KfK 4017
Dezember 1985

Investigations on Detection Sensitivity of the NRTA Method for Different Size Reprocessing Facilities

Part I:
Input Data and Analysis of Results

D. Gupta, U. Bicking, G. Koutsouvelis

Part II:
Results of Computer Simulation

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Part II: Results of Computer Simulation

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ISSN 0303-4003

Abstract

The capability and limitations of the NRTA method (Near-Real-Time Accountancy method) in reprocessing facilities with different throughputs and inventories and measurement uncertainties, were investigated with a detailed computer simulated data base. These investigations have confirmed the earlier findings that the NRTA method could permit under certain operating conditions and for a number of realistic diversion scenarios, a perceptible improvement in the detection capability. Depending on the conditions prevailing, such improvements could be by a factor of 10-20, both for the detectable amounts and the detection time, over the conventional material balance method with annual inventories.

The reasons for and the conditions which would permit such improvements have been discussed in detail with numerical examples in the report.

Untersuchungen über Entdeckungen von Verlustmengen durch die Methode der Echtzeitbilanzierung für Wiederaufarbeitungsanlagen unterschiedlicher Größe

Zusammenfassung

An Hand einer detaillierten parametrischen Untersuchung mit computer-simulierten Datensätzen wurde die Empfindlichkeit der Echtzeitbilanzierungsmethode (Near Real Time Accountancy Method) in Wiederaufarbeitungsanlagen mit verschiedenen Durchsätzen und Pu-Inventaren im Prozeßbereich untersucht. Die Untersuchung bestätigt die frühere Feststellung, daß diese Methode unter gewissen Betriebsbedingungen und bei einer Anzahl von realistischen Abzweigszenarien eine merkliche Verbesserung bei der Entdeckung abgezweigter Mengen und der Entdeckungszeit ermöglichen kann. Die Verbesserungen können, je nach den vorliegenden Bedingungen, gegenüber der konventionellen Bilanzierungsmethode mit jährlicher Inventur bei einem Faktor zwischen 10 und 20 liegen.

Die möglichen Gründe für diese Verbesserungen, sowie die Bedingungen, unter denen solche Verbesserungen erwartet werden können, werden an Hand konkreter Beispiele in dem Bericht ausführlich diskutiert.

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List of Abbreviations

BP	balancing period
C-I, I-C	constant inventory in the process MBA in kg
DS	diversion scenarios
D_T	detection time expressed as the number of BPs after which the diversion of a given amount M can be detected with a given P_D
FT	facility throughput in t/a
LR-I, I-LR	linearly reduced inventories in the process MBA with decreasing FT in kg Pu
LI	limits of error in inventory measurements in kg
LT	limits of error in throughput measurements in kg
LMUF	limits of error of Material Unaccounted For in kg
M	total amount of Pu assumed to be diverted for a given diversion scenario, in kg
ΔM	fraction of M assumed to be diverted per balancing period for a given diversion scenario, in kg
MBA	material balance area
P_D	detection probability in % with a false alarm rate α of 5 %
σ_i, σ	measurement uncertainties at the input of a reprocessing facility, in %, rest of the measurement uncertainties being the same as given in Table 1
α	false alarm rate, fixed at 5 % throughout the investigations

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Note: All the input data used in the present investigations are included in Tables 1-11B.

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Table I (ctd.)

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Table I (ctd.)

Table No.	Contents
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Abbreviations frequently used:

BP	balancing period
C-I, I-C	constant inventory in the process MBA in kg
DS	diversion scenarios
D_T	detection time expressed as the number of BPs after which the diversion of a given amount M can be detected with a given P_D
FT	facility throughput in t/a
LR-I, I-LR	linearly reduced inventories in the process MBA with decreasing FT in kg Pu
LI	limits of error in inventory measurements in kg
LT	limits of error in throughput measurements in kg
LMUF	limits of error of Material Unaccounted For in kg
M	total amount of Pu assumed to be diverted for a given diversion scenario, in kg
ΔM	fraction of M assumed to be diverted per balancing period for a given diversion scenario, in kg
MBA	material balance area
P_D	detection probability in % with a false alarm rate α of 5 %
σ_i, σ	measurement uncertainties at the input of a reprocessing facility, in %, rest of the measurement uncertainties being the same as given in Table 1
α	false alarm rate, fixed at 5 % throughout the investigations

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7A, 7B	P_D (%) vs ΔM/LMUF, for different FT with I-C and different σ_i's for DS - 7 (7A presented on normal paper, 7B on probability paper)
8A, 8B, 8C	P_D vs M for different FT with I-LR and different σ_i's (8A 0.1 %, 8B 1 %, 8C 2 %) for DS - 1
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Table II: List of Figures

Fig. No.	Description
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18A, 18B, 18C	P_D vs BP with FT as parameter for M = 5 kgPu for different σ_i's (18A 0.5 %, 18B 1 %, 18C 2 %) and DS - 7
19A, 19B, 19C	P_D vs BP with FT as parameter with 1 % σ_i for M = 5 kg (19A), 10 kg (19B) and 20 kg (19C) and DS - 7
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21A, 21B	Number of BP's at which P_D > 95 % is obtained for a given M in a facility with I-LR (21A) and I-C (21B) for DS - 7

Abbreviations frequently used:

BP	balancing period
C-I, I-C	constant inventory in the process MBA in kg
DS	diversion scenarios
D_T	detection time expressed as the number of BPs after which the diversion of a given amount M can be detected with a given P_D
FT	facility throughput in t/a
LR-I, I-LR	linearly reduced inventories in the process MBA with decreasing FT in kg Pu
LI	limits of error in inventory measurements in kg
LT	limits of error in throughput measurements in kg
LMUF	limits of error of Material Unaccounted For in kg
M	total amount of Pu assumed to be diverted for a given diversion scenario, in kg
ΔM	fraction of M assumed to be diverted per balancing period for a given diversion scenario, in kg
MBA	material balance area
P_D	detection probability in % with a false alarm rate α of 5 %
σ_i, σ	measurement uncertainties at the input of a reprocessing facility, in %, rest of the measurement uncertainties being the same as given in Table 1
α	false alarm rate, fixed at 5 % throughout the investigations

Table III: Tables and corresponding figures with some comments.

Content	Table No.	Figure No.	Comments
FT, I, σ_i's for reprocessing facilities investigated	1		Input data no corresponding figures are given
var, LMUF, LT, LI for σ_i = 0,5, 1, 2 % FT = 1000, 500, 240, 100 for I-LR Same as in 2A but for I-C.	2A 2B	1A, 1B	LMUF is linear with I-LR, curved with I-C; LMUF values converge to LI values for 100 t/a and to LT values for 1000 t/a.
Diversion strategies (DS) and ΔM/DS for DS - 1, 2, 3, 4, 5, 6, 7	3, 4	-	Input data no corresponding figures.
ΔM/LMUF for σ_i = 0.5, 1, 2 % FT = 1000, 500, 240, 100 for I-LR Same as in 5A but for I-C. Both tables for DS - 1	5A 5B	2A (σ_i 1 %) 2B (σ_i 1 %)	Figures 2A and 2B are only examples for 1 % $\sigma_S = \sigma_R$. For I-LR, ΔM/LMUF values increase continuously since LMUF → 0 for low FT. For I-C they tend to converge to a constant value for smaller facility sizes since LMUF → LI → constant.
ΔM/LMUF for σ = 0.5, 1, 2 % for FT = 1000 and for σ = 1 % for FT = 500, 240, 100; only for I-LR for DS - 2, 3, 4, 5, 6	DS2 - Tab.6 DS3 - Tab.7 DS4 - Tab.8 DS5 - Tab.9 DS6 - Tab.10	no corresponding figures	Figs. 2A and 3A are illustrative figures for these tables also. No special comments.
ΔM/LMUF for σ = 0.5, 1, 2 % FT = 1000, 500, 240, 100; I-LR Same as in Table 11A but for I-C. for DS - 7	11A 11B	3A (σ 1 %) 3B (σ 1 %)	Figs. 3A and 3B are only given as examples for 1 % = $\sigma_S = \sigma_R$. Same trend is seen as for DS 1 in Figs. 2A and 2B. For a given DS same values of ΔM/LMUF are obtained for different FT and inventory values. This opens up the possibility of simplifying the use of NRTA methods.
P_D vs. M and FT converted to ΔM/LMUF values for different σ_i = 0.5, 1, 2 % for I-LR Same as in 12A but for I-C. for DS - 1	12A (M, FT) 12B (M, FT)	4A, 4B (converted to ΔM/LMUF values from Tables 5A, 5B)	P_D vs. ΔM/LMUF presentation makes it possible to determine the sensitivity of NRTA in a simple fashion for different FT I's and σ_is: i) LMUF/BP to be calculated for a facility, the ΔM which is assumed to be diverted abruptly fixed, then the P_D is read for the corresponding ΔM/LMUF value or ii) for a given P_D the corresponding ΔM/LMUF value read from the curve for a given DS and M determined for different MUF/BP for a facility. Examples given in the report.
P_D vs. ΔM/LMUF for σ = 1 % FT = 1000, 500, 240, 100 and I-LR for DS - 2, 3, 4, 5, 6	DS2 - Tab.13 DS3 - Tab.14 DS4 - Tab.15 DS5 - Tab.16 DS6 - Tab.17	Fig. 5A, 5B (presented on normal and probability paper respectively)	Same comments as for Tables 12A, 12B and Figs. 4A, 4B.
P_D vs. ΔM/LMUF for σ = 0.5, 1, 2 % for I-LR Same as in Table 18A but for I-C. for DS - 7	18A (M, FT) 18B (M, FT)	6A, 6B 7A, 7B (presentations are made for ΔM/LMUF values from Tables 11A, 11B)	Same comments as for Tables 12A, 12B and Figs. 4A, 4B.
P_D vs. BP for σ = 0.5, 1, 2 % for FT = 1000, 500, 240, 100 for I-LR for DS - 1 P_D vs. BP for σ = 0.5, 1, 2 % for FT = 1000, 500, 240, 100 for I-LR for DS - 7	19, 20, 21 22, 23, 24	17 18	1. The tables contain only the data for 1000 t/a facility. Data for the rest of the facilities are directly taken for the figures from computer printouts. 2. Only the values for 5 kg have been presented in the figures to illustrate the general trend.

Abbreviations frequently used:

BP	balancing period
C-I, I-C	constant inventory in the process MBA in kg
DS	diversion scenarios
D_T	detection time expressed as the number of BPs after which the diversion of a given amount M can be detected with a given P_D
FT	facility throughput in t/a
LR-I, I-LR	linearly reduced inventories in the process MBA with decreasing FT in kg Pu
LI	limits of error in inventory measurements in kg
LT	limits of error in throughput measurements in kg
LMUF	limits of error of Material Unaccounted For in kg
M	total amount of Pu assumed to be diverted for a given diversion scenario, in kg
ΔM	fraction of M assumed to be diverted per balancing period for a given diversion scenario, in kg
MBA	material balance area
P_D	detection probability in % with a false alarm rate α of 5 %
σ_i, σ	measurement uncertainties at the input of a reprocessing facility, in %, rest of the measurement uncertainties being the same as given in Table 1
α	false alarm rate, fixed at 5 % throughout the investigations

Content	Table No.	Figure No.	Comments
P_D vs. BP for σ = 1 % FT = 1000,500, 240, 100 for I-LR for DS - 7	22, 23, 24	19	1. The tables contain only the data for 1000 t/a facility. Data for the rest of the facilities are directly taken for the figures from computer printouts. 2. Only the values for M = 5 kg (Fig. 19A), 10 kg (19B) and 20 kg (19C) are presented in the figures to indicate the general trend.
P_D vs. BP for σ = 1 FT = 1000, 500, 240, 100 for I-LR for DS - 1, 2, 3, 4, 5, 6, 7	DS1 - Tab.25-28 DS2 - Tab.29-32 DS3 - Tab.33-36 DS4 - Tab.37-40 DS5 - Tab.41-44 DS6 - Tab.45-48 DS7 - Tab.49-52	17 for DS - 1 18, 19 DS - 7	1. The data in the tables indicate that similar P_D values are obtained by the test procedure used in the investigation, for the first five DS; these DS can be considered to be as abrupt diversion and DS 6 and 7 as protracted diversion. 2. Above certain values of M for a given facility, same P_D for all DS is obtained. 3. The larger the value of M or smaller the facility, the shorter is the detection time.
P_D vs. M with FT as parameters for different σ_is and I-LR Same as in Fig. 8 but with I-C. for DS - 1	53A	8 9	1. The P_D improves with reduced σ_is and/or smaller size facilities. 2. The improvements in P_D are slightly dampened for smaller facilities with I-C since LIs for small facilities are increased.
P_D vs. M with FT as parameters for σ_i = 0.5, 1, 2 % for I-LR Same as in Fig. 10 but for I-C for DS - 7	53B	10 11	1. With low values of σ's (0.5, 1 %) 100 % P_D for all values of M and both I-LR and I-C in a 100 t/a facility. 2. For I-C P_D = 100 for 100 t/a facility for all values of M and σ's investigated. 3. P_D vs. M values are about same for all small facilities because LMUF → LI → constant for all these facilities.
P_D vs. M for I-LR and I-C for σ_i's = 1, 2 % for FT = 500 Same as in Fig. 12 but for FT = 240 for DS - 7	53B	12 13	1. The values for 1000 t/a are same for all the parameters, the 100 t/a facility shows insignificant differences, therefore, values only for FT = 500, 240 shown in Figs. 12 and 13. All the values for DS - 1 differ insignificantly. Therefore, only those for DS - 7 have been shown. 2. The difference between I-LR/I-C is smaller for 500 t/a than 240 t/a.
M which can be detected with P_D = 95 % for different FT, σ_i's and I-LR Same as Table 54 but for I-C for DS - 1	54 55	16A	1. M for 95 % P_D is linear in FT. } for I-LR. 2. M for a facility is linear in σ_i. } 3. M for 95 % P_D is slightly concave for I-C.
M which can be detected with P_D = 95 % for different FT and σ's with I-LR Same as in Table 56 but for I-C. for DS - 7	56 57	16B	1. In general M in which can be detected with 95 % P_D increases for all the FTs < 500 for all σ's. 2. In general M is larger for I-C than I-LR for all smaller facilities.
D_T expressed as number of BP at which >95 % P is obtained for different FT, 1 % σ, (58) 0,5 %, 1 %, 2 % (58A), I-LR for DS - 1 and DS - 7 Same as in Tabs. 58, 58A but for I-C for DS - 1 and DS - 7	58, 58A 59, 59A	20A, B 21A, B	With increasing M or decreasing FT D_T improves, i.e. ≥ 95 % P_D is obtained at an earlier BP.
P_D as a function of DS D_T as a function of DS	60 61	no Figs. no Figs.	The values for P_D for DS - 1-5 appear similar and, therefore, these DS can be considered to be abrupt diversion, particularly for smaller amounts. With larger amounts M P_D values for DS - 1, 7 tend to converge.

Investigations on Detection Sensitivity of the NRTA Method for Different Size Reprocessing Facilities

Part I: Input Data and Analysis of Results

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Executive Summary

1. Introduction

In an international workshop on the Near-Real-Time Accountancy (NRTA) method /1/, it was recognized and confirmed that sequentially generated material balance data in the process MBA of a reprocessing facility could provide under certain operating conditions, a more sensitive detection capability for a possible diversion than that obtained in a conventional material balance method, in which a material balance is struck normally every year.

In the present report (part I and part II) detailed investigations with computer simulated data with different relevant parameters for a reprocessing facility have been carried out to analyze the influence of these parameters on the sensitivity of the NRTA method.

2. Parameters Investigated

The main sets of parameters investigated in this report are the facility throughputs (FT) and inventories (I-LR, I-C), measurement uncertainties at the input accountability tank σ_i's, amounts assumed to be diverted M and

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diversion scenarios DS (for explanation of the abbreviations see page A-3 and Tables I, II, III). These parameters are listed in chapter 2, part I of the report.

3. Input Data

The 1000 t/a reprocessing facility as described in /5/ has been used as the reference facility, working 200 days/a. A material balance has been assumed to be made every 10 working days so that, 20 balancing periods, BP, are obtained per year, with 20 separate MUF values. In the case of linearly reduced inventories, I-LR, the other facility throughputs (500, 240, 100 t/a) and inventories are linearly scaled down from the reference case. For the cases with constant inventories, I-C, the facility throughputs are scaled down for the other facilities, but the process inventories for all the facilities are kept constant at the level of the reference facility i.e. 450 kg of Pu. Only the measurement uncertainties σ_i at the input of the reprocessing facility are varied in the range of 0.5 %, 1 % and 2 %, the other measurement uncertainties are kept the same as in the case of the reference facility.

The same seven diversion scenarios (DS-1 to DS-7) which were first used in /2/, have been chosen for this series of investigations as well. DS-1 in which a given amount M is assumed to be diverted during a single balancing period is defined as the abrupt mode of diversion. DS-7 is on the other hand, defined as the protracted mode of diversion. In this mode, the same given amount is assumed to be diverted in equal portions over 20 successive balancing periods. The DS-2 to DS-6 fall in between these two extreme diversion scenarios. For each of the diversion scenarios, 20 diversion free BPs are assumed to exist after which a particular mode of diversion begins. For each of the parameters a complete run length for 40 BPs has been made.

The two sided Page's test /2, 3, 4/ has been chosen for analyzing the sensitivity of the NRTA method. The reasons for this particular choice have been discussed in detail in para. 1 of part I of this report.

4. Analysis of Results

The results of the present series of investigations have been presented in two parts. Part I contains the input data and the analysis of the results. In part II all the results of computer simulation have been presented.

These results can broadly be categorized into two groups, one dealing with the amounts which can be detected with a probability of detection $P_D \geq 95$ % under a given set of conditions and the other, dealing with the detection time D_T i.e. the time which elapses after the amount, assumed to be diverted under a given set of conditions, can be detected with a probability of detection P_D of ≥ 95 %.

In all these investigations, the P_D with the false alarm rate α of 5 % at the end of the 40th BP (or at the end of 20th BP when counted from the starting point of a diversion at the 20st BP) has been used as the main indicator for the sensitivity analysis.

4.1 General Findings

The investigations have in general confirmed the earlier findings /2/ that the NRTA method can improve the sensitivity of the capability of detection of a diversion over the conventional balancing method.

i) With the same measurement systems and operating conditions as in the reference 1000 t/a facility, it may be possible to detect about 28 kg of Pu if diverted according to the protracted mode of diversion and about 17 kg of Pu if diverted abruptly - both with a $P_D \simeq 95$ %. This corresponds to an improvement by a factor of $\simeq$10-20(depending on the mode of diversion) over that possible in a conventional material balancing method.

ii) New is the finding that not only the detectable amounts for a given P_D, but the detection time D_T also, improves with the NRTA method.

In the same reference facility of 1000 t/a, an abrupt diversion of 25 kg Pu for example, could be detected within 3 weeks of the diversion with over 99 % P_D i.e. almost with certainty.

iii) In general, both the P_D and D_T improves with increasing values of the ratio ΔM/LMUF (ΔM: amounts assumed to be diverted per BP; LMUF: measurement uncertainty of material unaccounted for). This happens:

- in a facility with improved values of measurement uncertainties at the input σ_i and with increasing amounts assumed to be diverted per BP

- for a given measurement uncertainty σ_i and process inventory, with decreasing size of the facility

- when one proceeds from protracted to abrupt mode of diversion.

iv) For a given facility, the sensitivity of the NRTA method decreases with increasing amounts of process inventory. However, the reduction in the sensitivity is somewhat dampened by the fact that, the systematic component of the measurement uncertainty for process inventory, cancels out and therefore, does not contribute to the total uncertainty of the MUF per balancing period.

4.2 Simplified Method of Sensitivity Method Evaluation

An interesting side effect of these investigations is the recognition of the fact, that the ratio ΔM/LMUF (ΔM: amount assumed to be diverted per balancing period; LMUF: the limit of uncertainty of MUF per balancing period), could provide a simplified basis for an a priori analysis of the sensitivity of the NRTA method in different size reprocessing facilities.

The main reason for this simplification lies in the fact that for a given assumed diversion scenario, the same values of $\Delta M/LMUF$ are obtained for different facility throughputs, inventories and measurement uncertainties. If the $\Delta M/LMUF$ values are plotted against the corresponding P_D values on a probability graph paper for a given DS, a straight line is obtained. The possibilities of using this simplified method is illustrated in para. 4.2 of part I of this report.

4.3 Sensitivity of the NRTA Method for Detectable Amounts M

The sensitivity has been investigated for different facility throughputs and inventories (FT, I-LR, I-C), measurement uncertainties (σ_i's) and diversion scenarios DS. The P_D has been determined for all these parameters for different values of M in the range of 5-40 kg of Pu at intervals of 5 kg. Out of a large number of specific findings discussed in detail in paras. 4.3-4.3.3 of part I of this report some are worth repeating in the summary.

i) In all the cases with linarly reduced inventories (I-LR), the detectable amount M for $P_D \simeq 95$ % decreases linearly with decreasing size of the facility and decreasing value of σ_i. This M is somewhat smaller for abrupt diversion DS-1 than for protracted diversion DS-7. For example
M/P_D 95 is 17 kg for 1000 t/a reducing to 1.7 kg in 100 t/a for DS-1
and is 28 kg for 1000 t/a reducing to 2.8 kg in 100 t/a for DS-7.
In the final analysis, this linearity is caused mainly by the systematic component of the measurement uncertainty at the input which is linear in the total amount measured.

ii) In the cases with constant inventories, M/P_D 95 for some smaller facilities increases, the rate of increase being larger for the smaller size facilities, since for these facilities, the uncertainty in the inventory measurements (LI) dominates the total uncertainty of the MUF (LMUF). For the same reason, the influence of σ_i's on the sensitivity of the NRTA method in smaller size facilities (for I-C) gets reduced. In a 100 t/a facility for example, the M/P_D 95 remains around 8 kg for DS-1 and 10 kg for DS-7 for all the values of σ_i's considered.

iii) Remarkable improvements in the sensitivity of the NRTA method are observed with 0.5 % σ_i at the input. For a 1000 t/a facility with a detection capability of 11-18 kg Pu (M/P_D 95) for DS-1 to DS-7 respectively, for about 20,900 kg of Pu measured per year, the sensitivity corresponds to about 1 per 1000. With constant inventories in smaller facilities, the M/P_D 95 ranging between 8-10 kg, the sensitivity remains around 3 per 1000.

iv) The difference in the sensitivity of detection between abrupt and protracted diversion vanishes above a certain value of M, i.e above this amount, the sensitivity becomes independent of the diversion strategies considered here. This amount depends on the facility size, measurement uncertainty at the input and the amount of inventory in the process MBA. For a 1 % σ_i at the input, this value of M is about 30 kg ($P_D \geq 95$ %) for a 1000 t/a and 10 kg for a 100 t/a facility for <u>all</u> inventory conditions and diversion scenarios considered.

4.4 Sensitivity of the NRTA Method with Regard to Detection Time D_T

New in this series of investigations is the analysis of sensitivity of the NRTA method with regard to detection time D_T. The D_T is defined here as the time interval which elapses after the diversion of the amount M is assumed to start, until the detection of this amount takes place with a probability of detection of ≥ 95 %. The detection time is expressed as the number of BPs after which a detection with the given P_D takes place. Since all the diversion scenarios DS in this series have been assumed to start at the 21st BP (i.e. after 20 diversion free BPs), the counting of the elapsed number of BPs starts from the 21st BP so that 21. BP = 1. BP.

As in the case of the detectable amounts M, the detection time D_T improves in general with larger values of ΔM/LMUF. The detailed analysis of this part of the results, is given in paras. 4.4-4.4.3 of part I of this report. A number of interesting trends however, has been presented here:

i) In a given facility, there is always a minimum amount M_o for a $P_D \geq 95$ %, below which the D_T cannot be shortened to a value which is less than 20 BP i.e. one year, after a diversion has been assumed to begin. However, with increasing amounts, the D_T in the same facility improves in general.

In the 1000 t/a reference facility, the minimum amount M_o which can be detected for DS-7 with $P_D \geq 95$ % at the end of the 20th BP is 28.3 kg. With M = 30 kg, a detection with $P_D \geq 95$ % can be made already after the 18th BP. Such improvements are much more pronounced in smaller facilities with I-LR.

ii) In the cases with constant inventories I-C, the D_T is lengthened or the P_D reduced for a given value of M and σ_i. However, with increasing values of M for smaller facilities, the D_T and P_D values tend to cluster around a single value, which is independent of the σ_i's. For example, for M = 15 kg , in both 240 t/a and 100 t/a facilities, the D_T remains around 3 BP with $P_D \simeq 99$ % for DS-1 and around 15 BP with $P_D \simeq 97$ % for DS-7 for <u>all the values of σ_i's</u> considered. This particular effect can directly be traced back to the dominating influence of LI in the LMUF for the smaller size facilities with constant inventories. With still larger values of M the differences amongst the cases with different process inventories and diversion scenarios also tend to disappear. For example, for M = 30 kg a D_T = 1 BP is obtained for a $P_D \geq 99.9$ % for all the three small facilities, for all the σ_i, DS and inventory cases considered.

iii) Whenever the diversion of an amount M is detected within 3 BPs after it has been assumed to begin, this detection is associated with a very high value of nearly 100 %. This is independent of the diversion scenarios considered. The high values of P_D associated with very short detection times, is mainly caused by the fact that the ratios ΔM/LMUF in such cases are always so large that they force the P_D to shoot up almost immediately to very high values. As a result a $P_D \geq 99.9$ % is obtained within the first few balancing periods after a diversion has been assumed to begin.

iv) Of the seven diversion scenarios considered in this series, the first five scenarios may be considered to belong to the category of abrupt diversion and the 6th and 7th to the protracted diversion. Considered from the point of view of the sensitivity, this means that the sensitivity of the NRTA method remains virtually the same for the first five diversion scenarios and then may get reduced somewhat (depending on the facility size and inventory and σ_i's at the input) in the cases for DS-6 and DS-7.

5. Concluding Remarks

The main purpose of the present series of detailed investigations with computer simulated data, had been to understand and recognize the factors which influence the sensitivity of the detection capability of the NRTA method in a reprocessing facility, and not so much to generate absolute numbers. These numbers are important mainly as indicator for recognizing some general trends.

5.1 Sensitivity

The most important conclusion to be drawn from these investigations is the confirmation of the fact that the NRTA method provides a significant improvement in the sensitivity of the detection capability and detection time over the conventional material balance method in a reprocessing facility. The improvement may be in the range of a factor of 10-20, depending on the facility size, amounts of process inventory, accuracy of measurement system and the possible mode of diversion.

5.2 Test Procedure Used

The statistical test procedure i.e. the two sided Page's test used in these investigations, appears to maintain its sensitivity over a wide range of abrupt and protracted diversion scenarios considered. The only important boundary condition which needs to be fulfilled is the existence of a number of diversion free balancing periods. This is the situation encountered routinely by the IAEA.

The sensitivity of this test procedure may, however, be reduced for the so-called alternating diversion scenarios in which a certain amount is assumed to be withdrawn from the process MBA during a balancing period and a smaller amount introduced in the MBA at a later balancing period. Other test procedures /6, 7/ may provide better sensitivity for such scenarios. It would, therefore, always be advantageous for the Agency to apply a number of test procedures for the same set of NRTA data from a reprocessing facility, to ensure a broad coverage for different possibilities of diversions, without loosing the sensitivity.

5.3 Computer Simulated and Realistic Data Base

The results discussed in this report are obtained through computer simulation. Under actual operating conditions in a reprocessing facility, because of deviations from the simulated situations which may exist in the facility, the sensitivity may suffer. This would mean only an upward revision of the absolute numbers for M, P_D and D_T obtained through simulation. The fundamental advantages of the NRTA method are, however, not expected to disappear.

Some research activities are under way to use actual operation data from reprocessing facilities for testing the sensitivity of the NRTA method.

Investigations on Detection Sensitivity of the NRTA Method for Different Size Reprocessing Facilities

Part I: Input Data and Analysis of Results

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1. Introduction

In an international workshop on the near real time accountancy (NRTA) /1/, it was recognized and confirmed that sequentially generated material balance data in a reprocessing facility could provide, under certain operating condition, a more sensitive detection capability with regard to the amount and the detection time compared to those obtained under the conditions of a conventional material balance system in which a balance is struck only after a given period of about one year. Some of the statistical test methods considered particularly in connection with the NRTA measure, were investigated in some detail in /3/. The main conclusion of this investigation has been that a number of test methods may have to be considered to cover a large spectrum of loss patterns and boundary conditions. No single test pattern provides the same detection sensitivity for all conceivable loss patterns of diversion scenarios.

However, one particular statistical test method, i.e. the two-sided Page's test for MUF residuals (MUFR), increases the detection sensitivity significantly, specially for such cases in which the diversion scenario begins after a number of diversion free balancing periods /4/. For example, it was shown with simulated data for a 1000 t/a reprocessing facility that about 30 Kg of Pu could be detected with a probability of detection (P_D) of 95 % and a false alarm rate (α) for 5 % using this type of test methods. The detection capability reduces to over 350 Kg of Pu for the same P_D and α and the detection time increases to one year if one carries out the material balance according to the conventional system every year /2/.

Under normal Agency safeguards practice, diversion free balancing periods are encountered very frequently. In fact, since 1977 the Agency has always stated that it has no indication to believe that a diversion has taken place for all the cases in which it has been exercising its safeguards activities. For these cases, therefore, the sequential test of MUFR could be applied. Also, whenever the Agency issues a no-diversion statement at the end of a year, all the data generated in that year in the respective bulk handling facilities including reprocessing, could be assumed to have been generated under no diversion conditions. If, for example, under such conditions, MUF data in a reprocessing facility were to be generated at every ten day interval, and the facility operated for 200 days per year, 20 data sets for 20 balacing periods would have been generated under diversion free conditions. Since such conditions are expected to be present the normal case in the future, as was in the past, the two-sided sequential test could be used for these facilities and could provide a fairly useful and powerful tool in finding out a deviation from a diversion free condition in a facility.

The present series of parametric investigations were carried out to establish the sensitivity of this method under a given set of operating conditions, as well as, to recognize any simplification possibility for using this method under routine conditions. The investigations have been restricted to the seven diversion scenarios considered in /2/. Subsequent investigations indicate that the two-sided sequential test procedure may loose some of its sensitivity for the so-called "alternating diversion strategies" i.e. strategies in which a certain amount of material is assumed to be withdrawn from the process during a balancing period and a part of it added to the process during a subsequent balancing period. Other test procedures appear to have better sensitivities for such strategies /6, 7/.

These investigations were based on computer simulated data. The input data for the simulation and the analysis of the results are presented in part I of this report. The results of the computer simulation are compiled in part II of this report.

2. Parameters Considered

The following parameters were considered:

No.	Parameters		Variations considered
1.	Facility Throughput, FT	t/a	1000, 500, 240, 100
1.1	Inventory linearly reduced, I-LR	kgPu	450, 225, 108, 45
1.2	Inventory kept constant, I-C	kgPu	450, 450, 450, 450
2.	Measurement uncertainties at the input accountability, σ_i	%	0,5 1 2
3.	Amounts assumed to be diverted, M	kgPu	5 10 15 20 25 30 35 40
4.	Diversion Scenarios, DS		1 2 3 4 5 6 7 (see Table 3 for clarification) for all the parameters under 1,1.1,1.2,2 and 3

The MUF values were assumed to be generated every 10 days, so that one Balancing Period (BP) corresponds to 10 days of operation. For each of the parameters, 40 BPs were considered out of which the first 20 BPs (1 year of operation) were assumed to be diversion free, so that all the diversion scenarios begin at the 21st BP. Therefore, in a number of tables containing the results of investigations, whenever relevant, the 21st BP was considered to be the first BP for counting the number of BPs after which a diversion with a given probability of detection was calculated.

The same MUF generation model as in /2/ has been used for the parametric investigations with, however, the two-sided Page's test instead of the power-one test used in /2/. The threshold values for the false alarm rate α for each of the balancing periods has been so chosen that a value of $\alpha = 0.05$ at the end of the 40th balance period is attained.

A Monte Carlo simulation was used and 10,000 runs were made for each set of parameters. In all these investigations the material balance of only Pu in the process MBA was considered.

3. Comments on Input Data

3.1 Throughputs, Inventories, Measurement Uncertainties (Table 1)

For the present series of parametric investigations, reprocessing facilities with the annual inputs of heavy material of 1000 t, 500 t, 240 t and 100 t were considered. In the main series, the process inventory of Pu was reduced linearly with decreasing throughputs (abbr. I-LR or LR-I). The values for 1000 t/a facility was taken as the reference data base and reproduced from /5/.

In a second series of investigations, the process inventory of 450.6 Kg Pu for the 1000 t/a facility, was kept constant for all the other facilities (abbr. I-C or C-I), mainly to find out the influence of variations in inventories on the sensitivity of the NRTA method.

Whereas the measurement uncertainties σ_i's for the input in the reprocessing facility (i.e. input accountability tank) were varried from 0.5 %, 1 % to 2 % (both the random and the systematic error components), those for the process inventories, product and waste streams were assumed to remain unchanged and kept the same as those for the 1000 t/a facility /5/. In all the cases, the random and the systematic error components for a given measurement were considered to be equal.

3.2 Variance and MUF Values for Different Size Facilities (Tables 2A, 2B)

The variances and limits of error for the material unaccounted for (LMUF) for each of the facilities are calculated for a single balancing period with 10 operating days. There are 20 such balancing periods (BP) in a calendar year.

For facilities with linearly reduced inventories (I-LR), the corresponding LMUF values per balancing period get reduced linearly with decreasing throughputs (Table 2A, Fig. 1A). The LMUF/BP for the 1000 t/a facility with 0.5 % measurement uncertainty at the input, is for example, 4.09 kg of Pu reducing linearly to 0.409 kg Pu for the 100 t/a facility

(Fig. 1A). The LMUF values are however, not exactly linear in measurement uncertainty at the input. An increase by a factor of 4 from 0.5 % to 2 %, causes for a given facility, an increase in the LMUF values by a factor of 2.61. The contribution of the variances of the input measurement to the total variance of MUF in a facility increases with increasing measurement uncertainty. With 0.5 % it amounts to about 47 % increasing to about 93 % for 2 % measurement uncertainty at the input. With values around 1 % and above (considered to be the normal case), the input measurement uncertainty dominates the LMUF for facilities with linearly reduced inventories.

In the cases where the inventories in a process MBA are assumed to be constant at 405.6 kg Pu for all the facilities (Table 2B, Fig. 1B), the LMUF values tend to converge to the limits of errors of the inventory measurement (LI) values for the small facilities to around 3-4 kg Pu (240 t/a, 100 t/a). This is almost independent of the values of the measurement uncertainties at the input. In larger facilities (500 t/a) the LI has still a relatively high influence for lower measurement uncertainties (82 % for 0.5 % in a 500 t/a facility) which gets reduced with increasing values of measurement uncertainties at the input (≈ 25 % for 2 %). The absolute values of LMUF with constant inventory increase (as is to be expected) considerably for the small size facilities over those with linearly reduced inventories. For a 100 t/a facility, LMUF for 0.5 % is higher by a factor of about 7 (3 kg to 0.4 kg Pu). For 2 % measurement uncertainty, the LMUF with constant inventory remains at about 3 kg Pu for the 100 t/a facility but reducing to about 1 kg with linearly reduced inventory so that the factor reduces from 7 to 3. This indicates that the advantage expected out of a facility with linearly reduced inventories is partially reduced with increasing measurement uncertainties at the input.

3.3 Diversion Scenarios (Tables 3, 4)

The diversion scenarios investigated in this report are summarized in Tables 3 and 4.

Diversion scenario 1 (DS - 1) means that the total amount M is assumed to be diverted from the process MBA, during the first balancing period (after 20 diversion free balancing periods). Since the material balancing takes place after every 10 days of operation, this particular diversion can become visible to the Agency for the first time through the analysis of the MUF values only after the first balancing period in which a diversion of the whole amount M takes place. This diversion scenario is defined as abrupt diversion.

In diversion scenario 7 (DS - 7) the total amount M is assumed to be diverted in equal portions over 20 successive BPs (also after 20 diversion free BPs). This diversion scenario is defined as the protracted diversion. In this case, parts of the total diversions become visible only after a material balance is struck in the process MBA for a balancing period.

The diversion scenarios DS 2-6 fall in between the two extremes of abrupt and protracted diversion.

Table 4 shows the diversion rates for different amounts M for a given diversion scenario. A diversion of 10 kg for DS - 1, abrupt diversion, means for example, that the whole amount is assumed to be diverted during the first BP (after 20 diversion free BPs). The diversion of the same amount of 10 kg in the DS - 7 mode (protracted diversion) would mean that 0.5 kg Pu/BP (started after 20 diversion free BPs), would be assumed to be diverted and continued sucessively up to the next 20 BPs. For DS - 2, the diversion rate for 10 kg of M would be 5 kg/BP distributed over the first two BPs (again after 20 diversion free periods). For DS 3-6 the corresponding amounts for 10 kg of M are assumed to be diverted over 3, 4, 5 or 10 balancing periods, always starting with the first BP after 20 diversion free periods (table 4).

3.4 <u>ΔM/LMUF Values for Different Diversion Scenarios and Facility Sizes</u> (Tables 5A, 5B, 6-10, 11A, 11 B; Figs. 2A, 2B; 3A, 3B)

Since the abrupt and protracted diversions (DS 1, 7) correspond to the two extreme cases of scenarios considered here, the complete sets of the ΔM/LMUF values for all the parameters investigated, are included for these two cases in Tables 5A, 5B for DS - 1 and 11A, 11B for DS - 7. For the rest of the diversion scenarios (DS 2-6), values for only one set of parameters, i.e. 1 % measurement uncertainty and linearly reduced inventories (I-LR), have been presented in Tables 6-10. In these tables, values for 0.5 and 2 % measurement uncertainties for a 1000 t/a facility have also been included for ready reference.

Two definite trends in these values can be recognized:

1. The same values of ΔM/LMUF are obtained for different size facilities considered (Figs. 2-3). Particularly this fact permits a simplification in the use of the NRTA method on a routine basis. This possibility is analyzed in some detail later on (see Chapter 4: Analysis of Results).

2. ΔM/LMUF values for facilities with linearly reduced inventories increase continuously with decreasing facility size or increasing values of M (Figs. 2A, 3A). On the other hand, those with constant inventories, do not increase that rapidly (Figs. 2B, 3B), since the LMUF values for a facility with constant inventories tend to converge to a constant value, approximately corresponding to the limits of error of the inventory measurements in that facility. This may have the consequence that larger inventories in the process area would tend to reduce the sensitivity of an NRTA method (Chapter 4: Analysis of Results).

4. Analysis of Results

The results of the present series of investigations can be broadly categorized into two groups, one dealing with the amounts which can be detected under a given set of conditions and the other, dealing with the detection time i.e. the time which elapses after the amount, assumed to be diverted under a given set of conditions, can be detected with a probability of detection of $\geq$ 95 %. In all these investigations, the probability of detection P_D with the false alarm rate α of 5 %, has been taken to be the main indicator for assessing the sensitivity of the NRTA method under the different sets of conditions investigated.

Throughout the analysis some abbreviations have been used to avoid the repetition of the same word. These abbreviations are explained below as well as at the beginning of the report (page A-3) and in the tables I, II, III.

Abbreviations frequently used:

BP	balancing period
C-I, I-C	constant inventory in the process MBA in kg
DS	diversion scenarios
D_T	detection time expressed as the number of BPs after which the diversion of a given amount M can be detected with a given P_D
FT	facility throughput in t/a
LR-I, I-LR	linearly reduced inventories in the process MBA with decreasing FT in kg Pu
LI	limits of error in inventory measurements in kg
LT	limits of error in throughput measurements in kg
LMUF	limits of error of Material Unaccounted For in kg
M	total amount of Pu assumed to be diverted for a given diversion scenario, in kg
ΔM	fraction of M assumed to be diverted per balancing period for a given diversion scenario, in kg
MBA	material balance area
P_D	detection probability in % with a false alarm rate α of 5 %
σ_i, σ	measurement uncertainties at the input of a reprocessing facility, in %, rest of the measurement uncertainties being the same as given in Table 1
α	false alarm rate, fixed at 5 % throughout the investigations

Before, however, the detailed analysis of the sensitivity of the NRTA method is presented, some general comments are made on this method and on some simplification possibilities which can be used in assessing the sensitivity of this method.

4.1 General Remarks

The present series of investigations has confirmed the main findings in /2/ i.e. the NRTA method provides, under the boundary conditions considered and with the test procedure used, a significant improvement both in the amount which can be detected with $\geq$ 95 % P_D and in the detection time D_T, over the classical material balance method (in which a material balance in a facility is struck once a year, on the basis of which a safeguards relevant statement is made).

For example in the 1000 t/a reference facility, an abrupt diversion of about 16 kg of Pu could be detected with a 95 % P_D within less than 4 weeks of the diversion. A protracted diversion of about 28 kg Pu could be detected with 95 % P_D immediately after the last balance period (i.e. the 20th balance period) at which the last portion of this amount had been assumed to be diverted.

Compared to the classical method of annual material balancing, in which approximately 330 kg of Pu if diverted, could be detected with 95 % P_D, a year after the diversion had taken place, the NRTA method provides both for the abrupt and for the protracted diversion an improvement of over a factor 10 (a factor 20 for the abrupt diversion) and an improvement of a factor of 12 (one month instead of 12 months) in detection time D_T for the abrupt diversion.

It is to be recognized, however, that these improvements can be expected only if a number of boundary conditions are met, the most important being the following two:

- A number of diversion free balancing periods should exist, since only then can the test procedure used in these investigations provide the maximum detection probability.
- The diversion scenarios or loss patterns which the facility operator might use, should be known generally.

It was indicated earlier (see introduction) that the Agency has up to now, encountered on a routine basis, the conditions of diversion free balancing periods in almost all the facilities in which it has been safeguarding nuclear materials. The test procedure considered here, in combination with other measures, may cover a large number of cases which are encountered on a routine basis and, therefore, may form an important part of the Agency activities.

The second condition i.e., that the loss patterns should be known to the Agency, has to be taken more seriously, since the Agency in principle, would not know the type of diversion strategies which a State might like to follow. However, the results of the present investigations show, that the difference in the sensitivity of the NRTA method between the two extreme diversion possibilities considered i.e. the abrupt and the protracted, with regard to the amount M, is relatively small. For example it is less than a factor of two i.e. 16-28 kg of Pu for a 1000 t/a facility with 1 % σ_i. The sensitivity of the test procedure for all the intermediate diversion scenarios remains in this range which is still better by a factor of 10 or more over the conventional balancing method for a wide spectrum of feasible diversion scenarios. Besides, the results of these investigations indicate also that above a certain amount for a given facility, the probability of detection for all the diversion scenarios considered converge to a value of about 100 %. The smaller the facility the smaller is this amount (for a 1000 t/a facility this high probability of detection is obtained for about 50 kg of Pu and 5 kg for a 100 t/a facility with 1 % σ_i and linearly reduced inventory). Past experience has repeatedly shown that it is more useful to have a number of practicable measures, each of which is sensitive for a limited spectrum of feasible diversion strategies than one single measure which is less sensitive but can cover all conceivable diversion patterns i.e. completely independent of the diversion scenario.

It is, therefore, the considered opinion of the authors that the NRTA method with the test procedure used in combination with some other test procedures /6, 7/ may provide a powerful safeguards tool for detecting the loss of relevant amounts of nuclear materials in the process MBA of a reprocessing facility. However, because of its somewhat restrictive coverage of diversion possibilities, it may have to be supplemented by a number of other measures.

4.2 Simplified Possibilities of Sensitivity Analysis for NRTA Method (Figs. 4A, 4B, 5A, 5B, 6A, 6B, 7A, 7B)

One of the important side effects of the present series of investigation is the finding that an a priori analysis of the sensitivity of the NRTA method can be significantly simplified for the different sets of parameters considered in these investigations, by using the ratio of ΔM/LMUF for determining the probability of detection of an amount assumed to be diverted in a facility (ΔM = amount assumed to be diverted per balancing period, LMUF = limit of uncertainty of MUF in a facility in that balancing period).

The ratio of ΔM/LMUF can be considered to be the diversion rate per LMUF. Since the LMUF is a function of the measurement system used in a facility, LMUF is a unique characteristic of that facility. This unique characteristic determines, in the final analysis, the capability or the limitations, i.e. the sensitivity of the NRTA method for detecting a diversion (for that matter any other material balance method). The smaller the LMUF per balancing period, the higher is the probability of detection for a given M in a facility.

ΔM is the amount assumed to be diverted per balancing period and is a function of the assumed diversion strategy. For an abrupt diversion strategy (DS - 1) ΔM = M i.e. the total amount is assumed to be diverted during the first balancing period (after 20 diversion free periods). In the protracted diversion strategy DS - 7, $\Delta M = M/20$ is assumed to be diverted in equal portions in each of the successive 20 balancing periods so that, after the 20th balancing period (i.e. after one year of operation), the total amount M would have been diverted. The larger the ΔM per balancing period, the higher is the probability of detection for a given LMUF for that balancing period.

The main reason for the improvement in the sensitivity of the NRTA method over the conventional balancing method could lie in the fact that, the reference values of the LMUF against which the probability of detection for a given amount is estimated, is much smaller in the case of the test procedure used for the NRTA method (than the conventional balancing method), since the LMUF value per balancing period is used instead of the annual value of the LMUF as in the case of the conventional balancing method (i.e. for a 1000 t/a facility, LMUF/BP = 6.02 kg whereas the annual LMUF is ≃ 100 kg). The deviation from the normally expected LMUF value is sequentially registered and tested in the NRTA method after each balancing period. The test procedure can therefore, detect the diversion of a relatively smaller amount (which appears as a deviation from the normal LMUF values) and also much earlier than in a conventional annual balancing method, since the test for a diversion is carried out every 10 days (in the present series of investigations) after a material balance is struck.

For the test procedure used in these investigations, P_D is a monotonously increasing function of ΔM/LMUF for all the diversion strategies considered. The values of P_D plotted against ΔM/LMUF on a linear graph paper give the well known S-formed curve for probability functions with the Gausian distribution (Figs. 4A for DS 1, 5A for DS 2, 3, 4, 5, 6, and 6A, 7A for DS 7).

If plotted on a probability paper (linear in abscissa), the same values can be fitted approximately to a straight line (Fig. 4B for DS 1, 5B for DS 2, 3, 4, 5, 6 and 6B and 7B for DS 7). The values obtained from the straight lines lie, compared to the actual values obtained through computer calculations, on the conservative side.

Each of the curves for a given diversion strategy incorporates all the values of P_D for different facility sizes, and different σ_i values, and in the curve for DS - 1, also the different values of inventories (I-LR, I-C). Rest of the curves incorporate values of the linearly reduced inventories only. For DS - 7 an additional curve, Fig. 7B, with values for constant inventories has been included since for this particular strategy, the values for the I-C were somewhat higher than for I-LR above the 90-99 % range of P_D.

4.2.1 Possibilities of Using the Curves

The possibilities of using these curves are illustrated with the help of a number of numerical examples for DS - 1 and DS - 7. The detailed analysis of the results is provided in subsequent chapters.

Fig. 4B provides the P_D values (in the ordinate) for different values of ΔM/LMUF for DS - 1 i.e. for abrupt diversion.

Question 1: What is the amount of Pu (in kg) which can be detected with a P_D of 95 % in the reference facility with 1000 t/a throughput and a process inventory of 450 kg of Pu with the measurement uncertainty of 1 % at the input for a diversion strategy DS - 1?

Answer to Q 1: In obtaining the answer to Q 1 following steps are necessary.

Step 1: The corresponding value of ΔM/LMUF for P_D = 95 % is obtained from Fig. 4B which is: 2.75

Step 2: From Fig. 1A (or Table 2A) the LMUF value/BP for the 1000 t/a facility with 1 % σ is obtained which is: 6.02 kg

Answer to Q 1: The amount which can be detected with P_D = 95 % is $2.75 \cdot 6.02 =$ 16.56 kg Pu

<u>Question 2</u>: What is the amount which can be detected with a P_D = 95 % in the same facility but with measurement uncertainties at the input of 0.5 % and 2 % respectively for DS-1?

<u>Answer to Q 2</u>

<u>Step 1</u>: The LMUF values in a 1000 t/a facility (Table 2A) are 4.096 kg Pu for 0.5 % and 10.69 kg for 2 % respectively. The corresponding values of M for P_D = 95 % are, therefore, 2.75•4.096 = <u>11.26</u> kg Pu for 0.5 % or 2.75•10.69 = <u>29.4</u> kg Pu for 2 % σ_i.

It is to be noted that the values of M's actually calculated for these two measurement uncertainties are 11.58 and 27.0 kg of Pu respectively (Table 54).

<u>Question 3</u>: What are the amounts which could be detected with the same P_D = 95 % in different size facilities with I-LR all for 1 % σ_i?

<u>Answer to Q 3</u> (DS - 1) FT →	1200 t/a	500 t/a	100 t/a
1. The corresponding LMUF per BP values for these facilities (Table 2A, for 1200 t/a facility extrapolated from the 1000 t/a facility since LMUF is linear in σ_i for all facilities) kgPu	7.2	3.01	0.602
2. M which could be detected with P_D = 95 % (2.75•$LMUF_i$) kg Pu	<u>19.86</u>	<u>8.77</u>	<u>1.65</u>

It is to be seen that the sensitivity of the NRTA method increases rapidly with decreasing size of the facility or decreasing values of σ_i's at the input (which is equivalent).

The sensitivy increases also if two independent process lines, each having half the throughput and inventory of a single line is used in a facility. For example, in a 1000 t/a facility having two independent process lines each of 500 t/a, the amount which could be detected in such a facility with a P_D = 95 % and 1 % σ_i at the input, would not be 16.53 kg Pu as calculated for a 1000 t/a facility but $\sqrt{8.77^2+8.77^2}$ = 12.4 kg Pu. However, to ensure this lower value, the two independent process lines must have two truly independent measurement systems.

The procedure illustrated above can be used for other diversion strategies and other LMUF or P_D values as well.

Sometimes it would be useful to establish the sensitivity of the NRTA method for a given amount in different size facilities.

Question 4: a) What is the P_D for 8 kg Pu assumed to be diverted abruptly (DS - 1) in different size facilities (500, 240 and 100 t/a) with 1 % σ_i at the input either for linearly reduced (I-LR) or constant (I-C) inventories?

b) How are the P_D values altered for the same mode of diversion of 8 kg if in the same facilities, the σ_i's are changed from 1 % to 0.5 or to 2 %?

Answer to Q 4a for I-LR				
FT →	t/a	500	240	100
Step 1: LMUF for 1 % σ_i and I-LR (Fig. 11)	kg Pu	3.01	1.44	0.602
ΔM/LMUF for 8 kg	-	2.66	5.56	13.29
Step 2: P_D for the corresponding ΔM/LMUF (Fig. 4B)	%	94.5	>99.99	>99.99

It is to be noted that for abrupt diversion DS - 1, a P_D>99 % is obtained for all values of ΔM/LMUF which are > 3.2.

Answer to Q 4a for I-C FT →	t/a	500	240	100
Step 1: Values of LMUF with				
1 % σ_i and I-C (Tab. 2B)	kgPu	3.9	3.2	3.037
ΔM/LMUF values for 8 kg	-	2.05	2.5	2.64
Step 2: Corresponding P_D values				
(Fig. 2B)	%	74	91.5	94.2

The accurately calculated values (Table 55) show that for the 100 t/a facility with constant inventory, 7.76 kg Pu could be detected with 95 % P_D. Further it is to be noted that approximately the same values of ΔM/LMUF (2.64 kg and 2.66 kg respectively) are obtained for 100 t/a facility with I-C and 500 t/a facility with I-LR both for a σ_i = 1 %.

Answer to Q 4b for I-LR FT →	t/a	500		240		100	
	σ_i %	0.5	2	0.5	2	0.5	2
Step 1: LMUF for the three							
facilities (Tab. 2A)	kgPu	2.0	5.3	0.98	2.6	0.41	1.07
ΔM/LMUF for 8 kg	-	4.0	1.51	8.16	3.08	19.51	7.48
Step 2: Corresponding P_D values							
from Fig. 4B	%	>99.9	41.0	>99.9	99.0	>99.9	>99.9

For a 500 t/a faciliy, the P_D values for 8 kg Pu improves from 94 % to 99.9 % when the measurement uncertainty at the input goes down from 1 % to 0.5 % and the P_D goes down to 41 % when the measurement uncertainty goes up from 1 to 2 %. For the rest of the facilities the P_D values are always greater than 99 %.

This series of examples is closed with

Question 5: What is the minimum amount which could be detected with a P_D = 95 in the facilities 500, 240 and 100 t/a for 1 % σ_i and I-C for protracted diversion DS - 7? (Table 57, Fig. 7B)

Answer to Q 5:

Step 1: The ΔM/LMUF value for a P_D = 95 % for DS - 7 is read from Fig. 7B to be = 0.202

	FT →	t/a	500	240	100
Step 2:	LMUF for these facilities for 1 % σ_i and I-C (Tab. 2B)	kg	3.9	3.2	3.037
Step 3:	Corresponding values of ΔM/BP to obtain the value of ΔM/LMUF = 0.202	ΔM/BP kgPu	0.80	0.65	0.61
Step 4:	Total amount M which can be detected with P_D 95 % ΔM/BP•20 (since ΔM/BP is assumed to be diverted successively over 20 balancing periods)	kg	16.1	13.0	12.2
	The values of M actually calculated (Tab. 57)	kgPu	16.57	11.5	9.89

It can be seen that for smaller facilities, the straight line drawn in Fig. 7B provides somewhat conservative values (i.e. 15-25 % higher than the amounts of Pu found by actual calculations). However, the curves have been purposely drawn in a way that fairly conservative values are obtained. This appears to be particularly desirable in view of the fact that the results which are obtained in these investigations through a simulation of facility data may not cover all the restrictions prevalent in a facility. Under actual operating conditions, therefore, the sensitivity of the NRTA method is bound to be reduced.

It is expected that the series of numerical examples presented above, would suffice to illustrate the different ways in which the sensitivity of the NRTA method can be investigated in a simplified manner with the help of the linearized probability curves generated as examples for these investigations.

4.3 Sensitivity with regard to Detectable Amounts M

The sensitivity of the NRTA method with regard to the amounts M in kg Pu which could be detected with different probabilities of detections P_D, was analyzed for the following sets of parameters (for clarification of the abbreviations see page A-1 or Tables I, II, III):

1. Plant throughputs and inventories (FT, I-LR, I-C)
2. Amounts assumed to be diverted (ΔM, M)
3. Measurement uncertainties at the input (σ_i's)
4. Diversion scenarios (DS)

The different sets of parameters influence each other directly or indirectly. Therefore, in considering the influence of the different sets of parameters, the following restrictions have been observed:

- For analyzing the influences of facility throughputs and inventories only the results for 1 % σ_i and DS - 1, 7 have been considered.

- For analyzing the influence of measurement uncertainties the results for DS - 1 and 7 have been considered.

- For analyzing the influence of DS only, the results for σ_i = 1 % have been considered.

Wherever appropriate, besides the detailed analysis for these parameters some general trends involving all the parameters when considered simultaneously, have been indicated.

4.3.1 Facility Throughputs and Inventories (Tables 54, 55, 56, 57)

a) Facility Throughput with I-LR (Figs. 16A, 16B)

For any given probability of detection, P_D, and measurement uncertainty, σ_i, the amount assumed to be diverted or lost decreases with decreasing size of the facility with linearly reduced inventories (I-LR). For P_D = 95 % this reduction is linear with facility throughput. In the case of an abrupt diversion (DS - 1) and σ_i = 1 %, this amount is about 17 kg of Pu in the 1000 t/a facility reducing linearly to about 1.7 kg Pu in the 100 t/a facility.

For protracted diversion (DS - 7) the same general trend is observed only with the difference that the absolute values of the amounts which can be detected with the same P_D = 95 % are higher. For the 1000 t/a facility the corresponding amount is about 28 kg reducing to 2.8 kg in a 100 t/a facility for this strategy.

The reason for linearity in the case of I-LR is the fact that the LMUF/BP is also linear in FT for I-LR (Table 2A). In the final analysis, the linearity of LMUF is mainly caused by the systematic part of the measurement uncertainty at the input of a reprocessing facility, which increases linearly with increasing amounts measured at the input.

b) Facility Throughput with I-C (Figs. 16A, 16B)

It was indicated earlier that two different amounts of process inventories were considered. In one case the process inventory were reduced linearly with the throughput. In the other case, the process inventory in the reference case of 1000 t/a facility of 450.6 kg Pu was kept the same for all the other three facilities. For a 100 t/a facility a 450.6 kg Pu of process inventory is an extreme case and is not expected to be encountered in reality, since this inventory amounts to about 45 % of the annual input of 1000 kg of Pu. However, these extreme values can indicate the maximum possible deviations in the sensitivities of the NRTA method which could be expected if the process inventories in the facilities were to be larger than those assumed in the case of linearly reduced inventories.

The amounts which can be detected for the cases with I-C are generally higher than those for the I-LR for both DS - 1 and 7. Surprisingly enough though, they are not as high as would have been expected if only the absolute amounts and the associated measurement uncertainties for different classes of inventory materials were taken into account (Table 2B). The following table illustrates this point for different M (kg Pu) with P_D = 95 % and σ_i = 1 % for I-LR and I-C in facilities with different throughputs (Tables 54, 55, 56, 57).

t/a	DS - 1		DS - 7	
	I-LR	I-C	I-LR	I-C
	M	M	M	M
1000	16.53	16.53	28.3	28.3
500	8.27	10.97	14.1	16.57
240	3.93	8.6	6.8	11.50
100	1.66	7.76	2.8	9.89

For the 1000 t/a facility the M values for I-LR and I-C are same for a given diversion strategy since the process inventory is the same in both the cases. In a 500 t/a facility the value of M increases from 8.27 kg to a merely 10.97 kg when one goes from the I-LR to a I-C situation for DS - 1. In the case of DS - 7 this increase is from 14.1 to 16.57 kg for the same facility. The increase in the smaller size facilities is more significant.

It is to be noted that the reduction of M for a given P_D for I-C is not exactly linear in facility size but slightly concave against the ordinate. This is because of the increasingly larger influence of LI (limits of uncertainty of the inventory measurement) on the total LMUF for smaller size facilities.

Also the rate of increase in the value of the ratio M I-C/M I-LR (see Table 54/55 for DS - 1 and 56/57 for DS - 7) increases with decreasing facility size as shown below (for σ_i = 1 %):

Ratio	FT t/a	DS = 1	DS = 7
	500	1.33	1.18
M_{I-C}/M_{I-LR}	240	2.17	1.69
	100	4.67	3.53

This increase is also caused by the increasing influence of LI (in the constant inventory case) on the total LMUF with decreasing facility size. It is to be noted that with higher P_D values this ratio increases for the same facility as shown in the following chapter.

In the sequential test procedure used in these investigations, the systematic part of the measurement component for the inventory cancels out /4/, during the balancing period. This fact i.e. the elimination of the systematic part of the measurement component of the inventory from the LMUF dampens somewhat the reduction in the sensitivity of the NRTA method with increasing amounts of process inventory.

4.3.2 Different Values of M Assumed to be Diverted (Tables 12A, 12B, 18A, 18B, 53A, 53B)

For any facility size and diversion strategy, P_D is a monotonously increasing function of M assumed to be diverted or lost (Figs. 8, 9, 10, 11). The slope of the probability curves is steeper for smaller size facilities or for smaller values of σ_i's. For all these facilities and diversion strategies considered, it is allways possible to obtain a P_D of ≃ 100 % for an amount of M which is considerably less than that obtainable under the conventional balancing method. This is illustrated for DS - 1 and 7 in the following table for the cases of σ_i = 1 %, I-LR and I-C (excerpts from Tables 53A, 53B and Figs. 8, 9, 10, 11).

FT t/a	1000	500		240		100	
		I-LR	I-C	I-LR	I-C	I-LR	I-C
DS - 1; M $\geq$ kg (P_D≃100 %)	21	10.5	15.5	5.1	12.5	2.1	10.5
DS - 7; M $\geq$ kg (P_D≃100 %)	35	17.5	20	8.5	15.3	3.5	12.5
Ratio $\frac{M_1}{M_7}$	1.67	1.67	1.29	1.67	1.22	1.67	1.19

It is worthwhile to note that the sensitivity of the NRTA method is reduced in general if one goes from I-LR to I-C situation although not as strongly as the change in the inventory amount would suggest. The detection capability reduces (as expressed by the amounts which can be detected for a P_D≃100 %) for example for the 500 t/a facility, from 10.5 to 15.5 kg Pu, i.e. by a factor of 1.5 only, although the amount of process inventory in this facility while going from I-LR to I-C increases by a factor of two (from 225 to 450 kg Pu). This factor is however larger for the smaller facilities (2.45 for 240 t/a and 5 for 100 t/a). The reason appears to lie in the fact that the percentage contribution of LI to the total LMUF/BP in a facility increases with decreasing throughput of the facility (Tables 2A and 2B).

Two additional points are worth mentioning in this connection:

- When one goes from the abrupt to the protracted diversion mode (D 1 to D 7), the sensitivity of the NRTA method is reduced also, but not drastically. In all the facilities for I-LR, the reduction is by a factor of 1.67, although in the case of protracted diversion (DS - 7), the rate of diversion per balancing period is reduced (against the abrupt diversion DS - 1) by a factor of 20. As mentioned earlier, the reason appears to lie in the fact that the actual value of LMUF/BP against which the deviation is tested, is relatively low (about 6 kg of Pu/BP for DS - 7 against 100 kg for an annual balance).

- In the cases of I-C, the reduction factor improves for smaller facilities (1000 t: 1.67; 500 t: 1.29; 240 t: 1.22; 100 t: 1.19) while going from the abrupt to the protracted mode of diversion. An improvement in the reduction factor means that relatively speaking smaller amounts can be detected in a smaller facility with large inventory amounts compared to larger facilities with the same inventory amounts with a given P_D. The reason is also as mentioned earlier, the relative reduction in the LI because of the elimination of the systematic part of the error for the measurement of inventory.

4.3.3 Measurement Uncertainties (Tables 53A, 53B, 54, 55, 56, 57)

Different categories of limits of uncertainties (LT - Limits of uncertainties for throughput measurements consisting of those for input, product and waste streams and LI - Limits of uncertainties for the different classes of inventory materials measurements in the process inventory), contribute to the total LMUF per balancing period. Out of these, the contribution from the measurement uncertainties at the input of a reprocessing facility is normally the highest. The influence of this particular measurement uncertainty on the sensitivity of the NRTA method was therefore, analyzed in the frame of the present series of investigations. The values of the uncertainties chosen for this parametric variations are 0.5 %, 1 % and 2 % (both for the systematic and the random components which are assumed to be equal). Higher or lower values for this measurement uncertainty are not considered to be realistic. In Tables 2A and 2B the LMUF, LT and LI values for all the four facilities and for the two alternative inventory situations (I-LR and I-C) considered, have been included for the 3 σ_i values.

a) Facility Throughputs with I-LR (Tables 54, 56)

For a given facility and a diversion strategy, the sensitivity of NRTA method improves with decreasing measurement uncertainties, the rate of increase is however different for different facility throughputs and inventories, measurement uncertainties and diversion strategies.

The amounts M which can be detected with a P_D = 95 % (Tables 54/55) are all linear in σ_is for all the facilities with I-LR and for all diversion strategies. The main reasons being the dominance of the systematic component of the measurement system used for throughput and inventory, which is linearly proportional to the amount measured, and also the fact that throughput and inventories of the four facilities considered, are linearly proportional in the cases for I-LR.

The following table shows the relation between σ_is and M's with P_D = 95 % for DS - 1 and 7 in different facilities with I-LR (excerpts from Tables 54, 56).

t/a	DS - 1			DS - 7		
	$M_{\sigma 0.5}$	$M_{\sigma 2.0}$	$M_{\sigma 2}/M_{\sigma 0.5}$	$M_{\sigma 0.5}$	$M_{\sigma 2.0}$	$M_{\sigma 2}/M_{\sigma 0.5}$
1000	11.58	27	2.33	17.9	51.7	2.88
500	5.8	13.5	2.33	8.9	25.6	2.88
240	2.78	6.5	2.33	4.3	12.4	2.88
100	1.16	2.7	2.33	1.8	5.17	2.88

This table indicates that for DS 1 and DS 7 respectively, ratios $M_{\sigma 0.5}/M_{\sigma 2.0}$ are same for all the four facilities (for DS 1 = 2.33 and for DS 7 = 2.88). An increase of a factor 4 in the σ_i's (0.5 % to 2 %) at the input accountability tank causes an increase in the detectable amount for P_D = 95 % of 2.33 for DS - 1 for all the facilities and 2.88 for DS - 7 for all the facilities. Three points are worth noting (all relevant only to the I-LR cases):

- An increase of a factor 4 in the σ_i's at the input causes a decrease in the sensitivity of the NRTA method by a factor between 2.3 to 2.8 depending on the diversion strategy assumed. This means that the reduction in the sensitivity is not that severe with increasing σ_i values. The reason being again the dampening effect caused by the constant contribution of the LI to the total LMUF values.

- The amounts detectable with 0.5 % σ_i and P_D = 95 % are remarkably low, about 12 kg for DS - 1 and 18 kg for DS - 7 for a 1000 t/a facility. Since more than 20,000 kg of Pu are measured for the throughput (about the same amount at the input and the output) and 2x450 kg Pu for the inventory during one full year, 12-18 kg of Pu correspond to less than 1 per 1000 sensitivity for the NRTA method. This sensitivity is also obtained in other size facilities as well for the I-LR case.

- The NRTA method is more sensitive for abrupt than for protracted diversions, both with regard to the absolute amounts and to the rate, when one proceeds from a measurement uncertainty of 0.5 % to 2 % at the input accountability.

b) Facility Throughputs with I-C (Tables 56, 57)

The following table illustrates the relation between σ_i's and M's with P_D = 95 % for DS - 1 and DS - 7 in different facilities with I-C (excerpts from Tables 56, 57).

t/a	DS - 1			DS - 7		
	$M_{\sigma 0.5}$	$M_{\sigma 2.0}$	$M_{\sigma 2}/M_{\sigma 0.5}$	$M_{\sigma 0.5}$	$M_{\sigma 2.0}$	$M_{\sigma 2}/M_{\sigma 0.5}$
1000	11.58	27	2.33	17.9	51.7	2.88
500	8.89	16.2	1.82	12.2	27.65	2.26
240	7.94	10.6	1.33	10.2	15.8	1.54
100	7.47	8.27	1.10	9.5	10.9	1.14

Compared to the I-LR cases, the M values for a given P_D for I-C situation are higher in the cases of 500 t/a, 240 t/a and 100 t/a facilities. After taking into consideration the values in the above table, the following points are worth noting:

- An increase of factor 4 in σ_i's at the input accountability tank for the cases with I-C, causes an increase in the detectable amounts by a factor of only 2.33 for DS - 1 and 2.88 for DS - 7 for the 1000 t/a facility, which is the same as in the case of I-LR. These factors however, get reduced with decreasing size of the facility. For a 500 t/a facility the factor gets reduced from 2.33 to 1.82 for DS - 1 and from 2.88 to 2.26 for DS - 7. In a 100/a facility this reduction is much higher from 2.33 to 1.10 for DS - 1 and from 2.88 to 1.14 for DS - 7. This reduction in practical terms means that in the case with constant inventories (I-C) as considered here, a worsening of measurement uncertainties at the input by a factor of 4, would not cause a significant reduction in the sensitivity of the NRTA method for small size facilities in the range of 500-100 t/a. The same trend is seen if one goes from an abrupt to a protracted mode of diversion. The reason for this stability in the sensitivity of the NRTA method in the cases with I-C may be traced back as already mentioned to the following factors:

i) The decreasing contribution of LT (or increasing contribution of LI) to LMUF with decreasing facility size (Table 2B).

ii) The elimination of the contribution of the systematic error component in the inventory measurements to the LMUF/BP. This factor becomes more important for smaller size facilities because the ratio of inventory to throughput increases.

- Although the values of M for P_D = 95 % increases with I-C, the sensitivity of the NRTA method still remains high, and in the smaller size facilities, the detectable amounts tend to cluster around the same range. For example, in a 500 t/a facility, the amounts which can be detected with P_D = 95 % and 0.5 % σ_i, varies between 9 and 12 kg for DS 1 and 7 respectively. With a total amount of about 1900 kg of Pu measured in the facility in a year, these amounts correspond still to a sensitivity of about 1 in 1000, i.e. same as in all the cases with I-LR. The sensitivity reduces, however, as one goes to smaller size facilities. For a 240 t/a the detectable amounts varying between 8 and 10 kg Pu, correspond to a sensitivity of about 2 per 1000 and for the 100 t/a facility this is about 3 per 1000 (detectable amounts varying between 7.5 and 9.5 kg Pu for DS 1 and 7 respectively).

c) <u>Comparison Between the Cases I-LR and I-C</u> (Figs. 12, 13, 14, 15)

- The trends in the development of the probability of detection versus amounts (P_D vs M) for the two inventory situations considered (I-LR and I-C) are shown as examples for the two facilities 500 t/a and 240 t/a in Figs. 12 and 13 for the cases of σ_i - 1 and 2 % with DS - 7. Values of M for the 100 t per year facility reach so rapidly a $P_D \simeq 100$ % that they cannot be shown on the same scale on a comparative basis with the other facility sizes. For a 500 t/a facility the P_D values are relatively close to each other for the I-LR and I-C situations. These values become closer for the two inventory situations either with increasing values of σ_i's or increasing values of M. For example, in this facility for 1 % σ_i, all the values of $M \geq 15$ kg for both I-LR and I-C situations have $P_D \simeq 100$ %. For 2 % σ_i this is the case for $M \geq 20$.kg.

- Another example for P_D values as a function of detectable amounts M for different σ_i's is shown in Figs. 14 and 15 for 1000 t/a and 500 t/a facilities respectively for DS - 7. For the smaller facility, both the cases of I-LR and I-C have been shown. In all the cases, P_D improves for a given M with smaller values of σ_i.

  In a 240 t/a facility (see data in the table above) about 16 kg of Pu could be detected with $P_D \geq 95$ % for <u>all</u> the measurement uncertainties, all the inventory situations and all diversion strategies considered in the present series of investigation. In a 500 t/a facility, this is the case for about 28 kg of Pu and in a 1000 t/a facility for about 52 kg of Pu.

4.3.4 Diversion Scenarios

The seven diversion scenarios DS - 1 to DS - 7 considered in the present series of investigations, were first discussed in /2/ for checking the statistical sequential test procedure used in that report. The seven strategies are presented in Tables 3 and 4 and explained in chapter 3. The main purpose for using particularly this series of diversion scenarios is to test the sensitivity of the NRTA method with the particular test procedure, for a number of abrupt and protracted diversion scenarios as defined in the report. Investigations on other and more versatile sequential test procedures /6,7/ initiated subsequent to these series of investigations, tend to indicate that the type of Page's test considered here, may not respond in a sensitive manner to the so-called "alternating diversion scenarios", i.e. scenarios in which a certain amount of material is assumed to be withdrawn during a balancing period, with a part of it added at a subsequent balancing period. To cover such diversion scenarios, the present test procedure will have to be complemented by other ones capable of providing adequate probability of detections for amounts relevant for international safeguards. The test procedures being investigated /6,7/ appear to possess such capabilities.

The Page's test, however, still remains a powerful testing tool for the conditions considred and precisely defined in the introduction of this report.

Most of the relevant results for the two diversion strategies DS - 1 and DS - 7 have been discussed under the chapters 4.1 to 4.3. These two strategies are also the most relevant ones from the point of view of the sensitivity of the NRTA method for the abrupt and protracted diversion scenarios. In the subsequent discussions, therefore, only those parts of the results, which have a bearing on the diversion strategies as a whole have been touched upon. All the discussions in this chapter are restricted to those cases with linearly reduced inventories (I-LR) in the facilities only, and with a σ_i = 1 % at the input.

a) Facility Throughputs with I-LR (Tables 25-52, 60)

In general, the P_D decreases for a given amount M when one proceeds from DS - 1 to DS - 7. The absolute values of P_D and M depend, however, on the throughput and the measurement uncertainty at the input of a reprocessing facility:

- The P_D remains approximately at the same level of about 40 % for the first five diversion scenarios DS - 1 to DS - 5 for 10 kg in a 1000 t/a facility (or for 5 kg for 500 t/a and for 1 kg for 100 t/a facility) then dropping down to 30 % for the DS = 6 and finally to 20 % for DS = 7. A similar trend is observed for 20 and 30 kg of Pu for the 1000 t/a facility (and for the proportionally reduced values for 500 t/a, 240 t/a and 100 t/a facility respectively). From the general trends of these curves, it may be concluded that the first 5 diversion strategies considered here belong approximately to the abrupt diversion category and only the DS - 6 and DS - 7 may be considered to belong to the category of protracted diversion. This particular finding would mean in practical terms, that the NRTA method with the test procedure used, would maintain its sensitivity approximately at the same level for all the diversion scenarios in which a diversion is assumed to occur during the 1-5 successive BPs.

b) Different Values of M (Tables 12A, 29, 33, 37, 41, 45, 18A)

- With increasing values of M, the rate of decrease in the P_D values as one proceeds from DS - 1 to DS - 7 goes through a maximum and then approaches a value = 1 as shown in the following table for 1000 t/a; σ_i = 1 %; I-LR.

DS → / M kgPu ↓	1 P_D(%)	2 P_D	3 P_D	4 P_D	5 P_D	6 P_D	7 P_D	$\frac{P_D\ 1}{P_D\ 7}$
5	11.7	11	12	11	11	10	8.7	1.34
10	41.5	40	40	39	39	33	20.4	2.03
20	99.8	99	99	98	98	93	69.1	1.44
25	100	100	100	99	99	99	88	1.14
30	100	100	100	100	100	99	97.1	1.03
40	100	100	100	100	100	100	100	1.00

The maximum value of the P_D 1/P_D 7 of 2.06 at around 15 kg Pu is mainly caused by the nature of the probability function in which, the lowest value of P_D for all diversion strategies is set at 5 % = false alarm rate and the highest value of P_D's that can be obtained for all strategies is ≃ 100 %. At these two extreme ends the ratio of P_D1/P_D7 has the value of 1. In between these two values the P_D1/P_D7 goes through a maximum for some values of M for a facility, which is mainly governed by the σ_i at the input.

It is to be noted that the difference between the P_D1 and P_D7 value (in the case of I-LR) vanishes for fairly low values of M as one goes to smaller facilities or in the same facility as one improves on the measurement uncertainties. For 1 % σ_i for example, a P_D≃100 % is obtained for all diversion strategies in a 1000 t/a facility for an amount of M = 40 kg. This amount is 20 kg for 500 t/a and 4 kg for a 100 t/a facility. For 0.5 % σ_i this is the case for M = 25 in a 1000 t/a reducing to 2.5 kg in a 100 t/a facility.

4.4 Sensitivity with regard to Detection Time (D_T) (Tables 58, 59)

The detection time defined in the frame of these investigations, is the time interval which elapses after the diversion of an amount M starts, until the detection of this amount takes place with a given probability of detection. A P_D value of $\geq$ 95 % was chosen for this analysis. Since in all the parametric variations considered here, a diversion scenario has been assumed to begin at the 21st balancing period (after 20 diversion free balancing periods), the counting of the elapsed number of balancing periods in this chapter (as shown in Tables 58, 59, 60, 61 and the corresponding figures) after a diversion begins, starts from the 21st balancing period so that 21 BP = 1 BP.

As in the cases for detectable amounts, the sensitivity of the NRTA method with regard to the detection time was analyzed for different facility throughputs and inventories, measurement uncertainties at the input and diversion scenarios.

In general, the detection times improve:
- with decreasing size of the facility and decreasing amounts of process inventory
- with improved values of σ_i's at the input
- when one goes from the protracted (DS - 7) to abrupt (DS - 1) mode of diversions.

It is to be noted that in the frame of the present test procedure, the corresponding value of false alarm rate α for a given probability of detection P_D has been designed to develop in time in such a way that it attains the value of about 5 % at the end of the 40th BP (or 20th BP when counted as in Tables 58, 59, 60, 61 and Figs. 20, 21).

This development is shown in the following table as an example for a 1000 t/a facility; σ_i - 1 %; DS - 7 for M = 30 kg. .

No. of BP	α %	P_D % (for 30 kg Pu)
1-20	≃0	≃0
21(1)+	0.90	0.91
22(2)	1.01	1.31
25(5)	1.47	7.57
30(10)	2.54	55.27
35(15)	3.63	88.29
36(16)	3.84	91.16
37(17)	4.13	93.30
38(18)	4.47	95.15
39(19)	4.72	96.27
40(20)	4.93	97.14

+Numbers in brackets ( ) are the number of BP's counted from the beginning of a diversion.

This particular relation between α and P_D for a given BP means that a P_D value for any BP before the 40th balancing period, will always have a corresponding α value which is less than 5 %. Therefore, such P_D values would not be strictly comparable with those for the 40th BP. Since, however, for a given set of conditions, any P_D values for an amount M with a given value of α will always be higher for a higher value of this α, one could consider the P_D values for earlier BP's to be the minimum probability of detection P_D which could be attained in any case for α = 5 %. After these general remarks, some detailed discussions on the sensitivity of the NRTA method with regard to the detection time D_T follow.

4.4.1 Facility Throughputs and Inventories

a) Facility Throughputs with I-LR (Table 58)

Figs. 17 and 18 show as examples, the manner in which the probability of detection P_D develops as a function of the number of balancing periods for different facility throughputs with I-LR under a given set of conditions. Fig. 17 depicts the development in different facilities for DS - 1, Fig. 18 for DS - 7. Both sets of curves are for an amount of M of 5 kg Pu and σ_i values of 0.5 (17A, 18A), 1 (17B, 18B) and 2 % (17C, 18C). The curves for M = 5 kg were chosen as examples since with higher values of M, the smaller facilities reach fairly rapidly the 100 % P_D values, so that the trends can not be traced properly.

In these cases a particular curve for a given facility will be valid for another facility with the same boundary conditions for the corresponding values of M. For example in Fig. 17C, the curve for 500 t/a facility (DS - 1; σ_i = 2 % and M = 5 kg) will be the same for a 1000 t/a facility for M = 10 kg, a 240 t/a facility for M = 2.4 kg and a 100 t/a facility for M = 1 kg Pu.

With increasing amounts of M in a given facility or decreasing size of the facility for the same amount, not only does the P_D increase but the detection time improves also. This is illustrated in the following table:

$\sigma_i = 1\ \%$; DS - 7, I-LR (excerpts from Table 58)

t/a	M(kgPu)	P_D %	BP
1000	25	88.02	20
	30	95.15	18
	40	96.20	12
500	10	69.10	20
	15	95.15	18
	25	98.62	10
100	5	95.98	9
	10	99.39	5
	25	100	3

Interesting points to note (as examples):

- In a 1000 t/a facility, 25 kg of Pu could be detected with a P_D = 88 % at the end of the 20th BP after the diversion has been assumed to begin according to the protracted mode of diversion (DS - 7). For a 30 kg of diversion, according to the same diversion mode in the same facility, a detection probability of 95 % is obtained already at the end of the 18th balancing period, i.e. for this amount not only has the P_D improved from 88 to 95 % against the previous case (25 kg diversion) but the detection time has also improved by above 10 % (D_T shortened from 20th to 18th BP). A 40 % improvement over a 30 kg diversion in the D_T is obtained in the same facility for a diversion of 40 kg Pu.

- In a 500 t/a or a 100 t/a facility, the same trend in the improvement of P_D and D_T is observed but for much smaller amounts and much shorter detection times.

b) Facility Throughputs with I-C (Table 59)

The main effect of constant inventories on the detection time for a facility is to reduce the probability of detection or to lengthen the detection time for a given amount M (the 1000 t/a facility remains unaffected in this case, since for this facility I-LR = I-C). The extent of increase in the D_T depends on the facility size and the amount considered as seen from the following table (excerpt from Table 59) and Figs. 20 and 21:

σ_i = 1 %; DS - 7, I-C:

t/a	M(kgPu)	P_D %	BP
500	10	53.8	20
	15	89.7	20
	20	96.26	16
	25	98.29	13
100	5	37.34	20
	10	95.41	20
	15	97.05	14
	20	97.27	11
	25	99.39	10

- In a 500 t/a facility the P_D goes down to 53.8 % (from 69.1 % for the I-LR case) for 10 kg, at the end of the 20 BP. For a 25 kg diversion the detection time increases for a $P_D \simeq 98$ % to 13 BP (from 10 BP for the I-LR case).

- In a 100 t/a facility, the P_D for 5 kg goes down to 37.34 % at the end of the 20th BP (95.98 P_D at the end of 9 BP in the case of I-LR). For 25 kg, the D_T increases to 9 BP (from 3 BP for I-LR) for a P_D = 100 %.

4.4.2 Measurement Uncertainties at the Input and Detection Time D_T (Tables 58A, 59A)

The results of this series of investigations are summarized in Tables 58A and 59A. The general trend is approximately the same as in the case of the detectable amounts, i.e. the detection time improves with increasing value of the ratio ΔM/LMUF. This is the case with decreasing values of σ_i's or increasing amounts of M in a given facility or for a given σ_i, with decreasing size of the facility. It is to be noted also that the value of ΔM/LMUF increases when one proceeds from protracted to abrupt diversion mode. However, besides this general comments some specific conclusions can also be drawn from the results obtained:

- In a given facility, there is always a minimum amount M for a given P_D, below which the detection time cannot be shortened to a value which is less than 20 BP i.e. one year, after a diversion has been assumed to begin. However, with increasing amounts, the D_T in the same facility improves in general. The rate of improvement depends mainly on the σ_i's at the input, but also on the diversion scenarios assumed. This is illustrated below in the two following tables for DS - 1 and DS - 7.

FT: 1000 t/a; DS - 1

$\sigma_i \to$ 0.5 %			1 %			2 %		
Mkg	P_D%	BP	Mkg	P_D%	BP	Mkg	P_D%	BP
11.6	95.0	20	16.5	95.0	20	27	95	20
12	95.46	7	17	95.45	6	30	95.77	2
13.5	96.37	4	18.5	95.04	3	35	99.92	2
30	97.97	1	25	99.92	2	40	97.84	1
			35	99.64	1			

FT: 1000 t/a; DS - 7

$\sigma_i \rightarrow$ 0.5 %			1 %			2 %		
Mkg	P_D%	BP	Mkg	P_D%	BP	Mkg	P_D%	BP
17.9	95	20	28.3	95	20	51.7	95	20
20	95.32	17	30	95.01	18	60	96.26	16
25	96.07	12	40	96.2	12	70	95.88	12
70	97.04	5	100	99.39	5	150	98.91	5

A number of points are worth noting from these two tables:

- The rate of improvement in the absolute amount M and in the detection time D_T is higher for DS - 1 than for DS - 7. In the case of DS - 1 for example, the D_T improves in the 1000 t/a facility from 20 BP to 1 BP, when one increases the amount M from 11.6 kg Pu to 30 kg for σ_i = 0.5 %. The same improvement in D_T is obtained for σ_i = 2 %, if one increases the M from 27 kg to 40 kg. For DS - 7, these improvements are much more sluggish, as shown in the second table above.

- For a given amount M in a facility with I-LR, D_T or P_D improves with increasing accuracy at the input tank, for both DS - 1 and DS - 7, as is shown below:

1000 t/a; I-LR; DS - 1 for 15 kg			1000 t/a; I-LR; DS - 7 for 25 kg		
σ_i%	P_D%	BP	σ_i%	P_D%	BP
2	30	20	2	36	20
1	87	20	1	88	20
0.5	96	3	0.5	96	13

The rate of the improvement in D_T is higher for DS - 1 than for DS - 7.

- In the cases with constant inventories I-C, for smaller facilities, a somewhat similar trend as in the I-LR cases is seen for the 500 t/a facility for relatively small detectable amounts M. However, for larger M's as well as for the other smaller facilities (240 t/a, 100 t/a), P_D and D_T tend to cluster around about the same value. This is illustrated below.

	DS - 1			DS - 7	
	σ_i	P_D	BP	P_D	BP
15 kg 240 t/a	2 %	98	3	92	20
	1 %	99	3	97	16
	0.5 %	99	3	96	14
15 kg 100 t/a	2 %	99	3	96	15
	1 %	99	3	97	14
	0.5 %	99	3	98	14

This phenomenon of clustering around approximately the same values of P_D and BP for a given M indicates that for the small facilities with I-C, above a certain value of M, the P_D's and D_T's are <u>independent</u> of the measurement uncertainty σ_i's at the input accountability tank. For these cases, the uncertainty in the <u>inventory measurement</u> (LI), and <u>not</u> the throughput measurements, determine the LMUF values, which as was discussed earlier, determines the P_D and D_T values for a given M in a facility.

- The rate of improvements in D_T with increasing amounts of M for facilities with I-LR, is <u>higher</u> for larger σ_i values. For example with 2 % σ_i's in a 1000 t/a facility for DS - 1, an increase of M from 27 to 30 kg i.e. a factor of 1.11 brings about an improvement in D_T from 20 to 2 BP i.e. a factor of 10. With 0.5 % σ_i an increase in M from 11.6 to 13.5 kg i.e. an increase by a factor 1.16 improves the D_T in the same facility by a factor of 5 only (20 BP to 4 BP). This result is somewhat unexpected since the larger σ_i values have in general smaller slopes for the corresponding probability curves. However, this improvement could be caused by the fact that within a certain range of M values, the probability of detection increases more rapidly for larger than for smaller σ_i values, with smaller increments in M. This rapid increase in P_D values causes at the same time a shortening of D_T.

- Whenever a diversion of a given amount M is detected within 3 BP's (about 4 weeks), it is associated with a fairly high probability of detection. This is independent of the diversion scenarios considered as is shown below (for cases with I-LR only):

M:kg	Facility: t/a	σ_i%	DS	P_D/BP
35	1000	2	1	99.92/2
25	100	0.5	7	100/2
15	100	0.5	7	99.61/3
10	240	2	1	100/1

The high value of P_D associated with very short detection times, is mainly caused by the fact that the ratio ΔM/LMUF in such cases is always so high that it forces the P_D to shoot up almost immediately to very high values (see for example Figs. 4B and 6B). As a result a $P_D \geq 99$ % is obtained within the first few balancing periods after a diversion has been assumed to begin.

4.4.3 Diversion Strategies DS and Detection Time D_T (Table 61, Figs. 20, 21)

The influence of the seven diversion strategies considered here on the detection time was analyzed in the frame of these investigations for I-LR and σ_i = 1 % and is summarized in Table 61. The question of how the amounts of process inventories in a facility would influence the detection time was also investigated for the two extreme diversion scenarios DS - 1 and DS - 7. The nature of influence is indicated as examples in Figs. 20 and 21.

In all these investigations the D_T has been expressed as the number of balancing periods BP (after which a diversion has been assumed to start) at which a detection of the amount M is possible with a $P_D \geq 95$ %. Since 1 BP = 10 working days, the number of BP's multiplied by 10 gives the number of working days after which the detection with the given P_D takes place. For example a BP = 3 for M = 10 kg in a 500 t/a facility with the abrupt diversion mode of DS - 1 in Table 61 would mean that in this facility, if 10 kgs of Pu were to be removed abruptly at one time from the process MBA at the 21st BP (after 20 diversion free periods), this diversion would be detected through the NRTA method, within 30 days with a probability of detection of 98.57 %.

A number of interesting points can be discerned out of these results:

- The results presented in Table 61 confirm the earlier conclusion that out of the 7 diversion scenarios considered here, the first 5 belong to the category of abrupt diversion and the scenarios 6 and 7 to that of protracted diversion.

- The D_T (expressed in BP's) for a given M and P_D improves in general gradually from DS - 7 to 6, shows a downward jump in going to 5 and remains within a relatively short range while going from DS - 5 to DS - 1. This general trend is illustrated below with M = 10 and M = 40 kg of Pu for the 4 facilities considered (excerpts from Table 61).

<u>σ_i = 1 %; I-LR</u>

DS→	1		2		3		4		5		6		7	
Mkg→ / FT t/a ↓	10	40	10	40	10	40	10	40	10	40	10	40	10	40
1000 BP →	20*	1	20*	1	20*	2	20*	3	20*	3	20*	6	20*	12
500 BP →	3	1	4	1	4	2	5	2	6	2	20*	3	20*	6
240 BP →	1	1	2	1	2	1	3	1	3	1	6	2	11	3
100 BP →	1	1	1	1	1	1	2	1	2	1	3	1	5	2

*Whenever 20 BP has been intered in the tables, $P_D \geq 95$ % cannot be obtained in these cases.

- For a 1000 t/a facility with M = 40 kg for example, D_T drops from 12 to 6 BP if one proceeds from DS - 7 to DS - 6 and then remains in the range of 3 - 1 BP if one proceeds further from DS - 5 to DS - 1.

- The difference in D_T between DS - 7 and DS - 1 for a given amount M, decreases as one proceeds from larger to smaller size facilities. For example in a 1000 t/a facility with M = 40 kg, D_T drops from 12 BP for DS - 7 to 1 BP for DS - 1, i.e. by a factor of 12. This factor is 6 in a 500 t/a, 3 in a 240 t/a and 2 in a 100 t/a facility.

a) Different values of M (Table 61)

If a given amount M_o can be detected in a facility at the end of the 20th BP with a P_D = 95 % (Tables 54, 55, 56, 57), then for all other $M > M_o$, the same M_o (or a larger amount) will be detected with at least 95 % P_D but with a shorter detection time. This is shwon below for a 500 t/a facility for all the diversion strategies considered (excerpts from Table 61).

FT = 500 t/a; I-LR; σ_i = 1 %, total amount M assumed to be diverted = 15 kg

DS →	1	2	3	4	5	6	7
M_o^+ with P_D = 95 % kg	8.27	8.25	8.31	8.55	8.6	10.2	14.1
No. of BP with $P_D \geq$ 95 % and M = 15	2	2	3	4	4	8	19
corresponding P_D%	100	99.8	99.3	100	100	98.55	96.27
amount diverted up to this BP kg	15	15	15	15	12	12	14.25

+The values for M_o are reproduced from Tables 54 for DS - 1 and 56 for DS - 7 and from Figs. 5B for the rest of the DS.

Points to be noted are:

- The M_o values (i.e. the amount of Pu which can be detected with 95 % P_D at the end of the 20th BP) under the conditions specified for this table, are shown in the first line of the above table for all the diversion scenarios considered. For DS - 1, the M = 15 kg is assumed to be diverted abruptly and completely during the first BP (after 20 diversion free periods). This diversion will be detected with $P_D \simeq 100$ % already in the 2nd BP. In DS - 6, the same 15 kg have been assumed to be diverted in equal portions (i.e. 1.5 kg/BP) during 10 successive BP's starting with the 1st BP. For this strategy with 15 kg, a P_D = 98.55 % is attained after the 8th BP. Up to the 8th BP 1.5•8 = 12 kg of Pu would have been diverted. In the examples cited in the table, the amounts which can be detected with these high P_D's are always larger than the corresponding M_o values.

  The results in the table above indicate also in an unequivocal way, that the first 5 DS considered here, belong to the same category of diversion scenarios i.e. that of abrupt diversion. All the M_o values for these 5 strategies are around 8 kg of Pu.

- In a given facility and DS, the D_T improves with increasing amounts of M assumed to be diverted. This fact is illustrated below for a 500 t/a facility with DS - 7.

  FT = 500 t/a; I-LR; σ_i = 1 %; DS - 7

Total M assumed to be diverted kg	20	30	40
No. of BP	16	10	8
with P_D%	96.26	98.65	98.06
corresponding amounts diverted up to this BP	16	15	16

It is to be noted that the amounts which could be detected with the given P_D's are around 16 kg of Pu for all the three cases. However, for a total amount of 20 kg assumed to be diverted, this high P_D value of 96.26 % is obtained at the 16th BP. For an amount of 30 kg the number of BP's improves to 10 and for a 40 kg diversion to a BP value of 8. This improvement can be traced back directly to the large ΔM/LMUF values which increase monotonously with increasing M in a given facility.

b) Comparison Between the Cases with I-LR and I-C (Figs. 20, 21)

Figs. 20 and 21 show the influence of process inventories or detection times for the two extreme diversion scenarios DS - 1 and DS - 7 (Tables 58, 59).

It is to be noted that for DS - 1 (Figs. 20A, 20B), the main difference in D_T for the two inventory situations LR-I and C-I, lies in a significant increase in the D_T (or a worsening of P_D at the end of the 20th BP when relevant) for the latter case, in the range of 5-10 kg of M, as shown below.

DS - 1; σ_i = 1 % (excerpt from Tables 58, 59)

FT(t/a)	500		240		100	
M(kg)	5	10	5	10	5	10
LR-I (BP/P_D)	20/41	3/98	3/99	1/100	1/100	1/100
C-I (BP/P_D)	20/25	20/88	20/44	5/97	20/54	5/99

The difference in D_T between the two inventory cases reduces rapidly with increasing values of M and disappears completely for all values of M ≥ 30 kg - the D_T being equal to 1 BP for all these cases.

- With DS - 7 (Figs. 21A, 21B) all the D_T values for the two inventory situations I-LR and I-C are relatively high compared to those for DS - 1. Seen graphically, these D_T values for DS - 7 appear to stretch more against the amounts M than those for DS - 1.

- For the cases with constant inventories for DS - 7, all the D_T values appear to cluster around the same range with increasing amounts assumed to be diverted. This is illustrated below for the three small facilities 500 t/a, 240 t/a and 100 t/a:

I-C; σ_i = 1 %; DS - 7

Mkg → / FT(t/a) ↓	25	30	35	40
500 (D_T expressed in BP)	12	10	9	8
240 (D_T) →	10	9	8	7
100 (D_T) →	9	8	7	7

This particular behaviour for D_T in the cases with constant inventories, can be explained mainly by the fact, that in all these cases the LMUF/BP for the 3 facilities with constant inventory, ranges around approximately the same value of 3-4 kg of Pu. Since the contribution of measurement uncertainties from throughput measurements are relatively small, the LMUF in these cases is mainly determined by the inventory measurement uncertainty. It may be recalled that practically the same behaviour was observed for different σ_i's and D_T for constant inventory cases in these facilities (see para. 4.4.2).

5. Concluding Remarks

The main purpose of the present series of detailed investigations with computer simulated data, had been to understand and recognize the factors which influence the sensitivity of the detection capability of the NRTA method in a reprocessing facility, and not so much to generate absolute numbers. These numbers are important mainly as indicator for recognizing some general trends.

5.1 Sensitivity

The most important conclusion to be drawn from these investigations is the confirmation of the fact that the NRTA method provides a significant improvement in the sensitivity of the detection capability and detection time over the conventional material balance method.in a reprocessing facility. The improvement may be in the range of a factor of 10-20, depending on the facility size, amounts of process inventory, accuracy of measurement system and the possible mode of diversion.

5.2 Test Procedure Used

The statistical test procedure i.e. the two sided Page's test used in these investigations, appears to maintain its sensitivity over a wide range of abrupt and protracted diversion scenarios considered. The only important boundary condition which needs to be fulfilled is the existence of a number of diversion free balancing periods. This is the situation encountered routinely by the IAEA.

The sensitivity of this test procedure may, however, be reduced for the so-called alternating diversion scenarios in which a certain amount is assumed to be withdrawn from the process MBA during a balancing period and a smaller amount introduced in the MBA at a later balancing period. Other test procedures /6, 7/ may provide better sensitivity for such scenarios. It would, therefore, always be advantageous for the Agency to apply a number of test procedures for the same set of NRTA data from a reprocessing facility, to ensure a broad coverage for different possibilities of diversions, without loosing the sensitivity.

5.3 Computer Simulated and Realistic Data Base

The results discussed in this report are obtained through computer simulation. Under actual operating conditions in a reprocessing facility, because of deviations from the simulated situations which may exist in the facility, the sensitivity may suffer. This would mean only an upward revision of the absolute numbers for M, P_D and D_T obtained through simulation. The fundamental advantages of the NRTA method are, however, not expected to disappear.

Some research activities are under way to use actual operation data from reprocessing facilities for testing the sensitivity of the NRTA method.

Table 1: Throughputs, Inventories and Measurement Uncertainties (σ's) for Reprocessing Facilities Considered for Investigations

Throughput								
tHM/a	1000		500		240		100	
tPu/a	10		5		2.4		1.0	
	kgPu/Batch	Batch/d	kgPu/B	B/d	kgPu/B	B/d	kgPu/B	B/d
Input	16.73	3	8.365	3	4.015	3	1.673	3
Product	25.0	2	12.5	2	6.0	2	2.50	2
Waste	0.2	1	0.1	1	0.048	1	0.02	1
Process Inventory[1] |kgPu|								
Head-End	196.5		98.25		47.16		19.65	
1. Pu-Cycle	7.6		3.80		1.82		0.76	
2. Pu-Cycle	50.0		25.00		12.00		5.00	
3. Pu-Cycle	134.0		67.00		32.16		13.40	
Pu-Concn.	62.5		31.25		15.0		6.25	
Total	450.6		225.25		108.14		45.06	

Measurement Uncertainties[2]; $\sigma_S = \sigma_R$ |%|

Throughput		Inventory	
Input Ac.Tank	1.0	Head-End	1.0
Product	0.20	1. Pu-Cycle	1.0
Waste	25.0	2. Pu-Cycle	0.5
		3. Pu-Cycle	0.5
		Pu-Concn.	0.5

1. In the main series of investigations the process inventory of Pu was reduced linearly with decreasing throughput (abbreviation LR-I or I-LR). The value for 1000 t/a facility was taken as the reference value and reproduced from Ref. /5/.
In a second series of investigations, the process inventories of Pu were kept constant at 450.6 kg Pu for all the facilities (abbreviation I-C or C-I) to find out the influence of variations in inventories on the sensitivity of the NRTA method.

2. Whereas the measurement uncertainties for the input in the reprocessing facility (i.e. input accountability tank) were varied from 0.5 %, 1 %, to 2 %, those for the process inventories and product and waste streams were kept unchanged for these investigations.

Table 2A: Variances and LMUFs for Different Size Facilities with Linearly Reduced Inventories (LR-I) and Different Measurement Uncertainties at Input Accountability Tank

Measurement Uncertainties $\sigma_S = \sigma_R$	1000 t/a	500 t/a	240 t/a	100 t/a
0.5 %				
Var.MUF $\|kgPu\|^2$	16.78	4.19	0.97	0.17
LMUF |kgPu|	4.0969	2.0485	0.9832	0.4097
L-Thrpt. |kgPu|	2.8	1.4	0.67	0.28
L-Inventory |kgPu|	3.0	1.50	0.72	0.3
1 %				
Var.MUF $\|kgPu\|^2$	36.30	9.08	2.10	0.36
LMUF |kgPu|	6.0255	3.0128	1.4461	0.6026
L-Thrpt. |kgPu|	5.2	2.61	1.26	0.52
L-Inventory |kgPu|	3.0	1.50	0.72	0.3
2 %				
var.MUF $\|kgPu^2\|$	114.39	28.60	6.59	1.14
LMUF |kgPu|	10.6957	5.3478	2.5668	1.0696
L-Thrpt. |kgPu|	10.3	5.13	2.46	1.03
L-Inventory |kgPu|	3.0	1.50	0.72	0.3

$L = \sqrt{\text{variance}}$

Table 2B: Variances and LMUFs for Different Size Facilities with Constant Inventories (C-I) and Different Measurement Uncertainties at Input Accountability Tank

Measurement Uncertainties $\sigma_S = \sigma_R$	1000 t/a	500 t/a	240 t/a	100 t/a
0.5 %				
Var.MUF $\|kgPu\|^2$	16.78	10.91	9.40	9.03
LMUF $\|kgPu\|$	4.0969	3.3031	3.0665	3.005
L-Thrpt. $\|kgPu\|$	2.8	1.40	0.67	0.28
L-Inventory $\|kgPu\|$	3.0	3.0	3.0	3.0
1 %				
Var.MUF $\|kgPu\|^2$	36.30	15.79	10.52	9.23
LMUF $\|kgPu\|$	6.0255	3.9737	3.2446	3.0374
L-Thrpt. $\|kgPu\|$	5.2	2.61	1.26	0.52
L-Inventory $\|kgPu\|$	3.0	3.0	3.0	3.0
2 %				
Var.MUF $\|kgPu^2\|$	114.40	35.31	15.02	10.0
LMUF $\|kgPu\|$	10.6957	5.9425	3.876	3.1633
L-Thrpt. $\|kgPu\|$	10.3	5.13	2.46	1.03
L-Inventory $\|kgPu\|$	3.0	3.0	3.0	3.0

$L = \sqrt{\text{variance}}$

Table 3: Diversion Scenarios (DS) Considered for Investigations

Diversion Scenarios	1	2	3	4	5	6	7
No. of working days [d] over which a given amount of Pu (M) is assumed to be uniformly diverted	10	20	30	40	50	100	200
No. of Balancing Periods (BP)	1	2	3	4	5	10	20

Table 4: Amounts (ΔM) Assumed to be Diverted per Balancing Period for the Different Diversion Scenarios

Diversion Scenarios[1] → / Total Amount (M) assumed to be diverted |kgPu| ↓	1 (1 BP)	2 (2 BP)	3 (3 BP)	4 (4 BP)	5 (5 BP)	6 (10 BP)	7 (20 BP)
5 [kgPu]	5	2.5	1.67	1.25	1.0	0.5	0.25
10	10	5.0	3.34	2.5	2.0	1.0	0.5
15	15	7.5	5	3.75	3.0	1.5	0.75
20	20	10.0	6.67	5.0	4.0	2.0	1.0
25	25	12.5	8.33	6.25	5.0	2.5	1.25
30	30	15.0	10	7.5	6.0	3.0	1.5
40	40	20.0	13.33	10	8.0	4.0	2.0

1. Since the first 20 Balancing Periods (BP) are assumed to be diversion free, the counting of BP in the tables starts from the 21st BP, i.e. 21.BP = 1.BP.

Table 5A: ΔM/LMUF for Different Facility Throughputs with Linearly Reduced Inventories (LR-I) and Different σ's and DS - 1

Facility Size ↓ |tU/a|	M |kgPu| →	5	10	15	20	25	30	40
	σ |%|*							
1000	1.0	0.83	1.66	2.49	3.32	4.15	4.98	6.64
	0.5	1.22	2.44	3.66	4.88	6.10	7.32	9.76
	2.0	0.47	0.93	1.40	1.87	2.34	2.80	3.74
500	1.0	1.66	3.32	4.98	6.64	8.30	9.95	13.28
	0.5	2.44	4.88	7.32	9.76	12.20	14.65	19.53
	2.0	0.93	1.87	2.8	3.74	4.67	5.61	7.48
240	1.0	3.45	6.90	10.37	13.79	17.29	20.74	27.66
	0.5	5.10	10.20	15.26	20.34	25.42	30.51	40.68
	2.0	1.95	3.89	5.84	7.79	9.74	11.69	15.58
100	1.0	8.30	16.59	24.89	33.19	41.48	49.78	66.38
	0.5	12.20	24.39	36.59	48.82	61.02	73.22	97.60
	2.0	4.67	9.35	14.02	18.69	23.37	28.04	37.39

*In Tables 5A, 5B for DS - 1 and Tables 11A, 11B for DS - 7, three sets of values, i.e. for 1 %, 0.5 % and 2 % measurement uncertainties at the input are included for linearly reduced inventories (Tables 5A and 11A) and constant inventories (Tables 5B and 11B) for different facility throughputs. In the rest of the tables (6-10) three sets of values for 1 %, 0.5 % and 2 % measurement uncertainties have been included only for the 1000 t/a facility. Rest of the values for the different facilities are for 1 % measurement uncertainty at the input. All the values in Tables 6-10 are for linearly reduced inventories only.

Table 5B: ΔM/LMUF for Different Facility Throughputs with Constant Inventories (C-I) and Different σ's and DS - 1

Facility Size ↓ |tU/a|	M |kgPu| →	5	10	15	20	25	30	40
	σ |%|*							
1000	1.0	0.83	1.66	2.49	3.32	4.15	4.98	6.64
	0.5	1.22	2.44	3.66	4.88	6.10	7.32	9.76
	2.0	0.47	0.93	1.40	1.87	2.34	2.80	3.74
500	1.0	1.26	2.52	3.77	5.03	6.29	7.55	10.07
	0.5	1.51	3.03	4.54	6.06	7.57	9.08	12.10
	2.0	0.84	1.68	2.52	3.37	4.21	5.05	6.73
240	1.0	1.54	3.08	4.62	6.16	7.71	9.25	12.33
	0.5	1.63	3.26	4.89	6.52	8.15	9.78	13.04
	2.0	1.29	2.58	3.87	5.15	6.44	7.73	10.31
100	1.0	1.64	3.29	4.93	6.58	8.23	9.87	13.16
	0.5	1.67	3.33	4.99	6.66	8.31	9.98	13.31
	2.0	1.58	3.16	4.74	6.32	7.90	9.48	12.65

*In Tables 5A, 5B for DS - 1 and Tables 11A, 11B for DS - 7, three sets of values, i.e. for 1 %, 0.5 % and 2 % measurement uncertainties at the input are included for linearly reduced inventories (Tables 5A and 11A) and constant inventories (Tables 5B and 11B) for different facility throughputs. In the rest of the tables (6-10) three sets of values for 1 %, 0.5 % and 2 % measurement uncertainties have been included only for the 1000 t/a facility. Rest of the values for the different facilities are for 1 % measurement uncertainty at the input. All the values in Tables 6-10 are for linearly reduced inventories only.

Table 6: ΔM/LMUF for Different Size Facilities and DS - 2

1000*	0.42 0.60 0.23	0.83 1.22 0.47	1.25 1.83 0.70	1.67 2.44 0.93	2.08 3.05 1.17	2.5 3.66 1.40	3.33 4.88 1.87
500	0.83	1.67	2.5	3.33	4.17	5.0	6.67
240	1.72	3.45	5.17	6.9	8.62	10.34	13.79
100	4.17	8.33	12.5	16.67	20.8	25.0	33.3

Table 7: ΔM/LMUF for Different Size Facilities and DS - 3

1000*	0.28 0.41 0.16	0.56 0.81 0.31	0.83 1.22 0.47	1.11 1.63 0.62	1.39 2.03 0.78	1.67 2.44 0.93	2.22 3.25 1.25
500	0.56	1.11	1.67	2.22	2.78	3.33	4.44
240	1.15	2.30	3.45	4.60	5.74	6.90	9.19
100	2.78	5.57	8.33	11.12	13.88	16.67	22.22

*In Tables 5A, 5B for DS - 1 and Tables 11A, 11B for DS - 7, three sets of values, i.e. for 1 %, 0.5 % and 2 % measurement uncertainties at the input are included for linearly reduced inventories (Tables 5A and 11A) and constant inventories (Tables 5B and 11B) for different facility throughputs. In the rest of the tables (6-10) three sets of values for 1 %, 0.5 % and 2 % measurement uncertainties have been included only for the 1000 t/a facility. Rest of the values for the different facilities are for 1 % measurement uncertainty at the input. All the values in Tables 6-10 are for <u>linearly reduced inventories</u> only.

Table 8: ΔM/LMUF for Different Size Facilities and DS - 4

Facility Size [tU/a] ↓ \ M [kgPu] →	5	10	15	20	25	30	40
1000*	0.21 0.30 0.12	0.42 0.60 0.23	0.63 0.91 0.35	0.83 1.22 0.47	1.04 1.52 0.58	1.25 1.83 0.7	1.67 2.44 0.93
500	0.42	0.83	1.25	1.67	2.08	2.5	3.33
240	0.86	1.72	2.59	3.45	4.31	5.17	6.9
100	2.08	4.17	6.25	8.33	10.42	12.5	16.67

Table 9: ΔM/LMUF for Different Size Facilities and DS - 5

1000*	0.17 0.24 0.09	0.33 0.49 0.19	0.5 0.73 0.28	0.67 0.98 0.37	0.83 1.22 0.47	1.0 1.46 0.56	1.33 1.95 0.75
500	0.33	0.67	1.0	1.33	1.67	2.0	2.67
240	0.69	1.38	2.07	2.76	3.45	4.14	5.52
100	1.67	3.33	5.0	6.67	8.33	10	13.33

Table 10: ΔM/LMUF for Different Size Facilities and DS - 6

1000*	0.08 0.12 0.05	0.17 0.24 0.09	0.25 0.37 0.14	0.33 0.49 0.19	0.42 0.60 0.23	0.5 0.73 0.28	0.67 0.98 0.37
500	0.17	0.33	0.5	0.67	0.83	1.0	1.33
240	0.34	0.69	1.03	1.38	1.72	2.07	2.76
100	0.83	1.67	2.5	3.33	4.17	5.0	6.67

*In Tables 5A, 5B for DS - 1 and Tables 11A, 11B for DS - 7, three sets of values, i.e. for 1 %, 0.5 % and 2 % measurement uncertainties at the input are included for linearly reduced inventories (Tables 5A and 11A) and constant inventories (Tables 5B and 11B) for different facility throughputs. In the rest of the tables (6-10) three sets of values for 1 %, 0.5 % and 2 % measurement uncertainties have been included only for the 1000 t/a facility. Rest of the values for the different facilities are for 1 % measurement uncertainty at the input. All the values in Tables 6-10 are for linearly reduced inventories only.

Table 11A: ΔM/LMUF for Different Facility Throughputs with Linearly Reduced Inventories (LR-I) and Different σ's and DS - 7

Facility Size ↓ |tU/a|	M|kgPu| |kgPu/BP| →	5 0.25	10 0.5	15 0.75	20 1.0	25 1.25	30 1.5	40 2.0
	σ |%|*							
1000	1.0	0.04	0.08	0.13	0.17	0.21	0.25	0.33
	0.5	0.06	0.12	0.18	0.24	0.30	0.37	0.49
	2.0	0.02	0.05	0.07	0.09	0.12	0.14	0.19
500	1.0	0.08	0.17	0.25	0.33	0.42	0.5	0.67
	0.5	0.12	0.24	0.37	0.49	0.61	0.73	0.98
	2.0	0.05	0.09	0.14	0.19	0.23	0.28	0.37
200	1.0	0.17	0.34	0.52	0.69	0.86	1.03	1.38
	0.5	0.26	0.51	0.76	1.02	1.27	1.53	2.04
	2.0	0.10	0.19	0.29	0.39	0.49	0.58	0.78
100	1.0	0.42	0.83	1.25	1.67	2.08	2.5	3.33
	0.5	0.61	1.22	1.83	2.44	3.05	3.66	4.88
	2.0	0.23	0.47	0.70	0.93	1.17	1.40	1.89

*In Tables 5A, 5B for DS - 1 and Tables 11A, 11B for DS - 7, three sets of values, i.e. for 1 %, 0.5 % and 2 % measurement uncertainties at the input are included for linearly reduced inventories (Tables 5A and 11A) and constant inventories (Tables 5B and 11B) for different facility throughputs. In the rest of the tables (6-10) three sets of values for 1 %, 0.5 % and 2 % measurement uncertainties have been included only for the 1000 t/a facility. Rest of the values for the different facilities are for 1 % measurement uncertainty at the input. All the values in Tables 6-10 are for linearly reduced inventories only.

Table 11B: ΔM/LMUF for Different Facility Throughputs with Constant Inventories (C-I) and Different σ's and DS - 7

Facility Size ↓ |tU/a|	M|kgPu| |kgPu/BP| →	5 0.25	10 0.5	15 0.75	20 1.0	25 1.25	30 1.5	40 2.0
	σ |%|*							
1000	1.0	0.04	0.08	0.13	0.17	0.21	0.25	0.33
	0.5	0.06	0.12	0.18	0.24	0.30	0.37	0.49
	2.0	0.02	0.05	0.07	0.09	0.12	0.14	0.19
500	1.0	0.06	0.13	0.19	0.25	0.32	0.38	0.50
	0.5	0.07	0.15	0.23	0.30	0.38	0.45	0.60
	2.0	0.04	0.08	0.12	0.17	0.21	0.25	0.34
240	1.0	0.08	0.15	0.23	0.31	0.37	0.46	0.62
	0.5	0.08	0.16	0.24	0.32	0.40	0.49	0.65
	2.0	0.06	0.13	0.19	0.26	0.32	0.39	0.52
100	1.0	0.08	0.16	0.25	0.33	0.41	0.49	0.66
	0.5	0.08	0.17	0.25	0.33	0.42	0.50	0.67
	2.0	0.08	0.16	0.24	0.32	0.40	0.47	0.63

*In Tables 5A, 5B for DS - 1 and Tables 11A, 11B for DS - 7, three sets of values, i.e. for 1 %, 0.5 % and 2 % measurement uncertainties at the input are included for linearly reduced inventories (Tables 5A and 11A) and constant inventories (Tables 5B and 11B) for different facility throughputs. In the rest of the tables (6-10) three sets of values for 1 %, 0.5 % and 2 % measurement uncertainties have been included only for the 1000 t/a facility. Rest of the values for the different facilities are for 1 % measurement uncertainty at the input. All the values in Tables 6-10 are for linearly reduced inventories only.

Table 12A:+Detection Probabilities (P_D %) after the 40th BP for Different Values of M(kgPu) and Facility Throughputs with Linearly Reduced Inventories (LR-I) for DS - 1

Facility Thrpt. ↓ |tU/a|	M |kgPu| →	5 P_D	10 P_D	15 P_D	20 P_D	25 P_D	30 P_D	40 P_D
	σ |%|*							
1000	1.0	11.71	41.54	87.89	99.83	100	100	100
	0.5	22.94	84.02	99.89	100	100	100	100
	2.0	6.86	14.13	30.42	59.20	88.36	98.93	100
500	1.0	41.54	99.83	100	100	100	100	100
	0.5	84.02	100	100	100	100	100	100
	2.0	14.12	59.19	98.93	100	100	100	100
240	1.0	99.91	100	100	100	100	100	100
	0.5	100	100	100	100	100	100	100
	2.0	65.01	100	100	100	100	100	100
100	1.0		All values ≃ 100					
	0.5							
	2.0							

*The measurement uncertainties are for the input. Rest of the measurement uncertainties are as in Table 1.

+The corresponding values of ΔM/LMUF for different values of M are taken from Table 5A for generating the values in Figs. 4A and 4B.

Table 12B: +Detection Probabilities (P_D %) after the 40th BP for Different Values of M(kgPu) and Facility Throughputs with Constant Inventories (C-I) for DS - 1

Facility Thrpt. |tU/a| ↓	M |kgPu| →	5 P_D	10 P_D	15 P_D	20 P_D	25 P_D	30 P_D	40 P_D
	σ |%|*							
1000	1.0	11.71	41.54	87.89	99.83	100	100	100
	0.5	22.94	84.02	99.89	100	100	100	100
	2.0	6.86	14.13	30.42	59.20	88.36	98.93	100
500	1.0	25.78	88.73	99.96	100	100	100	100
	0.5	41.00	98.76	100	100	100	100	100
	2.0	12.10	43.46	89.92	99.87	100	100	100
240	1.0	44.27	99.22	100	100	100	100	100
	0.5	52.58	99.77	100	100	100	100	100
	2.0	27.68	91.37	99.98	100	100	100	100
100	1.0	54.87	99.85	100	100	100	100	100
	0.5	59.35	99.89	100	100	100	100	100
	2.0	47.93	99.57	100	100	100	100	100

*The measurement uncertainties are for the input. Rest of the measurement uncertainties are as in Table 1.

+The corresponding values of ΔM/LMUF for different values of M are taken from Table 5B for generating the values in Figs. 4A and 4B.

Table 13: Detection Probabilities (P_D) for Different Values of ΔM/LMUF and Facility Throughputs with LR-I's for DS - 2

No.	ΔM/LMUF	Probability of Detection P_D(%)	Facility Throughput tU/a	LMUF kgPu	Total Diverted Amount (M) kgPu	Remarks
1	0.42	11.71	1000	6.0	5	All the values are for Measurement Uncertainties as in Table 1, with those for the Input: $\sigma_S = \sigma_R = 1$ %
2	0.83	40.76	1000	6.0	10	
3	0.83	40.76	500	3.0	5	
4	1.25	86.28	1000	6.0	15	
5	1.67	99.63	500	3.0	10	
6	1.67	99.63	1000	6.0	20	
7	1.72	99.82	240	1.45	5	
8	2.08	100	1000	6.0	25	
9	2.5	100	500	3.0	15	
10	3.45	100	240	1.45	10	

All other values of ΔM/LMUF ⩾ 2.08 have $P_D \simeq 100$

Table 14: Detection Probabilities (P_D) for Different Values of ΔM/LMUF and Facility Throughputs with LR-I's for DS - 3

No.	ΔM/LMUF	Probability of Detection P_D(%)	Facility Throughput tU/a	LMUF kgPu	Total Diverted Amount (M) kgPu	Remarks
1	0.28	11.62	1000	6.0	5	All the values are for Measurement Uncertainties as in Table 1, with those for the Input: $\sigma_S = \sigma_R = 1$ %
2	0.56	40.10	1000	6.0	10	
3	0.56	40.10	500	3.0	5	
4	0.83	84.38	1000	6.0	15	
5	1.11	99.37	500	3.0	10	
6	1.11	99.37	1000	6.0	20	
7	1.15	99.66	240	1.45	5	
8	1.39	100	1000	6.0	25	
9	1.67	100	500	3.0	15	
10	2.30	100	240	1.45	10	

All other values of ΔM/LMUF ⩾ 1.39 have $P_D \simeq 100$

Note: In Tables 13-17 values for the different facilities have been included for linearly reduced inventories only.

Table 15: Detection Probabilities (P_D) for Different Values of ΔM/LMUF and Facility Throughputs with LR-I's for DS - 4

No.	ΔM/LMUF	Probability of Detection P_D (%)	Facility Throughput tU/a	LMUF kgPu	Total Diverted Amount (M) kgPu	Remarks
1	0.21	11.49	1000	6.0	5	All the values are for Measurement Uncertainties as in Table 1, with those for the Input: $\sigma_S = \sigma_R = 1$ %
2	0.42	39.14	1000	6.0	10	
3	0.42	39.14	500	3.0	5	
4	0.63	82.35	1000	6.0	15	
5	0.83	98.97	1000	6.0	20	
6	0.83	98.97	500	3.0	10	
7	0.86	99.45	240	1.45	5	
8	1.04	99.98	1000	6.0	25	
9	1.25	100	1000	6.0	30	
10	1.25	100	500	3.0	15	

All other values of ΔM/LMUF ⩾ 1.25 have $P_D \simeq 100$

Table 16: Detection Probabilities (P_D) for Different Values of ΔM/LMUF and Facility Throughputs with LR-I's for DS - 5

No.	ΔM/LMUF	Probability of Detection P_D (%)	Facility Throughput tU/a	LMUF kgPu	Total Diverted Amount (M) kgPu	Remarks
1	0.17	11.30	1000	6.0	5	All the values are for Measurement Uncertainties as in Table 1, with those for the Input: $\sigma_S = \sigma_R = 1$ %
2	0.33	38.27	1000	6.0	10	
3	0.33	38.27	500	3.0	5	
4	0.50	79.99	1000	6.0	15	
5	0.67	98.46	500	3.0	10	
6	0.67	98.46	1000	6.0	20	
7	0.69	99.09	240	1.45	5	
8	0.83	99.98	1000	6.0	25	
9	1.0	100	1000	6.0	30	
10	1.0	100	500	3.0	15	

All other values of ΔM/LMUF ⩾ 1.0 have $P_D \simeq 100$

Note: In Tables 13-17 values for the different facilities have been included for linearly reduced inventories only.

Table 17: Detection Probabilities (P_D) for Different Values of ΔM/LMUF and Facility Throughputs with LR-I's for DS - 6

No.	ΔM/LMUF	Probability of Detection P_D (%)	Facility Throughput tU/a	LMUF kgPu	Total Diverted Amount (M) kgPu	Remarks
1	0.08	10.60	1000	6.0	5	All the values are for Measurement Uncertainties as in Table 1, with those for the Input: $\sigma_S = \sigma_R = 1$ %
2	0.17	32.72	1000	6.0	10	
3	0.17	32.72	500	3.0	5	
4	0.25	67.45	1000	6.0	15	
5	0.33	92.77	1000	6.0	20	
6	0.33	92.77	500	3.0	10	
7	0.34	94.87	240	1.45	5	
8	0.42	99.37	1000	6.0	25	
9	0.5	99.96	1000	6.0	30	
10	0.5	99.96	500	3.0	15	
11	0.67	100	1000	6.0	40	
12	0.67	100	500	3.0	20	
13	0.69	100	240	1.45	10	

All other values of ΔM/LMUF $\geqslant$ 0.67 have $P_D \simeq 100$

Note: In Tables 13-17 values for the different facilities have been included for linearly reduced inventories only.

Table 18A:[+] Detection Probabilities (P_D%) at the End of the 40th BP for Different Values of M(kgPu) and Facility Throughputs with LR-I's for DS - 7

Facility Thrpt. ↓ |tU/a|	M |kgPu| →	5 P_D	10 P_D	15 P_D	20 P_D	25 P_D	30 P_D	40 P_D
	σ |%|*							
1000	1.0	8.76	20.45	42.69	69.10	88.02	97.14	99.98
	0.5	14.24	47.26	84.20	98.34	99.97	100	100
	2.0	6.08	9.47	15.27	24.08	36.54	50.86	77.45
500	1.0	20.45	69.10	97.14	99.98	100	100	100
	0.5	47.25	98.33	100	100	100	100	100
	2.0	9.47	24.08	50.86	77.45	93.64	98.86	100
240	1.0	73.05	100	100	100	100	100	100
	0.5	99.03	100	100	100	100	100	100
	2.0	26.04	80.70	99.32	100	100	100	100
100	1.0	All values ≃ 100						
	0.5	All values ≃ 100						
	2.0	93.64	Rest ≃ 100					

*The measurement uncertainties are for the input. Rest of the measurement uncertainties are as in Table 1.

[+] The corresponding values of ΔM/LMUF for different values of M are taken from 11A for generating the values in Figs. 6A and 6B.

Table 18B:+ Detection Probabilities (P_D %) at the End of the 40th BP for Different Values of M(kgPu) and Facility Throughputs with C-I's for DS - 7

Facility Thrpt. ↓ |tU/a|	M |kgPu| →	5 P_D	10 P_D	15 P_D	20 P_D	25 P_D	30 P_D	40 P_D
	σ |%|*							
1000	1.0	8.76	20.45	42.69	69.10	88.02	97.14	99.98
	0.5	14.24	47.26	84.20	98.34	99.97	100	100
	2.0	6.08	9.47	15.27	24.08	36.54	50.86	77.45
500	1.0	15.71	53.80	86.77	99.35	100	100	100
	0.5	25.59	82.00	99.52	100	100	100	100
	2.0	8.96	21.45	45.04	71.66	89.90	97.77	100
240	1.0	28.25	86.05	99.82	100	100	100	100
	0.5	35.52	94.10	100	100	100	100	100
	2.0	16.85	57.99	92.44	99.68	100	100	100
100	1.0	37.34	95.41	Rest ≃ 100				
	0.5	40.27	96.90	Rest ≃ 100				
	2.0	31.14	90.28	99.96	Rest ≃ 100			

*The measurement uncertainties are for the input. Rest of the measurement uncertainties are as in Table 1.

+The corresponding values of ΔM/LMUF for different values of M are taken from Table 11B for generating the values in Figs. 7A and 7B.

Table 19 FT = 1000 t/a DS - 1 $\sigma_S = \sigma_R = 0.5$ % for Input

M kg Pu → / No. BP ↓, P_D →	5	10	15	20	25	30	40
21	0.01	0.04	0.12	0.31	0.69	0.98	1.0
25	0.11	0.71	1.0	1.0	1.0	1.0	1.0
30	0.19	0.82	1.0	1.0	1.0	1.0	1.0
35	0.21	0.83	1.0	1.0	1.0	1.0	1.0
40	0.23	0.84	1.0	1.0	1.0	1.0	1.0

Table 20 FT = 1000 t/a DS - 1 $\sigma_S = \sigma_R = 1$ % for Input

M kg Pu → / No. BP ↓, P_D →	5	10	15	20	25	30	40
21	0.01	0.03	0.09	0.22	0.49	0.87	1.0
25	0.05	0.31	0.83	0.99	1.0	1.0	1.0
30	0.09	0.38	0.86	1.0	1.0	1.0	1.0
35	0.10	0.39	0.86	1.0	1.0	1.0	1.0
40	0.11	0.41	0.88	1.0	1.0	1.0	1.0

Table 21 FT = 1000 t/a DS - 1 $\sigma_S = \sigma_R = 2\%$ for Input

M kg Pu → / No. BP ↓, P_D →	5	10	15	20	25	30	40
21	0.01	0.02	0.05	0.11	0.24	0.46	0.98
25	0.03	0.08	0.24	0.53	0.86	0.98	1.0
30	0.04	0.10	0.27	0.56	0.86	0.98	1.0
35	0.05	0.12	0.28	0.57	0.87	0.98	1.0
40	0.07	0.14	0.30	0.60	0.88	0.99	1.0

Note: All values in Tables 19-21 are for process inventories linearly reduced with decreasing facility throughputs (LR-I).

Tables 19-21: Probability of detection (P_D) for a 1000 t/a facility as a function of the number of balancing periods (BP) for different amounts of Pu (M), assumed to be diverted and different measurement uncertainties (σ_S, σ_R) for the input, with the rest of the uncertainties being the same as in Table 1; FT = Facility Throughput (tU/a); for DS - 1. See Table 3 for explanation of the number.

Table 22	FT = 1000 t/a		DS - 7		$\sigma_S = \sigma_R$ = 0.5 % for Input	
No. BP ↓ / M kg Pu → / P_D →	5	10	15	20	25	30	40
21	0.009	0.009	0.009	0.009	0.009	0.009	0.009
25	0.017	0.022	0.033	0.054	0.091	0.14	0.33
30	0.04	0.10	0.26	0.51	0.77	0.93	0.99
35	0.08	0.28	0.63	0.90	0.98	1.0	1.0
40	0.14	0.47	0.84	0.98	1.0	1.0	1.0

Table 23	FT = 1000 t/a		DS - 7		$\sigma_S = \sigma_R$ = 1 % for Input		
No. BP ↓ / M kg Pu → / P_D →	5	10	15	20	25	30	40
21	0.009	0.009	0.009	0.009	0.009	0.009	0.009
25	0.016	0.019	0.024	0.035	0.052	0.076	0.16
30	0.032	0.058	0.11	0.22	0.37	0.55	0.87
35	0.056	0.12	0.27	0.49	0.72	0.88	1.0
40	0.09	0.2	0.43	0.69	0.88	0.98	1.0

Table 24	FT = 1000 t/a		DS - 7		$\sigma_S = \sigma_R$ = 2 % for Input		
No. BP ↓ / M kg Pu → / P_D →	5	10	15	20	25	30	40
21	0.009	0.009	0.009	0.009	0.009	0.009	0.009
25	0.016	0.017	0.018	0.022	0.026	0.034	0.055
30	0.027	0.035	0.049	0.072	0.11	0.16	0.31
35	0.044	0.063	0.096	0.15	0.23	0.34	0.60
40	0.06	0.09	0.15	0.24	0.36	0.50	0.77

Note: All values in Tables 22-24 are for LR-I's.

Tables 22-24: Probability of detection (P_D) for a 1000 t/a facility as a function of the number of balancing periods (BP) for different amounts of Pu (M), assumed to be diverted and different measurement uncertainties (σ_S, σ_R) for the input, with the rest of the uncertainties being the same as in Table 1;
FT = Facility Throughput (tU/a);
for DS - 7. See Table 3 for explanation of the number.

Table 25/23 FT = 1000 t/a DS - 1 $\sigma_S = \sigma_R = 1$ % for Input

No ↓BP \ M kg Pu → / P_D →	5	10	15	20	25	30	40
21	0.01	0.03	0.09	0.22	0.49	0.87	1.0
25	0.05	0.31	0.83	0.99	1.0	1.0	1.0
30	0.09	0.38	0.86	1.0	1.0	1.0	1.0
35	0.10	0.39	0.86	1.0	1.0	1.0	1.0
40	0.11	0.41	0.88	1.0	1.0	1.0	1.0

Table 26 FT = 500 t/a DS - 1 $\sigma_S = \sigma_R = 1$ % for Input

No ↓BP \ M kg Pu → / P_D →	5	10	15	20	25	30	40
21	0.03	0.22	0.87	1.0	1.0	1.0	1.0
25	0.31	0.99	1.0	1.0	1.0	1.0	1.0
30	0.38	0.99	1.0	1.0	1.0	1.0	1.0
35	0.39	0.99	1.0	1.0	1.0	1.0	1.0
40	0.42	0.99	1.0	1.0	1.0	1.0	1.0

Table 27 FT = 240 t/a DS - 1 $\sigma_S = \sigma_R = 1$ % for Input

No ↓BP \ M kg Pu → / P_D →	5	10	15	20	25	30	40
21	0.25	1.0	1.0	1.0	1.0	1.0	1.0
25	0.99	1.0	1.0	1.0	1.0	1.0	1.0
30	0.99	1.0	1.0	1.0	1.0	1.0	1.0
35	1.0	1.0	1.0	1.0	1.0	1.0	1.0
40	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Table 28 FT = 100 t/a DS - 1 $\sigma_S = \sigma_R = 1$ % for Input

No ↓BP \ M kg Pu → / P_D →	5	10	15	20	25	30	40
21 25 30 35 40	All values of P_D = 1.0						

Note: All the values in Tables 25-28 are for LR-I's.

Tables 25-28: Probability of detection (P_D) for different facility throughputs (FT) as a function of the number of balancing periods (BP) for different amounts of Pu (M), assumed to be diverted for DS - 1. See Table 3 for explanation of the number. $\sigma_S = \sigma_R$ = systematic and random measurement uncertainties at the input, rest being the same as in Table 1.

Table 29	FT = 1000 t/a		DS - 2	$\sigma_S = \sigma_R$ = 1% for Input			
M kg Pu → / No. ↓BP / P_D →	5	10	15	20	25	30	40
21	0.01	0.01	0.02	0.03	0.05	0.09	0.22
25	0.05	0.29	0.79	0.99	1.0	1.0	1.0
30	0.09	0.38	0.85	0.99	1.0	1.0	1.0
35	0.10	0.39	0.85	0.99	1.0	1.0	1.0
40	0.11	0.40	0.86	0.99	1.0	1.0	1.0

Table 30	FT = 500 t/a		DS - 2	$\sigma_S = \sigma_R$ = 1% for Input			
M kg Pu → / No. ↓BP / P_D →	5	10	15	20	25	30	40
21	0.01	0.03	0.09	0.22	0.49	0.87	1.0
25	0.29	0.99	1.0	1.0	1.0	1.0	1.0
30	0.38	0.99	1.0	1.0	1.0	1.0	1.0
35	0.39	0.99	1.0	1.0	1.0	1.0	1.0
40	0.41	0.99	1.0	1.0	1.0	1.0	1.0

Table 31	FT = 240		DS - 2	$\sigma_S = \sigma_R$ = 1% for Input			
M kg Pu → / No. ↓BP / P_D →	5	10	15	20	25	30	40
21	0.04	0.25	0.93	1.0	1.0	1.0	1.0
25	0.99	1.0	1.0	1.0	1.0	1.0	1.0
30	0.99	1.0	1.0	1.0	1.0	1.0	1.0
35	0.99	1.0	1.0	1.0	1.0	1.0	1.0
40	0.99	1.0	1.0	1.0	1.0	1.0	1.0

Table 32	FT = 100 t/a		DS - 2	$\sigma_S = \sigma_R$ = 1 % for Input			
M kg Pu → / No. ↓BP / P_D →	5	10	15	20	25	30	40
21	0.49						
25 30 35 40	All other values of P_D = 1.0						

Note: All the values in Tables 29-32 are for LR-I's.

Tables 29-32: Probability of detection (P_D) for different facility throughputs (FT) as a function of the number of balancing periods (BP) for different amounts of Pu (M), assumed to be diverted for DS - 2. See Table 3 for explanation of the number. $\sigma_S = \sigma_R$ = systematic and random measurement uncertainties at the input, rest being the same as in Table 1.

Table 33 FT = 1000 t/a DS - 3 $\sigma_S = \sigma_R$ = 1% for Input

No. BP ↓ \ M kg Pu → / P_D →	5	10	15	20	25	30	40
21	0.009	0.01	0.01	0.02	0.03	0.03	0.06
25	0.05	0.25	0.74	0.98	0.99	1.0	1.0
30	0.08	0.36	0.83	0.99	1.0	1.0	1.0
35	0.10	0.39	0.83	0.99	1.0	1.0	1.0
40	0.12	0.40	0.84	0.99	1.0	1.0	1.0

Table 34 FT = 500 t/a DS - 3 $\sigma_S = \sigma_R$ = 1 % for Input

No. BP ↓ \ M kg Pu → / P_D →	5	10	15	20	25	30	40
21	0.01	0.02	0.03	0.06	0.12	0.22	0.62
25	0.25	0.98	1.0	1.0	1.0	1.0	1.0
30	0.37	0.99	1.0	1.0	1.0	1.0	1.0
35	0.39	0.99	1.0	1.0	1.0	1.0	1.0
40	0.40	0.99	1.0	1.0	1.0	1.0	1.0

Table 35 FT = 240 t/a DS - 3 $\sigma_S = \sigma_R$ = 1% for Input

No. BP ↓ \ M kg Pu → / P_D →	5	10	15	20	25	30	40
21	0.02	0.07	0.25	0.72	0.99	1.0	1.0
25	0.99	1.0	1.0	1.0	1.0	1.0	1.0
30	0.99	1.0	1.0	1.0	1.0	1.0	1.0
35	0.99	1.0	1.0	1.0	1.0	1.0	1.0
40	0.99	1.0	1.0	1.0	1.0	1.0	1.0

Table 36 FT = 100 t/a DS - 3 $\sigma_S = \sigma_R$ = 1% for Input

No. BP ↓ \ M kg Pu → / P_D →	5	10	15	20	25	30	40
21	0.12	0.98					
25	All other values for P_D = 1.0						
30							
35							
40							

Note: All the values in Tables 33-36 are for LR-I's.

Tables 33-36: Probability of detection (P_D) for different facility throughputs (FT) as a function of the number of balancing periods (BP) for different amounts of Pu (M), assumed to be diverted for DS - 3. See Table 3 for explanation of the number. $\sigma_S = \sigma_R$ = systematic and random measurement uncertainties at the input, rest being the same as in Table 1.

Table 37 FT = 1000 t/a DS - 4 $\sigma_S = \sigma_R$ = 1% for Input

No. BP ↓ \ M kg Pu →, P_D →	5	10	15	20	25	30	40
21	0.009	0.01	0.01	0.01	0.02	0.02	0.03
25	0.04	0.21	0.65	0.96	0.99	1.0	1.0
30	0.08	0.36	0.80	0.98	0.99	1.0	1.0
35	0.1	0.38	0.81	0.98	0.99	1.0	1.0
40	0.11	0.39	0.82	0.98	0.99	1.0	1.0

Table 38 FT = 500 t/a DS - 4 $\sigma_S = \sigma_R$ = 1% for Input

No. BP ↓ \ M kg Pu →, P_D →	5	10	15	20	25	30	40
21	0.01	0.01	0.02	0.03	0.05	0.09	0.22
25	0.21	0.96	1.0	1.0	1.0	1.0	1.0
30	0.37	0.99	1.0	1.0	1.0	1.0	1.0
35	0.38	0.99	1.0	1.0	1.0	1.0	1.0
40	0.39	0.99	1.0	1.0	1.0	1.0	1.0

Table 39 FT = 240 t/a DS - 4 $\sigma_S = \sigma_R$ = 1% for Input

No. BP ↓ \ M kg Pu →, P_D →	5	10	15	20	25	30	40
21	0.01	0.03	0.10	0.25	0.57	0.93	1.0
25	0.97	1.0	1.0	1.0	1.0	1.0	1.0
30	0.99	1.0	1.0	1.0	1.0	1.0	1.0
35	0.99	1.0	1.0	1.0	1.0	1.0	1.0
40	0.99	1.0	1.0	1.0	1.0	1.0	1.0

Table 40 FT = 100 t/a DS - 4 $\sigma_S = \sigma_R$ = 1% for Input

No. BP ↓ \ M kg Pu →, P_D →	5	10	15	20	25	30	40
21	0.05	0.49					
25							
30	All other values for P_D = 1.0						
35							
40							

Note: All the values in Tables 37-40 are for LR-I's.

Tables 37-40: Probability of detection (P_D) for different facility throughputs (FT) as a function of the number of balancing periods (BP) for different amounts of Pu (M), assumed to be diverted for DS - 4. See Table 3 for explanation of the number. $\sigma_S = \sigma_R$ = systematic and random measurement uncertainties at the input, rest being the same as in Table 1.

Table 41	FT = 1000 t/a		DS - 5		$\sigma_S = \sigma_R$ = 1% for Input		
No. ↓BP / M kg Pu → / P_D →	5	10	15	20	25	30	40
21	0.009	0.009	0.01	0.01	0.01	0.02	0.02
25	0.06	0.15	0.50	0.88	0.99	1.0	1.0
30	0.08	0.35	0.78	0.98	0.99	1.0	1.0
35	0.10	0.37	0.79	0.98	0.99	1.0	1.0
40	0.11	0.38	0.80	0.98	0.99	1.0	1.0

Table 42	FT = 500 t/a		DS -5		$\sigma_S = \sigma_R$ = 1% for Input		
No. ↓BP / M kg Pu → / P_D →	5	10	15	20	25	30	40
21	0.009	0.01	0.02	0.02	0.03	0.05	0.10
25	0.16	0.88	1.0	1.0	1.0	1.0	1.0
30	0.35	0.98	1.0	1.0	1.0	1.0	1.0
35	0.38	0.98	1.0	1.0	1.0	1.0	1.0
40	0.38	0.98	1.0	1.0	1.0	1.0	1.0

Table 43	FT = 240 t/a		DS - 5		$\sigma_S = \sigma_R$ = 1% for Input		
No. ↓BP / M kg Pu → / P_D →	5	10	15	20	25	30	40
21	0.01	0.03	0.05	0.12	0.26	0.49	0.98
25	0.59	1.0	1.0	1.0	1.0	1.0	1.0
30	0.99	1.0	1.0	1.0	1.0	1.0	1.0
35	0.99	1.0	1.0	1.0	1.0	1.0	1.0
40	0.99	1.0	1.0	1.0	1.0	1.0	1.0

Table 44	FT = 100 t/A		DS - 5		$\sigma_S = \sigma_R$ = 1% for Input		
No. ↓BP / M kg Pu → / P_D →	5	10	15	20	25	30	40
21	0.03	0.22	0.87				
25 / 30 / 35 / 40	All other values for P_D = 1.0						

Note: All the values in Tables 41-44 are for LR-I's.

Tables 41-44: Probability of detection (P_D) for different facility throughputs (FT) as a function of the number of balancing periods (BP) for different amounts of Pu (M), assumed to be diverted for DS - 5. See Table 3 for explanation of the number. $\sigma_S = \sigma_R$ = systematic and random measurement uncertainties at the input, rest being the same as in Table 1.

Table 45 FT = 1000 DS - 6 $\sigma_S = \sigma_R = 1\%$ for Input

No. ↓BP \ M kg Pu → / P_D →	5	10	15	20	25	30	40
21	0.009	0.009	0.009	0.009	0.01	0.01	0.01
25	0.02	0.03	0.07	0.16	0.30	0.50	0.88
30	0.05	0.22	0.55	0.87	0.98	0.99	1.0
35	0.09	0.31	0.66	0.92	0.99	0.99	1.0
40	0.10	0.33	0.67	0.93	0.99	0.99	1.0

Table 46 FT = 500 t/a DS - 6 $\sigma_S = \sigma_R = 1\%$ for Input

No. ↓BP \ M kg Pu → / P_D →	5	10	15	20	25	30	40
21	0.009	0.009	0.01	0.01	0.01	0.02	0.02
25	0.03	0.15	0.50	0.88	0.99	1.0	1.0
30	0.22	0.87	0.99	1.0	1.0	1.0	1.0
35	0.31	0.92	0.99	1.0	1.0	1.0	1.0
40	0.33	0.93	0.99	1.0	1.0	1.0	1.0

Table 47 FT = 240 t/a DS - 6 $\sigma_S = \sigma_R = 1\%$ for Input

No. ↓BP \ M kg Pu → / P_D →	5	10	15	20	25	30	40
21	0.01	0.01	0.02	0.03	0.04	0.05	0.12
25	0.18	0.92	1.0	1.0	1.0	1.0	1.0
30	0.90	1.0	1.0	1.0	1.0	1.0	1.0
35	0.95	1.0	1.0	1.0	1.0	1.0	1.0
40	0.95	1.0	1.0	1.0	1.0	1.0	1.0

Table 48 FT = 100 t/a DS - 6 $\sigma_S = \sigma_R = 1\%$ for Input

No. ↓BP \ M kg Pu → / P_D →	5	10	15	20	25	30	40
21	0.01	0.03	0.09	0.22	0.49	0.87	
25	0.99						
30	All other values of P_D = 1.0						
35							
40							

Note: All the values in Tables 45-48 are for LR-I's.

Tables 45-48: Probability of detection (P_D) for different facility throughputs (FT) as a function of the number of balancing periods (BP) for different amounts of Pu (M), assumed to be diverted for DS - 6. See Table 3 for explanation of the number. $\sigma_S = \sigma_R$ = systematic and random measurement uncertainties at the input, rest being the same as in Table 1.

Table 49/20 FT = 1000 t/a DS − 7 $\sigma_S = \sigma_R$ = 1% for Input

No. BP ↓ \ M kg Pu → (P_D →)	5	10	15	20	25	30	40
21	0.009	0.009	0.009	0.009	0.009	0.009	0.009
25	0.016	0.02	0.02	0.04	0.05	0.08	0.16
30	0.03	0.06	0.11	0.22	0.37	0.55	0.87
35	0.056	0.12	0.27	0.49	0.72	0.88	1.0
40	0.09	0.2	0.43	0.69	0.88	0.97	1.0

Table 50 FT = 500 t/a DS − 7 $\sigma_S = \sigma_R$ = 1% for Input

No. BP ↓ \ M kg Pu → (P_D →)	5	10	15	20	25	30	40
21	0.009	0.009	0.009	0.009	0.01	0.01	0.01
25	0.02	0.04	0.08	0.15	0.29	0.50	0.89
30	0.06	0.22	0.55	0.87	0.98	0.99	1.0
35	0.12	0.49	0.88	0.99	1.0	1.0	1.0
40	0.20	0.69	0.97	0.99	1.0	1.0	1.0

Table 51 FT = 240 t/a DS − 7 $\sigma_S = \sigma_R$ = 1% for Input

No. BP ↓ \ M kg Pu → (P_D →)	5	10	15	20	25	30	40
21	0.009	0.01	0.01	0.01	0.01	0.02	0.03
25	0.04	0.18	0.56	0.92	0.99	1.0	1.0
30	0.24	0.90	0.99	1.0	1.0	1.0	1.0
35	0.53	0.99	1.0	1.0	1.0	1.0	1.0
40	0.73	1.0	1.0	1.0	1.0	1.0	1.0

Table 52 FT = 100 t/a DS − 7 $\sigma_S = \sigma_R$ = 1% for Input

No. BP ↓ \ M kg Pu → (P_D →)	5	10	15	20	25	30	40
21	0.01	0.01	0.02	0.03	0.05	0.09	0.22
25	0.30	0.99					
30	0.98						
35	All other values of P_D = 1.0						
40							

Note: All the values in Tables 49-52 are for LR-I's.

Tables 49-52: Probability of detection (P_D) for different facility throughputs (FT) as a function of the number of balancing periods (BP) for different amounts of Pu (M), assumed to be diverted for DS - 7. See Table 3 for explanation of the number. $\sigma_S = \sigma_R$ = systematic and random measurement uncertainties at the input, rest being the same as in Table 1.

Table 53A: Detection probabilities (P_D %) at the end of the 40th balancing period (BP) for different amounts of Pu (M in kg) and different facility throughputs (FT) with different measurement uncertainties (σ's in %) at the input and different inventory amounts (LR-I inventory linearly reduced; C-I for constant inventories) for DS - 1

M |kgPu|	σ %	1000 t/a LR-I P_D	1000 t/a C-I P_D	500 t/a LR-I P_D	500 t/a C-I P_D	240 t/a LR-I P_D	240 t/a C-I P_D	100 t/a LR-I P_D	100 t/a C-I P_D
5	0.5	22.94	22.94	84.02	41.00	100	52.58	100	59.35
	1.0	11.71	11.71	41.54	25.78	99.91	44.27	100	54.87
	2.0	6.86	6.86	14.12	12.10	65.01	27.68	100	47.93
10	0.5	84.02	84.02	100	98.76	100	99.77	100	99.89
	1.0	41.54	41.54	99.83	88.73	100	99.22	100	99.85
	2.0	14.13	14.13	59.19	43.46	100	91.37	100	99.57
15	0.5	99.89	99.89	100	100	100	100	100	100
	1.0	87.89	87.89	100	99.96	100	100	100	100
	2.0	30.42	30.42	98.93	89.92	100	99.98	100	100
20	0.5	100	100	100	100	100	100	100	100
	1.0	99.83	99.83	100	100	100	100	100	100
	2.0	59.20	59.20	100	99.87	100	100	100	100
25	0.5	100	100	100	100	100	100	100	100
	1.0	100	100	100	100	100	100	100	100
	2.0	88.36	88.36	100	100	100	100	100	100
30	0.5	100	100	100	100	100	100	100	100
	1.0	100	100	100	100	100	100	100	100
	2.0	98.36	98.36	100	100	100	100	100	100
40	0.5	100	100	100	100	100	100	100	100
	1.0	100	100	100	100	100	100	100	100
	2.0	100	100	100	100	100	100	100	100

Table 53B: Detection probabilities (P_D %) at the end of the 40th balancing period (BP) for different amounts of Pu (M in kg) and different facility throughputs (FT) with different measurement uncertainties (σ's in %) at the input and different inventory amounts (LR-I inventory linearly reduced; C-I for constant inventories) for DS - 7

M |kgPu|	σ %	1000 t/a LR-I P_D	1000 t/a C-I P_D	500 t/a LR-I P_D	500 t/a C-I P_D	240 t/a LR-I P_D	240 t/a C-I P_D	100 t/a LR-I P_D	100 t/a C-I P_D
5	0.5	14.24	14.24	47.25	25.59	99.03	35.52	100	40.27
	1.0	8.73	8.76	20.45	15.71	73.05	28.25	100	37.34
	2.0	6.08	6.08	9.47	8.96	26.04	16.85	93.64	31.14
10	0.5	47.26	47.26	98.33	82.00	100	94.10	100	96.90
	1.0	20.45	20.45	69.10	53.80	100	86.03	100	95.41
	2.0	9.47	9.47	24.08	21.45	80.70	57.99	100	90.28
15	0.5	84.20	84.20	100	99.52	100	100	100	100
	1.0	42.69	42.69	97.14	89.77	100	99.82	100	100
	2.0	15.27	15.27	50.86	45.04	99.32	92.44	100	99.96
20	0.5	98.34	98.34	100	100	100	100	100	100
	1.0	69.10	69.10	99.98	99.35	100	100	100	100
	2.0	24.08	24.08	77.45	71.66	100	99.68	100	100
25	0.5	99.97	99.97	100	100	100	100	100	100
	1.0	88.02	88.02	100	100	100	100	100	100
	2.0	36.54	36.54	93.64	89.90	100	100	100	100
30	0.5	100	100	100	100	100	100	100	100
	1.0	97.14	97.14	100	100	100	100	100	100
	2.0	50.86	50.86	98.86	97.77	100	100	100	100
40	0.5	100	100	100	100	100	100	100	100
	1.0	99.98	99.98	100	100	100	100	100	100
	2.0	77.45	77.45	100	100	100	100	100	100

Table 54: M (kgPu) which could be detected with P_D = 95 % for different FT with LR-I's and different σ_i's for DS - 1

Facility |t/a| ↓ / σ_i →	0.5 % M (kgPu)	0.5 % ΔM/LMUF per BP	1 % M (kgPu)	1 % ΔM/LMUF per BP	2 % M (kgPu)	2 % ΔM/LMUF per BP
1000	11.58	2.83	16.53	2.75	27.0	2.52
500	5.8	2.83	8.27	2.75	13.5	2.52
240	2.78	2.83	3.97	2.75	6.50	2.53
100	1.16	2.83	1.66	2.75	2.70	2.52

Table 55: M (kgPu) which could be detected with P_D = 95 % for different FT with C-I's and different σ_i's for DS - 1

Facility |t/a| ↓ / σ_i →	0.5 % M (kgPu)	0.5 % ΔM/LMUF per BP	1 % M (kgPu)	1 % ΔM/LMUF per BP	2 % M (kgPu)	2 % ΔM/LMUF per BP
1000	11.58	2.83	16.53	2.75	27.0	2.52
500	8.89	2.70	10.97	2.76	16.2	2.73
240	7.936	2.58	8.6	2.65	10.6	2.73
100	7.47	2.48	7.76	2.55	8.27	2.61

Note: Abbreviations

- C-I constant inventory in kg
- DS diversion scenarios (s.Table 3)
- FT facility throughput in t/a
- LR-I linearly reduced inventories with decreasing FT in kg
- LI limits of error in inventory measurement in kg
- LT limits of error in throughput measurement in kg
- LMUF limits of error of Material Unaccounted For in kg
- M amount of Pu in kg assumed to be diverted for a given diversion scenario
- P_D detection probability in % with a false alarm rate of 5 %
- σ_i $\sigma_S = \sigma_R$ = measurement uncertainties at the input, rest being the same as given in Table 1
- α false alarm rate set at 5 %

Table 56: M (kgPu) which could be detected with P_D = 95 % for different FT with LR-I's and different σ_i's for DS - 7

Facility |t/a| ↓ / σ_i →	0.5 % M (kgPu)	0.5 % ΔM/LMUF per BP	1 % M (kgPu)	1 % ΔM/LMUF per BP	2 % M (kgPu)	2 % ΔM/LMUF per BP
1000	17.9	0.218	28.3	0.235	51.7	0.241
500	8.9	0.217	14.1	0.234	25.6	0.239
240	4.3	0.218	6.8	0.235	12.4	0.243
100	1.8	0.218	2.8	0.235	5.17	0.241

Table 57: M (kgPu) which could be detected with P_D = 95 % for different FT with C-I's and different σ_i's for DS - 7

Facility |t/a| ↓ / σ_i →	0.5 % M (kgPu)	0.5 % ΔM/LMUF per BP	1 % M (kgPu)	1 % ΔM/LMUF per BP	2 % M (kgPu)	2 % ΔM/LMUF per BP
1000	17.9	0.218	28.3	0.235	51.7	0.241
500	12.2	0.185	16.57	0.209	27.65	0.232
240	10.2	0.170	11.50	0.177	15.8	0.204
100	9.50	0.158	9.89	0.162	10.9	0.172

Table 58: Detection times (D_T), expressed as the number of balancing periods (BP) at which a $P_D \geq 95$ % is attained, as a function of FT with LR-I's and M for two extreme diversion scenarios DS - 1 (abrupt diversion) and DS - 7 (protracted diversion) for $\sigma_i = 1$ %

Facility Thrpt. (FT) \ M |kgPu|	5	10	15	20	25	30	35	40
1000 t/a								
DS - 1	11.71*	41.54*	87.89*	3 BP	2 BP	2 BP	1 BP	1 BP
DS - 7	8.76*	20.45*	42.69*	69.10*	88.02*	18 BP	14 BP	12 BP
500 t/a								
DS - 1	41.54*	3 BP	2 BP	1 BP	1 BP	1 BP	1 BP	1 BP
DS - 7	20.45*	69.10*	18 BP	12 BP	9 BP	8 BP	7 BP	6 BP
240 t/a								
DS - 1	3 BP	1 BP	1 BP	1 BP	1 BP	1 BP	1 BP	1 BP
DS - 7	73.05*	11 BP	7 BP	6 BP	5 BP	4 BP	4 BP	3 BP
100 t/a								
DS - 1	1 BP	1 BP	1 BP	1 BP	1 BP	1 BP	1 BP	1 BP
DS - 7	9 BP	5 BP	4 BP	3 BP	3 BP	2 BP	2 BP	2 BP

*Maximum attainable P_D at the end of the 20th balancing period after a diversion is assumed to begin. Since the first 20 balancing periods are assumed to be diversion free, the counting of BP in these tables starts from the 21st BP, so that 21. BP = 1. BP.

Table 58A: Detection times (D_T), expressed as the number of balancing periods (BP) at which a P_D > 95 % is attained, as a function of FT with LR-I's and M for two extreme diversion scenarios DS - 1 (abrupt diversion) and DS - 7 (protracted diversion) for σ_i = 0,5 %, 1 %, 2 % (numbers for σ_i = 1 % have been taken over from Table 58)

FT(I-LR) \ kgPu		5			15			25			35		
	σ_i%	0.5	1	2	0.5	1	2	0.5	1	2	0.5	1	2
1000 t/a	DS - 1	22.94*	11.71*	6.86*	3BP	87.89*	30.42*	2BP	2BP	88.36*	1BP	1BP	2BP
	DS - 7	14.24*	8.76*	6.08*	84.20*	42.69*	15.27*	13BP	88.02*	36.54*	9BP	14BP	65.25*
500 t/a	DS - 1	84.02*	41.54*	14.12*	1BP	2BP	2BP	1BP	1BP	1BP	1BP	1BP	1BP
	DS - 7	47.25*	20.45*	9.47*	11BP	18BP	50.85	7BP	9BP	93.64*	5BP	7BP	12BP
240 t/a	DS - 1	2BP	3BP	65.01*	1BP	1BP	1BP	1BP	1BP	1BP	1BP	1BP	1BP
	DS - 7	16BP	73.05*	26.04*	6BP	7BP	14BP	4BP	5BP	7BP	3BP	4BP	5BP
100 t/a	DS - 1	1BP	1BP	1BP	1BP	1BP	1BP	1BP	1BP	1BP	1BP	1BP	1BP
	DS - 7	7BP	9BP	93.64*	3BP	4BP	5BP	2BP	3BP	3BP	2BP	2BP	2BP

*Maximum attainable P_D at the end of the 20th balancing period after a diversion is assumed to begin. Since the first 20 balancing periods are assumed to be diversion free, the counting of BP in these tables starts from the 21st BP, so that 21. BP = 1. BP.

Table 59: Detection times (D_T), expressed as the number of balancing periods (BP) at which a P_D > 95 % is attained, as a function of FT with C-I's and M for two extreme diversion scenarios DS - 1 (abrupt diversion) and DS - 7 (protracted diversion) for σ_i = 1 %

Facility Thrpt. (FT) \ M |kgPu|	5	10	15	20	25	30	35	40
1000 t/a								
DS - 1	11.71*	41.54*	87.89*	3 BP	2 BP	2 BP	1 BP	1 BP
DS - 7	8.76*	20.45*	42.69*	69.10*	88.02*	18 BP	14 BP	12 BP
500 t/a								
DS - 1	25.78*	88.73*	3 BP	2 BP	2 BP	1 BP	1 BP	1 BP
DS - 7	15.71*	53.80*	89.77	16 BP	12 BP	10 BP	9 BP	8 BP
240 t/a								
DS - 1	44.27*	5 BP	3 BP	2 BP	2 BP	1 BP	1 BP	1 BP
DS - 7	28.25*	86.03	16 BP	12 BP	10 BP	9 BP	8 BP	7 BP
100 t/a								
DS - 1	54.87*	5 BP	3 BP	1 BP	1 BP	1 BP	1 BP	1 BP
DS - 7	37.34*	20 BP	14 BP	11 BP	9 BP	8 BP	7 BP	7 BP

*Maximum attainable P_D at the end of the 20th balancing period after a diversion is assumed to begin. Since the first 20 balancing periods are assumed to be diversion free, the counting of BP in these tables starts from the 21st BP, so that 21. BP = 1. BP.

Table 59A: Detection times (D_T), expressed as the number of balancing periods (BP) at which a P_D > 95 % is attained, as a function of FT with C-I's and M for two extreme diversion scenarios DS - 1 (abrupt diversion) and DS - 7 (protracted diversion) for σ_i = 0.5 %, 1 %, 2 % (numbers for σ_i = 1 % have been taken over from Table 59)

FT(I-) \ kgPu	5			15			25			35		
σ_i %	0.5	1	2	0.5	1	2	0.5	1	2	0.5	1	2
1000 t/a												
DS - 1	22.94*	11.71*	6.86*	3BP	87.89*	30.42*	2BP	2BP	88.36*	1BP	1BP	2BP
DS - 7	14.24*	8.76*	6.08*	84.20*	42.69*	15.27*	13BP	88.02*	36.54*	9BP	14BP	65.25*
500 t/a												
DS - 1	41.0*	25.78*	12.10*	3BP	3BP	89.92	2BP	2BP	2BP	1BP	1BP	1BP
DS - 7	25.59*	15.71*	8.96*	16BP	89.77*	45.04*	10BP	12BP	89.90*	8BP	9BP	14BP
240 t/a												
DS - 1	52.58*	44.27*	27.68*	3BP	3BP	3BP	2BP	2BP	2BP	1BP	1BP	1BP
DS - 7	35.52*	28.25*	16.85*	14BP	16BP	92.44*	9BP	10BP	12BP	7BP	8BP	9BP
100 t/a												
DS - 1	59.35*	54.87*	47.93*	3BP	3BP	3BP	2BP	2BP	2BP	1BP	1BP	1BP
DS - 7	40.27*	37.34*	31.14*	14BP	14BP	15BP	9BP	9BP	10BP	7BP	7BP	8BP

*Maximum attainable P_D at the end of the 20th balancing period after a diversion is assumed to begin. Since the first 20 balancing periods are assumed to be diversion free, the counting of BP in these tables starts from the 21st BP, so that 21. BP = 1 BP.

Table 60: Detection Probability (P_D %) as a Function of Diversion Scenarios (DS) for a Given Amount (M) for Different Facility Throughputs (FT) with I-LR and 1% σ .

FT ↓ t/a	DS → / M kg ↓	1 P_D	2 P_D	3 P_D	4 P_D	5 P_D	6 P_D	7 P_D
1000	5	11	11	12	11	11	10	9
500	5	42	41	40	39	38	33	20
240	5	100	99	99	99	99	95	73
100	5	100	100	100	100	100	100	100
1000	10	41	40	40	39	38	33	20
500	10	99	99	99	99	98	93	69
240	10	100	100	100	100	100	100	100
100	10	100	100	100	100	100	100	100
1000	20	100	99	99	98	98	93	69
500	20	100	100	100	100	100	100	99
240	20	100	100	100	100	100	100	100
100	20	100	100	100	100	100	100	100
1000	30	100	100	100	100	100	99	97
500	30	100	100	100	100	100	100	100
240	30	100	100	100	100	100	100	100
100	30	100	100	100	100	100	100	100
1000	40	100	100	100	100	100	100	100
500	40	100	100	100	100	100	100	100
240	40	100	100	100	100	100	100	100
100	40	100	100	100	100	100	100	100

Table 61: Detection times (D_T), expressed as the number of BP's with corresponding P_D's, as a function of diversion scenarios DS, for a given amount M and different facility throughputs FT with I-LR and σ_i = 1 %

M kgPu	FT t/a	DS* - 1 BP/P_D	2 BP/P_D	3 BP/P_D	4 BP/P_D	5 BP/P_D	6 BP/P_D	7 BP/P_D
10	1000	20/41.54	20/40.76	20/40.10	20/39.14	20/38.27	20/32.72	20/20.45
	500	3/98.57	4/98.60	4/95.77	5/95.97	6/95.73	20/92.77	20/69.10
	240	1/100	2/100	1/98.59	3/100	3/97.96	6/99.47	11/95.14
	100	1/100	1/100	1/98.55	2/100	2/100	3/99.99	5/99.39
15	1000	20/87.89	20/86.28	20/84.38	20/82.35	20/79.99	20/67.45	20/40.69
	500	2/100	2/99.80	3/99.99	4/100	4/98.19	8/98.55	18/95.15
	240	1/100	2/100	2/100	2/99.6	3/100	4/99.14	7/95.87
	100	1/100	1/100	1/100	1/100	2/100	2/99.80	4/100
25	1000	2/99.92	3/99.96	3/97.96	4/99.14	5/99.39	9/95.98	20/88.02
	500	1/100	2/100	2/100	3/100	3/99.99	5/99.39	9/95.98
	240	1/100	1/100	1/99.49	2/100	2/100	3/100	5/99.72
	100	1/100	1/100	1/100	1/100	1/100	2/100	3/100
30	1000	2/100	2/99.80	3/99.99	4/100	4/98.19	8/98.55	18/95.15
	500	1/100	2/100	2/100	2/99.80	3/100	4/98.19	8/98.55
	240	1/100	1/100	1/100	2/100	2/100	3/100	4/99.14
	100	1/100	1/100	1/100	1/100	1/100	2/100	2/99.80
40	1000	1/100	1/100	2/96.84	3/99.99	3/96.26	6/98.90	12/96.20
	500	1/100	1/100	2/100	2/100	2/100	3/96.26	6/98.90
	240	1/100	1/100	1/100	1/100	1/98.55	2/100	3/97.96
	100	1/100	1/100	1/100	1/100	1/100	1/100	2/100

*For clarification of DS-numbers see Table 3. Whenever a value of BP = 20 has been entered in the table, the corresponding P_D value indicates that for the given M, a 95 % P_D cannot be obtained at the end of the balancing period.

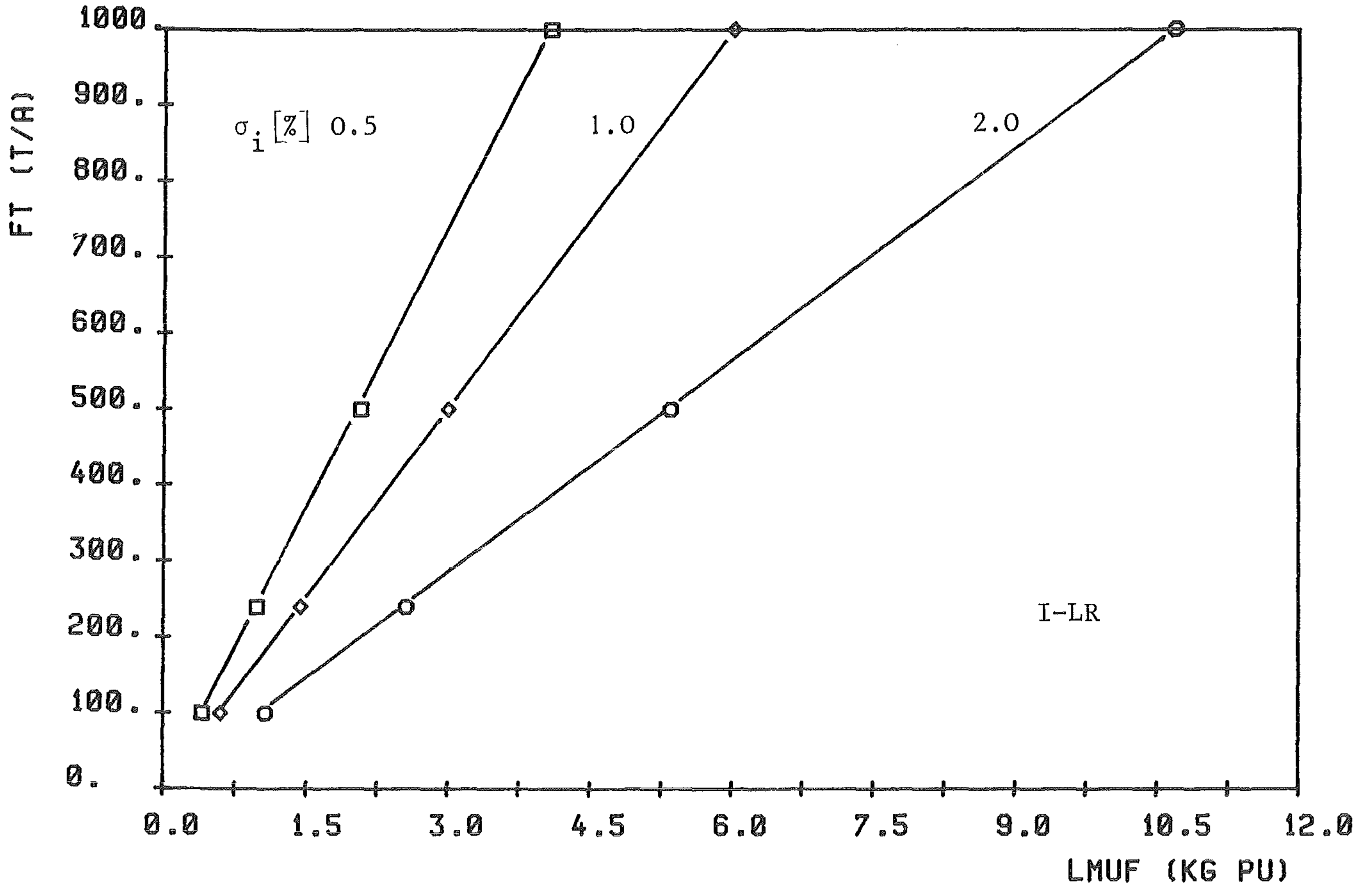


Fig. 1A: LMUF for Different Facility Throughputs (FT, t/a) and Different Measurement Uncertainties at the Input (σ_i) with Inventories Linearly Reduced (I-LR), (Table 2A) per balancing period.

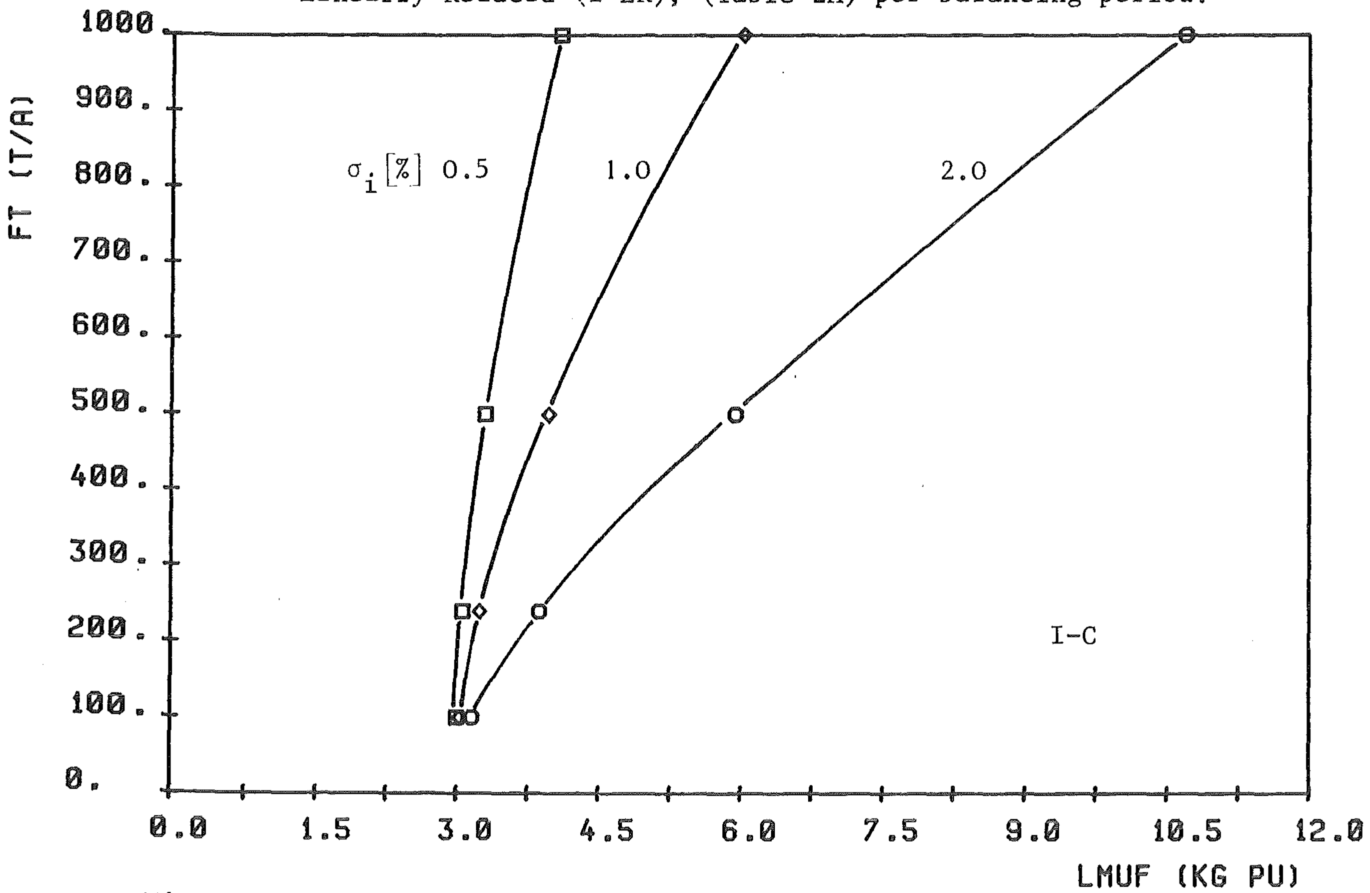


Fig. 1B: LMUF for Different Facility Throughputs (FT, t/a) and Different Measurement Uncertainties at the Input (σ_i) with Constant Inventories (I-C), (Table 2B) per balancing period.

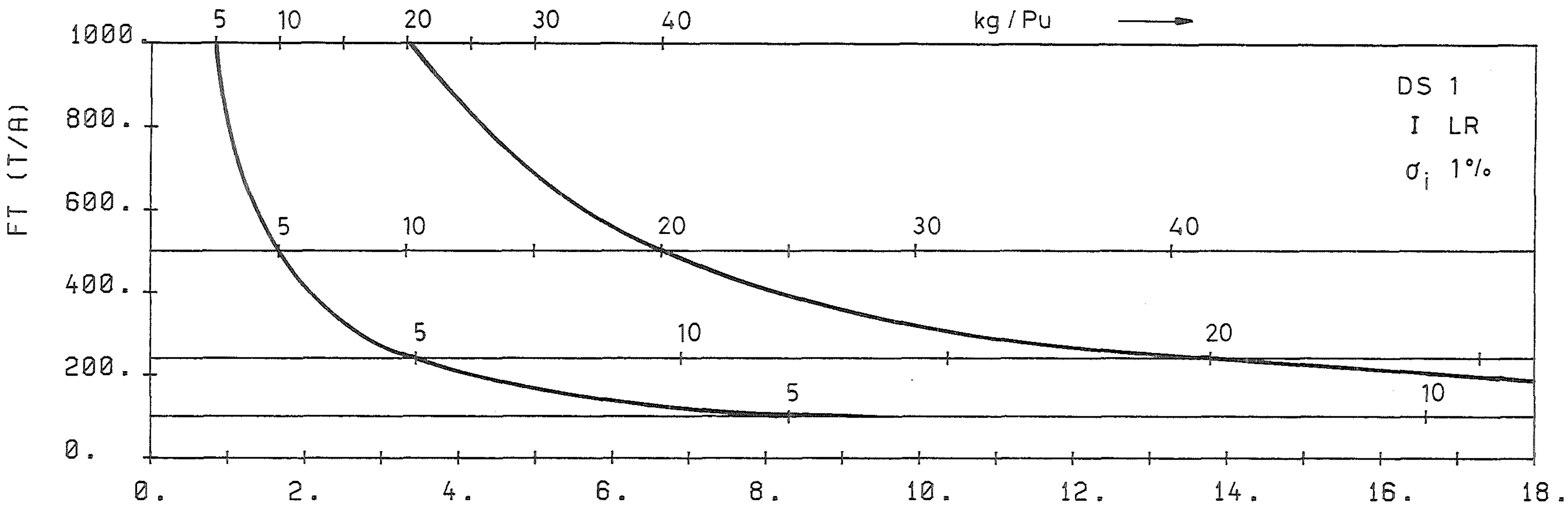


Fig. 2A: ΔM/LMUF for Different Facility Throughputs with Linearly Reduced Inventories and 1 % Measurement Uncertainty at Input (Table 5A) for Diversion Scenario - 1

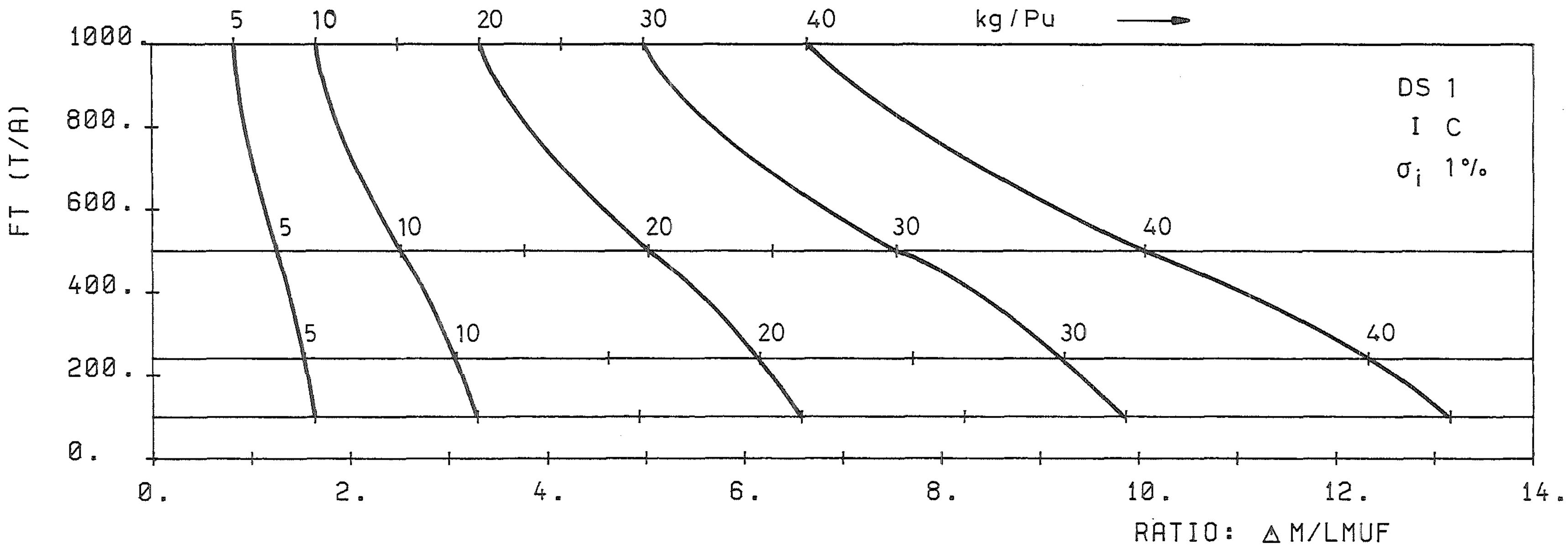


Fig. 2B: ΔM/LMUF for Different Facility Throughputs with Constant Inventories and 1 % Measurement Uncertainty at Input (Table 5B) for Diversion Scenario - 1

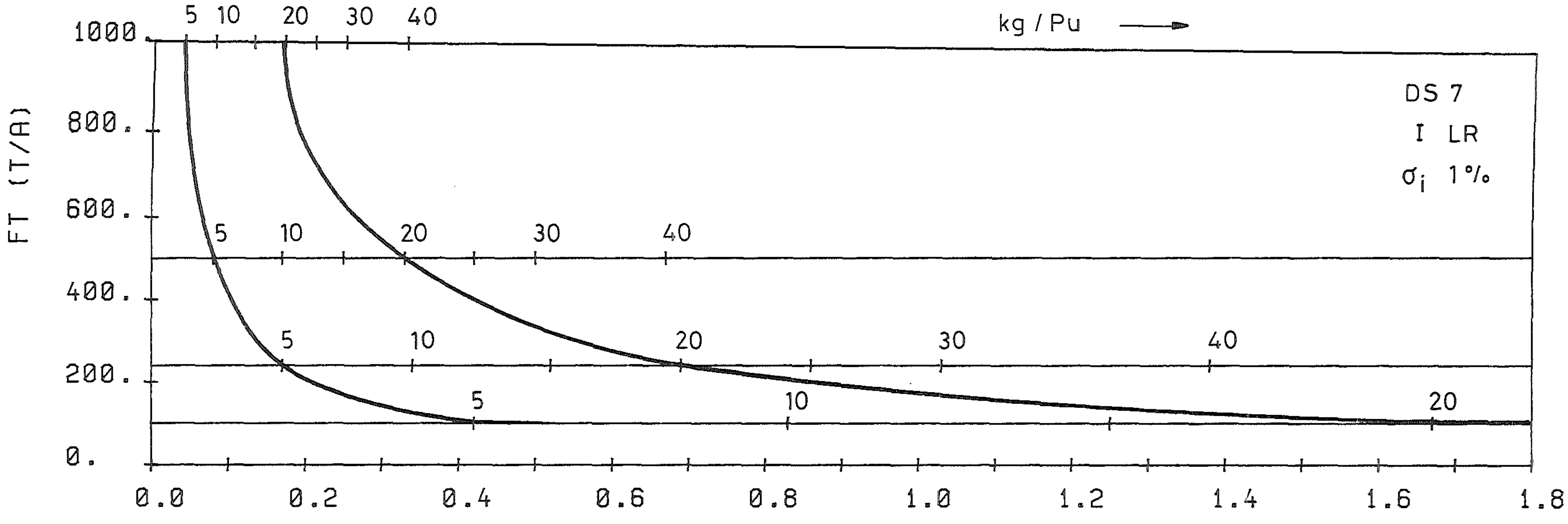


Fig. 3A: ΔM/LMUF for Different Facility Throughputs with Linearly Reduced Inventories and 1 % Measurement Uncertainty at Input (Table 11A) for Diversion Scenario – 7

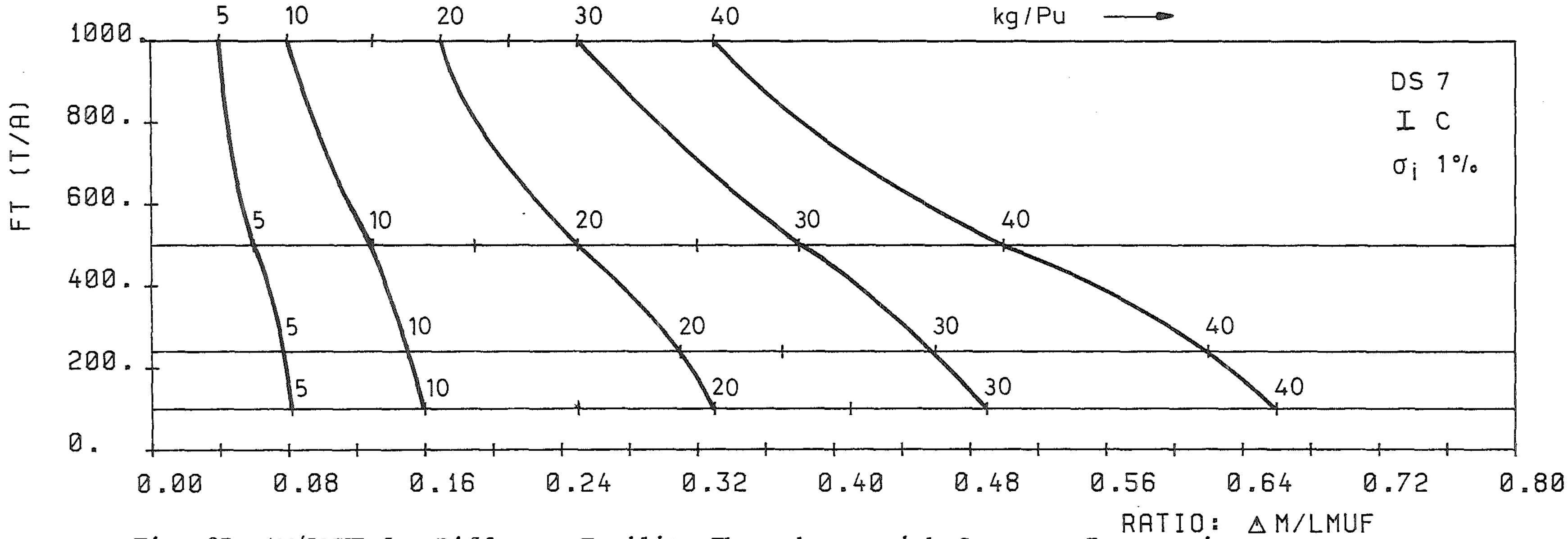


Fig. 3B: ΔM/LMUF for Different Facility Throughputs with Constant Inventories and 1 % Measurement Uncertainty at Input (Table 11B) for Diversion Scenario – 7

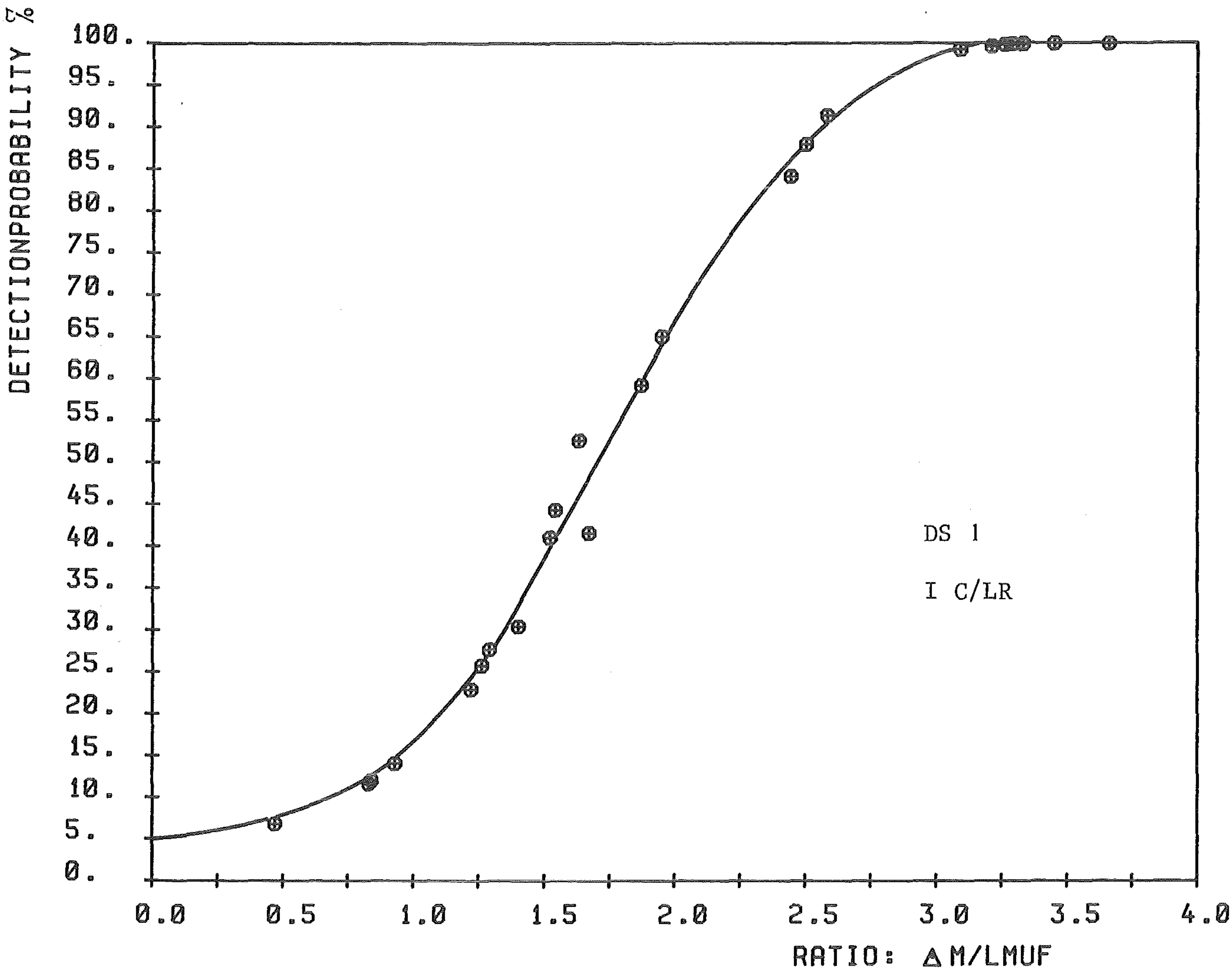


Fig. 4A: Detection Probabilities for Different Values of ΔM/LMUF, Different Facility Throughputs with Linearly Reduced (I-LR) and Constant Inventories (I-C) and for Different Measurement Uncertainties at the Input for Diversion Scenario - 1. (Tables 5A, 5B, 12A, 12B)

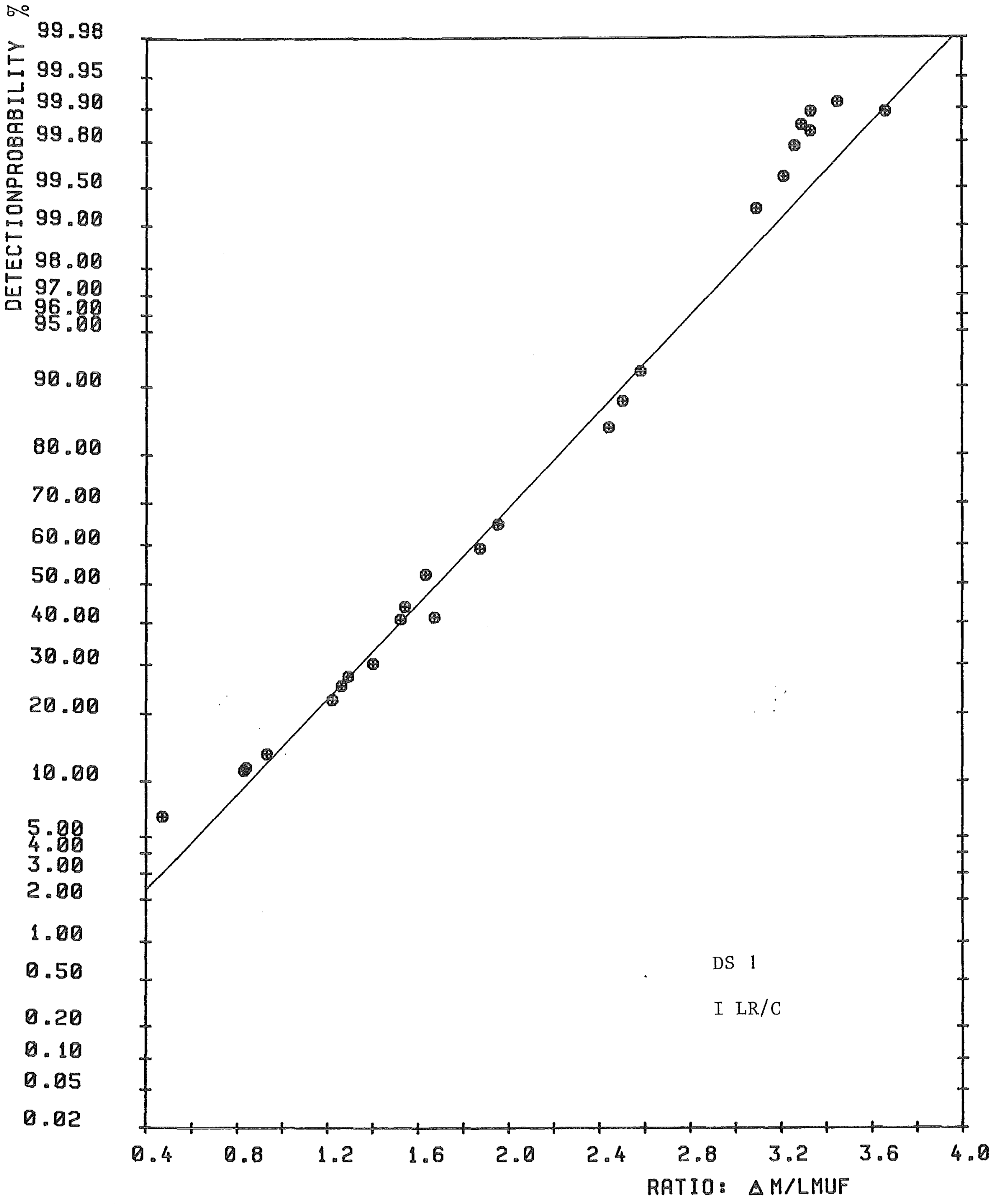


Fig. 4B: Detection Probabilities for Different Values of ΔM/LMUF, Different Facility Throughputs with Linearly Reduced (I-LR) and Constant Inventories (I-C) and for Different Measurement Uncertainties at the Input for Diversion Scenario - 1. (Tables 5A, 5B, 12A, 12B) The presentation is made on probability paper.

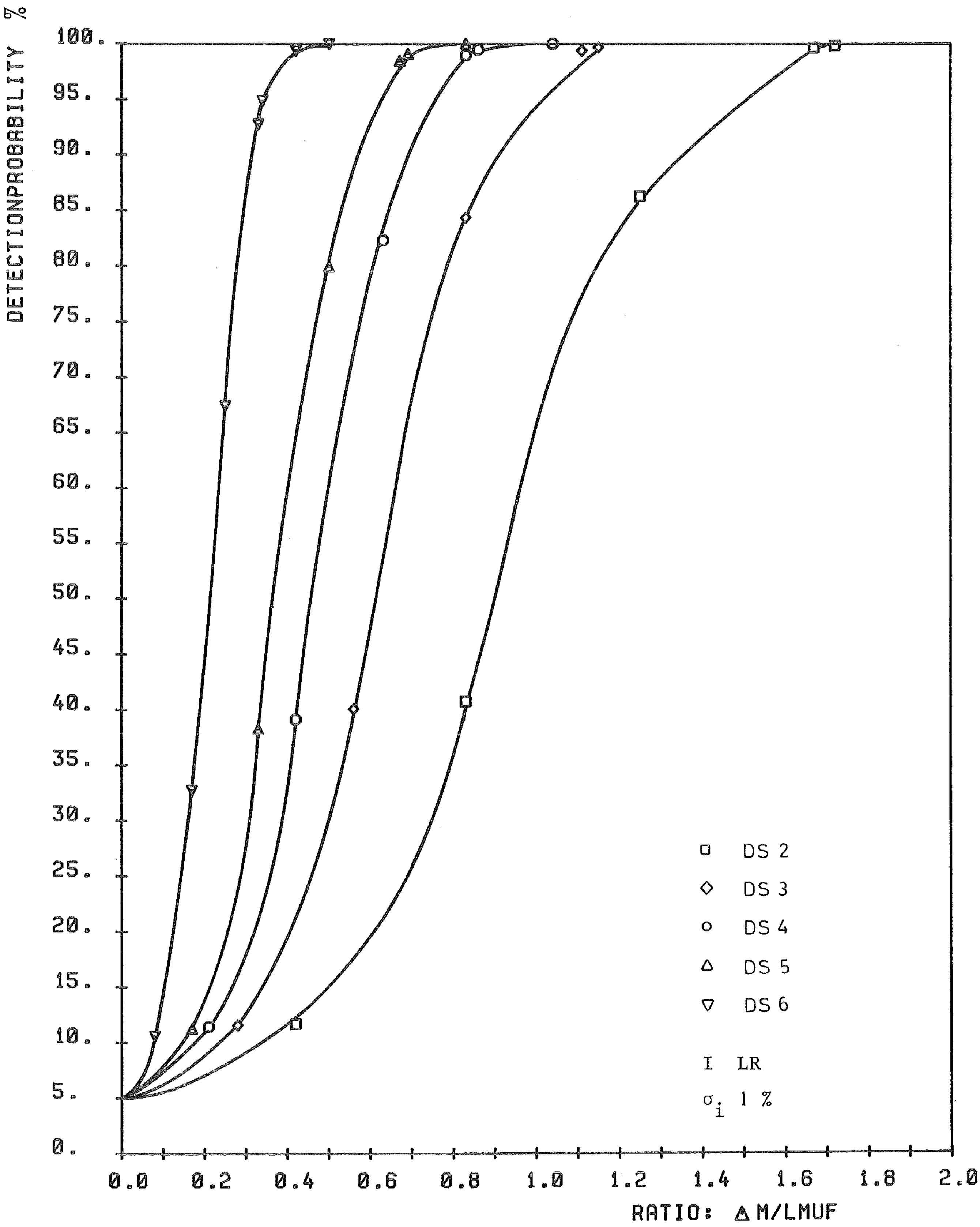


Fig. 5A: Detection Probabilities for Different Values of ΔM/LMUF, Different Facility Throughputs with Linearly Reduced Inventories and Measurement Uncertainty of 1 % at the Input for DS - 2, 3, 4, 5, 6. (Tables 13, 14, 15, 16, 17)

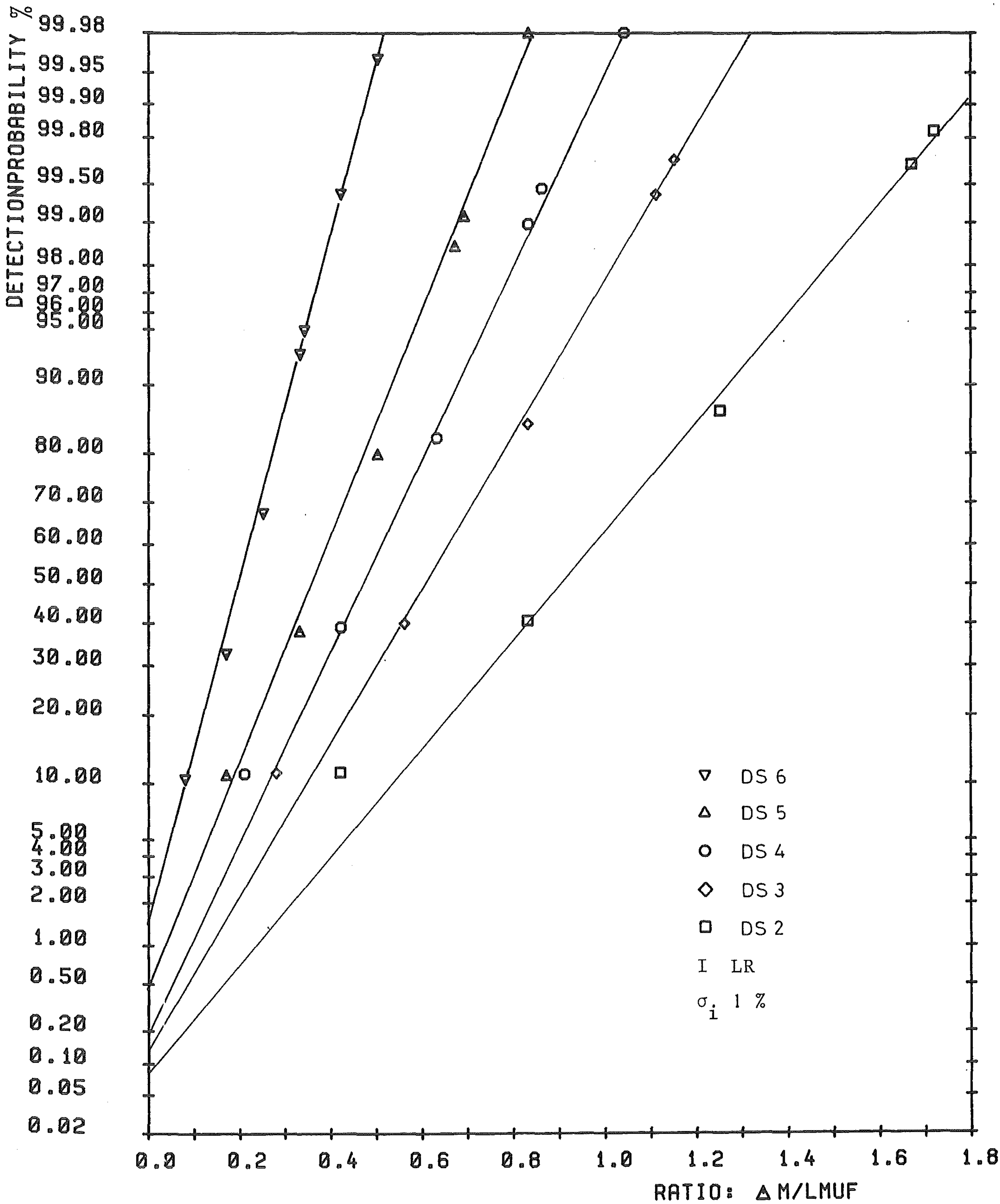


Fig. 5B: Detection Probabilities for Different Values of ΔM/LMUF, Different Facility Throughputs with Linearly Reduced Inventories and Measurement Uncertainty of 1 % at the Input for DS - 2, 3, 4, 5, 6. (Tables 13, 14, 15, 16, 17) The presentation is made on probability paper.

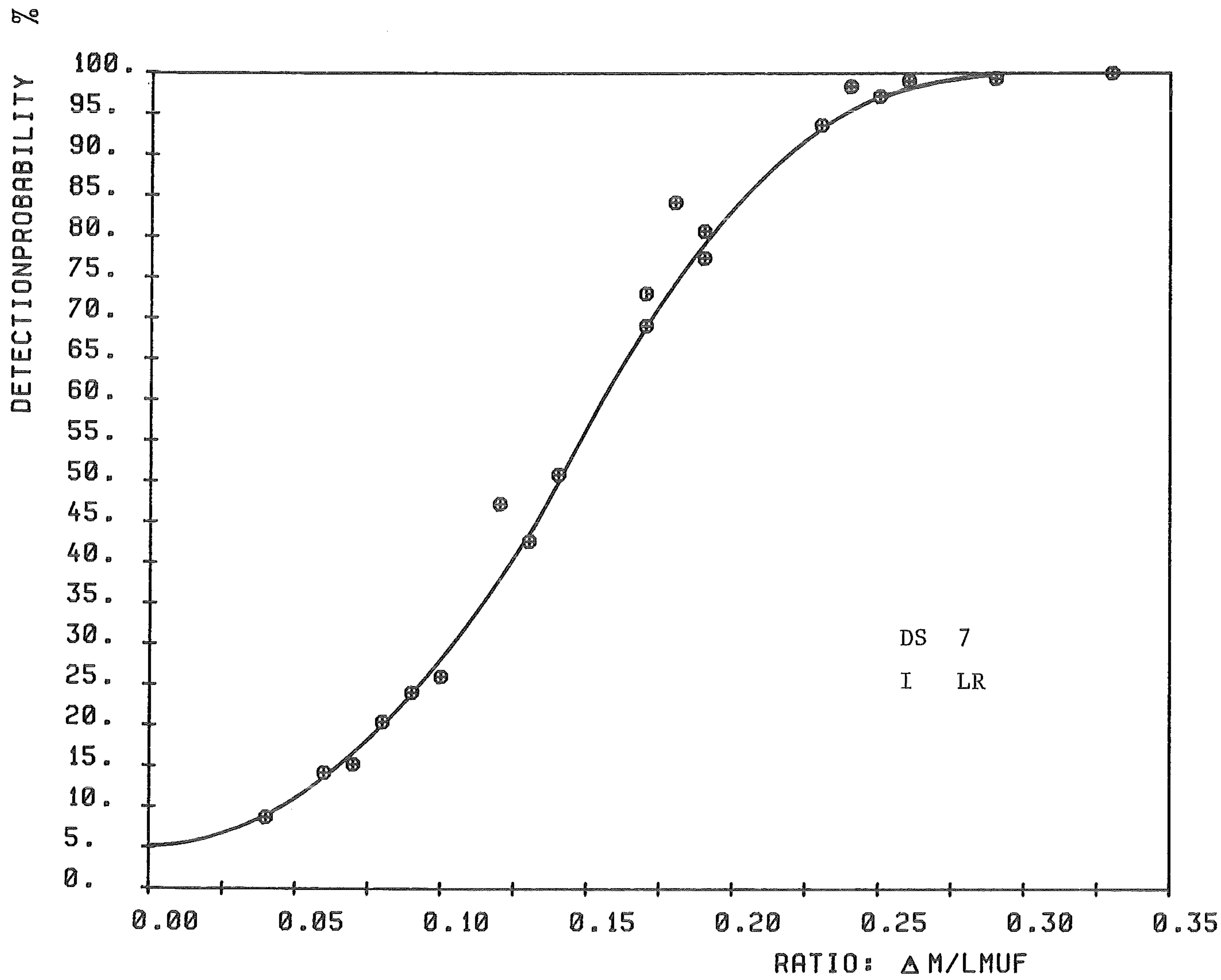


Fig. 6A: Probability of Detection for Different Values of ΔM/LMUF, Different Facility Throughputs with Linearly Reduced Inventories and for Different Measurement Uncertainties at the Input for DS - 7. (Tables 11A, 18A)

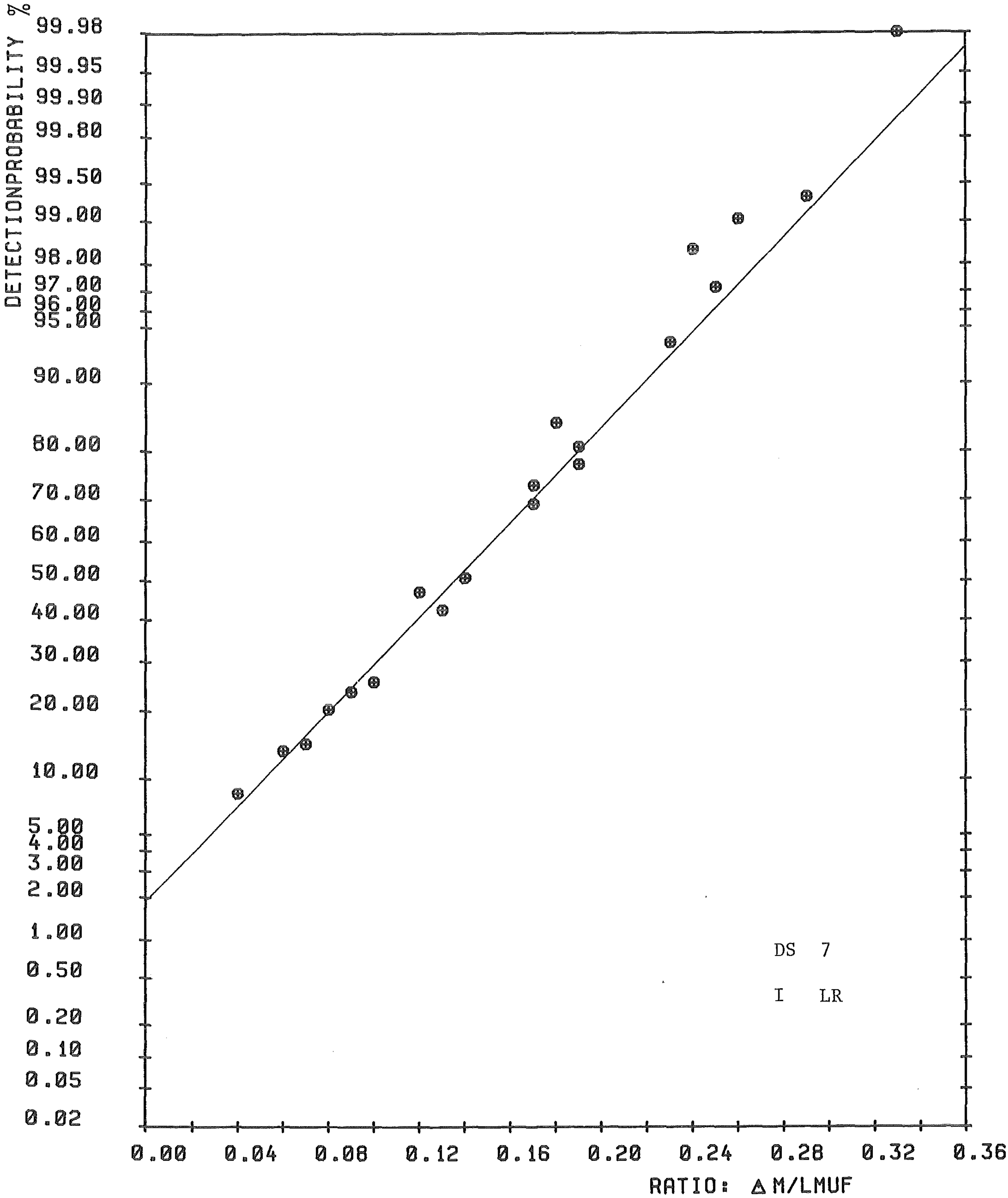


Fig. 6B: Probability of Detection for Different Values of ΔM/LMUF, Different Facility Throughputs with Linearly Reduced Inventories and for Different Measurement Uncertainties at the Input for DS - 7. (Tables 11A, 18A). The presentation is made on probability paper.

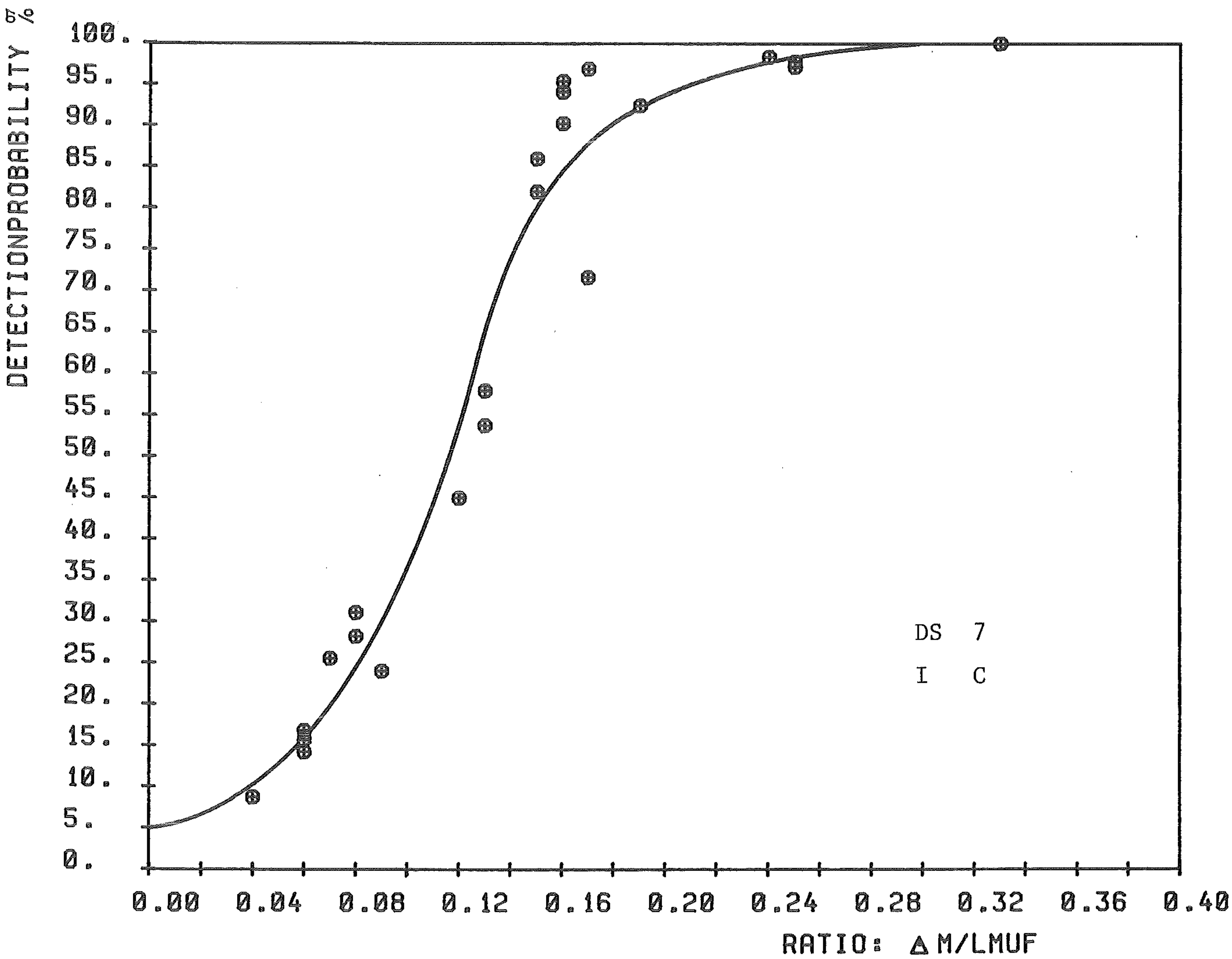


Fig. 7A: Probability of Detection for Different Values of ΔM/LMUF, Different Facility Throughputs with Constant Inventories and for Different Measurement Uncertainties at the Input for DS - 7. (Tables 11B, 18B)

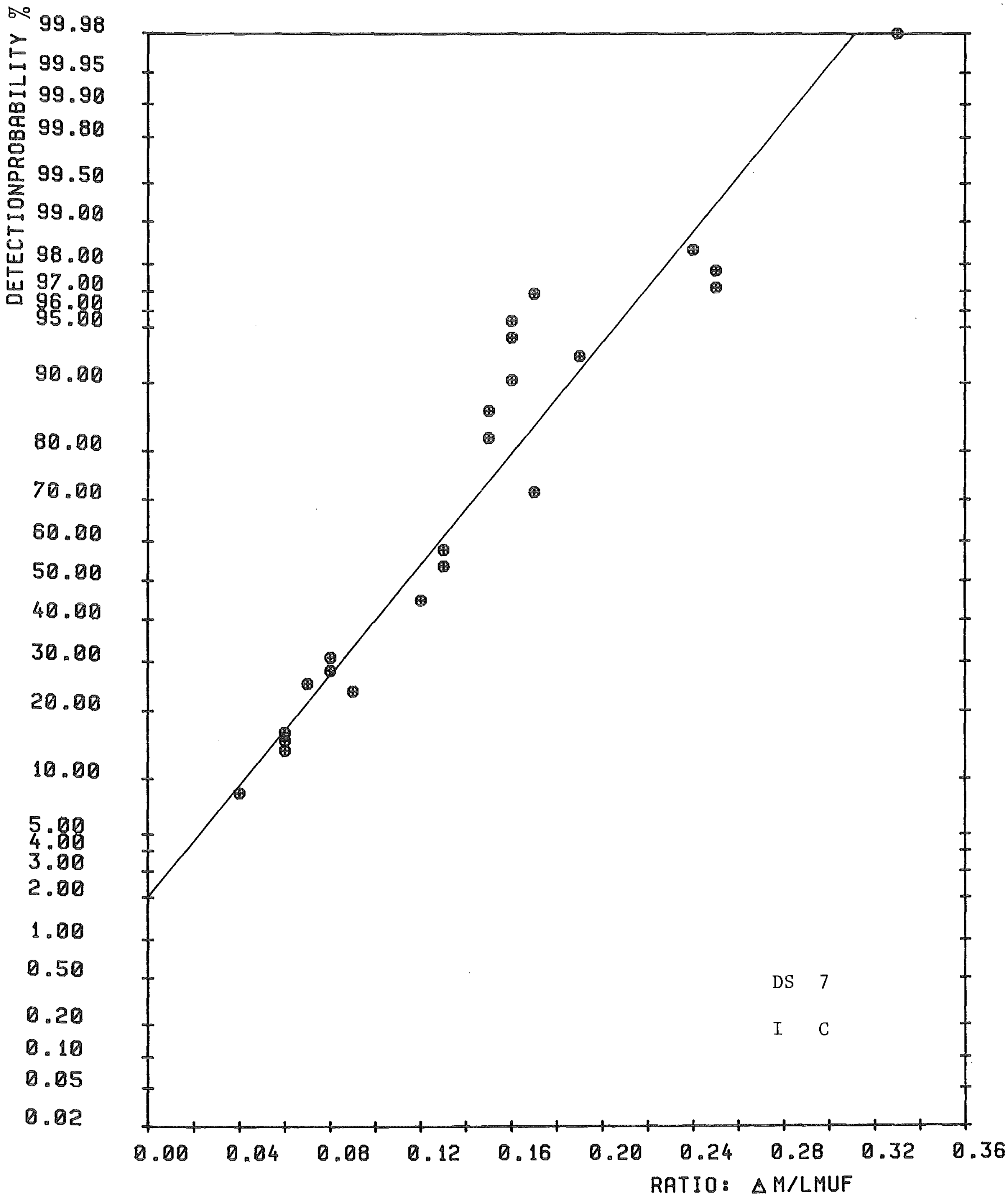


Fig. 7B: Probability of Detection for Different Values of ΔM/LMUF, Different Facility Throughputs with Constant Inventories and for Different Measurement Uncertainties at the Input for DS - 7. (Tables 11B, 18B). The presentation is made on probability paper.

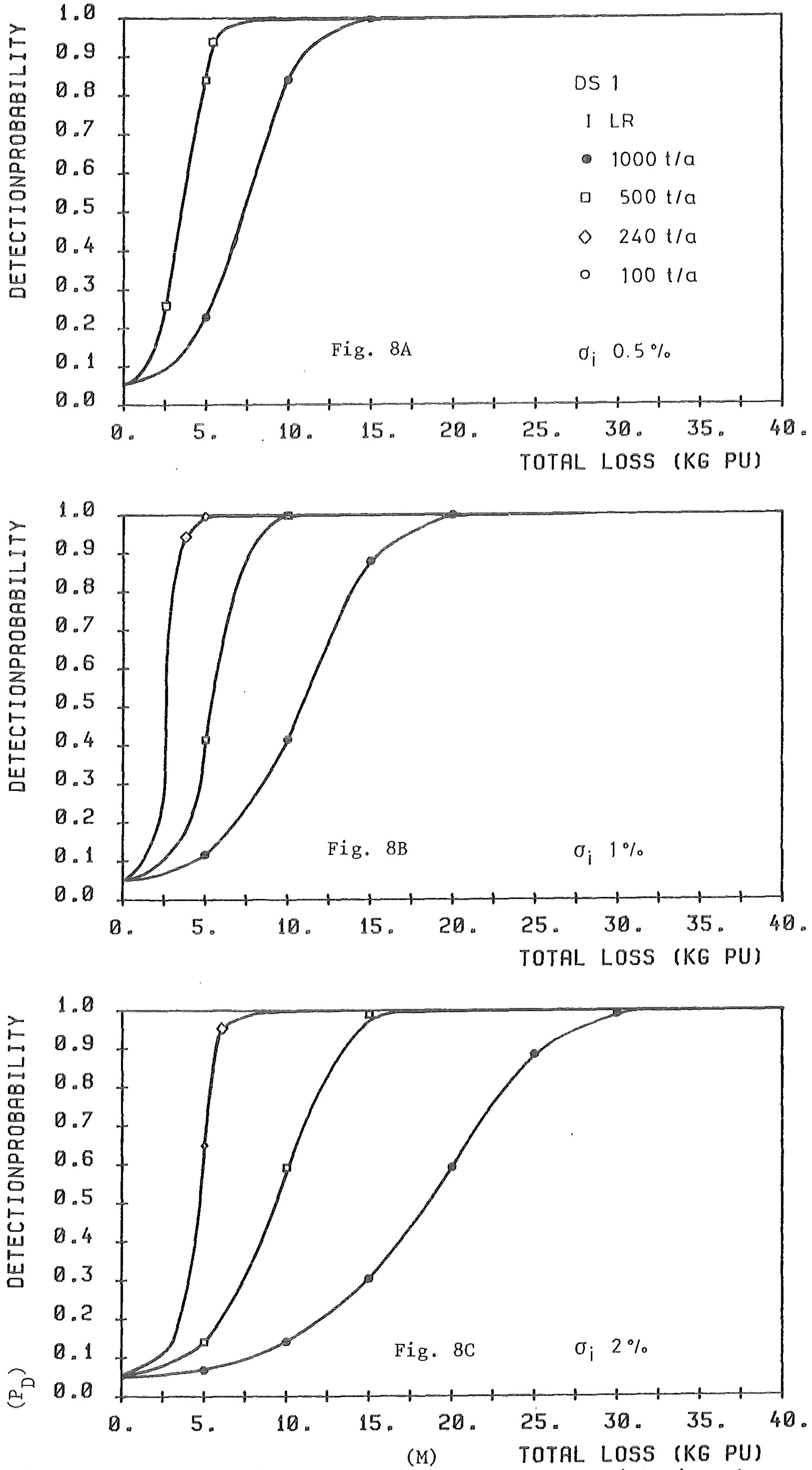


Fig. 8: P_D vs M for Different Facility Throughputs with Linearly Reduced Inventories and Different Measurement Uncertainties for DS - 1.(Table 53A)
Figs.: 8A (0.5 %); 8B (1 %), 8C (2 %)

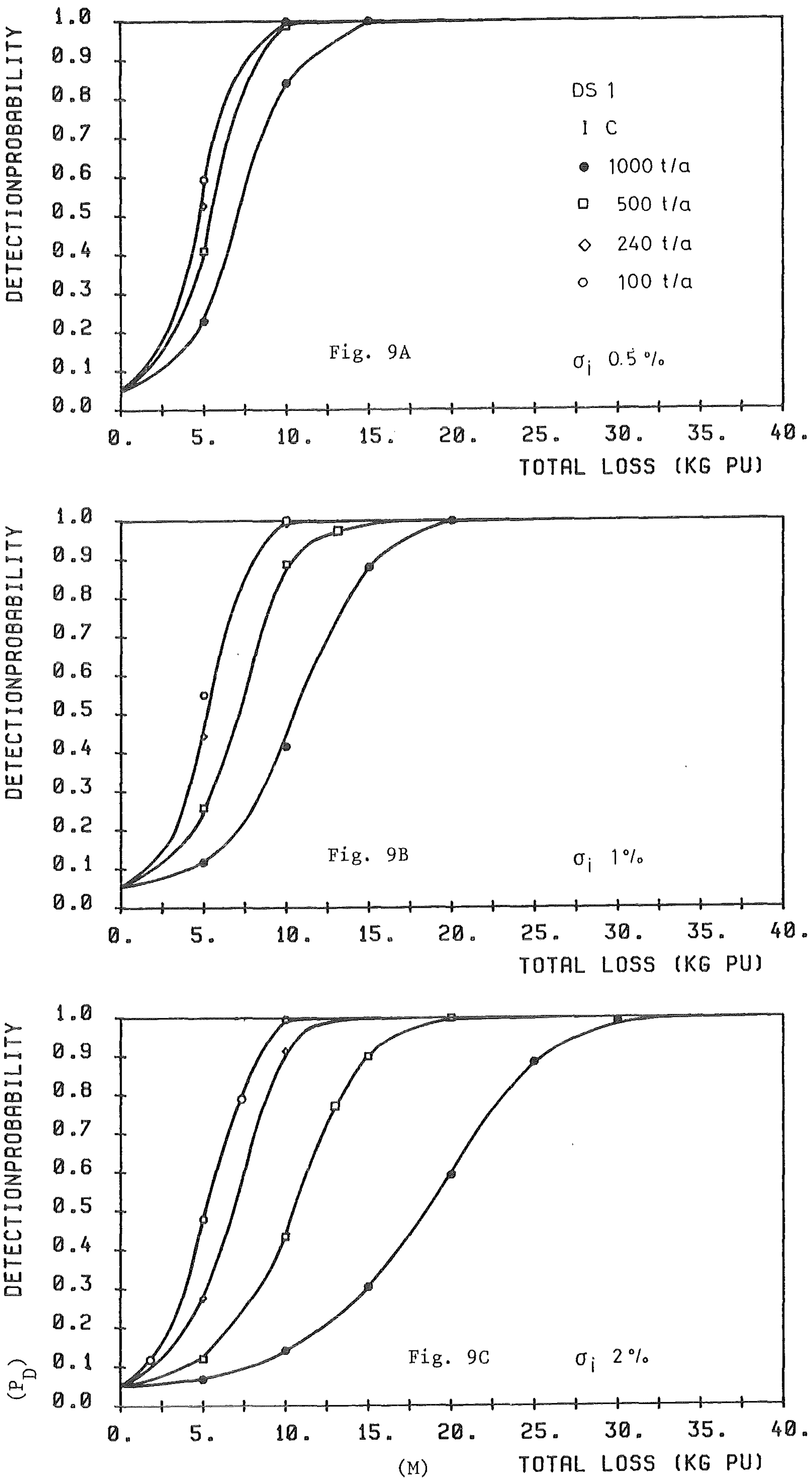
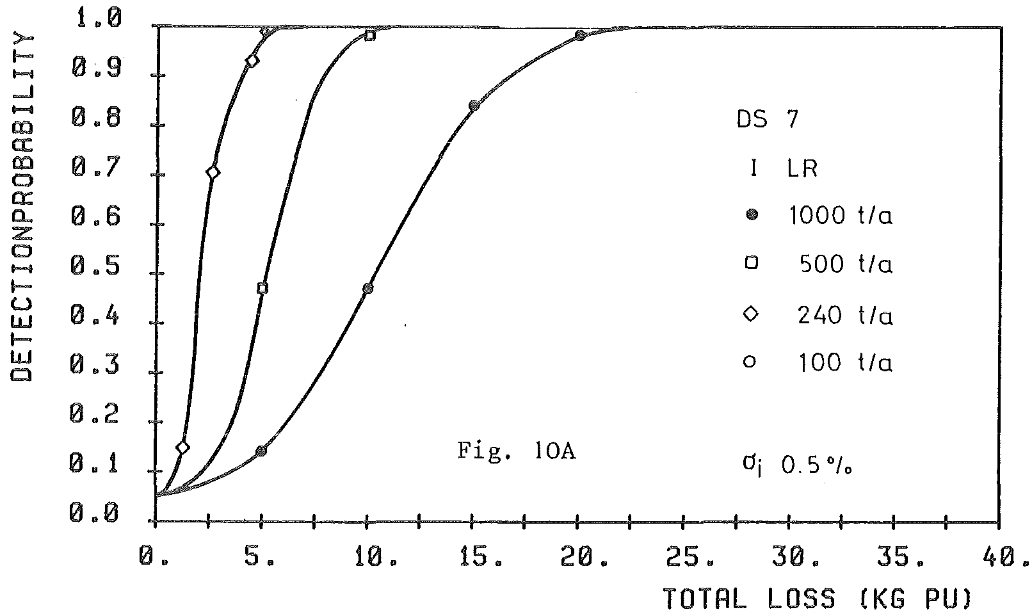
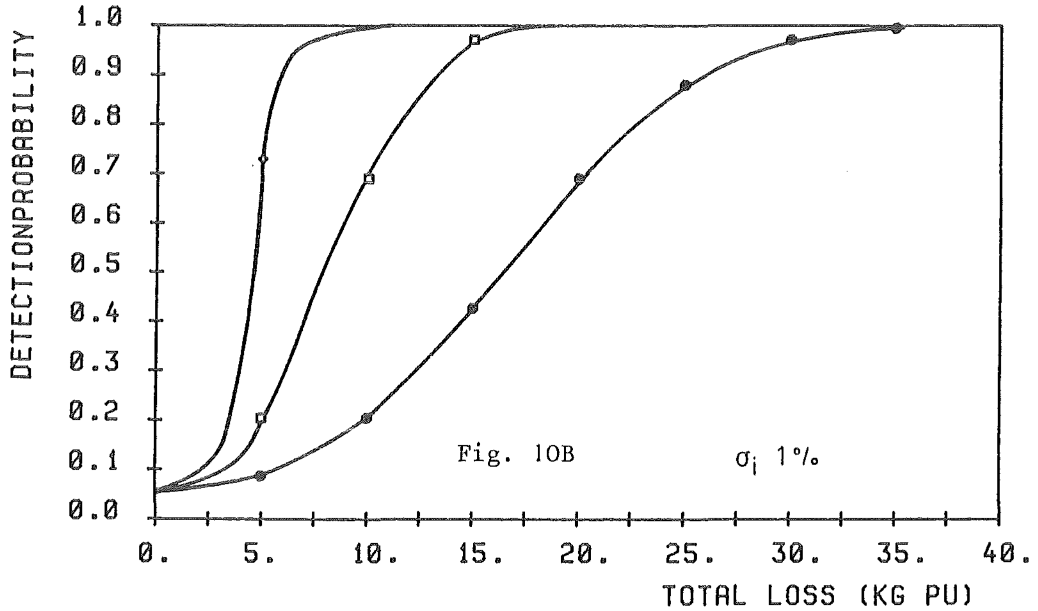


Fig. 9: P_D vs M for Different Facility Throughputs with Constant Inventories and Different Measurement Uncertainties for DS - 1. (Table 53A)
Figs.: 9A (0.5 %); 9B (1 %); 9C (2 %)





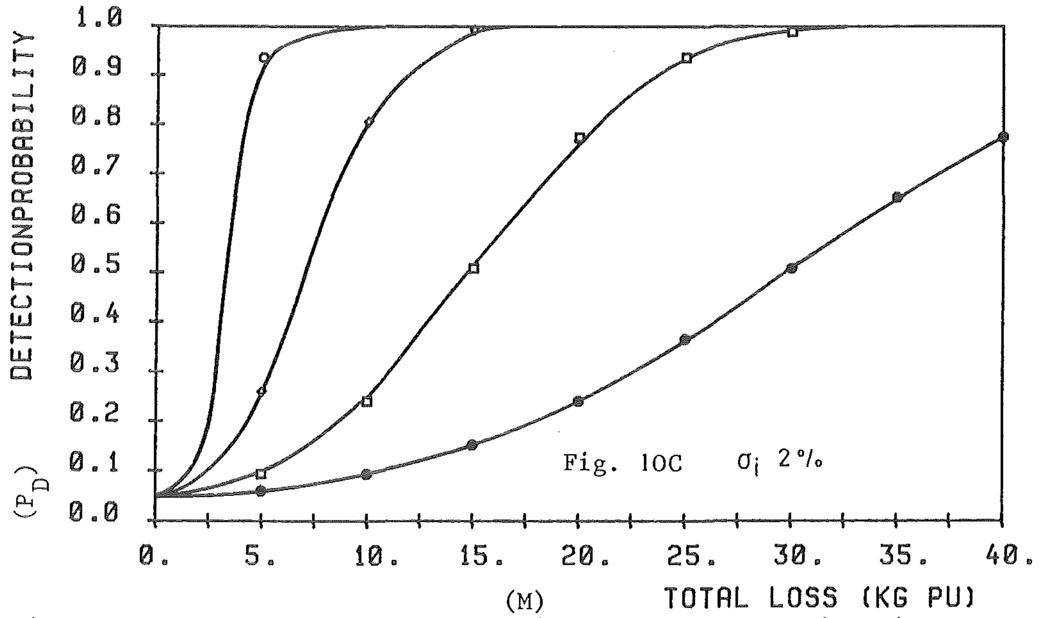


Fig. 10: P_D vs M for Different Facility Throughputs with Linearly Reduced Inventories and Different Measurement Uncertainties for DS - 7. (Table 53B)
Figs.: 10A (0.5 %); 10B (1 %); 10C (2 %)

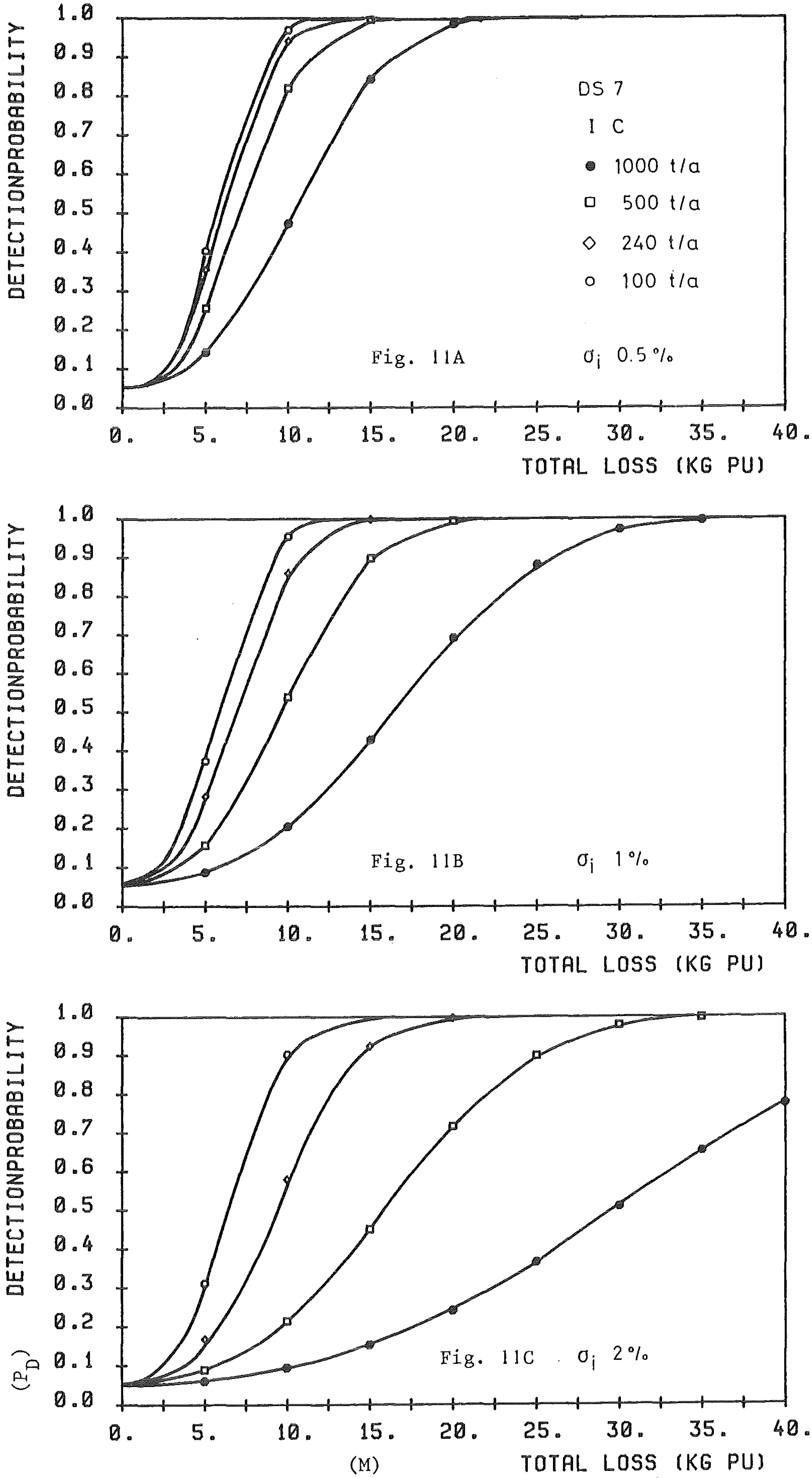


Fig. 11: P_D vs M for Different Facility Throughputs with Constant Inventories and Different Measurement Uncertainties for DS - 7. (Table 53B)
Figs.: 11A (0.5 %); 11B (1 %); 11C (2 %)

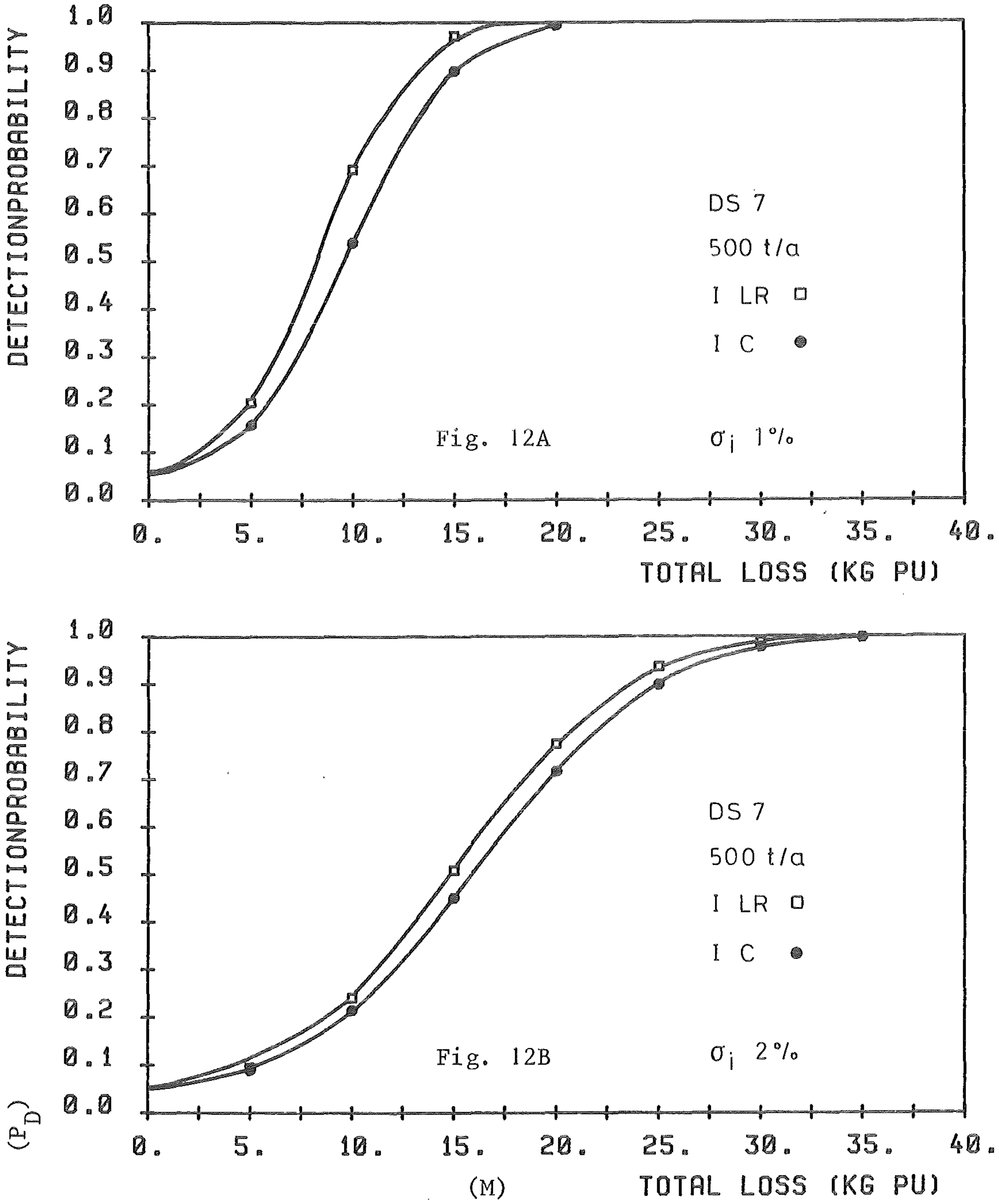
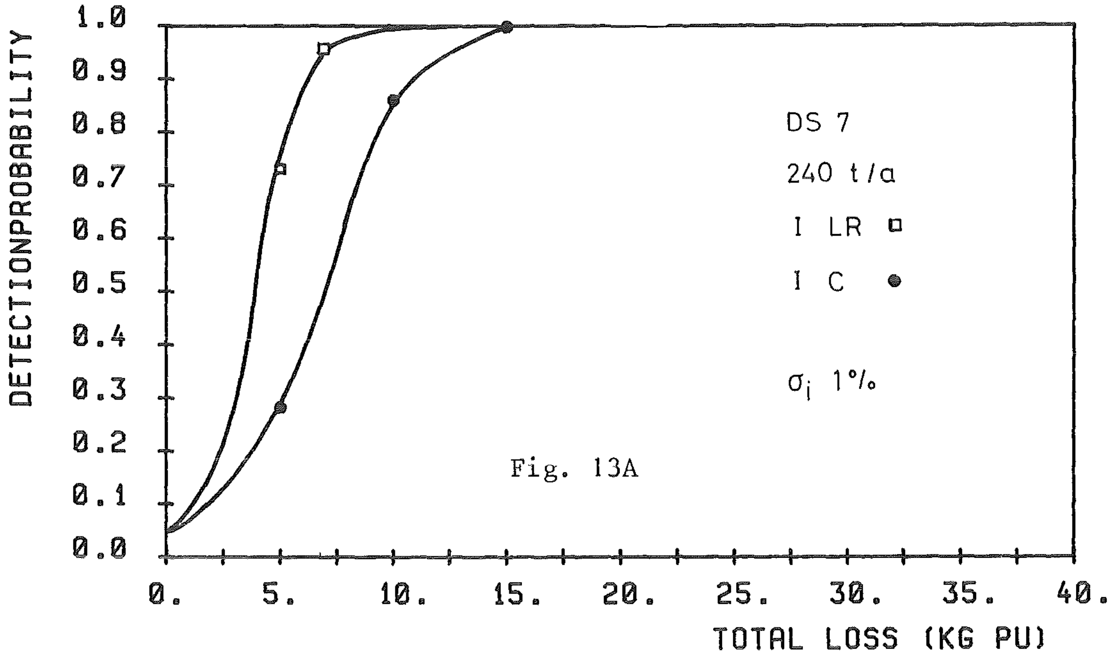


Fig. 12: P_D vs M with Linearly Reduced and Constant Inventories in a 500 t/a Facility for DS - 7 with 1 % (Fig. 12A) and 2 % (Fig. 12B) Measurement Uncertainty at the Input (Table 53B).



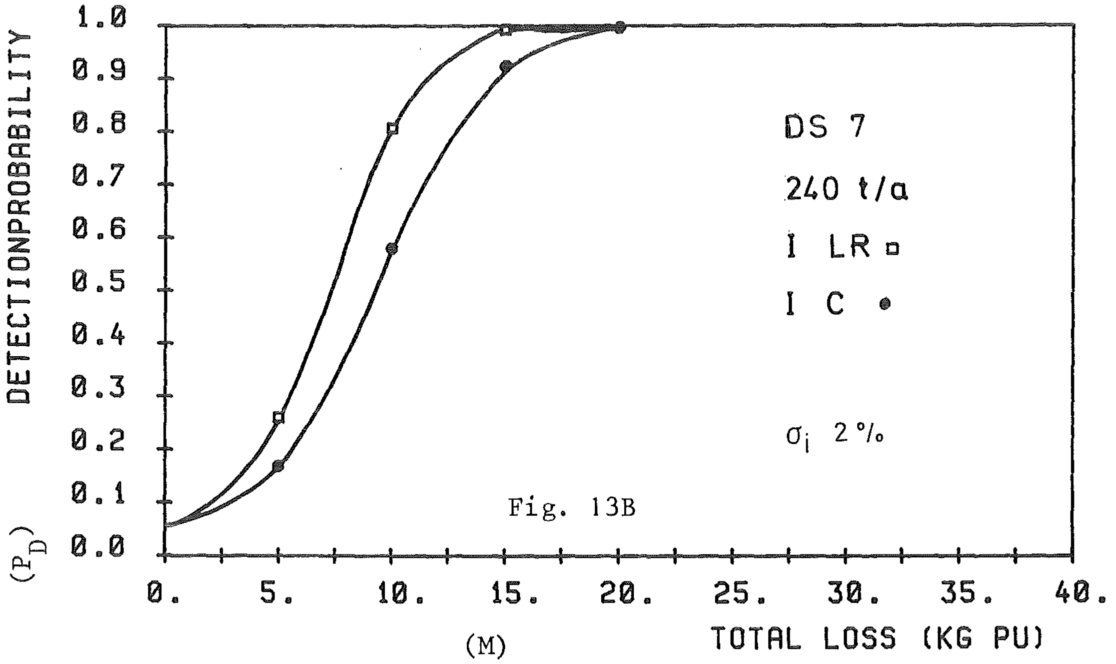


Fig. 13: P_D vs M with Linearly Reduced and Constant Inventories in a 240 t/a Facility for DS - 7 with 1 % (Fig. 13A) and 2 % (Fig. 13B) Measurement Uncertainty at the Input (Table 53B).

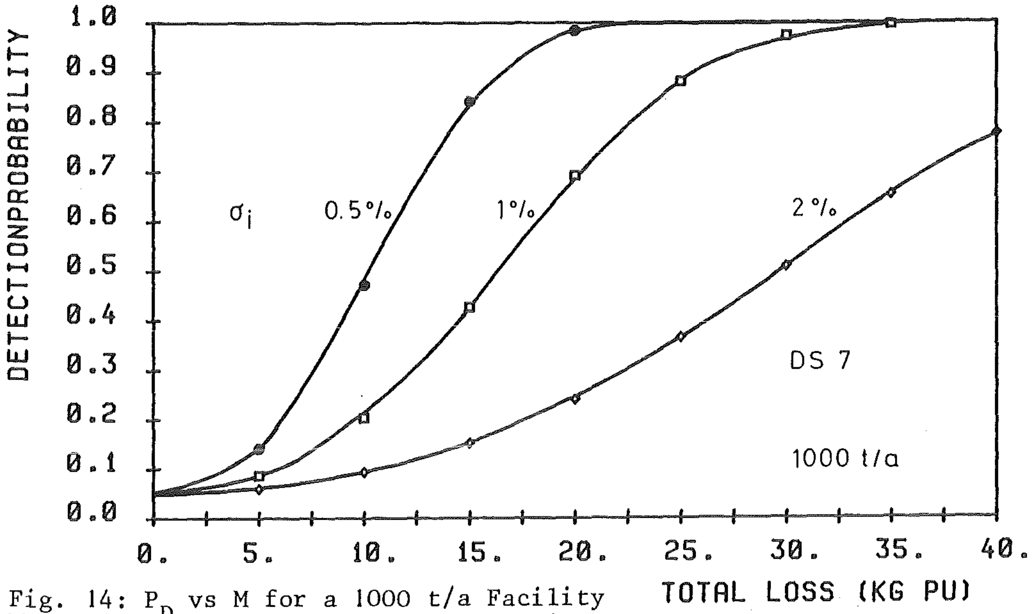


Fig. 14: P_D vs M for a 1000 t/a Facility with Measurement Uncertainties as parameter for DS - 7. (Table 53B)

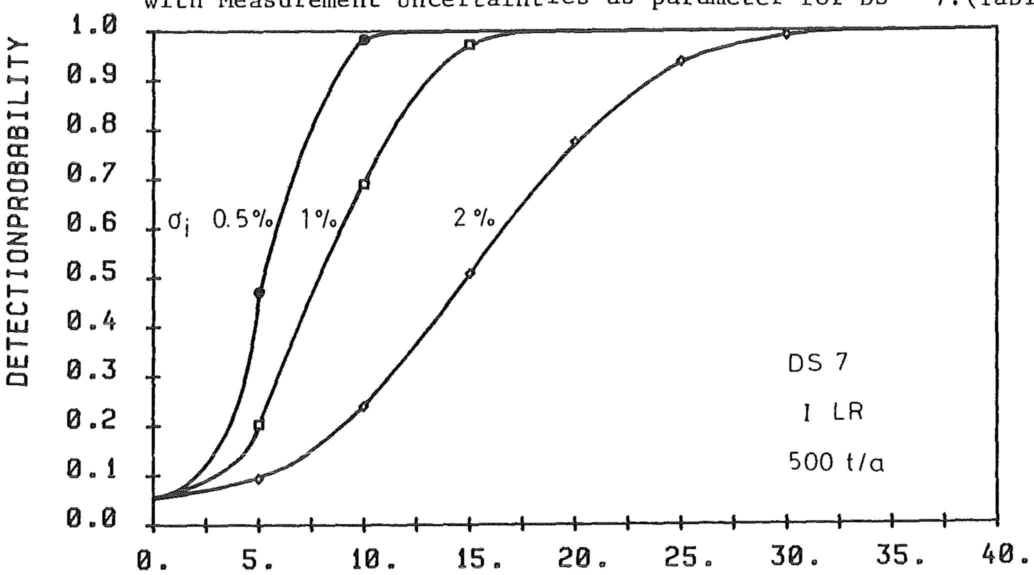


Fig. 15A: P_D vs M for a 500 t/a Facility with Measurement Uncertainties as Parameter for DS - 7. (Table 53B)

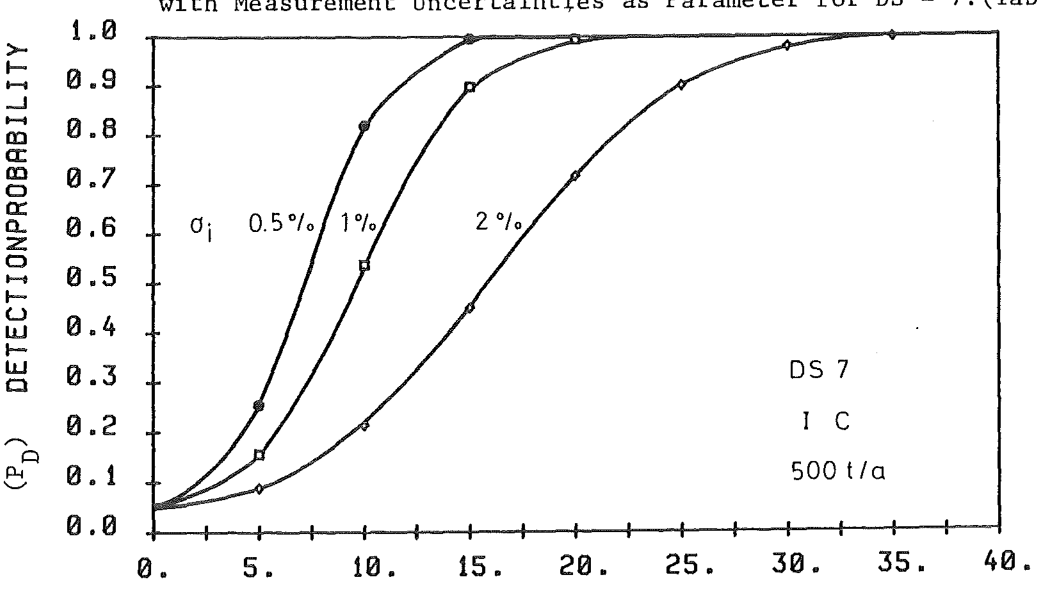


Fig. 15B: P_D vs M for a 500 t/a Facility with Measurement Uncertainties as Parameter for DS - 7. (Table 53B)

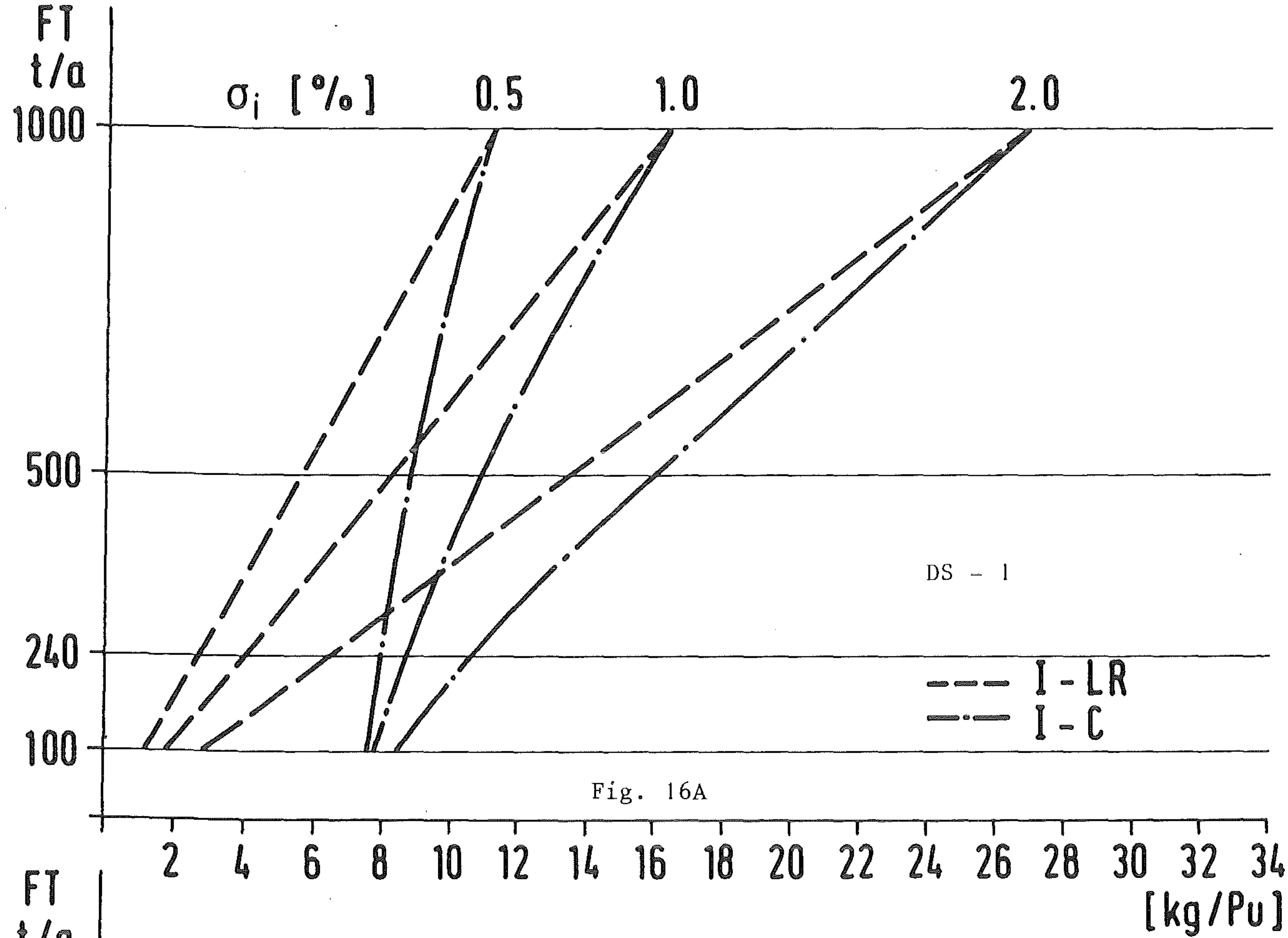


Fig. 16A

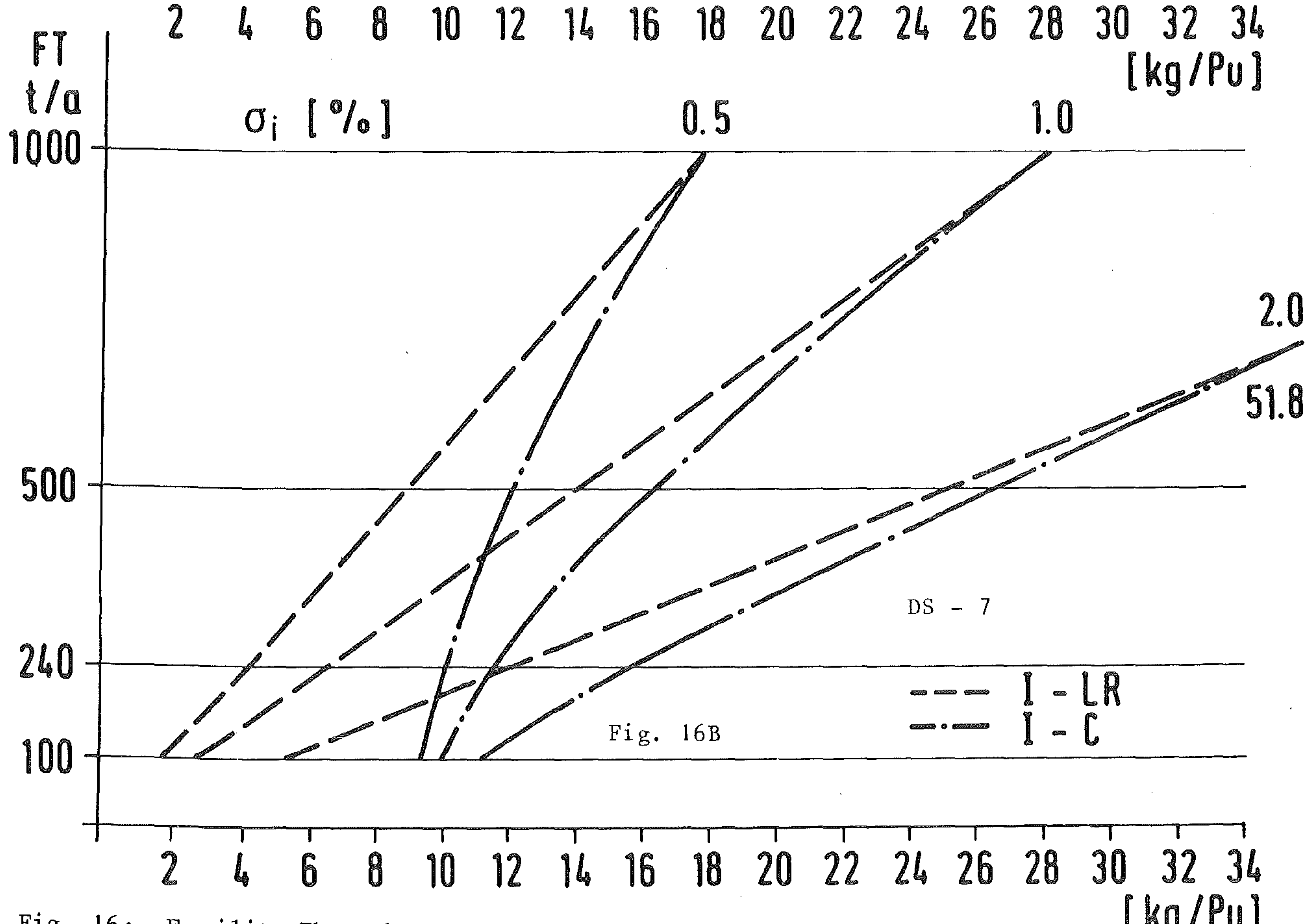


Fig. 16B

Fig. 16: Facility Throughput vs kg Pu which can be detected with P_D = 95% with Measurement Uncertainties and Inventory Amounts as Parameter; Figs: 16A for DS - 1; 16B for DS - 7 (Tables 54, 55, 56, 57)

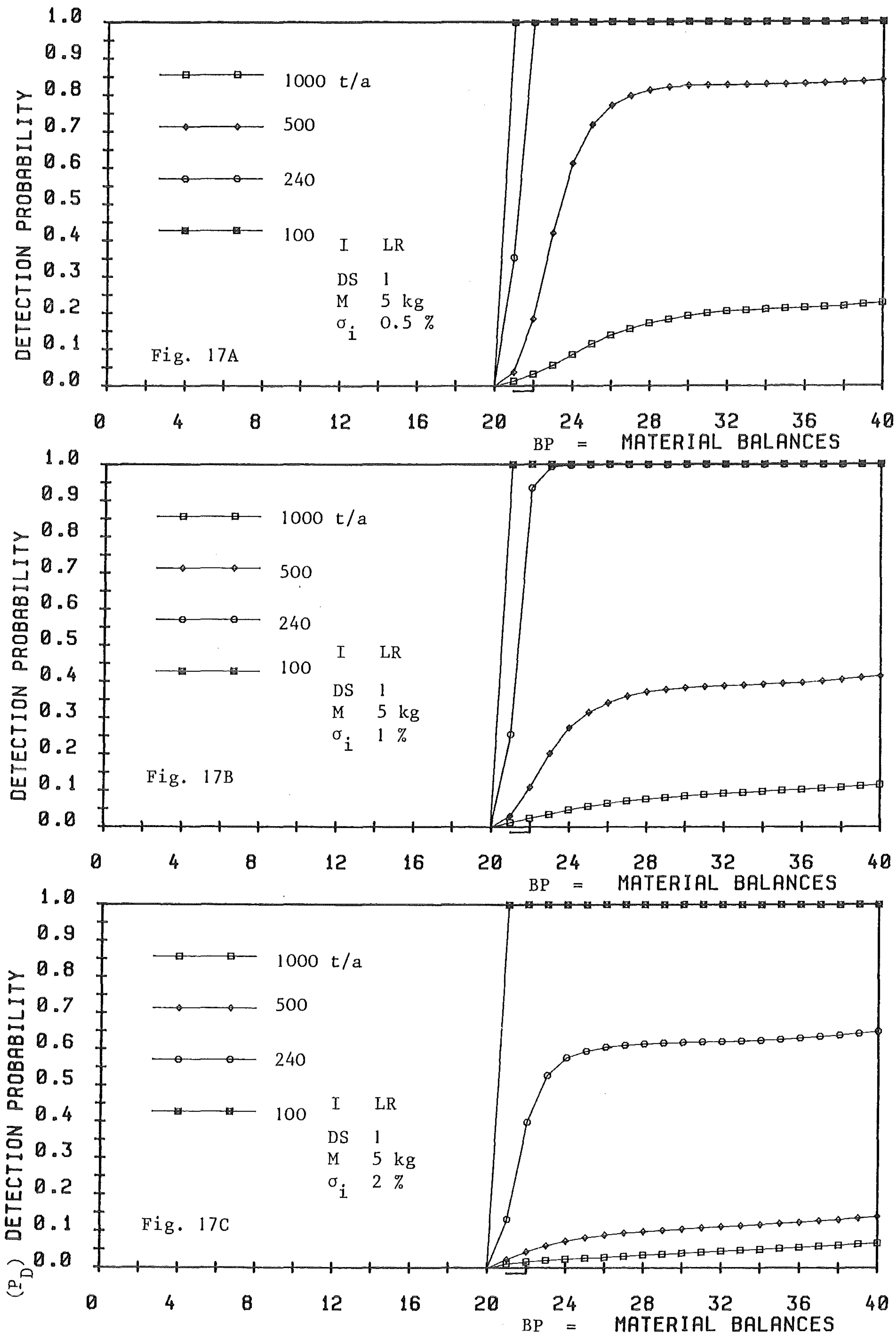


Fig. 17: P_D vs BP with Facility Throughput as Parameter for M = 5 kg and DS - 1, with Measurement Uncertainties of 0.5 % (Fig. 17A), 1 % (Fig. 17B) and 2 % (Fig. 17C). (Tables 19, 20, 21 for 1000 t/a)

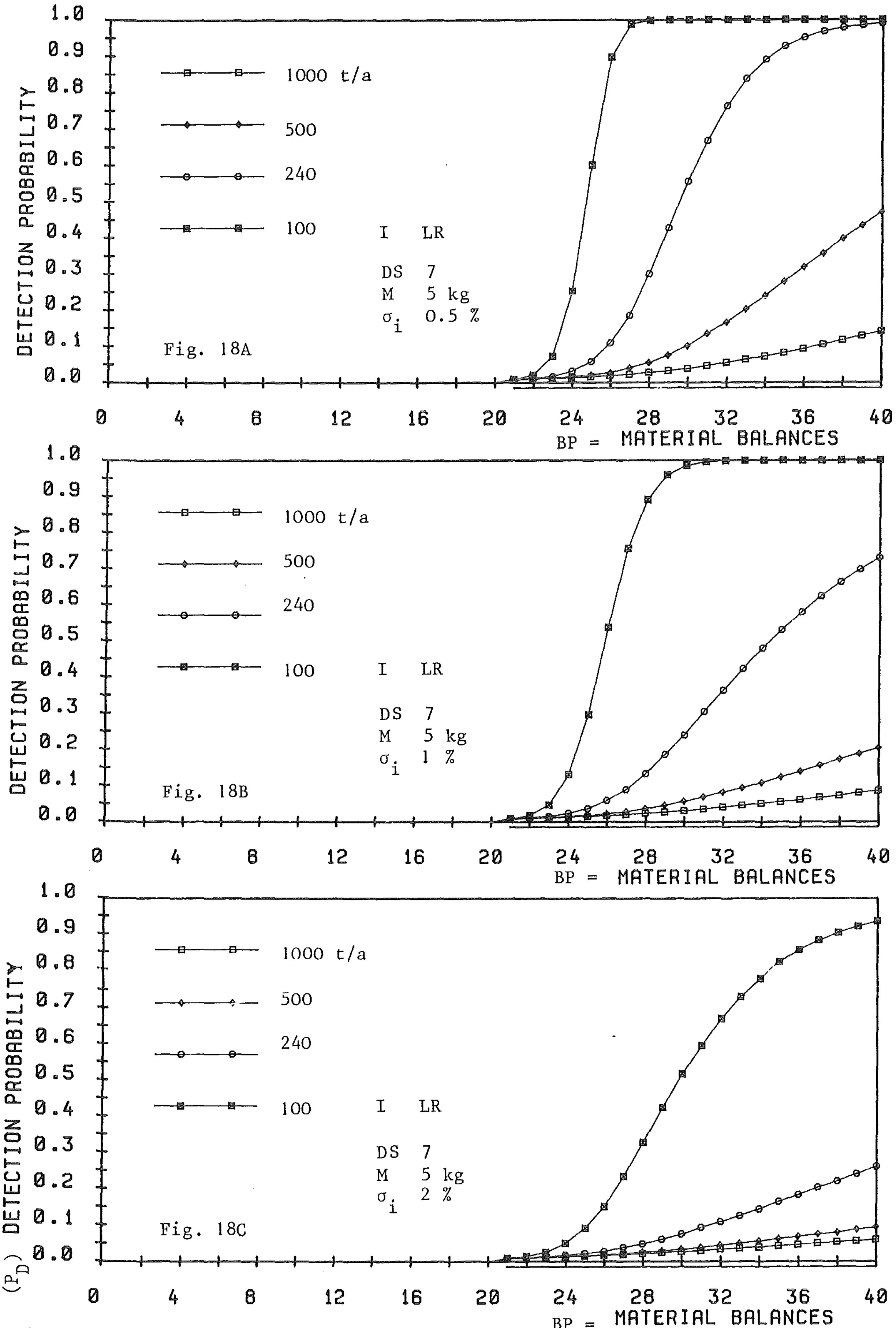


Fig. 18: P_D vs BP with Facility Throughput as Parameter for M = 5 kg and DS - 7, with Measurement Uncertainties of 0.5 % (Fig. 18A), 1 % (Fig. 18B) and 2 % (Fig. 18C). (Tables 22, 23, 24 for 1000 t/a)

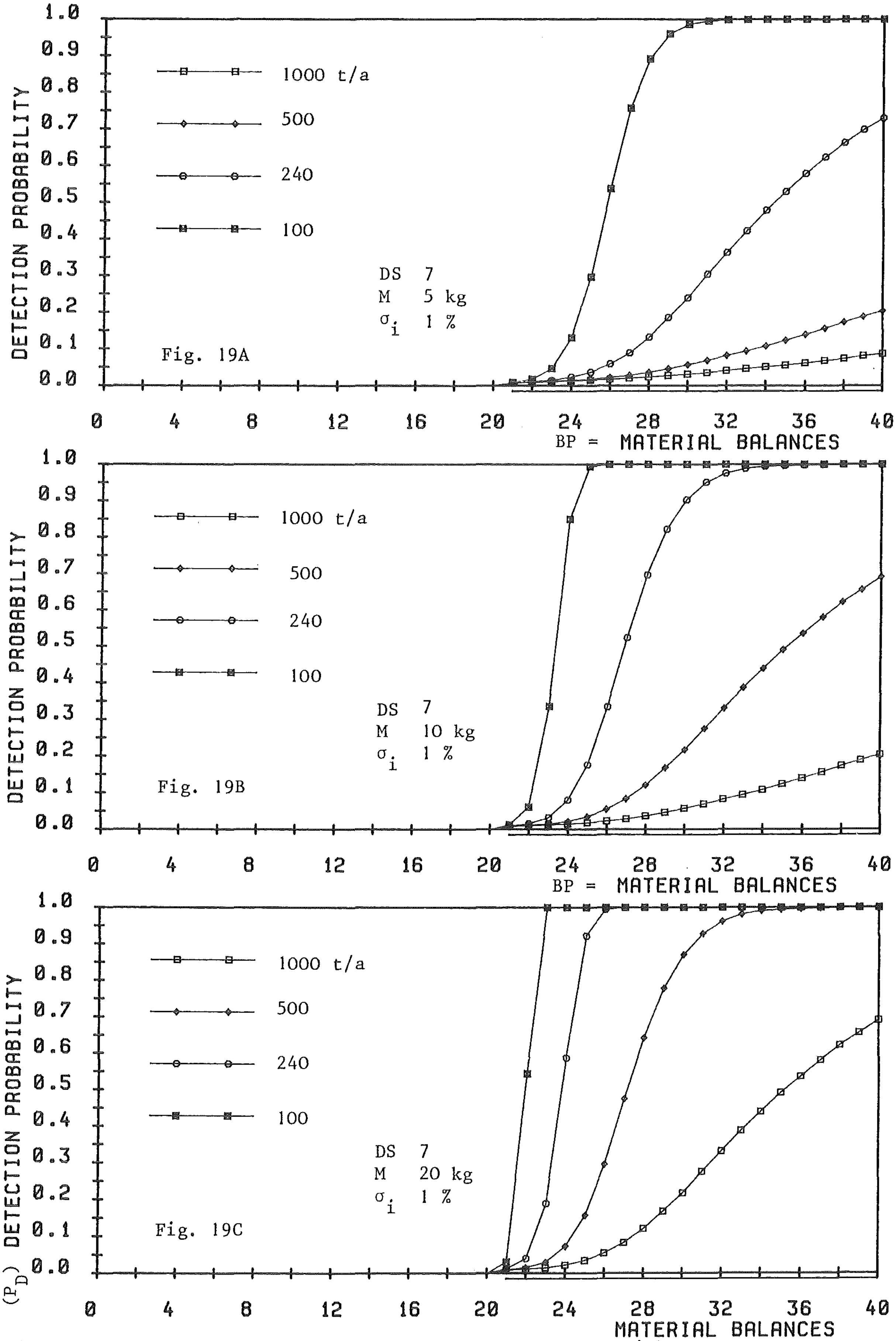


Fig. 19: P_D vs BP with Facility Throughput as Parameter with Measurement Uncertainty of 1 % and DS - 7 for M = 5 kg (Fig. 19A), 10 kg (Fig. 19B) and 20 kg (Fig. 19C). (Tables 49,50,51,52)

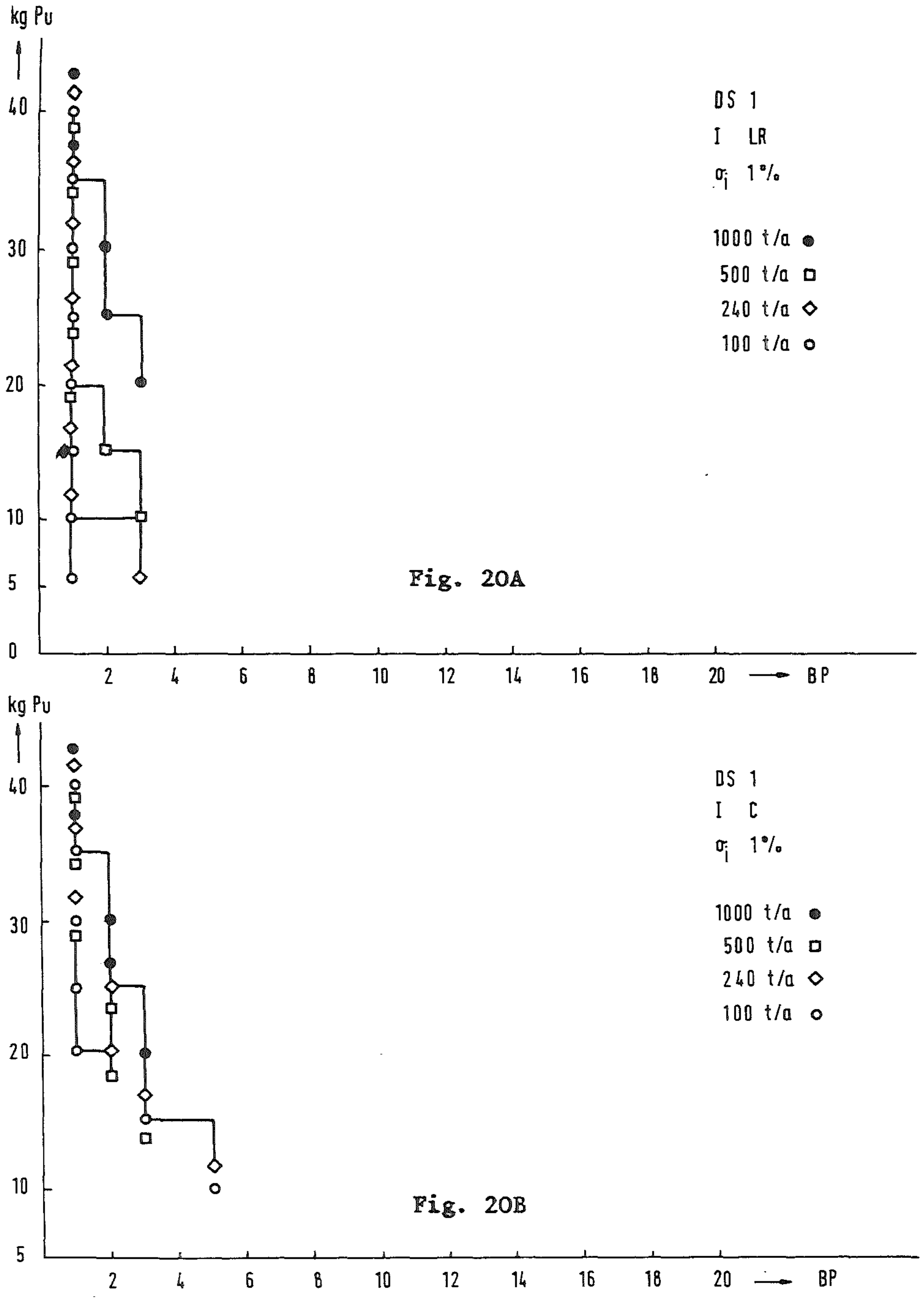


Fig. 20: No. of BP's at which $P_D \geq 95$ % is obtained for a given M(kg Pu) in a Facility with Reduced (Fig. 20A) or Constant (Fig. 20B) Inventory for DS – 1 (Tables 58,59)

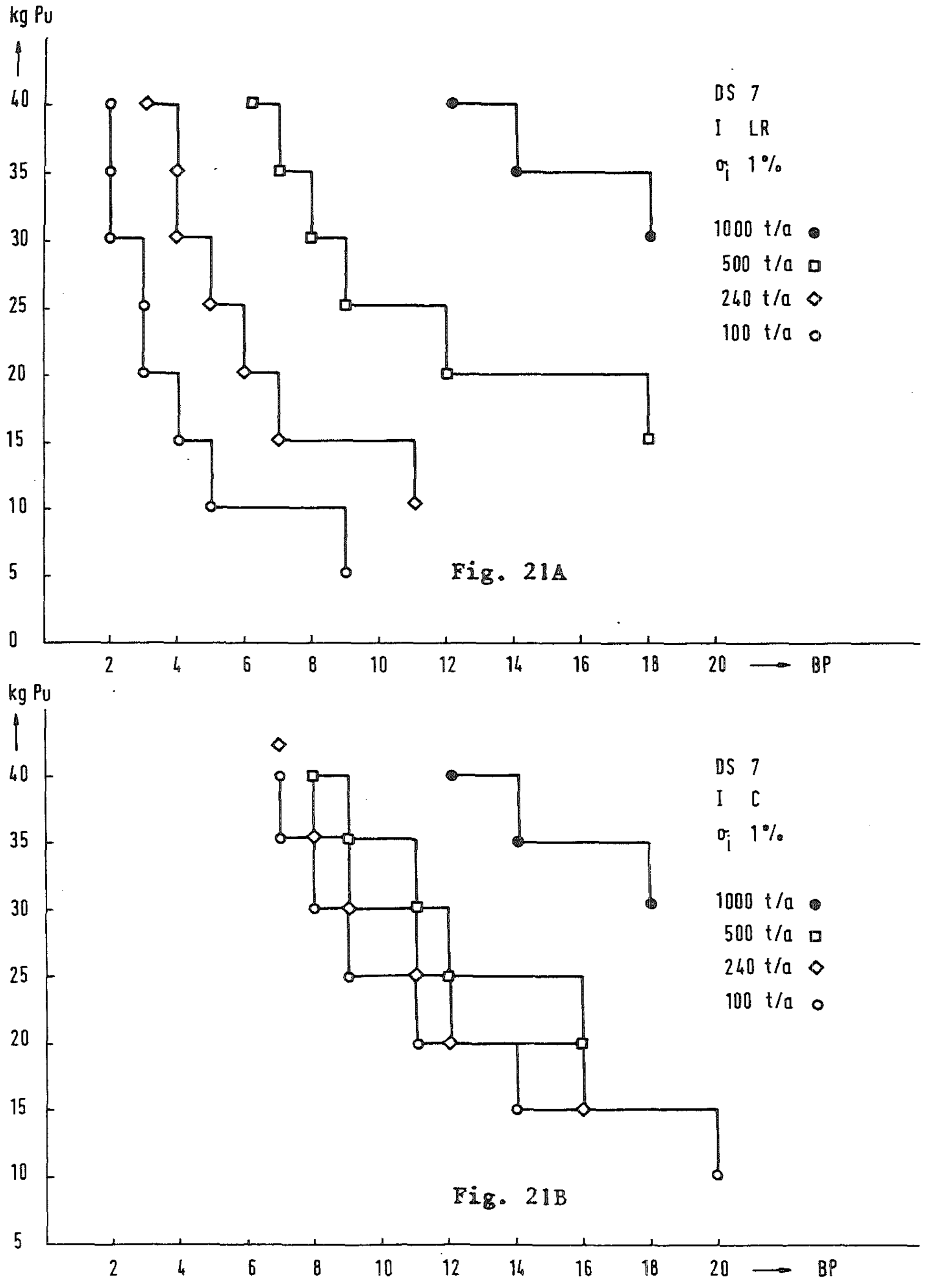


Fig. 21: No. of BP's at which $P_D \geq 95$ % is obtained for a given M(kg Pu) in a Facility with Reduced (Fig. 21A) or Constant (Fig. 21B) Inventory for DS – 7 (Tables 58,59)

Acknowledgement

The authors would like to thank Dr. R. Beedgen, Institut für Datenverarbeitung in der Technik, Kernforschungszentrum Karlsruhe, for valuable discussions and suggestions during the preparation of this report.

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6. R. Seifert — unpublished report of the KfK (1985)

7. R. Seifert — unpublished report of the KfK (1985)

Investigations on Detection Sensitivity of the NRTA Method for Different Size Reprocessing Facilities

Part II: Results of Computer Simulation

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Kernforschungszentrum Karlsruhe

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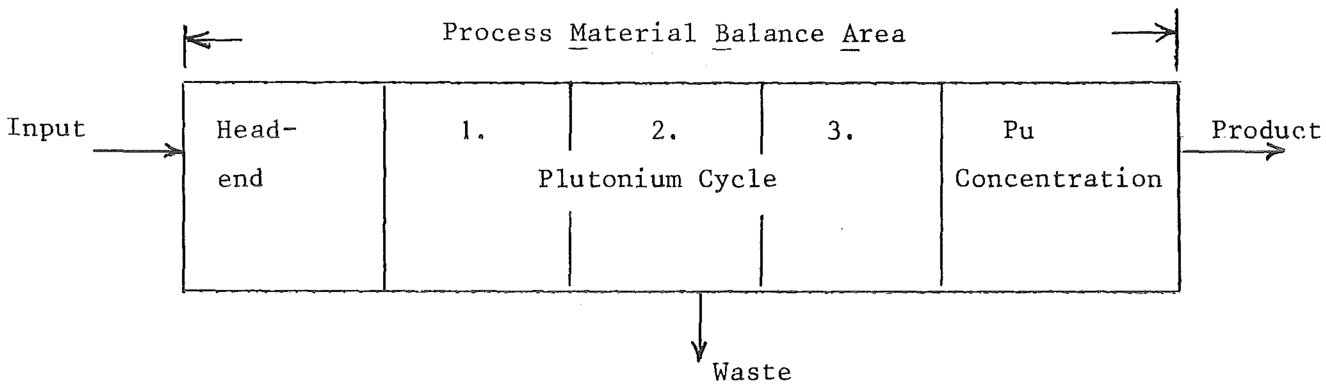
1. Introduction

The results of computer simulation, which have formed the basis for analysis in Part I of the Report: "Investigations on Detection Sensitivity of the NRTA Method for Different Size Reprocessing Facilities" are compiled in this volume. The graphical presentations, some of which were also generated directly in computers and used in Part I of the report, have not been reproduced in this part.

2. Block Model Used

The block model for the reprocessing facility which was developed earlier /2/ and used in the present simulation, is based on a 1000 t/a reference facility /5/. In its simplified form, for the generation of the simulated data base, the process MBA of the reference reprocessing facility is assumed to be subdivided into 5 inventory areas as shown below:



Block Diagram of a Reprocessing Facility

The facility is assumed to operate on a 200 d/a basis with the same amount of inventory in the process MBA for the whole period. A material balance across the process MBA is struck every 10 operating days so that there are 20 balancing periods (BP) per year. Recalibration of the measurement system takes place every two years (i.e. every 40. BP). For the computer simulation, only the Pu-cycle has been considered.

3. Parameters Considered

3.1 Facility Parameters

Two groups of parameters were considered:

a) Constant Inventory (I-C)

Facility throughput	t/a	1000	500	240	100
Process inventory	kgPu	450.6	450.6	450.6	450.6
Measurement uncertainty at the input ($\sigma_s = \sigma_R$)		0.5 %	1 %	2 %	

(all the other measurement uncertainties are assumed to be the same as in the reference case /5/)

In this case, the input to the facility is reduced from the reference 1000 t/a to 500 t/a, 240 t/a and 100 t/a. The process inventory of Pu in all the four facilities on the other hand, are kept constant at 450.6 kg Pu, i.e. that for the reference facility.

b) Linearly Reduced Inventory (I-LR)

Facility throughput	t/a	1000	500	240	100
Process inventory	kgPu	450.6	225.3	108.14	45.06
Measurement uncertainty at the input ($\sigma_s = \sigma_R$)		0.5 %	1 %	2 %	

(all the other measurement uncertainties are assumed to be the same as in the reference case /5/)

In the second group of paramters with I-LR, both the facility input and the process inventory are reduced linearly from the 1000 t/a reference facility to the three smaller facilities, i.e. 500 t/a, 240 t/a, 100 t/a respectively.

3.2 Diversion Scenarios and Amounts Assumed to be Diverted

a) Diversion Scenarios (Loss Scenarios Length)

Seven diversion scenarios, DS (in the computer print-outs expressed as loss scenario length) as developed in /2/ have been considered. They differ from each other by the number of balancing periods BP, over which a given amount M is assumed to be diverted in equal portions. DS - 1 for example means that a given amount M is assumed to be diverted over a single BP (loss scenario length - 1). This mode of diversion has been defined as "abrupt mode of diversion". DS - 7 on the other hand, means that the given amount M is assumed to be diverted in equal portions over 20 successive balancing periods (loss scenario length - 20). This mode is defined as the "protracted mode of diversion". The DS 2 - 6 fall in between these two extreme modes of diversions. The diversion scenarios and the corresponding loss scenarios lengths are shown below:

Diversion Scenario	1	2	3	4	5	6	7
Loss Scenario Length (BP)	1	2	3	4	5	10	20

In the simulation work carried out in the frame of these investigations, it has been assumed that all the diversion scenarios begin after 20 diversion free balancing periods. This means that the first act of diversion begins at the 21st BP, and in the case of DS - 7, ends at the 40th BP. For this reason, for each of the parameters considered a total run length of 40 BPs has been made.

b) Total Amount M Assumed to be Diverted

The range of M = 5 - 40 kg of Pu with an interval of 5 kg has been chosen for these investigations.

4. Statistical Test Procedure Used

Although a number of test procedures have been discussed in connection with the near-real-time accountancy measure /1, 2, 3, 4, 6, 7/, the two sided Page's test has been chosen for analyzing the sensitivity of the NRTA measure in this study. The reason for choosing this particular method has been discussed in detail in Part I of this report.

The probability of detection of an amount, in case it has been diverted from the process MBA, has been chosen to be the main indicator for analyzing the sensitivity of the test procedure in connection with the NRTA measure. The boundary conditions for the fals alarm rate (α) for a given probability of detection has been chosen in such a way that it reaches a value of 5 % at the end of the 40th balancing period. 10,000 Monte Carlo simulation runs were made for each of P_D values determined.

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7. R. Seifert — unpublished report of the KfK (1985)

INPUT DATA FOR PARAMETRIC VARIATIONS

PARAMETER INPUT FOR A BLOCK-MODEL OF A REPROCESSING FACILITY

THROUGHPUT (TONNES/YEAR)	: 1000.00
NUMBER OF WORKING DAYS	: 400
BALANCE INTERVAL IN DAYS	: 10
INTERVAL OF RECALIBRATIONS	: 40

	PU-INVENTORY (KG)	RELATIVE STANDARD DEVIATION (RANDOM)	(SYSTEMATIC)
HEAD-END	196.500	0.010	0.010
1.PU-CYCLE	7.600	0.010	0.010
2.PU-CYCLE	50.000	0.005	0.005
3.PU-CYCLE	134.000	0.005	0.005
PU-CONCENTRATION	62.500	0.005	0.005

	PU/BATCH (KG)	BATCHES DAY	RELATIVE STANDARD DEVIATION (RANDOM)	(SYSTEMATIC)
INPUT A	16.730	3	0.005	0.005
INPUT B	16.730	3	0.010	0.010
INPUT C	16.730	3	0.020	0.020
PRODUCT	25.000	2	0.002	0.002
WASTE	0.200	1	0.250	0.250

MEASUREMENT-ERROR OF INPUT A :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2) =	4.476054
	VARIANCE OF SYSTEMATIC ERROR	(") =	4.476054
TRANSFER :	VARIANCE OF RANDOM ERROR	(") =	0.284919
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(") =	7.547577
	VARIANCE OF MUF	(") =	16.784592
	MEASUREMENT-ERROR OF MUF	(KG) =	4.096900

MEASUREMENT-ERROR OF INPUT B :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2) =	4.476054
	VARIANCE OF SYSTEMATIC ERROR	(") =	4.476054
TRANSFER :	VARIANCE OF RANDOM ERROR	(") =	0.914678
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(") =	26.440308
	VARIANCE OF MUF	(") =	36.307083
	MEASUREMENT-ERROR OF MUF	(KG) =	6.025536

MEASUREMENT-ERROR OF INPUT C :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2) =	4.476054
	VARIANCE OF SYSTEMATIC ERROR	(") =	4.476054
TRANSFER :	VARIANCE OF RANDOM ERROR	(") =	3.433708
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(") =	102.011230
	VARIANCE OF MUF	(") =	114.397034
	MEASUREMENT-ERROR OF MUF	(KG) =	10.695655

INPUT DATA FOR PARAMETRIC VARIATIONS

PARAMETER INPUT FOR A BLOCK-MODEL OF A REPROCESSING FACILITY

THROUGHPUT (TONNES/YEAR) : 500.00
NUMBER OF WORKING DAYS : 400
BALANCE INTERVAL IN DAYS : 10
INTERVAL OF RECALIBRATIONS : 40

	PU-INVENTORY (KG)	RELATIVE STANDARD DEVIATION (RANDOM)	(SYSTEMATIC)
HEAD-END	196.500	0.010	0.010
1.PU-CYCLE	7.600	0.010	0.010
2.PU-CYCLE	50.000	0.005	0.005
3.PU-CYCLE	134.000	0.005	0.005
PU-CONCENTRATION	62.500	0.005	0.005

	PU/BATCH (KG)	BATCHES DAY	RELATIVE STANDARD DEVIATION (RANDOM)	(SYSTEMATIC)
INPUT A	8.365	3	0.005	0.005
INPUT B	8.365	3	0.010	0.010
INPUT C	8.365	3	0.020	0.020
PRODUCT	12.500	2	0.002	0.002
WASTE	0.100	1	0.250	0.250

MEASUREMENT-ERROR OF INPUT A :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2)	=	4.476054
	VARIANCE OF SYSTEMATIC ERROR	(")	=	4.476054
TRANSFER :	VARIANCE OF RANDOM ERROR	(")	=	0.071230
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(")	=	1.886896
	VARIANCE OF MUF	(")	=	10.910233
	MEASUREMENT-ERROR OF MUF	(KG)	=	3.303064

MEASUREMENT-ERROR OF INPUT B :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2)	=	4.476054
	VARIANCE OF SYSTEMATIC ERROR	(")	=	4.476054
TRANSFER :	VARIANCE OF RANDOM ERROR	(")	=	0.228670
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(")	=	6.610085
	VARIANCE OF MUF	(")	=	15.790862
	MEASUREMENT-ERROR OF MUF	(KG)	=	3.973772

MEASUREMENT-ERROR OF INPUT C :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2)	=	4.476054
	VARIANCE OF SYSTEMATIC ERROR	(")	=	4.476054
TRANSFER :	VARIANCE OF RANDOM ERROR	(")	=	0.858428
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(")	=	25.502838
	VARIANCE OF MUF	(")	=	35.313370
	MEASUREMENT-ERROR OF MUF	(KG)	=	5.942505

INPUT DATA FOR PARAMETRIC VARIATIONS

PARAMETER INPUT FOR A BLOCK-MODEL OF A REPROCESSING FACILITY

THROUGHPUT (TONNES/YEAR)	:	240.00
NUMBER OF WORKING DAYS	:	400
BALANCE INTERVAL IN DAYS	:	10
INTERVAL OF RECALIBRATIONS	:	40

	PU-INVENTORY (KG)	RELATIVE STANDARD DEVIATION (RANDOM)	(SYSTEMATIC)
HEAD-END	196.500	0.010	0.010
1.PU-CYCLE	7.600	0.010	0.010
2.PU-CYCLE	50.000	0.005	0.005
3.PU-CYCLE	134.000	0.005	0.005
PU-CONCENTRATION	62.500	0.005	0.005

	PU/BATCH (KG)	BATCHES DAY	RELATIVE STANDARD DEVIATION (RANDOM)	(SYSTEMATIC)
INPUT A	4.015	3	0.005	0.005
INPUT B	4.015	3	0.010	0.010
INPUT C	4.015	3	0.020	0.020
PRODUCT	6.000	2	0.002	0.002
WASTE	0.048	1	0.250	0.250

MEASUREMENT-ERROR OF INPUT A :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2)	=	4.476054
	VARIANCE OF SYSTEMATIC ERROR	(")	=	4.476054
TRANSFER :	VARIANCE OF RANDOM ERROR	(")	=	0.016410
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(")	=	0.434705
	VARIANCE OF MUF	(")	=	9.403222
	MEASUREMENT-ERROR OF MUF	(KG)	=	3.066467

MEASUREMENT-ERROR OF INPUT B :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2)	=	4.476054
	VARIANCE OF SYSTEMATIC ERROR	(")	=	4.476054
TRANSFER :	VARIANCE OF RANDOM ERROR	(")	=	0.052681
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(")	=	1.522819
	VARIANCE OF MUF	(")	=	10.527606
	MEASUREMENT-ERROR OF MUF	(KG)	=	3.244627

MEASUREMENT-ERROR OF INPUT C :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2)	=	4.476054
	VARIANCE OF SYSTEMATIC ERROR	(")	=	4.476054
TRANSFER :	VARIANCE OF RANDOM ERROR	(")	=	0.197762
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(")	=	5.875275
	VARIANCE OF MUF	(")	=	15.025146
	MEASUREMENT-ERROR OF MUF	(KG)	=	3.876228

INPUT DATA FOR PARAMETRIC VARIATIONS

PARAMETER INPUT FOR A BLOCK-MODEL OF A REPROCESSING FACILITY

THROUGHPUT (TONNES/YEAR)	:	100.00
NUMBER OF WORKING DAYS	:	400
BALANCE INTERVAL IN DAYS	:	10
INTERVAL OF RECALIBRATIONS	:	40

	PU-INVENTORY (KG)	RELATIVE STANDARD DEVIATION (RANDOM)	(SYSTEMATIC)
HEAD-END	196.500	0.010	0.010
1.PU-CYCLE	7.600	0.010	0.010
2.PU-CYCLE	50.000	0.005	0.005
3.PU-CYCLE	134.000	0.005	0.005
PU-CONCENTRATION	62.500	0.005	0.005

	PU/BATCH (KG)	BATCHES DAY	RELATIVE STANDARD DEVIATION (RANDOM)	(SYSTEMATIC)
INPUT A	1.673	3	0.005	0.005
INPUT B	1.673	3	0.010	0.010
INPUT C	1.673	3	0.020	0.020
PRODUCT	2.500	2	0.002	0.002
WASTE	0.020	1	0.250	0.250

MEASUREMENT-ERROR OF INPUT A :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2)	=	4.476054
	VARIANCE OF SYSTEMATIC ERROR	(")	=	4.476054
TRANSFER :	VARIANCE OF RANDOM ERROR	(")	=	0.002849
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(")	=	0.075476
	VARIANCE OF MUF	(")	=	9.030433
	MEASUREMENT-ERROR OF MUF	(KG)	=	3.005068

MEASUREMENT-ERROR OF INPUT B :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2)	=	4.476054
	VARIANCE OF SYSTEMATIC ERROR	(")	=	4.476054
TRANSFER :	VARIANCE OF RANDOM ERROR	(")	=	0.009147
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(")	=	0.264403
	VARIANCE OF MUF	(")	=	9.225657
	MEASUREMENT-ERROR OF MUF	(KG)	=	3.037377

MEASUREMENT-ERROR OF INPUT C :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2)	=	4.476054
	VARIANCE OF SYSTEMATIC ERROR	(")	=	4.476054
TRANSFER :	VARIANCE OF RANDOM ERROR	(")	=	0.034337
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(")	=	1.020114
	VARIANCE OF MUF	(")	=	10.006558
	MEASUREMENT-ERROR OF MUF	(KG)	=	3.163314

INPUT DATA FOR PARAMETRIC VARIATIONS

PARAMETER INPUT FOR A BLOCK-MODEL OF A REPROCESSING FACILITY

THROUGHPUT (TONNES/YEAR)	: 500.00
NUMBER OF WORKING DAYS	: 400
BALANCE INTERVAL IN DAYS	: 10
INTERVAL OF RECALIBRATIONS	: 40

	PU-INVENTORY (KG)	RELATIVE STANDARD DEVIATION (RANDOM)	(SYSTEMATIC)
HEAD-END	98.250	0.010	0.010
1.PU-CYCLE	3.800	0.010	0.010
2.PU-CYCLE	25.000	0.005	0.005
3.PU-CYCLE	67.000	0.005	0.005
PU-CONCENTRATION	31.250	0.005	0.005

	PU/BATCH (KG)	BATCHES DAY	RELATIVE STANDARD DEVIATION (RANDOM)	(SYSTEMATIC)
INPUT A	8.365	3	0.005	0.005
INPUT B	8.365	3	0.010	0.010
INPUT C	8.365	3	0.020	0.010
PRODUCT	12.500	2	0.002	0.002
WASTE	0.100	1	0.250	0.250

MEASUREMENT-ERROR OF INPUT A :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2)	=	1.119013
	VARIANCE OF SYSTEMATIC ERROR	(")	=	1.119013
TRANSFER :	VARIANCE OF RANDOM ERROR	(")	=	0.071230
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(")	=	1.886896
	VARIANCE OF MUF	(")	=	4.196151
	MEASUREMENT-ERROR OF MUF	(KG)	=	2.048451

MEASUREMENT-ERROR OF INPUT B :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2)	=	1.119013
	VARIANCE OF SYSTEMATIC ERROR	(")	=	1.119013
TRANSFER :	VARIANCE OF RANDOM ERROR	(")	=	0.228670
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(")	=	6.610085
	VARIANCE OF MUF	(")	=	9.076779
	MEASUREMENT-ERROR OF MUF	(KG)	=	3.012769

MEASUREMENT-ERROR OF INPUT C :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2)	=	1.119013
	VARIANCE OF SYSTEMATIC ERROR	(")	=	1.119013
TRANSFER :	VARIANCE OF RANDOM ERROR	(")	=	0.858428
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(")	=	25.502838
	VARIANCE OF MUF	(")	=	28.599289
	MEASUREMENT-ERROR OF MUF	(KG)	=	5.347830

INPUT DATA FOR PARAMETRIC VARIATIONS

PARAMETER INPUT FOR A BLOCK-MODEL OF A REPROCESSING FACILITY

THROUGHPUT (TONNES/YEAR)	:	240.00
NUMBER OF WORKING DAYS	:	400
BALANCE INTERVAL IN DAYS	:	10
INTERVAL OF RECALIBRATIONS	:	40

	PU-INVENTORY (KG)	RELATIVE STANDARD DEVIATION (RANDOM)	(SYSTEMATIC)
HEAD-END	49.125	0.010	0.010
1.PU-CYCLE	1.900	0.010	0.010
2.PU-CYCLE	12.500	0.005	0.005
3.PU-CYCLE	33.500	0.005	0.005
PU-CONCENTRATION	15.625	0.005	0.005

	PU/BATCH (KG)	BATCHES DAY	RELATIVE STANDARD DEVIATION (RANDOM)	(SYSTEMATIC)
INPUT A	4.015	3	0.005	0.005
INPUT B	4.015	3	0.010	0.010
INPUT C	4.015	3	0.020	0.020
PRODUCT	6.000	2	0.002	0.002
WASTE	0.048	1	0.250	0.250

MEASUREMENT-ERROR OF INPUT A :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2) =	0.257821
	VARIANCE OF SYSTEMATIC ERROR	(") =	0.257821
TRANSFER :	VARIANCE OF RANDOM ERROR	(") =	0.016410
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(") =	0.434705
	VARIANCE OF MUF	(") =	0.966756
	MEASUREMENT-ERROR OF MUF	(KG) =	0.983238

MEASUREMENT-ERROR OF INPUT B :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2) =	0.257821
	VARIANCE OF SYSTEMATIC ERROR	(") =	0.257821
TRANSFER :	VARIANCE OF RANDOM ERROR	(") =	0.052681
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(") =	1.522819
	VARIANCE OF MUF	(") =	2.091140
	MEASUREMENT-ERROR OF MUF	(KG) =	1.446077

MEASUREMENT-ERROR OF INPUT C :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2) =	0.257821
	VARIANCE OF SYSTEMATIC ERROR	(") =	0.257821
TRANSFER :	VARIANCE OF RANDOM ERROR	(") =	0.197762
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(") =	5.875275
	VARIANCE OF MUF	(") =	6.588678
	MEASUREMENT-ERROR OF MUF	(KG) =	2.566842

INPUT DATA FOR PARAMETRIC VARIATIONS

PARAMETER INPUT FOR A BLOCK-MODEL OF A REPROCESSING FACILITY

THROUGHPUT (TONNES/YEAR) : 100.00
NUMBER OF WORKING DAYS : 400
BALANCE INTERVAL IN DAYS : 10
INTERVAL OF RECALIBRATIONS : 40

	PU-INVENTORY (KG)	RELATIVE STANDARD DEVIATION (RANDOM)	(SYSTEMATIC)
HEAD-END	19.650	0.010	0.010
1.PU-CYCLE	0.760	0.010	0.010
2.PU-CYCLE	5.000	0.005	0.005
3.PU-CYCLE	13.400	0.005	0.005
PU-CONCENTRATION	6.250	0.005	0.005

	PU/BATCH (KG)	BATCHES DAY	RELATIVE STANDARD DEVIATION (RANDOM)	(SYSTEMATIC)
INPUT A	1.673	3	0.005	0.005
INPUT B	1.673	3	0.010	0.010
INPUT C	1.673	3	0.020	0.020
PRODUCT	2.500	2	0.002	0.002
WASTE	0.020	1	0.250	0.250

MEASUREMENT-ERROR OF INPUT A :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2) =	0.044761
	VARIANCE OF SYSTEMATIC ERROR	(") =	0.044761
TRANSFER :	VARIANCE OF RANDOM ERROR	(") =	0.002849
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(") =	0.075476
	VARIANCE OF MUF	(") =	0.167846
	MEASUREMENT-ERROR OF MUF	(KG) =	0.409690

MEASUREMENT-ERROR OF INPUT B :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2) =	0.044761
	VARIANCE OF SYSTEMATIC ERROR	(") =	0.044761
TRANSFER :	VARIANCE OF RANDOM ERROR	(") =	0.009147
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(") =	0.264403
	VARIANCE OF MUF	(") =	0.363071
	MEASUREMENT-ERROR OF MUF	(KG) =	0.602554

MEASUREMENT-ERROR OF INPUT C :

INVENTORY:	VARIANCE OF RANDOM ERROR	(KG**2) =	0.044761
	VARIANCE OF SYSTEMATIC ERROR	(") =	0.044761
TRANSFER :	VARIANCE OF RANDOM ERROR	(") =	0.034337
(PER DAY)	VARIANCE OF SYSTEMATIC ERROR	(") =	1.020114
	VARIANCE OF MUF	(") =	1.143971
	MEASUREMENT-ERROR OF MUF	(KG) =	1.069566

PROBABILITY OF DETECTION AS A FUNCTION OF
BALANCING PERIOD FOR

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+----------------------------------------+
|                                        |
|      DIVERSION SCENARIO      -  1      |
|      (LOSS-SCENARIO-LENGTH -  1)       |
|                                        |
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PARAMETERS CONSIDERED :

FACILITY THROUGHPUT	T/A	1000	500	240	100			
PROCESS INVENTORY	KG PU							
		- CONSTANT						
		- LINEAR REDUCED						
MEASUREMENT UNCERTAINTY AT THE INPUT		0.05 % (A)	0.1 % (B)	0.2 % (C)				
AMOUNT ASSUMED TO BE DIVERDED KG PU	5	10	15	20	25	30	35	40
(LOSS PATTERN)	1	2	3	4	5	6	7	8

SUMMARY OF RESULTS

LOSS-SCENARIO-LENGTH: 1
INVENTORY CONSTANT

THROUGHPUT (TONNES/YEAR) : 1000.00
INVENTORY (KG PU) : 450.60
TOTAL-LOSS (KG PU) :

	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
INPUT A:	22.94	84.02	99.89	100.00	100.00	100.00	100.00	100.00
INPUT B:	11.71	41.54	87.89	99.83	100.00	100.00	100.00	100.00
INPUT C:	6.86	14.13	30.42	59.20	88.36	98.93	99.99	100.00

THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 450.60

INPUT A:	41.00	98.76	100.00	100.00	100.00	100.00	100.00	100.00
INPUT B:	25.78	88.73	99.96	100.00	100.00	100.00	100.00	100.00
INPUT C:	12.10	43.46	89.92	99.87	100.00	100.00	100.00	100.00

THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 450.60

INPUT A:	52.58	99.77	100.00	100.00	100.00	100.00	100.00	100.00
INPUT B:	44.27	99.22	100.00	100.00	100.00	100.00	100.00	100.00
INPUT C:	27.68	91.37	99.98	100.00	100.00	100.00	100.00	100.00

THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 450.60

INPUT A:	59.35	99.89	100.00	100.00	100.00	100.00	100.00	100.00
INPUT B:	54.87	99.85	100.00	100.00	100.00	100.00	100.00	100.00
INPUT C:	47.93	99.57	100.00	100.00	100.00	100.00	100.00	100.00

INVENTORY LINEAR REDUCED

THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 225.30

INPUT A:	84.02	100.00	100.00	100.00	100.00	100.00	100.00	100.00
INPUT B:	41.54	99.83	100.00	100.00	100.00	100.00	100.00	100.00
INPUT C:	14.12	59.19	98.93	100.00	100.00	100.00	100.00	100.00

THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 108.14

INPUT A:	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
INPUT B:	99.91	100.00	100.00	100.00	100.00	100.00	100.00	100.00
INPUT C:	65.01	100.00	100.00	100.00	100.00	100.00	100.00	100.00

THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 45.06

INPUT A:	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
INPUT B:	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
INPUT C:	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

LOSS SCENARIO 1

TOTAL LOSS (KGPU)		5	10	15	20	25	30	35	40
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	5.000	10.000	15.000	20.000	25.000	30.000	35.000	40.000
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

THROUGHPUT (TONNES/YEAR) : 1000.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 0.5 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11	2	2	2	2	2	2	2	2	2
12	4	4	4	4	4	4	4	4	4
13	9	9	9	9	9	9	9	9	9
14	16	16	16	16	16	16	16	16	16
15	24	24	24	24	24	24	24	24	24
16	33	33	33	33	33	33	33	33	33
17	46	46	46	46	46	46	46	46	46
18	57	57	57	57	57	57	57	57	57
19	66	66	66	66	66	66	66	66	66
20	75	75	75	75	75	75	75	75	75
21	90	143	390	1176	3069	6924	9797	10000	10000
22	101	321	1844	6976	9942	10000	10000	10000	10000
23	114	566	4205	9652	10000	10000	10000	10000	10000
24	130	862	6126	9933	10000	10000	10000	10000	10000
25	147	1161	7182	9978	10000	10000	10000	10000	10000
26	166	1391	7708	9984	10000	10000	10000	10000	10000
27	184	1567	7976	9987	10000	10000	10000	10000	10000
28	204	1729	8129	9987	10000	10000	10000	10000	10000
29	232	1834	8216	9987	10000	10000	10000	10000	10000
30	254	1925	8250	9987	10000	10000	10000	10000	10000
31	275	2002	8267	9987	10000	10000	10000	10000	10000
32	295	2060	8273	9987	10000	10000	10000	10000	10000
33	306	2083	8279	9987	10000	10000	10000	10000	10000
34	330	2111	8289	9987	10000	10000	10000	10000	10000
35	363	2133	8294	9987	10000	10000	10000	10000	10000
36	384	2156	8306	9987	10000	10000	10000	10000	10000
37	413	2181	8325	9988	10000	10000	10000	10000	10000
38	447	2202	8343	9988	10000	10000	10000	10000	10000
39	472	2254	8365	9988	10000	10000	10000	10000	10000
40	493	2294	8402	9989	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 1000.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 1.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11	2	2	2	2	2	2	2	2	2
12	4	4	4	4	4	4	4	4	4
13	9	9	9	9	9	9	9	9	9
14	16	16	16	16	16	16	16	16	16
15	24	24	24	24	24	24	24	24	24
16	33	33	33	33	33	33	33	33	33
17	46	46	46	46	46	46	46	46	46
18	57	57	57	57	57	57	57	57	57
19	66	66	66	66	66	66	66	66	66
20	75	75	75	75	75	75	75	75	75
21	90	134	316	894	2237	4946	8751	9964	10000
22	101	246	1096	4117	8877	9992	10000	10000	10000
23	114	354	2028	6853	9857	10000	10000	10000	10000
24	130	483	2738	7916	9942	10000	10000	10000	10000
25	147	578	3161	8332	9966	10000	10000	10000	10000
26	166	655	3413	8480	9970	10000	10000	10000	10000
27	184	726	3602	8558	9970	10000	10000	10000	10000
28	204	776	3724	8606	9970	10000	10000	10000	10000
29	232	821	3792	8625	9972	10000	10000	10000	10000
30	254	861	3830	8638	9972	10000	10000	10000	10000
31	275	898	3864	8645	9972	10000	10000	10000	10000
32	295	932	3887	8650	9973	10000	10000	10000	10000
33	306	956	3909	8655	9973	10000	10000	10000	10000
34	330	985	3933	8660	9974	10000	10000	10000	10000
35	363	1014	3950	8674	9975	10000	10000	10000	10000
36	384	1037	3974	8688	9975	10000	10000	10000	10000
37	413	1072	4016	8709	9976	10000	10000	10000	10000
38	447	1100	4065	8725	9978	10000	10000	10000	10000
39	472	1132	4109	8753	9980	10000	10000	10000	10000
40	493	1171	4154	8789	9983	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 1000.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 2.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11	2	2	2	2	2	2	2	2	2
12	4	4	4	4	4	4	4	4	4
13	9	9	9	9	9	9	9	9	9
14	16	16	16	16	16	16	16	16	16
15	24	24	24	24	24	24	24	24	24
16	33	33	33	33	33	33	33	33	33
17	46	46	46	46	46	46	46	46	46
18	57	57	57	57	57	57	57	57	57
19	66	66	66	66	66	66	66	66	66
20	75	75	75	75	75	75	75	75	75
21	90	124	245	502	1175	2446	4667	7950	9784
22	101	174	450	1351	3428	7077	9577	9992	10000
23	114	216	619	1906	4651	8213	9814	9998	10000
24	130	250	746	2211	5142	8475	9852	9998	10000
25	147	277	844	2374	5344	8589	9858	9998	10000
26	166	297	908	2478	5451	8624	9861	9998	10000
27	184	325	966	2546	5514	8641	9862	9998	10000
28	204	363	1004	2606	5560	8653	9862	9998	10000
29	232	386	1041	2643	5581	8659	9862	9998	10000
30	254	412	1074	2684	5598	8662	9862	9998	10000
31	275	435	1108	2719	5619	8665	9864	9998	10000
32	295	469	1138	2746	5631	8670	9868	9998	10000
33	306	495	1165	2774	5647	8682	9871	9998	10000
34	330	518	1195	2803	5668	8689	9871	9998	10000
35	363	544	1229	2825	5694	8704	9874	9998	10000
36	384	570	1257	2867	5728	8724	9878	9998	10000
37	413	604	1299	2906	5768	8748	9884	9999	10000
38	447	633	1330	2950	5814	8770	9890	9999	10000
39	472	659	1369	2998	5857	8801	9892	9999	10000
40	493	686	1413	3042	5920	8836	9893	9999	10000

THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 0.5 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	152	432	1390	3639	7972	9939	10000	10000
22	101	375	2464	8517	9999	10000	10000	10000	10000
23	114	778	6265	9976	10000	10000	10000	10000	10000
24	130	1365	8525	10000	10000	10000	10000	10000	10000
25	147	1948	9350	10000	10000	10000	10000	10000	10000
26	166	2470	9640	10000	10000	10000	10000	10000	10000
27	184	2941	9779	10000	10000	10000	10000	10000	10000
28	204	3270	9828	10000	10000	10000	10000	10000	10000
29	232	3499	9849	10000	10000	10000	10000	10000	10000
30	254	3655	9860	10000	10000	10000	10000	10000	10000
31	275	3770	9864	10000	10000	10000	10000	10000	10000
32	295	3849	9865	10000	10000	10000	10000	10000	10000
33	306	3911	9866	10000	10000	10000	10000	10000	10000
34	330	3952	9866	10000	10000	10000	10000	10000	10000
35	363	3973	9867	10000	10000	10000	10000	10000	10000
36	384	3997	9867	10000	10000	10000	10000	10000	10000
37	413	4011	9867	10000	10000	10000	10000	10000	10000
38	447	4033	9868	10000	10000	10000	10000	10000	10000
39	472	4066	9870	10000	10000	10000	10000	10000	10000
40	493	4100	9876	10000	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 225.30

21	90	390	3069	9797	10000	10000	10000	10000	10000
22	101	1844	9942	10000	10000	10000	10000	10000	10000
23	114	4205	10000	10000	10000	10000	10000	10000	10000
24	130	6126	10000	10000	10000	10000	10000	10000	10000
25	147	7182	10000	10000	10000	10000	10000	10000	10000
26	166	7708	10000	10000	10000	10000	10000	10000	10000
27	184	7976	10000	10000	10000	10000	10000	10000	10000
28	204	8129	10000	10000	10000	10000	10000	10000	10000
29	232	8216	10000	10000	10000	10000	10000	10000	10000
30	254	8250	10000	10000	10000	10000	10000	10000	10000
31	275	8266	10000	10000	10000	10000	10000	10000	10000
32	295	8273	10000	10000	10000	10000	10000	10000	10000
33	306	8279	10000	10000	10000	10000	10000	10000	10000
34	330	8289	10000	10000	10000	10000	10000	10000	10000
35	363	8294	10000	10000	10000	10000	10000	10000	10000
36	384	8306	10000	10000	10000	10000	10000	10000	10000
37	413	8325	10000	10000	10000	10000	10000	10000	10000
38	447	8343	10000	10000	10000	10000	10000	10000	10000
39	472	8365	10000	10000	10000	10000	10000	10000	10000
40	493	8402	10000	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 1.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	147	399	1218	3204	7166	9843	10000	10000
22	101	331	1951	7347	9967	10000	10000	10000	10000
23	114	596	4643	9781	10000	10000	10000	10000	10000
24	130	944	6718	9971	10000	10000	10000	10000	10000
25	147	1311	7785	9989	10000	10000	10000	10000	10000
26	166	1563	8281	9994	10000	10000	10000	10000	10000
27	184	1786	8537	9995	10000	10000	10000	10000	10000
28	204	1965	8676	9995	10000	10000	10000	10000	10000
29	232	2101	8743	9995	10000	10000	10000	10000	10000
30	254	2203	8763	9995	10000	10000	10000	10000	10000
31	275	2295	8769	9995	10000	10000	10000	10000	10000
32	295	2343	8779	9995	10000	10000	10000	10000	10000
33	306	2370	8786	9995	10000	10000	10000	10000	10000
34	330	2399	8792	9995	10000	10000	10000	10000	10000
35	363	2417	8793	9995	10000	10000	10000	10000	10000
36	384	2435	8799	9995	10000	10000	10000	10000	10000
37	413	2464	8812	9996	10000	10000	10000	10000	10000
38	447	2492	8823	9996	10000	10000	10000	10000	10000
39	472	2539	8843	9996	10000	10000	10000	10000	10000
40	493	2578	8873	9996	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 225.30

21	90	316	2237	8751	10000	10000	10000	10000	10000
22	101	1096	8877	10000	10000	10000	10000	10000	10000
23	114	2028	9857	10000	10000	10000	10000	10000	10000
24	130	2738	9942	10000	10000	10000	10000	10000	10000
25	147	3161	9966	10000	10000	10000	10000	10000	10000
26	166	3413	9970	10000	10000	10000	10000	10000	10000
27	184	3602	9970	10000	10000	10000	10000	10000	10000
28	204	3722	9970	10000	10000	10000	10000	10000	10000
29	232	3790	9972	10000	10000	10000	10000	10000	10000
30	254	3829	9972	10000	10000	10000	10000	10000	10000
31	275	3863	9972	10000	10000	10000	10000	10000	10000
32	295	3886	9973	10000	10000	10000	10000	10000	10000
33	306	3908	9973	10000	10000	10000	10000	10000	10000
34	330	3932	9974	10000	10000	10000	10000	10000	10000
35	363	3949	9975	10000	10000	10000	10000	10000	10000
36	384	3973	9975	10000	10000	10000	10000	10000	10000
37	413	4016	9976	10000	10000	10000	10000	10000	10000
38	447	4065	9978	10000	10000	10000	10000	10000	10000
39	472	4109	9980	10000	10000	10000	10000	10000	10000
40	493	4154	9983	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 2.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	134	320	912	2286	5078	8857	9970	10000
22	101	248	1140	4289	9032	9996	10000	10000	10000
23	114	365	2142	7160	9892	10000	10000	10000	10000
24	130	502	2899	8180	9959	10000	10000	10000	10000
25	147	607	3342	8573	9971	10000	10000	10000	10000
26	166	687	3626	8712	9974	10000	10000	10000	10000
27	184	760	3812	8779	9976	10000	10000	10000	10000
28	204	812	3926	8831	9977	10000	10000	10000	10000
29	232	856	3990	8849	9977	10000	10000	10000	10000
30	254	898	4030	8859	9977	10000	10000	10000	10000
31	275	936	4060	8863	9977	10000	10000	10000	10000
32	295	969	4081	8866	9978	10000	10000	10000	10000
33	306	991	4104	8872	9978	10000	10000	10000	10000
34	330	1019	4127	8875	9979	10000	10000	10000	10000
35	363	1049	4144	8887	9979	10000	10000	10000	10000
36	384	1071	4172	8902	9979	10000	10000	10000	10000
37	413	1105	4211	8918	9981	10000	10000	10000	10000
38	447	1133	4258	8937	9983	10000	10000	10000	10000
39	472	1168	4300	8960	9986	10000	10000	10000	10000
40	493	1210	4346	8992	9987	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 225.30

21	90	245	1175	4667	9784	10000	10000	10000	10000
22	101	450	3428	9577	10000	10000	10000	10000	10000
23	114	619	4647	9813	10000	10000	10000	10000	10000
24	130	746	5140	9851	10000	10000	10000	10000	10000
25	147	844	5342	9858	10000	10000	10000	10000	10000
26	166	908	5450	9861	10000	10000	10000	10000	10000
27	184	966	5513	9862	10000	10000	10000	10000	10000
28	204	1004	5559	9862	10000	10000	10000	10000	10000
29	232	1041	5580	9862	10000	10000	10000	10000	10000
30	254	1074	5597	9862	10000	10000	10000	10000	10000
31	275	1108	5618	9864	10000	10000	10000	10000	10000
32	295	1138	5630	9868	10000	10000	10000	10000	10000
33	306	1165	5646	9871	10000	10000	10000	10000	10000
34	330	1195	5667	9871	10000	10000	10000	10000	10000
35	363	1228	5693	9874	10000	10000	10000	10000	10000
36	384	1256	5727	9878	10000	10000	10000	10000	10000
37	413	1298	5767	9885	10000	10000	10000	10000	10000
38	447	1329	5813	9890	10000	10000	10000	10000	10000
39	472	1368	5856	9892	10000	10000	10000	10000	10000
40	493	1412	5919	9893	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 0.5 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	158	450	1455	3854	8274	9966	10000	10000
22	101	400	2751	8942	10000	10000	10000	10000	10000
23	114	869	7052	9995	10000	10000	10000	10000	10000
24	130	1613	9174	10000	10000	10000	10000	10000	10000
25	147	2369	9759	10000	10000	10000	10000	10000	10000
26	166	3072	9900	10000	10000	10000	10000	10000	10000
27	184	3702	9948	10000	10000	10000	10000	10000	10000
28	204	4141	9961	10000	10000	10000	10000	10000	10000
29	232	4468	9968	10000	10000	10000	10000	10000	10000
30	254	4712	9972	10000	10000	10000	10000	10000	10000
31	275	4882	9975	10000	10000	10000	10000	10000	10000
32	295	4997	9976	10000	10000	10000	10000	10000	10000
33	306	5075	9976	10000	10000	10000	10000	10000	10000
34	330	5122	9976	10000	10000	10000	10000	10000	10000
35	363	5160	9976	10000	10000	10000	10000	10000	10000
36	384	5179	9976	10000	10000	10000	10000	10000	10000
37	413	5199	9976	10000	10000	10000	10000	10000	10000
38	447	5217	9976	10000	10000	10000	10000	10000	10000
39	472	5233	9977	10000	10000	10000	10000	10000	10000
40	493	5258	9977	10000	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 108.14

21	90	3540	10000	10000	10000	10000	10000	10000	10000
22	101	9984	10000	10000	10000	10000	10000	10000	10000
23	114	10000	10000	10000	10000	10000	10000	10000	10000
24	130	10000	10000	10000	10000	10000	10000	10000	10000
25	147	10000	10000	10000	10000	10000	10000	10000	10000
26	166	10000	10000	10000	10000	10000	10000	10000	10000
27	184	10000	10000	10000	10000	10000	10000	10000	10000
28	204	10000	10000	10000	10000	10000	10000	10000	10000
29	232	10000	10000	10000	10000	10000	10000	10000	10000
30	254	10000	10000	10000	10000	10000	10000	10000	10000
31	275	10000	10000	10000	10000	10000	10000	10000	10000
32	295	10000	10000	10000	10000	10000	10000	10000	10000
33	306	10000	10000	10000	10000	10000	10000	10000	10000
34	330	10000	10000	10000	10000	10000	10000	10000	10000
35	363	10000	10000	10000	10000	10000	10000	10000	10000
36	384	10000	10000	10000	10000	10000	10000	10000	10000
37	413	10000	10000	10000	10000	10000	10000	10000	10000
38	447	10000	10000	10000	10000	10000	10000	10000	10000
39	472	10000	10000	10000	10000	10000	10000	10000	10000
40	493	10000	10000	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 1.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	153	438	1412	3708	8072	9947	10000	10000
22	101	381	2548	8657	10000	10000	10000	10000	10000
23	114	801	6513	9985	10000	10000	10000	10000	10000
24	130	1432	8766	10000	10000	10000	10000	10000	10000
25	147	2074	9499	10000	10000	10000	10000	10000	10000
26	166	2633	9739	10000	10000	10000	10000	10000	10000
27	184	3151	9848	10000	10000	10000	10000	10000	10000
28	204	3519	9886	10000	10000	10000	10000	10000	10000
29	232	3787	9901	10000	10000	10000	10000	10000	10000
30	254	3975	9912	10000	10000	10000	10000	10000	10000
31	275	4108	9916	10000	10000	10000	10000	10000	10000
32	295	4199	9917	10000	10000	10000	10000	10000	10000
33	306	4247	9917	10000	10000	10000	10000	10000	10000
34	330	4284	9917	10000	10000	10000	10000	10000	10000
35	363	4310	9917	10000	10000	10000	10000	10000	10000
36	384	4331	9917	10000	10000	10000	10000	10000	10000
37	413	4345	9917	10000	10000	10000	10000	10000	10000
38	447	4365	9917	10000	10000	10000	10000	10000	10000
39	472	4396	9918	10000	10000	10000	10000	10000	10000
40	493	4427	9922	10000	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 108.14

21	90	2563	10000	10000	10000	10000	10000	10000	10000
22	101	9353	10000	10000	10000	10000	10000	10000	10000
23	114	9937	10000	10000	10000	10000	10000	10000	10000
24	130	9975	10000	10000	10000	10000	10000	10000	10000
25	147	9985	10000	10000	10000	10000	10000	10000	10000
26	166	9986	10000	10000	10000	10000	10000	10000	10000
27	184	9986	10000	10000	10000	10000	10000	10000	10000
28	204	9986	10000	10000	10000	10000	10000	10000	10000
29	232	9986	10000	10000	10000	10000	10000	10000	10000
30	254	9986	10000	10000	10000	10000	10000	10000	10000
31	275	9986	10000	10000	10000	10000	10000	10000	10000
32	295	9987	10000	10000	10000	10000	10000	10000	10000
33	306	9987	10000	10000	10000	10000	10000	10000	10000
34	330	9988	10000	10000	10000	10000	10000	10000	10000
35	363	9988	10000	10000	10000	10000	10000	10000	10000
36	384	9988	10000	10000	10000	10000	10000	10000	10000
37	413	9988	10000	10000	10000	10000	10000	10000	10000
38	447	9989	10000	10000	10000	10000	10000	10000	10000
39	472	9990	10000	10000	10000	10000	10000	10000	10000
40	493	9991	10000	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 2.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	150	403	1246	3278	7319	9869	10000	10000
22	101	340	2021	7592	9980	10000	10000	10000	10000
23	114	626	4907	9842	10000	10000	10000	10000	10000
24	130	998	7034	9986	10000	10000	10000	10000	10000
25	147	1391	8150	9992	10000	10000	10000	10000	10000
26	166	1675	8602	9996	10000	10000	10000	10000	10000
27	184	1922	8844	9997	10000	10000	10000	10000	10000
28	204	2125	8959	9997	10000	10000	10000	10000	10000
29	232	2283	9018	9998	10000	10000	10000	10000	10000
30	254	2379	9045	9998	10000	10000	10000	10000	10000
31	275	2464	9056	9998	10000	10000	10000	10000	10000
32	295	2516	9067	9998	10000	10000	10000	10000	10000
33	306	2549	9070	9998	10000	10000	10000	10000	10000
34	330	2589	9075	9998	10000	10000	10000	10000	10000
35	363	2608	9076	9998	10000	10000	10000	10000	10000
36	384	2627	9079	9998	10000	10000	10000	10000	10000
37	413	2657	9088	9998	10000	10000	10000	10000	10000
38	447	2687	9098	9998	10000	10000	10000	10000	10000
39	472	2731	9115	9998	10000	10000	10000	10000	10000
40	493	2768	9137	9998	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 108.14

21	90	1344	9926	10000	10000	10000	10000	10000	10000
22	101	4002	10000	10000	10000	10000	10000	10000	10000
23	114	5289	10000	10000	10000	10000	10000	10000	10000
24	130	5778	10000	10000	10000	10000	10000	10000	10000
25	147	5955	10000	10000	10000	10000	10000	10000	10000
26	166	6063	10000	10000	10000	10000	10000	10000	10000
27	184	6119	10000	10000	10000	10000	10000	10000	10000
28	204	6157	10000	10000	10000	10000	10000	10000	10000
29	232	6182	10000	10000	10000	10000	10000	10000	10000
30	254	6196	10000	10000	10000	10000	10000	10000	10000
31	275	6210	10000	10000	10000	10000	10000	10000	10000
32	295	6219	10000	10000	10000	10000	10000	10000	10000
33	306	6234	10000	10000	10000	10000	10000	10000	10000
34	330	6253	10000	10000	10000	10000	10000	10000	10000
35	363	6280	10000	10000	10000	10000	10000	10000	10000
36	384	6318	10000	10000	10000	10000	10000	10000	10000
37	413	6360	10000	10000	10000	10000	10000	10000	10000
38	447	6399	10000	10000	10000	10000	10000	10000	10000
39	472	6442	10000	10000	10000	10000	10000	10000	10000
40	493	6501	10000	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 0.5 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	159	458	1491	3980	8425	9970	10000	10000
22	101	408	2929	9129	10000	10000	10000	10000	10000
23	114	933	7447	9998	10000	10000	10000	10000	10000
24	130	1743	9400	10000	10000	10000	10000	10000	10000
25	147	2596	9856	10000	10000	10000	10000	10000	10000
26	166	3465	9955	10000	10000	10000	10000	10000	10000
27	184	4190	9973	10000	10000	10000	10000	10000	10000
28	204	4708	9984	10000	10000	10000	10000	10000	10000
29	232	5085	9987	10000	10000	10000	10000	10000	10000
30	254	5372	9989	10000	10000	10000	10000	10000	10000
31	275	5564	9989	10000	10000	10000	10000	10000	10000
32	295	5690	9989	10000	10000	10000	10000	10000	10000
33	306	5776	9989	10000	10000	10000	10000	10000	10000
34	330	5820	9989	10000	10000	10000	10000	10000	10000
35	363	5852	9989	10000	10000	10000	10000	10000	10000
36	384	5882	9989	10000	10000	10000	10000	10000	10000
37	413	5898	9989	10000	10000	10000	10000	10000	10000
38	447	5913	9989	10000	10000	10000	10000	10000	10000
39	472	5924	9989	10000	10000	10000	10000	10000	10000
40	493	5935	9989	10000	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 45.06

21	90	10000	10000	10000	10000	10000	10000	10000	10000
22	101	10000	10000	10000	10000	10000	10000	10000	10000
23	114	10000	10000	10000	10000	10000	10000	10000	10000
24	130	10000	10000	10000	10000	10000	10000	10000	10000
25	147	10000	10000	10000	10000	10000	10000	10000	10000
26	166	10000	10000	10000	10000	10000	10000	10000	10000
27	184	10000	10000	10000	10000	10000	10000	10000	10000
28	204	10000	10000	10000	10000	10000	10000	10000	10000
29	232	10000	10000	10000	10000	10000	10000	10000	10000
30	254	10000	10000	10000	10000	10000	10000	10000	10000
31	275	10000	10000	10000	10000	10000	10000	10000	10000
32	295	10000	10000	10000	10000	10000	10000	10000	10000
33	306	10000	10000	10000	10000	10000	10000	10000	10000
34	330	10000	10000	10000	10000	10000	10000	10000	10000
35	363	10000	10000	10000	10000	10000	10000	10000	10000
36	384	10000	10000	10000	10000	10000	10000	10000	10000
37	413	10000	10000	10000	10000	10000	10000	10000	10000
38	447	10000	10000	10000	10000	10000	10000	10000	10000
39	472	10000	10000	10000	10000	10000	10000	10000	10000
40	493	10000	10000	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 1.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	158	453	1471	3889	8332	9967	10000	10000
22	101	403	2825	9017	10000	10000	10000	10000	10000
23	114	890	7195	9996	10000	10000	10000	10000	10000
24	130	1661	9261	10000	10000	10000	10000	10000	10000
25	147	2451	9794	10000	10000	10000	10000	10000	10000
26	166	3219	9919	10000	10000	10000	10000	10000	10000
27	184	3865	9962	10000	10000	10000	10000	10000	10000
28	204	4339	9971	10000	10000	10000	10000	10000	10000
29	232	4675	9976	10000	10000	10000	10000	10000	10000
30	254	4936	9983	10000	10000	10000	10000	10000	10000
31	275	5115	9984	10000	10000	10000	10000	10000	10000
32	295	5238	9984	10000	10000	10000	10000	10000	10000
33	306	5312	9984	10000	10000	10000	10000	10000	10000
34	330	5360	9984	10000	10000	10000	10000	10000	10000
35	363	5399	9984	10000	10000	10000	10000	10000	10000
36	384	5422	9984	10000	10000	10000	10000	10000	10000
37	413	5441	9984	10000	10000	10000	10000	10000	10000
38	447	5458	9984	10000	10000	10000	10000	10000	10000
39	472	5466	9985	10000	10000	10000	10000	10000	10000
40	493	5487	9985	10000	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 45.06

21	90	10000	10000	10000	10000	10000	10000	10000	10000
22	101	10000	10000	10000	10000	10000	10000	10000	10000
23	114	10000	10000	10000	10000	10000	10000	10000	10000
24	130	10000	10000	10000	10000	10000	10000	10000	10000
25	147	10000	10000	10000	10000	10000	10000	10000	10000
26	166	10000	10000	10000	10000	10000	10000	10000	10000
27	184	10000	10000	10000	10000	10000	10000	10000	10000
28	204	10000	10000	10000	10000	10000	10000	10000	10000
29	232	10000	10000	10000	10000	10000	10000	10000	10000
30	254	10000	10000	10000	10000	10000	10000	10000	10000
31	275	10000	10000	10000	10000	10000	10000	10000	10000
32	295	10000	10000	10000	10000	10000	10000	10000	10000
33	306	10000	10000	10000	10000	10000	10000	10000	10000
34	330	10000	10000	10000	10000	10000	10000	10000	10000
35	363	10000	10000	10000	10000	10000	10000	10000	10000
36	384	10000	10000	10000	10000	10000	10000	10000	10000
37	413	10000	10000	10000	10000	10000	10000	10000	10000
38	447	10000	10000	10000	10000	10000	10000	10000	10000
39	472	10000	10000	10000	10000	10000	10000	10000	10000
40	493	10000	10000	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 2.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	155	443	1435	3766	8169	9957	10000	10000
22	101	388	2636	8797	10000	10000	10000	10000	10000
23	114	824	6744	9993	10000	10000	10000	10000	10000
24	130	1517	8974	10000	10000	10000	10000	10000	10000
25	147	2212	9629	10000	10000	10000	10000	10000	10000
26	166	2838	9819	10000	10000	10000	10000	10000	10000
27	184	3400	9910	10000	10000	10000	10000	10000	10000
28	204	3785	9930	10000	10000	10000	10000	10000	10000
29	232	4083	9942	10000	10000	10000	10000	10000	10000
30	254	4296	9953	10000	10000	10000	10000	10000	10000
31	275	4443	9953	10000	10000	10000	10000	10000	10000
32	295	4541	9954	10000	10000	10000	10000	10000	10000
33	306	4607	9955	10000	10000	10000	10000	10000	10000
34	330	4650	9955	10000	10000	10000	10000	10000	10000
35	363	4686	9955	10000	10000	10000	10000	10000	10000
36	384	4706	9955	10000	10000	10000	10000	10000	10000
37	413	4724	9955	10000	10000	10000	10000	10000	10000
38	447	4742	9955	10000	10000	10000	10000	10000	10000
39	472	4768	9956	10000	10000	10000	10000	10000	10000
40	493	4793	9957	10000	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 45.06

21	90	10000	10000	10000	10000	10000	10000	10000	10000
22	101	10000	10000	10000	10000	10000	10000	10000	10000
23	114	10000	10000	10000	10000	10000	10000	10000	10000
24	130	10000	10000	10000	10000	10000	10000	10000	10000
25	147	10000	10000	10000	10000	10000	10000	10000	10000
26	166	10000	10000	10000	10000	10000	10000	10000	10000
27	184	10000	10000	10000	10000	10000	10000	10000	10000
28	204	10000	10000	10000	10000	10000	10000	10000	10000
29	232	10000	10000	10000	10000	10000	10000	10000	10000
30	254	10000	10000	10000	10000	10000	10000	10000	10000
31	275	10000	10000	10000	10000	10000	10000	10000	10000
32	295	10000	10000	10000	10000	10000	10000	10000	10000
33	306	10000	10000	10000	10000	10000	10000	10000	10000
34	330	10000	10000	10000	10000	10000	10000	10000	10000
35	363	10000	10000	10000	10000	10000	10000	10000	10000
36	384	10000	10000	10000	10000	10000	10000	10000	10000
37	413	10000	10000	10000	10000	10000	10000	10000	10000
38	447	10000	10000	10000	10000	10000	10000	10000	10000
39	472	10000	10000	10000	10000	10000	10000	10000	10000
40	493	10000	10000	10000	10000	10000	10000	10000	10000

PROBABILITY OF DETECTION AS A FUNCTION OF BALANCING PERIOD FOR

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+----------------------------------------+
|                                        |
|       DIVERSION SCENARIO    -  2       |
|       (LOSS-SCENARIO-LENGTH -  2)      |
|                                        |
+----------------------------------------+
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PARAMETERS CONSIDERED :

FACILITY THROUGHPUT T/A	1000		500		240		100		
PROCESS INVENTORY KG PU	- CONSTANT - LINEAR REDUCED								
MEASUREMENT UNCERTAINTY AT THE INPUT	0.05 % (A)		0.1 % (B)			0.2 % (C)			
AMOUNT ASSUMED TO BE DIVERDED KG PU	5	10	15	20	25	30	35	40	
(LOSS PATTERN)	1	2	3	4	5	6	7	8	

SUMMARY OF RESULTS

LOSS-SCENARIO-LENGTH: 2
INVENTORY CONSTANT

THROUGHPUT (TONNES/YEAR) : 1000.00
INVENTORY (KG PU) : 450.60
TOTAL-LOSS (KG PU):

	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
INPUT A:	22.97	82.71	99.86	100.00	100.00	100.00	100.00	100.00
INPUT B:	11.71	40.76	86.28	99.63	100.00	100.00	100.00	100.00
INPUT C:	6.88	14.04	30.14	56.93	85.80	98.00	99.95	100.00

THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 450.60

	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
INPUT A:	41.37	98.63	100.00	100.00	100.00	100.00	100.00	100.00
INPUT B:	25.79	88.00	99.93	100.00	100.00	100.00	100.00	100.00
INPUT C:	12.13	42.98	88.34	99.74	100.00	100.00	100.00	100.00

THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 450.60

	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
INPUT A:	53.62	99.75	100.00	100.00	100.00	100.00	100.00	100.00
INPUT B:	45.06	99.17	100.00	100.00	100.00	100.00	100.00	100.00
INPUT C:	27.72	90.52	99.98	100.00	100.00	100.00	100.00	100.00

THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 450.60

	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
INPUT A:	60.33	99.90	100.00	100.00	100.00	100.00	100.00	100.00
INPUT B:	55.74	99.82	100.00	100.00	100.00	100.00	100.00	100.00
INPUT C:	48.97	99.48	100.00	100.00	100.00	100.00	100.00	100.00

INVENTORY LINEAR REDUCED

THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 225.30

	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
INPUT A:	82.71	100.00	100.00	100.00	100.00	100.00	100.00	100.00
INPUT B:	40.76	99.63	100.00	100.00	100.00	100.00	100.00	100.00
INPUT C:	14.03	56.93	98.00	100.00	100.00	100.00	100.00	100.00

THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 108.14

	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
INPUT A:	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
INPUT B:	99.82	100.00	100.00	100.00	100.00	100.00	100.00	100.00
INPUT C:	62.60	100.00	100.00	100.00	100.00	100.00	100.00	100.00

THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 45.06

	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
INPUT A:	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
INPUT B:	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
INPUT C:	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

LOSS SCENARIO 2

TOTAL LOSS (KGPU)		5	10	15	20	25	30	35	40
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	2.500	5.000	7.500	10.000	12.500	15.000	17.500	20.000
22	0.0	2.500	5.000	7.500	10.000	12.500	15.000	17.500	20.000
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

THROUGHPUT (TONNES/YEAR) : 1000.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 0.5 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11	2	2	2	2	2	2	2	2	2
12	4	4	4	4	4	4	4	4	4
13	9	9	9	9	9	9	9	9	9
14	16	16	16	16	16	16	16	16	16
15	24	24	24	24	24	24	24	24	24
16	33	33	33	33	33	33	33	33	33
17	46	46	46	46	46	46	46	46	46
18	57	57	57	57	57	57	57	57	57
19	66	66	66	66	66	66	66	66	66
20	75	75	75	75	75	75	75	75	75
21	90	101	143	245	390	684	1176	1935	3069
22	101	219	903	3280	7960	9935	10000	10000	10000
23	114	436	2901	8662	9994	10000	10000	10000	10000
24	130	732	5124	9790	10000	10000	10000	10000	10000
25	147	1042	6584	9946	10000	10000	10000	10000	10000
26	166	1302	7362	9973	10000	10000	10000	10000	10000
27	184	1502	7747	9979	10000	10000	10000	10000	10000
28	204	1691	7962	9981	10000	10000	10000	10000	10000
29	232	1815	8074	9981	10000	10000	10000	10000	10000
30	254	1922	8121	9983	10000	10000	10000	10000	10000
31	275	2020	8140	9984	10000	10000	10000	10000	10000
32	295	2075	8152	9984	10000	10000	10000	10000	10000
33	306	2103	8167	9984	10000	10000	10000	10000	10000
34	330	2132	8180	9984	10000	10000	10000	10000	10000
35	363	2151	8184	9984	10000	10000	10000	10000	10000
36	384	2169	8192	9984	10000	10000	10000	10000	10000
37	413	2198	8202	9984	10000	10000	10000	10000	10000
38	447	2224	8216	9985	10000	10000	10000	10000	10000
39	472	2265	8238	9985	10000	10000	10000	10000	10000
40	493	2297	8271	9986	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 1000.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 1.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11	2	2	2	2	2	2	2	2	2
12	4	4	4	4	4	4	4	4	4
13	9	9	9	9	9	9	9	9	9
14	16	16	16	16	16	16	16	16	16
15	24	24	24	24	24	24	24	24	24
16	33	33	33	33	33	33	33	33	33
17	46	46	46	46	46	46	46	46	46
18	57	57	57	57	57	57	57	57	57
19	66	66	66	66	66	66	66	66	66
20	75	75	75	75	75	75	75	75	75
21	90	100	134	210	316	521	894	1447	2237
22	101	185	614	2025	5440	9123	9980	10000	10000
23	114	301	1534	5437	9437	9996	10000	10000	10000
24	130	434	2388	7222	9860	10000	10000	10000	10000
25	147	545	2926	7972	9932	10000	10000	10000	10000
26	166	634	3259	8248	9946	10000	10000	10000	10000
27	184	716	3506	8371	9949	10000	10000	10000	10000
28	204	770	3649	8446	9951	10000	10000	10000	10000
29	232	819	3733	8475	9952	10000	10000	10000	10000
30	254	862	3778	8490	9952	10000	10000	10000	10000
31	275	902	3811	8497	9952	10000	10000	10000	10000
32	295	938	3833	8503	9952	10000	10000	10000	10000
33	306	960	3854	8509	9952	10000	10000	10000	10000
34	330	990	3877	8512	9953	10000	10000	10000	10000
35	363	1014	3896	8522	9955	10000	10000	10000	10000
36	384	1037	3922	8534	9957	10000	10000	10000	10000
37	413	1070	3954	8554	9957	10000	10000	10000	10000
38	447	1094	3989	8572	9958	10000	10000	10000	10000
39	472	1131	4037	8601	9960	10000	10000	10000	10000
40	493	1171	4076	8628	9963	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 1000.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 2.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11	2	2	2	2	2	2	2	2	2
12	4	4	4	4	4	4	4	4	4
13	9	9	9	9	9	9	9	9	9
14	16	16	16	16	16	16	16	16	16
15	24	24	24	24	24	24	24	24	24
16	33	33	33	33	33	33	33	33	33
17	46	46	46	46	46	46	46	46	46
18	57	57	57	57	57	57	57	57	57
19	66	66	66	66	66	66	66	66	66
20	75	75	75	75	75	75	75	75	75
21	90	96	124	163	245	342	502	784	1175
22	101	152	342	869	2071	4516	7726	9622	9984
23	114	199	539	1611	3957	7418	9519	9978	10000
24	130	236	695	2050	4743	8049	9693	9988	10000
25	147	265	813	2275	5064	8257	9733	9991	10000
26	166	288	893	2419	5217	8332	9747	9992	10000
27	184	321	954	2502	5296	8366	9752	9992	10000
28	204	359	990	2576	5348	8385	9756	9992	10000
29	232	384	1035	2621	5385	8398	9756	9992	10000
30	254	413	1068	2670	5403	8405	9756	9992	10000
31	275	435	1104	2706	5426	8410	9758	9992	10000
32	295	466	1136	2732	5439	8414	9759	9992	10000
33	306	494	1160	2756	5458	8422	9763	9993	10000
34	330	515	1187	2784	5475	8435	9763	9993	10000
35	363	540	1223	2811	5500	8453	9765	9993	10000
36	384	566	1248	2849	5537	8476	9769	9993	10000
37	413	603	1283	2886	5568	8497	9777	9993	10000
38	447	634	1314	2929	5611	8518	9785	9994	10000
39	472	661	1359	2969	5641	8549	9791	9994	10000
40	493	688	1404	3014	5693	8580	9800	9995	10000

THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 0.5 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	102	152	262	432	786	1390	2280	3639
22	101	246	1144	4310	9045	9996	10000	10000	10000
23	114	560	4197	9651	10000	10000	10000	10000	10000
24	130	1064	7429	9992	10000	10000	10000	10000	10000
25	147	1659	8923	10000	10000	10000	10000	10000	10000
26	166	2222	9446	10000	10000	10000	10000	10000	10000
27	184	2756	9680	10000	10000	10000	10000	10000	10000
28	204	3141	9779	10000	10000	10000	10000	10000	10000
29	232	3420	9816	10000	10000	10000	10000	10000	10000
30	254	3626	9841	10000	10000	10000	10000	10000	10000
31	275	3773	9851	10000	10000	10000	10000	10000	10000
32	295	3882	9853	10000	10000	10000	10000	10000	10000
33	306	3950	9857	10000	10000	10000	10000	10000	10000
34	330	3995	9858	10000	10000	10000	10000	10000	10000
35	363	4027	9858	10000	10000	10000	10000	10000	10000
36	384	4052	9858	10000	10000	10000	10000	10000	10000
37	413	4067	9858	10000	10000	10000	10000	10000	10000
38	447	4091	9858	10000	10000	10000	10000	10000	10000
39	472	4111	9859	10000	10000	10000	10000	10000	10000
40	493	4137	9863	10000	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 225.30

21	90	143	390	1176	3069	6924	9797	10000	10000
22	101	903	7960	10000	10000	10000	10000	10000	10000
23	114	2901	9994	10000	10000	10000	10000	10000	10000
24	130	5125	10000	10000	10000	10000	10000	10000	10000
25	147	6585	10000	10000	10000	10000	10000	10000	10000
26	166	7362	10000	10000	10000	10000	10000	10000	10000
27	184	7746	10000	10000	10000	10000	10000	10000	10000
28	204	7962	10000	10000	10000	10000	10000	10000	10000
29	232	8074	10000	10000	10000	10000	10000	10000	10000
30	254	8121	10000	10000	10000	10000	10000	10000	10000
31	275	8140	10000	10000	10000	10000	10000	10000	10000
32	295	8152	10000	10000	10000	10000	10000	10000	10000
33	306	8167	10000	10000	10000	10000	10000	10000	10000
34	330	8180	10000	10000	10000	10000	10000	10000	10000
35	363	8184	10000	10000	10000	10000	10000	10000	10000
36	384	8192	10000	10000	10000	10000	10000	10000	10000
37	413	8202	10000	10000	10000	10000	10000	10000	10000
38	447	8216	10000	10000	10000	10000	10000	10000	10000
39	472	8238	10000	10000	10000	10000	10000	10000	10000
40	493	8271	10000	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 1.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	101	147	250	399	708	1218	2007	3204
22	101	223	952	3483	8265	9957	10000	10000	10000
23	114	458	3165	8984	9997	10000	10000	10000	10000
24	130	788	5648	9885	10000	10000	10000	10000	10000
25	147	1152	7182	9979	10000	10000	10000	10000	10000
26	166	1438	7938	9989	10000	10000	10000	10000	10000
27	184	1695	8326	9991	10000	10000	10000	10000	10000
28	204	1896	8542	9991	10000	10000	10000	10000	10000
29	232	2063	8640	9991	10000	10000	10000	10000	10000
30	254	2178	8679	9992	10000	10000	10000	10000	10000
31	275	2274	8693	9992	10000	10000	10000	10000	10000
32	295	2334	8711	9992	10000	10000	10000	10000	10000
33	306	2373	8722	9992	10000	10000	10000	10000	10000
34	330	2414	8729	9992	10000	10000	10000	10000	10000
35	363	2435	8732	9992	10000	10000	10000	10000	10000
36	384	2455	8735	9992	10000	10000	10000	10000	10000
37	413	2487	8744	9992	10000	10000	10000	10000	10000
38	447	2515	8754	9992	10000	10000	10000	10000	10000
39	472	2547	8777	9992	10000	10000	10000	10000	10000
40	493	2579	8800	9993	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 225.30

21	90	134	316	894	2237	4946	8751	9964	10000
22	101	614	5440	9980	10000	10000	10000	10000	10000
23	114	1534	9437	10000	10000	10000	10000	10000	10000
24	130	2388	9860	10000	10000	10000	10000	10000	10000
25	147	2926	9932	10000	10000	10000	10000	10000	10000
26	166	3259	9946	10000	10000	10000	10000	10000	10000
27	184	3506	9949	10000	10000	10000	10000	10000	10000
28	204	3649	9951	10000	10000	10000	10000	10000	10000
29	232	3733	9952	10000	10000	10000	10000	10000	10000
30	254	3778	9952	10000	10000	10000	10000	10000	10000
31	275	3811	9952	10000	10000	10000	10000	10000	10000
32	295	3833	9952	10000	10000	10000	10000	10000	10000
33	306	3854	9952	10000	10000	10000	10000	10000	10000
34	330	3877	9953	10000	10000	10000	10000	10000	10000
35	363	3896	9955	10000	10000	10000	10000	10000	10000
36	384	3922	9957	10000	10000	10000	10000	10000	10000
37	413	3954	9957	10000	10000	10000	10000	10000	10000
38	447	3989	9958	10000	10000	10000	10000	10000	10000
39	472	4037	9960	10000	10000	10000	10000	10000	10000
40	493	4076	9963	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 2.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	100	134	214	320	531	912	1477	2286
22	101	187	628	2098	5614	9241	9985	10000	10000
23	114	309	1601	5671	9516	9998	10000	10000	10000
24	130	445	2524	7498	9894	10000	10000	10000	10000
25	147	561	3102	8247	9951	10000	10000	10000	10000
26	166	661	3473	8484	9961	10000	10000	10000	10000
27	184	744	3726	8598	9966	10000	10000	10000	10000
28	204	800	3862	8667	9966	10000	10000	10000	10000
29	232	853	3945	8701	9966	10000	10000	10000	10000
30	254	897	3995	8710	9966	10000	10000	10000	10000
31	275	934	4035	8716	9966	10000	10000	10000	10000
32	295	972	4063	8720	9966	10000	10000	10000	10000
33	306	1002	4081	8726	9966	10000	10000	10000	10000
34	330	1030	4102	8728	9967	10000	10000	10000	10000
35	363	1056	4122	8741	9968	10000	10000	10000	10000
36	384	1080	4146	8749	9969	10000	10000	10000	10000
37	413	1113	4178	8765	9969	10000	10000	10000	10000
38	447	1136	4214	8780	9970	10000	10000	10000	10000
39	472	1174	4264	8803	9971	10000	10000	10000	10000
40	493	1213	4298	8834	9974	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 225.30

21	90	124	245	502	1175	2446	4667	7950	9784
22	101	342	2071	7726	9984	10000	10000	10000	10000
23	114	539	3957	9519	10000	10000	10000	10000	10000
24	130	694	4743	9693	10000	10000	10000	10000	10000
25	147	812	5064	9733	10000	10000	10000	10000	10000
26	166	892	5216	9747	10000	10000	10000	10000	10000
27	184	953	5296	9752	10000	10000	10000	10000	10000
28	204	989	5348	9756	10000	10000	10000	10000	10000
29	232	1034	5384	9756	10000	10000	10000	10000	10000
30	254	1067	5403	9756	10000	10000	10000	10000	10000
31	275	1103	5426	9758	10000	10000	10000	10000	10000
32	295	1135	5439	9759	10000	10000	10000	10000	10000
33	306	1159	5458	9763	10000	10000	10000	10000	10000
34	330	1186	5475	9763	10000	10000	10000	10000	10000
35	363	1222	5500	9765	10000	10000	10000	10000	10000
36	384	1247	5537	9769	10000	10000	10000	10000	10000
37	413	1282	5568	9777	10000	10000	10000	10000	10000
38	447	1313	5611	9785	10000	10000	10000	10000	10000
39	472	1358	5641	9791	10000	10000	10000	10000	10000
40	493	1403	5693	9800	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 0.5 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	102	158	265	450	825	1455	2416	3854
22	101	256	1225	4716	9347	9999	10000	10000	10000
23	114	609	4782	9816	10000	10000	10000	10000	10000
24	130	1222	8214	10000	10000	10000	10000	10000	10000
25	147	1990	9464	10000	10000	10000	10000	10000	10000
26	166	2758	9801	10000	10000	10000	10000	10000	10000
27	184	3482	9922	10000	10000	10000	10000	10000	10000
28	204	3999	9949	10000	10000	10000	10000	10000	10000
29	232	4406	9963	10000	10000	10000	10000	10000	10000
30	254	4719	9970	10000	10000	10000	10000	10000	10000
31	275	4929	9971	10000	10000	10000	10000	10000	10000
32	295	5075	9973	10000	10000	10000	10000	10000	10000
33	306	5171	9974	10000	10000	10000	10000	10000	10000
34	330	5230	9975	10000	10000	10000	10000	10000	10000
35	363	5272	9975	10000	10000	10000	10000	10000	10000
36	384	5303	9975	10000	10000	10000	10000	10000	10000
37	413	5323	9975	10000	10000	10000	10000	10000	10000
38	447	5341	9975	10000	10000	10000	10000	10000	10000
39	472	5352	9975	10000	10000	10000	10000	10000	10000
40	493	5362	9975	10000	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 108.14

21	90	425	3540	9928	10000	10000	10000	10000	10000
22	101	8589	10000	10000	10000	10000	10000	10000	10000
23	114	9999	10000	10000	10000	10000	10000	10000	10000
24	130	10000	10000	10000	10000	10000	10000	10000	10000
25	147	10000	10000	10000	10000	10000	10000	10000	10000
26	166	10000	10000	10000	10000	10000	10000	10000	10000
27	184	10000	10000	10000	10000	10000	10000	10000	10000
28	204	10000	10000	10000	10000	10000	10000	10000	10000
29	232	10000	10000	10000	10000	10000	10000	10000	10000
30	254	10000	10000	10000	10000	10000	10000	10000	10000
31	275	10000	10000	10000	10000	10000	10000	10000	10000
32	295	10000	10000	10000	10000	10000	10000	10000	10000
33	306	10000	10000	10000	10000	10000	10000	10000	10000
34	330	10000	10000	10000	10000	10000	10000	10000	10000
35	363	10000	10000	10000	10000	10000	10000	10000	10000
36	384	10000	10000	10000	10000	10000	10000	10000	10000
37	413	10000	10000	10000	10000	10000	10000	10000	10000
38	447	10000	10000	10000	10000	10000	10000	10000	10000
39	472	10000	10000	10000	10000	10000	10000	10000	10000
40	493	10000	10000	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 1.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	102	153	263	438	797	1412	2320	3708
22	101	250	1170	4448	9147	9996	10000	10000	10000
23	114	574	4381	9711	10000	10000	10000	10000	10000
24	130	1111	7699	9996	10000	10000	10000	10000	10000
25	147	1760	9109	10000	10000	10000	10000	10000	10000
26	166	2386	9586	10000	10000	10000	10000	10000	10000
27	184	2972	9784	10000	10000	10000	10000	10000	10000
28	204	3396	9853	10000	10000	10000	10000	10000	10000
29	232	3724	9883	10000	10000	10000	10000	10000	10000
30	254	3945	9902	10000	10000	10000	10000	10000	10000
31	275	4119	9908	10000	10000	10000	10000	10000	10000
32	295	4226	9912	10000	10000	10000	10000	10000	10000
33	306	4308	9914	10000	10000	10000	10000	10000	10000
34	330	4357	9914	10000	10000	10000	10000	10000	10000
35	363	4397	9914	10000	10000	10000	10000	10000	10000
36	384	4426	9914	10000	10000	10000	10000	10000	10000
37	413	4447	9914	10000	10000	10000	10000	10000	10000
38	447	4467	9914	10000	10000	10000	10000	10000	10000
39	472	4481	9915	10000	10000	10000	10000	10000	10000
40	493	4506	9917	10000	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 108.14

21	90	354	2563	9346	10000	10000	10000	10000	10000
22	101	6182	10000	10000	10000	10000	10000	10000	10000
23	114	9679	10000	10000	10000	10000	10000	10000	10000
24	130	9929	10000	10000	10000	10000	10000	10000	10000
25	147	9965	10000	10000	10000	10000	10000	10000	10000
26	166	9971	10000	10000	10000	10000	10000	10000	10000
27	184	9974	10000	10000	10000	10000	10000	10000	10000
28	204	9975	10000	10000	10000	10000	10000	10000	10000
29	232	9975	10000	10000	10000	10000	10000	10000	10000
30	254	9975	10000	10000	10000	10000	10000	10000	10000
31	275	9975	10000	10000	10000	10000	10000	10000	10000
32	295	9975	10000	10000	10000	10000	10000	10000	10000
33	306	9975	10000	10000	10000	10000	10000	10000	10000
34	330	9975	10000	10000	10000	10000	10000	10000	10000
35	363	9976	10000	10000	10000	10000	10000	10000	10000
36	384	9976	10000	10000	10000	10000	10000	10000	10000
37	413	9976	10000	10000	10000	10000	10000	10000	10000
38	447	9977	10000	10000	10000	10000	10000	10000	10000
39	472	9978	10000	10000	10000	10000	10000	10000	10000
40	493	9982	10000	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 2.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	101	150	253	403	714	1246	2050	3278
22	101	226	987	3618	8412	9967	10000	10000	10000
23	114	474	3328	9121	9999	10000	10000	10000	10000
24	130	823	5945	9919	10000	10000	10000	10000	10000
25	147	1229	7534	9985	10000	10000	10000	10000	10000
26	166	1535	8279	9994	10000	10000	10000	10000	10000
27	184	1823	8640	9995	10000	10000	10000	10000	10000
28	204	2063	8827	9997	10000	10000	10000	10000	10000
29	232	2258	8927	9997	10000	10000	10000	10000	10000
30	254	2372	8963	9997	10000	10000	10000	10000	10000
31	275	2468	8984	9997	10000	10000	10000	10000	10000
32	295	2521	8991	9997	10000	10000	10000	10000	10000
33	306	2563	8999	9997	10000	10000	10000	10000	10000
34	330	2606	9006	9997	10000	10000	10000	10000	10000
35	363	2636	9009	9997	10000	10000	10000	10000	10000
36	384	2665	9010	9997	10000	10000	10000	10000	10000
37	413	2689	9016	9997	10000	10000	10000	10000	10000
38	447	2711	9022	9997	10000	10000	10000	10000	10000
39	472	2740	9037	9997	10000	10000	10000	10000	10000
40	493	2772	9052	9998	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 108.14

21	90	261	1344	5416	9926	10000	10000	10000	10000
22	101	2375	9998	10000	10000	10000	10000	10000	10000
23	114	4477	10000	10000	10000	10000	10000	10000	10000
24	130	5337	10000	10000	10000	10000	10000	10000	10000
25	147	5644	10000	10000	10000	10000	10000	10000	10000
26	166	5797	10000	10000	10000	10000	10000	10000	10000
27	184	5884	10000	10000	10000	10000	10000	10000	10000
28	204	5940	10000	10000	10000	10000	10000	10000	10000
29	232	5968	10000	10000	10000	10000	10000	10000	10000
30	254	5983	10000	10000	10000	10000	10000	10000	10000
31	275	6000	10000	10000	10000	10000	10000	10000	10000
32	295	6012	10000	10000	10000	10000	10000	10000	10000
33	306	6033	10000	10000	10000	10000	10000	10000	10000
34	330	6053	10000	10000	10000	10000	10000	10000	10000
35	363	6070	10000	10000	10000	10000	10000	10000	10000
36	384	6106	10000	10000	10000	10000	10000	10000	10000
37	413	6142	10000	10000	10000	10000	10000	10000	10000
38	447	6176	10000	10000	10000	10000	10000	10000	10000
39	472	6209	10000	10000	10000	10000	10000	10000	10000
40	493	6260	10000	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 0.5 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	102	159	267	458	838	1491	2487	3980
22	101	262	1288	4941	9451	10000	10000	10000	10000
23	114	639	5096	9875	10000	10000	10000	10000	10000
24	130	1337	8535	10000	10000	10000	10000	10000	10000
25	147	2192	9642	10000	10000	10000	10000	10000	10000
26	166	3085	9893	10000	10000	10000	10000	10000	10000
27	184	3880	9961	10000	10000	10000	10000	10000	10000
28	204	4495	9978	10000	10000	10000	10000	10000	10000
29	232	4953	9986	10000	10000	10000	10000	10000	10000
30	254	5309	9988	10000	10000	10000	10000	10000	10000
31	275	5557	9989	10000	10000	10000	10000	10000	10000
32	295	5710	9989	10000	10000	10000	10000	10000	10000
33	306	5818	9989	10000	10000	10000	10000	10000	10000
34	330	5896	9989	10000	10000	10000	10000	10000	10000
35	363	5939	9990	10000	10000	10000	10000	10000	10000
36	384	5977	9990	10000	10000	10000	10000	10000	10000
37	413	5997	9990	10000	10000	10000	10000	10000	10000
38	447	6012	9990	10000	10000	10000	10000	10000	10000
39	472	6025	9990	10000	10000	10000	10000	10000	10000
40	493	6033	9990	10000	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 45.06

21	90	6926	10000	10000	10000	10000	10000	10000	10000
22	101	10000	10000	10000	10000	10000	10000	10000	10000
23	114	10000	10000	10000	10000	10000	10000	10000	10000
24	130	10000	10000	10000	10000	10000	10000	10000	10000
25	147	10000	10000	10000	10000	10000	10000	10000	10000
26	166	10000	10000	10000	10000	10000	10000	10000	10000
27	184	10000	10000	10000	10000	10000	10000	10000	10000
28	204	10000	10000	10000	10000	10000	10000	10000	10000
29	232	10000	10000	10000	10000	10000	10000	10000	10000
30	254	10000	10000	10000	10000	10000	10000	10000	10000
31	275	10000	10000	10000	10000	10000	10000	10000	10000
32	295	10000	10000	10000	10000	10000	10000	10000	10000
33	306	10000	10000	10000	10000	10000	10000	10000	10000
34	330	10000	10000	10000	10000	10000	10000	10000	10000
35	363	10000	10000	10000	10000	10000	10000	10000	10000
36	384	10000	10000	10000	10000	10000	10000	10000	10000
37	413	10000	10000	10000	10000	10000	10000	10000	10000
38	447	10000	10000	10000	10000	10000	10000	10000	10000
39	472	10000	10000	10000	10000	10000	10000	10000	10000
40	493	10000	10000	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 1.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	102	158	265	453	829	1471	2446	3889
22	101	257	1245	4795	9384	10000	10000	10000	10000
23	114	621	4904	9842	10000	10000	10000	10000	10000
24	130	1263	8339	10000	10000	10000	10000	10000	10000
25	147	2073	9522	10000	10000	10000	10000	10000	10000
26	166	2870	9843	10000	10000	10000	10000	10000	10000
27	184	3617	9940	10000	10000	10000	10000	10000	10000
28	204	4170	9963	10000	10000	10000	10000	10000	10000
29	232	4582	9973	10000	10000	10000	10000	10000	10000
30	254	4897	9980	10000	10000	10000	10000	10000	10000
31	275	5127	9982	10000	10000	10000	10000	10000	10000
32	295	5275	9982	10000	10000	10000	10000	10000	10000
33	306	5378	9982	10000	10000	10000	10000	10000	10000
34	330	5445	9982	10000	10000	10000	10000	10000	10000
35	363	5486	9982	10000	10000	10000	10000	10000	10000
36	384	5522	9982	10000	10000	10000	10000	10000	10000
37	413	5542	9982	10000	10000	10000	10000	10000	10000
38	447	5556	9982	10000	10000	10000	10000	10000	10000
39	472	5565	9982	10000	10000	10000	10000	10000	10000
40	493	5574	9982	10000	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 45.06

21	90	4946	10000	10000	10000	10000	10000	10000	10000
22	101	10000	10000	10000	10000	10000	10000	10000	10000
23	114	10000	10000	10000	10000	10000	10000	10000	10000
24	130	10000	10000	10000	10000	10000	10000	10000	10000
25	147	10000	10000	10000	10000	10000	10000	10000	10000
26	166	10000	10000	10000	10000	10000	10000	10000	10000
27	184	10000	10000	10000	10000	10000	10000	10000	10000
28	204	10000	10000	10000	10000	10000	10000	10000	10000
29	232	10000	10000	10000	10000	10000	10000	10000	10000
30	254	10000	10000	10000	10000	10000	10000	10000	10000
31	275	10000	10000	10000	10000	10000	10000	10000	10000
32	295	10000	10000	10000	10000	10000	10000	10000	10000
33	306	10000	10000	10000	10000	10000	10000	10000	10000
34	330	10000	10000	10000	10000	10000	10000	10000	10000
35	363	10000	10000	10000	10000	10000	10000	10000	10000
36	384	10000	10000	10000	10000	10000	10000	10000	10000
37	413	10000	10000	10000	10000	10000	10000	10000	10000
38	447	10000	10000	10000	10000	10000	10000	10000	10000
39	472	10000	10000	10000	10000	10000	10000	10000	10000
40	493	10000	10000	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 2.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	102	155	264	443	813	1435	2360	3766
22	101	255	1202	4559	9243	9999	10000	10000	10000
23	114	586	4564	9764	10000	10000	10000	10000	10000
24	130	1160	7949	9997	10000	10000	10000	10000	10000
25	147	1872	9294	10000	10000	10000	10000	10000	10000
26	166	2554	9705	10000	10000	10000	10000	10000	10000
27	184	3198	9856	10000	10000	10000	10000	10000	10000
28	204	3660	9902	10000	10000	10000	10000	10000	10000
29	232	4019	9926	10000	10000	10000	10000	10000	10000
30	254	4294	9942	10000	10000	10000	10000	10000	10000
31	275	4485	9945	10000	10000	10000	10000	10000	10000
32	295	4597	9947	10000	10000	10000	10000	10000	10000
33	306	4693	9948	10000	10000	10000	10000	10000	10000
34	330	4752	9948	10000	10000	10000	10000	10000	10000
35	363	4793	9948	10000	10000	10000	10000	10000	10000
36	384	4817	9948	10000	10000	10000	10000	10000	10000
37	413	4840	9948	10000	10000	10000	10000	10000	10000
38	447	4861	9948	10000	10000	10000	10000	10000	10000
39	472	4875	9948	10000	10000	10000	10000	10000	10000
40	493	4897	9948	10000	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 45.06

21	90	2446	10000	10000	10000	10000	10000	10000	10000
22	101	10000	10000	10000	10000	10000	10000	10000	10000
23	114	10000	10000	10000	10000	10000	10000	10000	10000
24	130	10000	10000	10000	10000	10000	10000	10000	10000
25	147	10000	10000	10000	10000	10000	10000	10000	10000
26	166	10000	10000	10000	10000	10000	10000	10000	10000
27	184	10000	10000	10000	10000	10000	10000	10000	10000
28	204	10000	10000	10000	10000	10000	10000	10000	10000
29	232	10000	10000	10000	10000	10000	10000	10000	10000
30	254	10000	10000	10000	10000	10000	10000	10000	10000
31	275	10000	10000	10000	10000	10000	10000	10000	10000
32	295	10000	10000	10000	10000	10000	10000	10000	10000
33	306	10000	10000	10000	10000	10000	10000	10000	10000
34	330	10000	10000	10000	10000	10000	10000	10000	10000
35	363	10000	10000	10000	10000	10000	10000	10000	10000
36	384	10000	10000	10000	10000	10000	10000	10000	10000
37	413	10000	10000	10000	10000	10000	10000	10000	10000
38	447	10000	10000	10000	10000	10000	10000	10000	10000
39	472	10000	10000	10000	10000	10000	10000	10000	10000
40	493	10000	10000	10000	10000	10000	10000	10000	10000

PROBABILITY OF DETECTION AS A FUNCTION OF
BALANCING PERIOD FOR

DIVERSION SCENARIO - 3
(LOSS-SCENARIO-LENGTH - 3)

PARAMETERS CONSIDERED :

FACILITY THROUGHPUT	T/A	1000	500	240	100
PROCESS INVENTORY	KG PU	- CONSTANT - LINEAR REDUCED			

MEASUREMENT UNCERTAINTY	0.05 %	0.1 %	0.2 %
AT THE INPUT	(A)	(B)	(C)

AMOUNT ASSUMED TO BE								
DIVERDED KG PU	5	10	15	20	25	30	35	40
(LOSS PATTERN)	1	2	3	4	5	6	7	8

SUMMARY OF RESULTS

LOSS-SCENARIO-LENGTH: 3
INVENTORY CONSTANT

THROUGHPUT (TONNES/YEAR) : 1000.00
INVENTORY (KG PU) : 450.60
TOTAL-LOSS (KG PU):

	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
INPUT A:	22.89	81.60	99.77	100.00	100.00	100.00	100.00	100.00
INPUT B:	11.62	40.10	84.38	99.37	100.00	100.00	100.00	100.00
INPUT C:	6.79	13.72	29.24	54.66	82.62	96.72	99.80	100.00

THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 450.60

INPUT A:	41.93	98.53	100.00	100.00	100.00	100.00	100.00	100.00
INPUT B:	25.91	86.99	99.91	100.00	100.00	100.00	100.00	100.00
INPUT C:	12.02	42.14	86.45	99.53	100.00	100.00	100.00	100.00

THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 450.60

INPUT A:	54.37	99.78	100.00	100.00	100.00	100.00	100.00	100.00
INPUT B:	45.47	99.21	100.00	100.00	100.00	100.00	100.00	100.00
INPUT C:	27.81	89.79	99.96	100.00	100.00	100.00	100.00	100.00

THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 450.60

INPUT A:	61.04	99.90	100.00	100.00	100.00	100.00	100.00	100.00
INPUT B:	56.83	99.81	100.00	100.00	100.00	100.00	100.00	100.00
INPUT C:	49.67	99.45	100.00	100.00	100.00	100.00	100.00	100.00

INVENTORY LINEAR REDUCED

THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 225.30

INPUT A:	81.60	100.00	100.00	100.00	100.00	100.00	100.00	100.00
INPUT B:	40.11	99.38	100.00	100.00	100.00	100.00	100.00	100.00
INPUT C:	13.72	54.66	96.72	100.00	100.00	100.00	100.00	100.00

THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 108.14

INPUT A:	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
INPUT B:	99.66	100.00	100.00	100.00	100.00	100.00	100.00	100.00
INPUT C:	59.62	100.00	100.00	100.00	100.00	100.00	100.00	100.00

THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 45.06

INPUT A:	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
INPUT B:	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
INPUT C:	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

LOSS SCENARIO 3

TOTAL LOSS (KGPU)	5	10	15	20	25	30	35	40
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	1.666	3.333	5.000	6.666	8.333	10.000	11.666	13.333
22	0.0	1.666	3.333	5.000	6.666	8.333	10.000	11.666	13.333
23	0.0	1.666	3.333	5.000	6.666	8.333	10.000	11.666	13.333
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

THROUGHPUT (TONNES/YEAR) : 1000.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 0.5 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11	2	2	2	2	2	2	2	2	2
12	4	4	4	4	4	4	4	4	4
13	9	9	9	9	9	9	9	9	9
14	16	16	16	16	16	16	16	16	16
15	24	24	24	24	24	24	24	24	24
16	33	33	33	33	33	33	33	33	33
17	46	46	46	46	46	46	46	46	46
18	57	57	57	57	57	57	57	57	57
19	66	66	66	66	66	66	66	66	66
20	75	75	75	75	75	75	75	75	75
21	90	93	113	143	204	278	390	553	825
22	101	153	347	903	2176	4759	7960	9721	9992
23	114	302	1677	5904	9626	9999	10000	10000	10000
24	130	578	3859	9277	9997	10000	10000	10000	10000
25	147	879	5749	9855	10000	10000	10000	10000	10000
26	166	1176	6828	9939	10000	10000	10000	10000	10000
27	184	1406	7425	9966	10000	10000	10000	10000	10000
28	204	1618	7755	9972	10000	10000	10000	10000	10000
29	232	1763	7919	9972	10000	10000	10000	10000	10000
30	254	1896	7990	9975	10000	10000	10000	10000	10000
31	275	2007	8022	9975	10000	10000	10000	10000	10000
32	295	2065	8042	9975	10000	10000	10000	10000	10000
33	306	2095	8065	9975	10000	10000	10000	10000	10000
34	330	2133	8078	9975	10000	10000	10000	10000	10000
35	363	2156	8085	9975	10000	10000	10000	10000	10000
36	384	2182	8092	9975	10000	10000	10000	10000	10000
37	413	2208	8102	9976	10000	10000	10000	10000	10000
38	447	2238	8111	9976	10000	10000	10000	10000	10000
39	472	2270	8130	9976	10000	10000	10000	10000	10000
40	493	2289	8160	9977	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 1000.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 1.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11	2	2	2	2	2	2	2	2	2
12	4	4	4	4	4	4	4	4	4
13	9	9	9	9	9	9	9	9	9
14	16	16	16	16	16	16	16	16	16
15	24	24	24	24	24	24	24	24	24
16	33	33	33	33	33	33	33	33	33
17	46	46	46	46	46	46	46	46	46
18	57	57	57	57	57	57	57	57	57
19	66	66	66	66	66	66	66	66	66
20	75	75	75	75	75	75	75	75	75
21	90	94	108	134	181	251	316	449	636
22	101	138	276	614	1418	2924	5440	8218	9684
23	114	243	968	3365	7676	9796	9999	10000	10000
24	130	373	1883	6109	9576	9996	10000	10000	10000
25	147	494	2572	7406	9848	9998	10000	10000	10000
26	166	597	3017	7912	9889	9999	10000	10000	10000
27	184	686	3339	8116	9916	10000	10000	10000	10000
28	204	745	3517	8221	9920	10000	10000	10000	10000
29	232	803	3631	8275	9924	10000	10000	10000	10000
30	254	848	3696	8294	9925	10000	10000	10000	10000
31	275	891	3753	8303	9925	10000	10000	10000	10000
32	295	929	3785	8311	9925	10000	10000	10000	10000
33	306	959	3807	8319	9925	10000	10000	10000	10000
34	330	987	3833	8327	9926	10000	10000	10000	10000
35	363	1014	3856	8335	9926	10000	10000	10000	10000
36	384	1036	3872	8346	9926	10000	10000	10000	10000
37	413	1070	3901	8366	9931	10000	10000	10000	10000
38	447	1090	3927	8384	9931	10000	10000	10000	10000
39	472	1126	3972	8405	9935	10000	10000	10000	10000
40	493	1162	4010	8438	9937	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 1000.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 2.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
11	2	2	2	2	2	2	2	2	2
12	4	4	4	4	4	4	4	4	4
13	9	9	9	9	9	9	9	9	9
14	16	16	16	16	16	16	16	16	16
15	24	24	24	24	24	24	24	24	24
16	33	33	33	33	33	33	33	33	33
17	46	46	46	46	46	46	46	46	46
18	57	57	57	57	57	57	57	57	57
19	66	66	66	66	66	66	66	66	66
20	75	75	75	75	75	75	75	75	75
21	90	90	101	124	143	184	245	292	388
22	101	129	186	342	623	1189	2071	3534	5561
23	114	176	414	1145	2780	5618	8500	9757	9991
24	130	219	618	1775	4122	7309	9433	9945	10000
25	147	250	755	2102	4671	7785	9564	9968	10000
26	166	277	852	2285	4927	7939	9599	9970	10000
27	184	310	925	2397	5048	8002	9620	9970	10000
28	204	351	959	2481	5118	8055	9628	9970	10000
29	232	377	1013	2540	5170	8079	9631	9971	10000
30	254	407	1048	2597	5196	8090	9631	9971	10000
31	275	429	1086	2637	5217	8098	9631	9972	10000
32	295	461	1119	2665	5231	8101	9632	9972	10000
33	306	489	1145	2685	5251	8111	9632	9974	10000
34	330	513	1172	2709	5270	8119	9634	9975	10000
35	363	535	1206	2737	5288	8133	9635	9975	10000
36	384	565	1229	2767	5315	8152	9644	9975	10000
37	413	598	1261	2801	5349	8176	9651	9976	10000
38	447	628	1287	2835	5388	8199	9657	9978	10000
39	472	657	1328	2886	5419	8229	9665	9980	10000
40	493	679	1372	2924	5466	8262	9672	9980	10000

THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 0.5 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	94	119	152	220	292	432	645	956
22	101	163	402	1144	2861	6061	9045	9941	10000
23	114	368	2301	7661	9942	10000	10000	10000	10000
24	130	789	5760	9907	10000	10000	10000	10000	10000
25	147	1361	8199	9994	10000	10000	10000	10000	10000
26	166	1926	9168	9999	10000	10000	10000	10000	10000
27	184	2513	9553	9999	10000	10000	10000	10000	10000
28	204	2975	9724	10000	10000	10000	10000	10000	10000
29	232	3309	9787	10000	10000	10000	10000	10000	10000
30	254	3563	9825	10000	10000	10000	10000	10000	10000
31	275	3749	9836	10000	10000	10000	10000	10000	10000
32	295	3892	9845	10000	10000	10000	10000	10000	10000
33	306	3983	9850	10000	10000	10000	10000	10000	10000
34	330	4037	9851	10000	10000	10000	10000	10000	10000
35	363	4078	9851	10000	10000	10000	10000	10000	10000
36	384	4112	9852	10000	10000	10000	10000	10000	10000
37	413	4138	9852	10000	10000	10000	10000	10000	10000
38	447	4157	9852	10000	10000	10000	10000	10000	10000
39	472	4172	9852	10000	10000	10000	10000	10000	10000
40	493	4193	9853	10000	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 225.30

21	90	113	204	390	825	1668	3069	5371	8274
22	101	347	2176	7960	9992	10000	10000	10000	10000
23	114	1677	9626	10000	10000	10000	10000	10000	10000
24	130	3859	9997	10000	10000	10000	10000	10000	10000
25	147	5749	10000	10000	10000	10000	10000	10000	10000
26	166	6828	10000	10000	10000	10000	10000	10000	10000
27	184	7425	10000	10000	10000	10000	10000	10000	10000
28	204	7755	10000	10000	10000	10000	10000	10000	10000
29	232	7919	10000	10000	10000	10000	10000	10000	10000
30	254	7990	10000	10000	10000	10000	10000	10000	10000
31	275	8022	10000	10000	10000	10000	10000	10000	10000
32	295	8042	10000	10000	10000	10000	10000	10000	10000
33	306	8065	10000	10000	10000	10000	10000	10000	10000
34	330	8078	10000	10000	10000	10000	10000	10000	10000
35	363	8085	10000	10000	10000	10000	10000	10000	10000
36	384	8092	10000	10000	10000	10000	10000	10000	10000
37	413	8102	10000	10000	10000	10000	10000	10000	10000
38	447	8111	10000	10000	10000	10000	10000	10000	10000
39	472	8130	10000	10000	10000	10000	10000	10000	10000
40	493	8160	10000	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 1.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	94	116	147	207	279	399	569	844
22	101	155	363	952	2323	5041	8265	9793	9996
23	114	316	1796	6305	9737	10000	10000	10000	10000
24	130	618	4246	9487	10000	10000	10000	10000	10000
25	147	985	6274	9919	10000	10000	10000	10000	10000
26	166	1312	7447	9974	10000	10000	10000	10000	10000
27	184	1591	8007	9985	10000	10000	10000	10000	10000
28	204	1822	8322	9987	10000	10000	10000	10000	10000
29	232	2016	8480	9990	10000	10000	10000	10000	10000
30	254	2149	8541	9991	10000	10000	10000	10000	10000
31	275	2261	8580	9991	10000	10000	10000	10000	10000
32	295	2326	8611	9991	10000	10000	10000	10000	10000
33	306	2370	8623	9991	10000	10000	10000	10000	10000
34	330	2418	8639	9991	10000	10000	10000	10000	10000
35	363	2456	8642	9991	10000	10000	10000	10000	10000
36	384	2486	8645	9991	10000	10000	10000	10000	10000
37	413	2512	8652	9991	10000	10000	10000	10000	10000
38	447	2536	8658	9991	10000	10000	10000	10000	10000
39	472	2566	8673	9991	10000	10000	10000	10000	10000
40	493	2591	8699	9991	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 225.30

21	90	108	181	316	636	1230	2237	3816	6275
22	101	276	1418	5440	9684	10000	10000	10000	10000
23	114	968	7676	9999	10000	10000	10000	10000	10000
24	130	1884	9577	10000	10000	10000	10000	10000	10000
25	147	2572	9848	10000	10000	10000	10000	10000	10000
26	166	3018	9890	10000	10000	10000	10000	10000	10000
27	184	3340	9917	10000	10000	10000	10000	10000	10000
28	204	3518	9921	10000	10000	10000	10000	10000	10000
29	232	3632	9925	10000	10000	10000	10000	10000	10000
30	254	3697	9926	10000	10000	10000	10000	10000	10000
31	275	3754	9926	10000	10000	10000	10000	10000	10000
32	295	3786	9926	10000	10000	10000	10000	10000	10000
33	306	3808	9926	10000	10000	10000	10000	10000	10000
34	330	3834	9927	10000	10000	10000	10000	10000	10000
35	363	3857	9927	10000	10000	10000	10000	10000	10000
36	384	3873	9927	10000	10000	10000	10000	10000	10000
37	413	3902	9932	10000	10000	10000	10000	10000	10000
38	447	3928	9932	10000	10000	10000	10000	10000	10000
39	472	3973	9936	10000	10000	10000	10000	10000	10000
40	493	4011	9938	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 2.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	94	108	134	183	254	320	456	645
22	101	139	278	628	1460	3024	5614	8371	9735
23	114	247	1002	3495	7876	9841	10000	10000	10000
24	130	378	1977	6366	9660	9997	10000	10000	10000
25	147	510	2712	7669	9877	9999	10000	10000	10000
26	166	624	3199	8152	9921	10000	10000	10000	10000
27	184	714	3527	8343	9939	10000	10000	10000	10000
28	204	780	3721	8455	9944	10000	10000	10000	10000
29	232	841	3839	8516	9946	10000	10000	10000	10000
30	254	888	3896	8534	9946	10000	10000	10000	10000
31	275	933	3953	8542	9946	10000	10000	10000	10000
32	295	973	3983	8542	9946	10000	10000	10000	10000
33	306	1002	4010	8547	9946	10000	10000	10000	10000
34	330	1033	4035	8550	9947	10000	10000	10000	10000
35	363	1063	4054	8556	9947	10000	10000	10000	10000
36	384	1081	4069	8565	9947	10000	10000	10000	10000
37	413	1111	4096	8581	9951	10000	10000	10000	10000
38	447	1130	4124	8597	9951	10000	10000	10000	10000
39	472	1167	4170	8615	9952	10000	10000	10000	10000
40	493	1202	4214	8645	9953	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 500.00
INVENTORY (KG PU) : 225.30

21	90	101	143	245	388	680	1175	1925	3051
22	101	186	623	2071	5561	9214	9984	10000	10000
23	114	414	2780	8498	9991	10000	10000	10000	10000
24	130	618	4122	9433	10000	10000	10000	10000	10000
25	147	755	4670	9564	10000	10000	10000	10000	10000
26	166	852	4927	9599	10000	10000	10000	10000	10000
27	184	925	5048	9620	10000	10000	10000	10000	10000
28	204	959	5118	9628	10000	10000	10000	10000	10000
29	232	1013	5170	9631	10000	10000	10000	10000	10000
30	254	1048	5196	9631	10000	10000	10000	10000	10000
31	275	1086	5217	9631	10000	10000	10000	10000	10000
32	295	1119	5231	9632	10000	10000	10000	10000	10000
33	306	1145	5251	9632	10000	10000	10000	10000	10000
34	330	1172	5270	9634	10000	10000	10000	10000	10000
35	363	1206	5288	9635	10000	10000	10000	10000	10000
36	384	1229	5315	9644	10000	10000	10000	10000	10000
37	413	1261	5349	9651	10000	10000	10000	10000	10000
38	447	1287	5388	9657	10000	10000	10000	10000	10000
39	472	1328	5419	9665	10000	10000	10000	10000	10000
40	493	1372	5466	9672	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 0.5 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	94	120	158	226	303	450	675	999
22	101	164	415	1225	3121	6548	9347	9970	10000
23	114	386	2582	8170	9977	10000	10000	10000	10000
24	130	896	6524	9967	10000	10000	10000	10000	10000
25	147	1606	8888	10000	10000	10000	10000	10000	10000
26	166	2384	9632	10000	10000	10000	10000	10000	10000
27	184	3176	9863	10000	10000	10000	10000	10000	10000
28	204	3777	9919	10000	10000	10000	10000	10000	10000
29	232	4263	9957	10000	10000	10000	10000	10000	10000
30	254	4637	9971	10000	10000	10000	10000	10000	10000
31	275	4898	9975	10000	10000	10000	10000	10000	10000
32	295	5078	9977	10000	10000	10000	10000	10000	10000
33	306	5199	9978	10000	10000	10000	10000	10000	10000
34	330	5280	9978	10000	10000	10000	10000	10000	10000
35	363	5329	9978	10000	10000	10000	10000	10000	10000
36	384	5371	9978	10000	10000	10000	10000	10000	10000
37	413	5395	9978	10000	10000	10000	10000	10000	10000
38	447	5409	9978	10000	10000	10000	10000	10000	10000
39	472	5422	9978	10000	10000	10000	10000	10000	10000
40	493	5437	9978	10000	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 108.14

21	90	216	936	3540	8975	10000	10000	10000	10000
22	101	2501	10000	10000	10000	10000	10000	10000	10000
23	114	9797	10000	10000	10000	10000	10000	10000	10000
24	130	10000	10000	10000	10000	10000	10000	10000	10000
25	147	10000	10000	10000	10000	10000	10000	10000	10000
26	166	10000	10000	10000	10000	10000	10000	10000	10000
27	184	10000	10000	10000	10000	10000	10000	10000	10000
28	204	10000	10000	10000	10000	10000	10000	10000	10000
29	232	10000	10000	10000	10000	10000	10000	10000	10000
30	254	10000	10000	10000	10000	10000	10000	10000	10000
31	275	10000	10000	10000	10000	10000	10000	10000	10000
32	295	10000	10000	10000	10000	10000	10000	10000	10000
33	306	10000	10000	10000	10000	10000	10000	10000	10000
34	330	10000	10000	10000	10000	10000	10000	10000	10000
35	363	10000	10000	10000	10000	10000	10000	10000	10000
36	384	10000	10000	10000	10000	10000	10000	10000	10000
37	413	10000	10000	10000	10000	10000	10000	10000	10000
38	447	10000	10000	10000	10000	10000	10000	10000	10000
39	472	10000	10000	10000	10000	10000	10000	10000	10000
40	493	10000	10000	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 1.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	94	119	153	220	294	438	654	979
22	101	163	407	1170	2937	6205	9147	9956	10000
23	114	372	2384	7815	9955	10000	10000	10000	10000
24	130	812	5981	9930	10000	10000	10000	10000	10000
25	147	1421	8424	9996	10000	10000	10000	10000	10000
26	166	2053	9312	9999	10000	10000	10000	10000	10000
27	184	2708	9679	10000	10000	10000	10000	10000	10000
28	204	3199	9813	10000	10000	10000	10000	10000	10000
29	232	3590	9867	10000	10000	10000	10000	10000	10000
30	254	3864	9902	10000	10000	10000	10000	10000	10000
31	275	4075	9909	10000	10000	10000	10000	10000	10000
32	295	4212	9913	10000	10000	10000	10000	10000	10000
33	306	4307	9917	10000	10000	10000	10000	10000	10000
34	330	4379	9917	10000	10000	10000	10000	10000	10000
35	363	4431	9917	10000	10000	10000	10000	10000	10000
36	384	4464	9917	10000	10000	10000	10000	10000	10000
37	413	4492	9917	10000	10000	10000	10000	10000	10000
38	447	4514	9919	10000	10000	10000	10000	10000	10000
39	472	4529	9919	10000	10000	10000	10000	10000	10000
40	493	4547	9921	10000	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 108.14

21	90	188	709	2563	7222	9949	10000	10000	10000
22	101	1628	9859	10000	10000	10000	10000	10000	10000
23	114	8261	10000	10000	10000	10000	10000	10000	10000
24	130	9764	10000	10000	10000	10000	10000	10000	10000
25	147	9919	10000	10000	10000	10000	10000	10000	10000
26	166	9946	10000	10000	10000	10000	10000	10000	10000
27	184	9954	10000	10000	10000	10000	10000	10000	10000
28	204	9958	10000	10000	10000	10000	10000	10000	10000
29	232	9960	10000	10000	10000	10000	10000	10000	10000
30	254	9960	10000	10000	10000	10000	10000	10000	10000
31	275	9960	10000	10000	10000	10000	10000	10000	10000
32	295	9960	10000	10000	10000	10000	10000	10000	10000
33	306	9960	10000	10000	10000	10000	10000	10000	10000
34	330	9961	10000	10000	10000	10000	10000	10000	10000
35	363	9961	10000	10000	10000	10000	10000	10000	10000
36	384	9962	10000	10000	10000	10000	10000	10000	10000
37	413	9965	10000	10000	10000	10000	10000	10000	10000
38	447	9966	10000	10000	10000	10000	10000	10000	10000
39	472	9966	10000	10000	10000	10000	10000	10000	10000
40	493	9966	10000	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 2.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	94	117	150	208	280	403	582	862
22	101	155	367	987	2392	5205	8412	9835	9999
23	114	323	1875	6529	9787	10000	10000	10000	10000
24	130	650	4473	9601	10000	10000	10000	10000	10000
25	147	1042	6597	9944	10000	10000	10000	10000	10000
26	166	1392	7786	9985	10000	10000	10000	10000	10000
27	184	1703	8368	9990	10000	10000	10000	10000	10000
28	204	1967	8643	9994	10000	10000	10000	10000	10000
29	232	2199	8789	9996	10000	10000	10000	10000	10000
30	254	2340	8857	9996	10000	10000	10000	10000	10000
31	275	2453	8899	9996	10000	10000	10000	10000	10000
32	295	2512	8913	9996	10000	10000	10000	10000	10000
33	306	2565	8928	9996	10000	10000	10000	10000	10000
34	330	2617	8932	9996	10000	10000	10000	10000	10000
35	363	2654	8938	9996	10000	10000	10000	10000	10000
36	384	2682	8941	9996	10000	10000	10000	10000	10000
37	413	2705	8946	9996	10000	10000	10000	10000	10000
38	447	2728	8948	9996	10000	10000	10000	10000	10000
39	472	2756	8961	9996	10000	10000	10000	10000	10000
40	493	2781	8979	9996	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 240.00
INVENTORY (KG PU) : 108.14

21	90	151	424	1344	3513	7786	9926	10000	10000
22	101	699	6303	9998	10000	10000	10000	10000	10000
23	114	3181	9998	10000	10000	10000	10000	10000	10000
24	130	4636	10000	10000	10000	10000	10000	10000	10000
25	147	5209	10000	10000	10000	10000	10000	10000	10000
26	166	5443	10000	10000	10000	10000	10000	10000	10000
27	184	5571	10000	10000	10000	10000	10000	10000	10000
28	204	5643	10000	10000	10000	10000	10000	10000	10000
29	232	5680	10000	10000	10000	10000	10000	10000	10000
30	254	5707	10000	10000	10000	10000	10000	10000	10000
31	275	5724	10000	10000	10000	10000	10000	10000	10000
32	295	5739	10000	10000	10000	10000	10000	10000	10000
33	306	5758	10000	10000	10000	10000	10000	10000	10000
34	330	5773	10000	10000	10000	10000	10000	10000	10000
35	363	5792	10000	10000	10000	10000	10000	10000	10000
36	384	5816	10000	10000	10000	10000	10000	10000	10000
37	413	5849	10000	10000	10000	10000	10000	10000	10000
38	447	5878	10000	10000	10000	10000	10000	10000	10000
39	472	5910	10000	10000	10000	10000	10000	10000	10000
40	493	5962	10000	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 0.5 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	94	121	159	230	307	458	692	1015
22	101	165	426	1288	3261	6780	9451	9983	10000
23	114	399	2715	8406	9987	10000	10000	10000	10000
24	130	948	6861	9981	10000	10000	10000	10000	10000
25	147	1738	9133	10000	10000	10000	10000	10000	10000
26	166	2624	9762	10000	10000	10000	10000	10000	10000
27	184	3517	9927	10000	10000	10000	10000	10000	10000
28	204	4227	9966	10000	10000	10000	10000	10000	10000
29	232	4767	9983	10000	10000	10000	10000	10000	10000
30	254	5203	9986	10000	10000	10000	10000	10000	10000
31	275	5501	9988	10000	10000	10000	10000	10000	10000
32	295	5702	9988	10000	10000	10000	10000	10000	10000
33	306	5835	9988	10000	10000	10000	10000	10000	10000
34	330	5924	9989	10000	10000	10000	10000	10000	10000
35	363	5984	9990	10000	10000	10000	10000	10000	10000
36	384	6027	9990	10000	10000	10000	10000	10000	10000
37	413	6054	9990	10000	10000	10000	10000	10000	10000
38	447	6075	9990	10000	10000	10000	10000	10000	10000
39	472	6090	9990	10000	10000	10000	10000	10000	10000
40	493	6104	9990	10000	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 45.06

21	90	1668	9994	10000	10000	10000	10000	10000	10000
22	101	10000	10000	10000	10000	10000	10000	10000	10000
23	114	10000	10000	10000	10000	10000	10000	10000	10000
24	130	10000	10000	10000	10000	10000	10000	10000	10000
25	147	10000	10000	10000	10000	10000	10000	10000	10000
26	166	10000	10000	10000	10000	10000	10000	10000	10000
27	184	10000	10000	10000	10000	10000	10000	10000	10000
28	204	10000	10000	10000	10000	10000	10000	10000	10000
29	232	10000	10000	10000	10000	10000	10000	10000	10000
30	254	10000	10000	10000	10000	10000	10000	10000	10000
31	275	10000	10000	10000	10000	10000	10000	10000	10000
32	295	10000	10000	10000	10000	10000	10000	10000	10000
33	306	10000	10000	10000	10000	10000	10000	10000	10000
34	330	10000	10000	10000	10000	10000	10000	10000	10000
35	363	10000	10000	10000	10000	10000	10000	10000	10000
36	384	10000	10000	10000	10000	10000	10000	10000	10000
37	413	10000	10000	10000	10000	10000	10000	10000	10000
38	447	10000	10000	10000	10000	10000	10000	10000	10000
39	472	10000	10000	10000	10000	10000	10000	10000	10000
40	493	10000	10000	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 1.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	94	121	158	227	306	453	680	1002
22	101	165	420	1245	3167	6624	9384	9977	10000
23	114	392	2616	8260	9979	10000	10000	10000	10000
24	130	911	6669	9973	10000	10000	10000	10000	10000
25	147	1650	8990	10000	10000	10000	10000	10000	10000
26	166	2470	9686	10000	10000	10000	10000	10000	10000
27	184	3316	9894	10000	10000	10000	10000	10000	10000
28	204	3946	9940	10000	10000	10000	10000	10000	10000
29	232	4465	9966	10000	10000	10000	10000	10000	10000
30	254	4841	9977	10000	10000	10000	10000	10000	10000
31	275	5117	9979	10000	10000	10000	10000	10000	10000
32	295	5302	9980	10000	10000	10000	10000	10000	10000
33	306	5438	9981	10000	10000	10000	10000	10000	10000
34	330	5516	9981	10000	10000	10000	10000	10000	10000
35	363	5570	9981	10000	10000	10000	10000	10000	10000
36	384	5618	9981	10000	10000	10000	10000	10000	10000
37	413	5644	9981	10000	10000	10000	10000	10000	10000
38	447	5659	9981	10000	10000	10000	10000	10000	10000
39	472	5673	9981	10000	10000	10000	10000	10000	10000
40	493	5683	9981	10000	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 45.06

21	90	1230	9855	10000	10000	10000	10000	10000	10000
22	101	10000	10000	10000	10000	10000	10000	10000	10000
23	114	10000	10000	10000	10000	10000	10000	10000	10000
24	130	10000	10000	10000	10000	10000	10000	10000	10000
25	147	10000	10000	10000	10000	10000	10000	10000	10000
26	166	10000	10000	10000	10000	10000	10000	10000	10000
27	184	10000	10000	10000	10000	10000	10000	10000	10000
28	204	10000	10000	10000	10000	10000	10000	10000	10000
29	232	10000	10000	10000	10000	10000	10000	10000	10000
30	254	10000	10000	10000	10000	10000	10000	10000	10000
31	275	10000	10000	10000	10000	10000	10000	10000	10000
32	295	10000	10000	10000	10000	10000	10000	10000	10000
33	306	10000	10000	10000	10000	10000	10000	10000	10000
34	330	10000	10000	10000	10000	10000	10000	10000	10000
35	363	10000	10000	10000	10000	10000	10000	10000	10000
36	384	10000	10000	10000	10000	10000	10000	10000	10000
37	413	10000	10000	10000	10000	10000	10000	10000	10000
38	447	10000	10000	10000	10000	10000	10000	10000	10000
39	472	10000	10000	10000	10000	10000	10000	10000	10000
40	493	10000	10000	10000	10000	10000	10000	10000	10000

THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 450.60
MEASUREMENT-ERROR : 2.0 %

BALANCE PERIODS	FALSE ALARM RATE	TOTAL-LOSS (KG) 5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00
21	90	94	119	155	221	299	443	659	989
22	101	164	409	1202	3025	6372	9243	9963	10000
23	114	375	2487	7988	9969	10000	10000	10000	10000
24	130	849	6236	9952	10000	10000	10000	10000	10000
25	147	1511	8651	9998	10000	10000	10000	10000	10000
26	166	2209	9484	9999	10000	10000	10000	10000	10000
27	184	2924	9783	10000	10000	10000	10000	10000	10000
28	204	3476	9871	10000	10000	10000	10000	10000	10000
29	232	3901	9910	10000	10000	10000	10000	10000	10000
30	254	4235	9933	10000	10000	10000	10000	10000	10000
31	275	4465	9937	10000	10000	10000	10000	10000	10000
32	295	4612	9942	10000	10000	10000	10000	10000	10000
33	306	4735	9943	10000	10000	10000	10000	10000	10000
34	330	4805	9945	10000	10000	10000	10000	10000	10000
35	363	4858	9945	10000	10000	10000	10000	10000	10000
36	384	4890	9945	10000	10000	10000	10000	10000	10000
37	413	4916	9945	10000	10000	10000	10000	10000	10000
38	447	4937	9945	10000	10000	10000	10000	10000	10000
39	472	4954	9945	10000	10000	10000	10000	10000	10000
40	493	4967	9945	10000	10000	10000	10000	10000	10000

INVENTORY LINEAR REDUCED
THROUGHPUT (TONNES/YEAR) : 100.00
INVENTORY (KG PU) : 45.06

21	90	680	6894	10000	10000	10000	10000	10000	10000
22	101	9214	10000	10000	10000	10000	10000	10000	10000
23	114	10000	10000	10000	10000	10000	10000	10000	10000
24	130	10000	10000	10000	10000	10000	10000	10000	10000
25	147	10000	10000	10000	10000	10000	10000	10000	10000
26	166	10000	10000	10000	10000	10000	10000	10000	10000
27	184	10000	10000	10000	10000	10000	10000	10000	10000
28	204	10000	10000	10000	10000	10000	10000	10000	10000
29	232	10000	10000	10000	10000	10000	10000	10000	10000
30	254	10000	10000	10000	10000	10000	10000	10000	10000
31	275	10000	10000	10000	10000	10000	10000	10000	10000
32	295	10000	10000	10000	10000	10000	10000	10000	10000
33	306	10000	10000	10000	10000	10000	10000	10000	10000
34	330	10000	10000	10000	10000	10000	10000	10000	10000
35	363	10000	10000	10000	10000	10000	10000	10000	10000
36	384	10000	10000	10000	10000	10000	10000	10000	10000
37	413	10000	10000	10000	10000	10000	10000	10000	10000
38	447	10000	10000	10000	10000	10000	10000	10000	10000
39	472	10000	10000	10000	10000	10000	10000	10000	10000
40	493	10000	10000	10000	10000	10000	10000	10000	10000

PROBABILITY OF DETECTION AS A FUNCTION OF
BALANCING PERIOD FOR

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+--------------------------------------+
|                                      |
|      DIVERSION SCENARIO     -  4     |
|      (LOSS-SCENARIO-LENGTH -  4)     |
|                                      |
+--------------------------------------+
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PARAMETERS CONSIDERED :

FACILITY THROUGHPUT	T/A	1000	500	240	100
PROCESS INVENTORY	KG PU	- CONSTANT - LINEAR REDUCED			

MEASUREMENT UNCERTAINTY AT THE INPUT	0.05 % (A)	0.1 % (B)	0.2 % (C)

AMOUNT ASSUMED TO BE DIVERDED KG PU	5	10	15	20	25	30	35	40
(LOSS PATTERN)	1	2	3	4	5	6	7	8