor flag, whose purpose will be discussed in the next subsection. The last column contains the numerical element factor value, which is used by NICS to assign all uranium element weights.

The information in both the element and isotope factor tables is used by NICS to convert net weights of material to weights of uranium element and U-235 isotope. Both tables are edited using the FACT program based on the factor request form discussed earlier by Dan Noss.

B. Element Factors

Chart 2 shows the procedure used by NICS to assign element factors. After a material transfer document has been keypunched and submitted to the computer, NICS keys on the last two letters of the material composition code of each item. NICS then searches the element factor table for that two letter code and checks the value of the factor flag in the table. If the flag is zero, the numerical value from the third column is assigned to that item. If the flag is one, NICS assigns the value

CHART 1. Sample NICS Factor Tables

NICS - NUCLEAR INVENTORY CONTROL SYSTEM

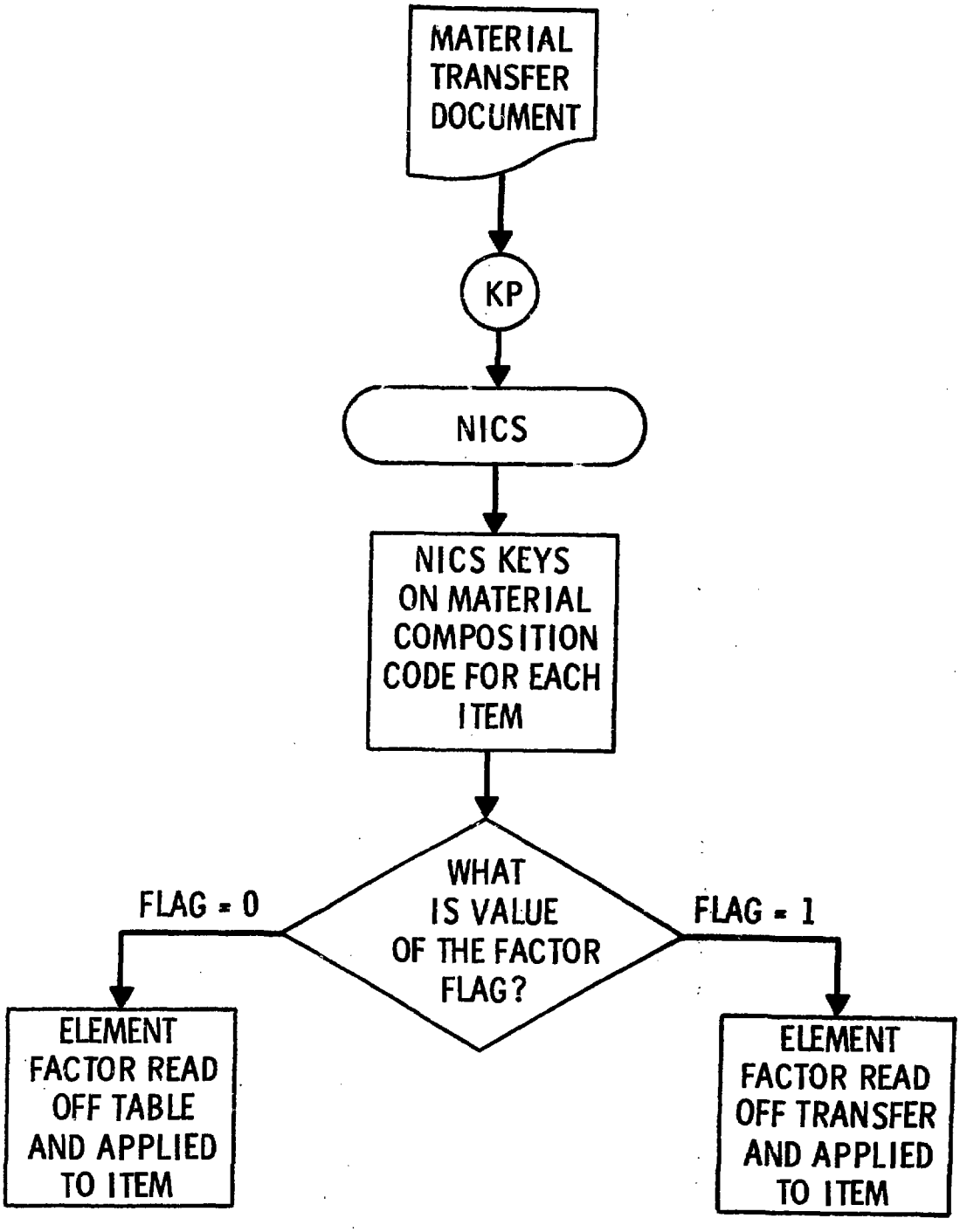
ISOTOPIC FACTOR TABLE

PROJECT CODE	ENR	ISOTOPIC FACTOR
0	E300	0.030000
1	E300	0.030000
2	E296	0.029600
3	E299	0.029900
4	E310	0.031000
5	E300	0.030000
6	E298	0.029800
7	E303	0.03030C
8	E301	0.030100

U-FACTOR TABLE

MATL COMP	UNIQUE FACTOR FLAG	U-FACTOR
UF	1	0.67600
UH	1	0.67600
PD	0	0.87600
GP	0	0.87600
OU	0	0.84500
SP	0	0.88100
RD	1	0.88100
UD	1	0.88100
HS	0	0.88100
AD	1	0.60000
DP	1	0.86000
SL	1	0.80000
DW	0	0.99999
FW	0	0.99999
LW	0	0.99999

CHART 2. Assignment of Element Factors



which was recorded on the transfer document. A schematic diagram of this process is shown on Chart 8.

From Chart 1, there are seven material composition codes for which the factor flag is one. The source of the element factor for these seven material composition codes varies. For full and empty UF_6 cylinders (codes UUF and UUH), the verified enrichment plant value is used. For ammonium diuranate, dirty powder, and grinder sludge (codes UAD, UDP, and USL), each item is sampled and analyzed by the Analytical Lab for percent uranium. This value is then applied by NICS to the item. For rods (code URD), the specific lot uranium factor, as determined by the Analytical Lab, is applied to each item. For bundles (code UUD), the value is determined by the bundle transfer program (BUNCO). This is accomplished by assembling the component rod IBM cards in a deck, and running them through BUNCO, which produces a summary like that shown in Chart 3. This summary lists the uranium content of each rod, and the total for the bundle. The bundle element factor is determined by dividing the bundle element weight by the bundle net weight. This procedure is equivalent to a weighted average of all component rods.

C. Isotope Factors

Charts 4 and 5 show how isotopic values are assigned to a project enrichment account. Uranium for a new account is received into ICA-1 based on the receivers measured weights, and the verified enrichment are added to the factor table, and the associated specific isotope factor is assigned a composite value of all uranium received. When material is subsequently transferred throughout the plant, NICS keys on the project and nominal enrichment codes recorded for each item on the material transfer documents. NICS then searches the isotope factor table for the same project and nominal enrichment, and assigns the associated isotope factor to that item. A schematic diagram of this process is shown in Chart 8.

When all the uranium has been processed, and the finished fuel bundles are ready for shipment, the project average enrichment is calculated. The procedure involved will be discussed in the next subsection. This value then replaces the initial value in the factor table, and is applied to all fuel bundles. The project average enrichment is also applied to all residual material, at the time of a physical inventory, using the INSUM program.

D. Project Average Enrichment

Charts 6 and 7 show the steps involved in determining the project average enrichment. For each lot of material produced, the plant measured isotope values are averaged and tested statistically against the enrichment plant (UF_6 cylinder) isotopic value from which the lot was derived. All lots within the project enrichment are then divided into two groups; those which pass the test, and those which fail it. In either case, the net weight of the lot is multiplied by the plant measured element factor for that lot to yield the lot element weight. That result is then multiplied by the appropriate isotope factor, based on the results of the test, to give the lot isotope weight. Lots passing the test use the enrichment plant isotope

CHART 3. Sample "BUNCO" Summary

***** B U N C O *****

BUNDLE TRANSFER PROGRAM

PROJECT = REACTOR POWER RELOAD 1

R PROJECT LETTER
0001 PROJECT CODE

NOMINAL ENR	U-235 FACTOR
*******	******
300	.030000

BUNDLE = BUNDLE03 PROJECT = REACTOR POWER RELOAD 1
****

ROD	NOM ENR	U-235 FACTOR	U FACTOR	NET WEIGHT	ELEMENT WEIGHT	ISOTOPE WEIGHT
---	---	---	---	---	---	---
ROD00010	300	.030000	.RR096	2837.50	2499.55	74.99
ROD00011	300	.030000	.RR095	2837.00	2499.26	74.98
ROD00012	300	.030000	.RR100	2838.00	2500.28	75.01
ROD00013	300	.030000	.RR105	2838.00	2500.42	75.01
ROD00014	300	.030000	.RR098	2837.50	2499.78	74.99
			TOTAL	14188.00	12499.29	374.98

BUNDLE = BUNDLE03 741 REPORT SUMMARY

NOM ENR	U-235 FACTOR	ELEMENT FACTOR	NET WEIGHT	ELEMENT WEIGHT	ISOTOPE WEIGHT
---	---	---	---	---	---
300	.030000	.RR098	14188.00	12499.29	374.98

CHART 4. Assignment of Isotope Factors

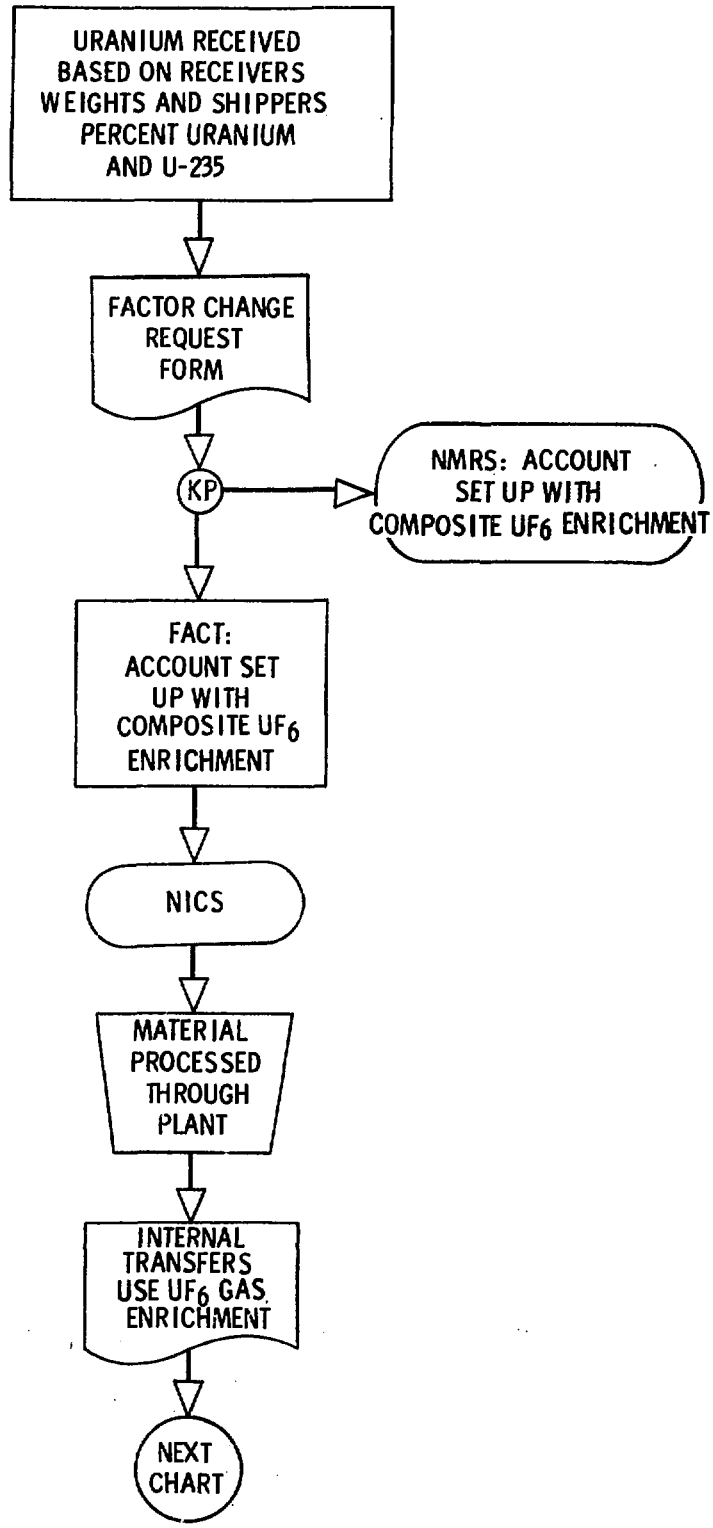


CHART 5. Assignment of Isotope Factors

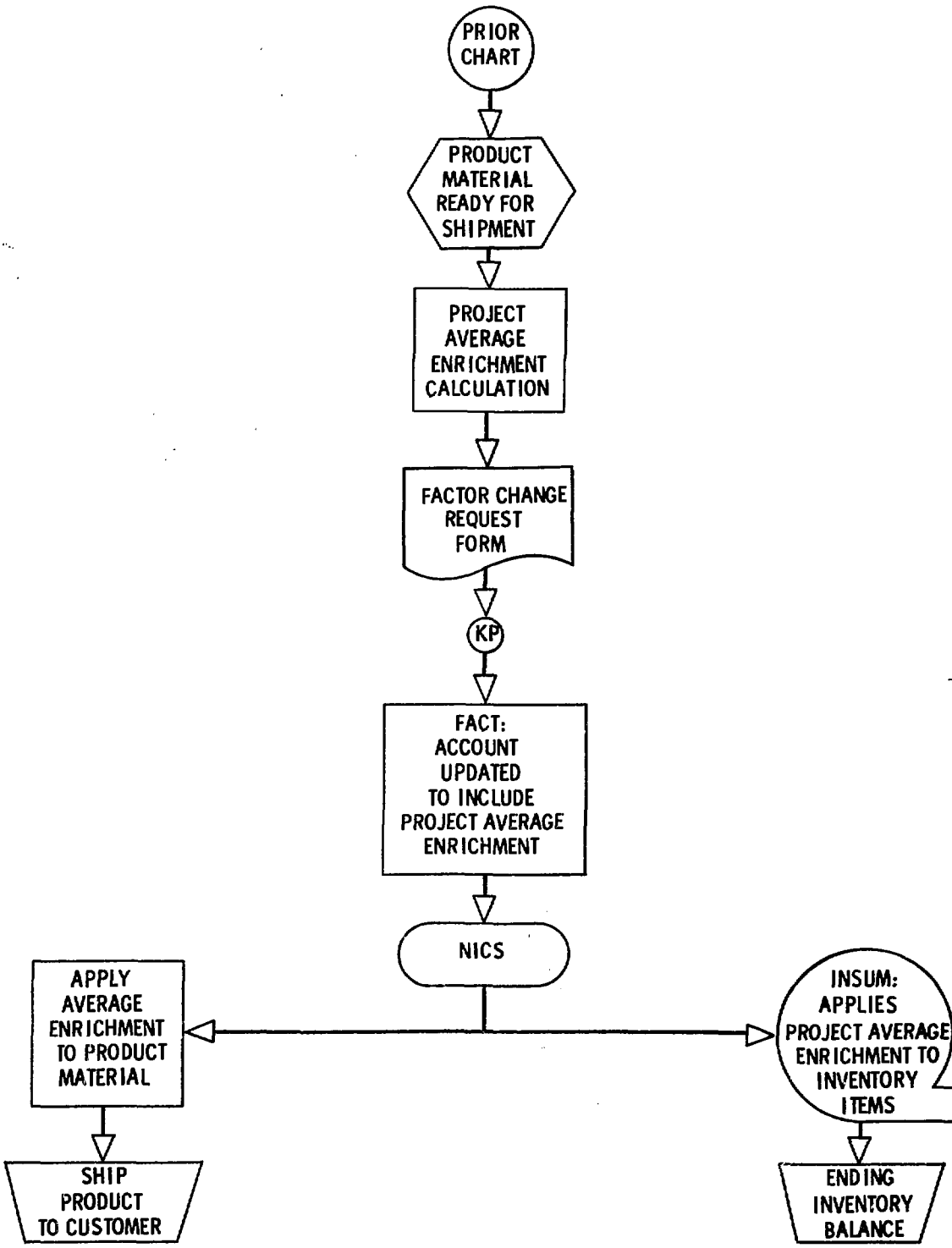


CHART 6. Project Average Enrichment

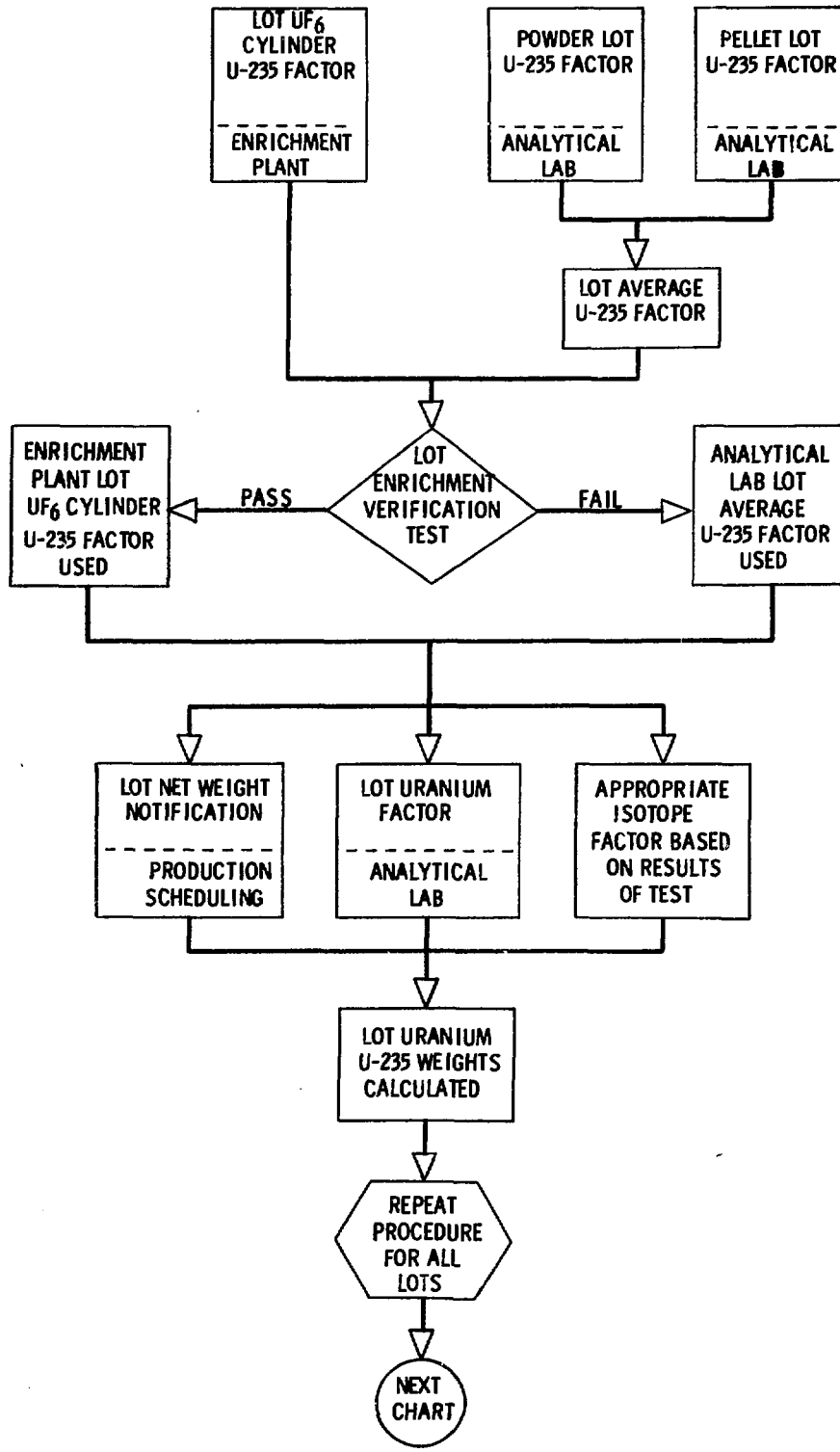


CHART 7. Project Average Enrichment

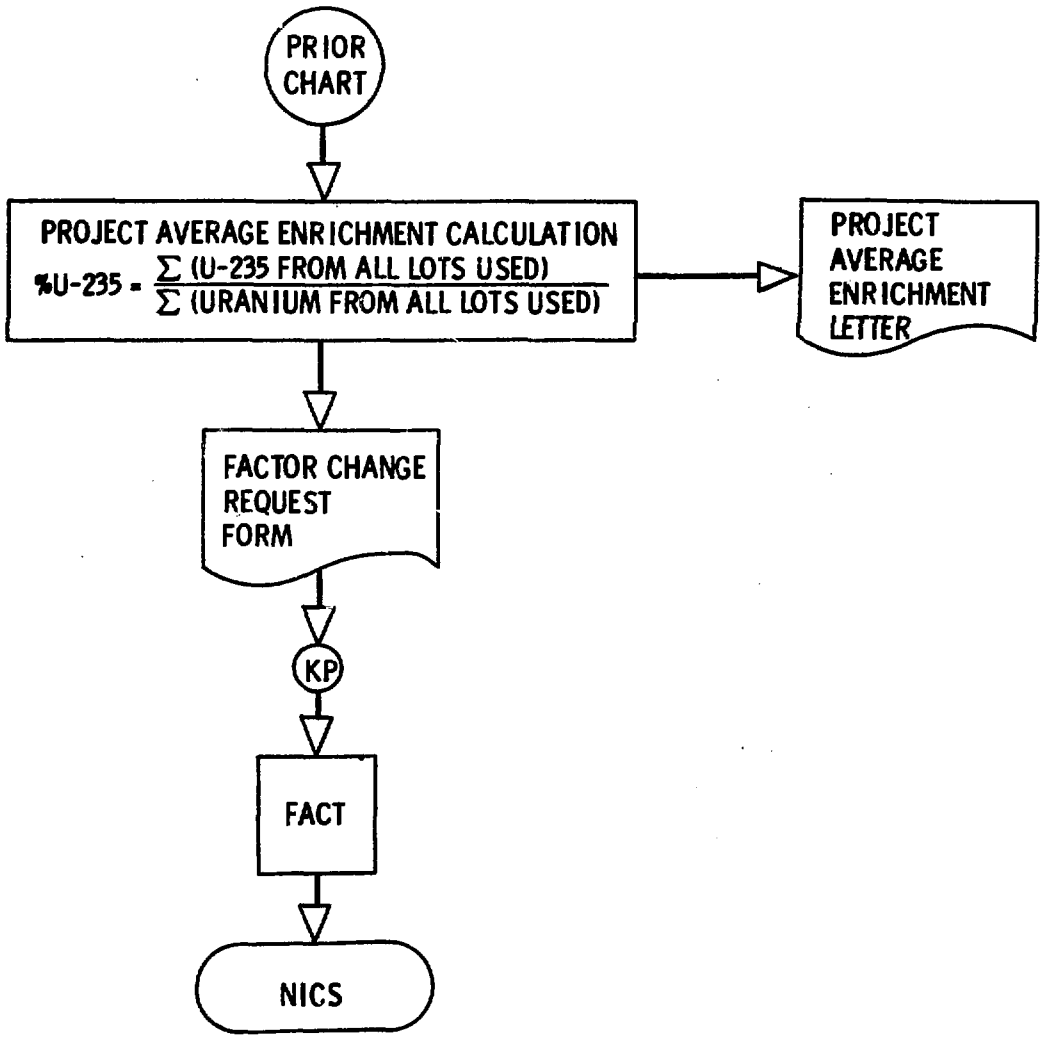
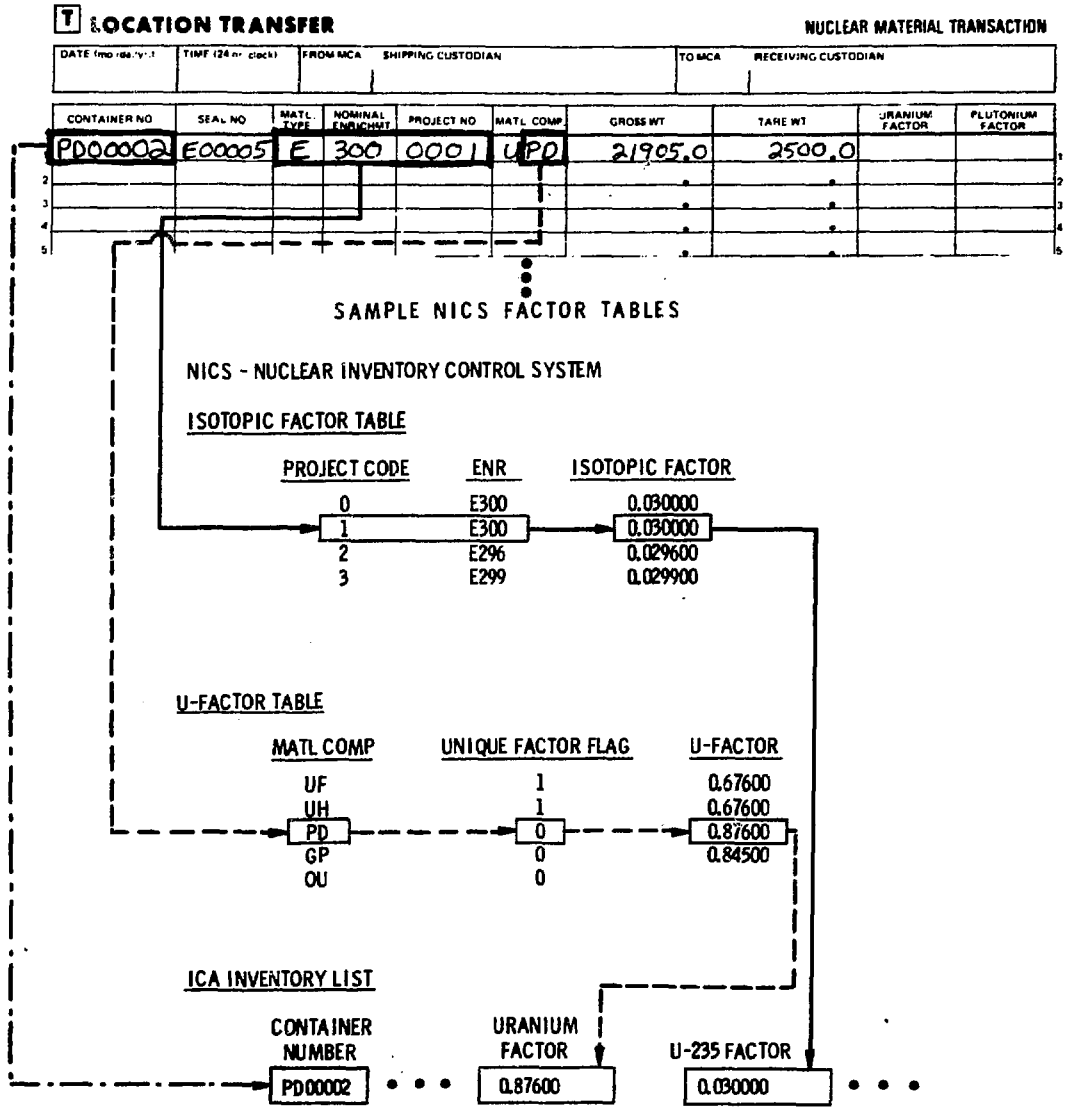


CHART 8. Step-by-Step Process for Assigning Element and Isotope Factors



factor, while those lots failing the test use the plant measured average lot isotope factor. The isotope and element weights for all lots used in the reload are summed, and the project average enrichment is determined by dividing the isotope weight sum by the element weight sum.

A summary of the assignment of element and isotope factors is provided in Chart 9.

E. Data Treatment

The uranium element factors for UO_2 powder and sintered pellets are based on the measured averages of powder and pellet lots. The values for those factors are monitored using cusum plots. The average values for percent uranium of each pellet and powder lot produced are plotted on a cusum graph. Typically five gravimetric analyses are done on each pellet lot and three on each powder lot. If a shift in the process average is detected by the cusum technique, a new factor which is based on the new process average is computed and entered into the factor table.

The uranium element factor data are examined for correctness by the Analytical Laboratory. The data are also evaluated statistically for internal consistency using a chi-square test before being included in the cusum plots.

The isotopic factor data used in determining the weighted average enrichment of a given project-enrichment are based on the average of the mass spectrometer measurements of samples taken from each powder-pellet lot produced. Typically two or more U-235 analyses are made on each pellet lot and one or more on the corresponding parent powder lot. The U-235 data are also evaluated for correctness and internal consistency before being used for accounting purposes.

The general subject of data treatment is discussed in more detail in the session on the Measurement Control Program.

CHART 9. Summary of Assignment of Factors by NICS

ELEMENT FACTORS

1. UF_6 GAS RECEIVED USING VERIFIED ENRICHMENT PLANT VALUES
2. FACTOR IN TABLE IS USED FOR INTERNAL TRANSFERS IF FLAG = 0
3. FACTOR ON TRANSFER IS USED FOR INTERNAL TRANSFERS IF FLAG = 1
    a) FOR CYLINDERS VERIFIED ENRICHMENT PLANT VALUE IS USED
    b) FOR SCRAP UO_2, ANALYTICAL LAB VALUE IS USED
    c) FOR RODS, LOT VALUE IS USED
    d) FOR BUNDLES, WEIGHTED AVERAGE OF COMPONENT ROD VALUES USED

ISOTOPE FACTORS

1. UF_6 GAS RECEIVED USING VERIFIED ENRICHMENT PLANT VALUES
2. PROJECT ENRICHMENT ACCOUNT SET UP USING COMPOSITE UF_6 GAS ENRICHMENT
3. INTERNAL TRANSFERS USE ENRICHMENT IN ISOTOPE FACTOR TABLE
4. PROJECT AVERAGE ENRICHMENT DETERMINED WHEN ALL MATERIAL HAS BEEN PROCESSED
    a) THIS VALUE IS APPLIED TO ALL BUNDLES PRIOR TO SHIPMENT
    b) THIS VALUE IS APPLIED TO INVENTORY ITEMS, VIA INSUM, FOR PHYSICAL INVENTORIES