IT CORPORATION

STANDARD OPERATING PROCEDURE

NUMBER: RPP-001

TITLE: Internal Exposure Control

APPROVED: _____ DATE: 9-27-96
Corporate Director of
Health and Safety

APPROVED: _____ DATE: 9/23/96
Health Physics Professional

APPROVED: _____ DATE: 26 Sep 96
Corporate Director of
Quality Assurance

CONTROLLED COPY NO. : ____

REVISION NO.	DATE
001	9/23/96

TABLE OF CONTENTS

1 PURPOSE AND OBJECTIVES

The purpose of this procedure is to describe the method for controlling internal radiation exposure. This procedure is applicable to all work activities that involve radioactive materials or the potential for internal exposure to radioactive materials. The objective of the procedure is to assure that the potential for internal radiation exposure of IT employees, visitors and contractors is minimized by establishing and enforcing good work practices, dose limits, and administrative dose control points.

2 RESPONSIBILITIES

2.1 Corporate Director of Health and Safety (Director) shall:

2.1.1 Assure that internal radiation exposures of all employees, visitors and contractors are maintained as low as is reasonably achievable (ALARA).

2.1.2 Approve all planned exposures in excess of regulatory or license limits.

2.2 Health Physics Professional (HPP) shall:

2.2.1 Approve all planned exposures in excess of administrative, regulatory or license limits.

2.2.2 Assist the RSO in performance of internal dose assessments, selection of appropriate bioassay methods, and determination of monitoring frequency.

2.2.3 Approve all internal dose assessments prior to entry into the dosimetry record.

2.2.4 Provide guidance to the Director and RSO on matters pertaining to internal dose assessment and internal exposure control.

2.2.5 Assist RSOs in designing and implementing a contamination control program.

2.3 Radiation Safety Officer (RSO) shall:

2.3.1 Develop and administer an industry-standard internal radiation monitoring program when applicable.

2.3.2 Approve all planned exposures in excess of administrative, regulatory, or license limits.

2.3.3 Design and implement a contamination control program that ensures that internal exposure to radioactive materials is minimized and that worker exposure to airborne and loose surface contamination is within allowed limits.

2.4 Project Managers and Fixed Facility Directors shall:

2.4.1 Disseminate this policy to all applicable personnel.

2.4.2 Enforce participation in the monitoring program as scheduled by the RSO.

2.4.3 Appropriate funds as necessary to implement a contamination control program as designed by the RSO and HPP.

2.5 **IT** Employees, Visitors, and Contractors shall:

2.5.1 Maintain an awareness of the internal radiation dose limits and follow radiological controls if pertinent to a job assignment.

2.5.2 Comply with **IT** policy in order to maintain their own internal radiation dose within prescribed limits.

2.5.3 Participate in the internal radiation monitoring program as directed by the RSO.

3 REFERENCES

3.1 Requirements and Specifications

3.1.1 IT Corporation Policy No. HS-700, "Radiation Protection Program Plan"

3.1.2 Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation", 1991.

3.2 Related Procedures

3.2.1 IT Corporation Procedure No. RPP-010, "Radiation Protection Records"

3.2.2 RPP-008, "Engineered Controls and Respiratory Protection"

3.3 Others

3.3.1 International Commission on Radiological Protection, "ICRP Task Group on Reference Man", ICRP Publication 23, 1975.

3.3.2 International Commission on Radiological Protection, "Limits of Intakes of Radionuclides by Workers", ICRP Publication 30, 1980.

3.3.3 International Commission on Radiological Protection, "Individual Monitoring for Intakes of Radionuclides by Workers: Design and Interpretation", ICRP Publication 54, 1987.

3.3.4 American National Standards Institute, "Practice for Occupational Radiation Exposure Records System", Report No. ANSI N13.6 - 1966 (R1982).

4 DEFINITIONS

4.1 Activity - Disintegration rate of a radioactive material stated in dps, becquerels, Ci or other acceptable unit.

4.2 Annual Limit on Intake (ALI) - The activity of a radionuclide which, if taken into the body, would irradiate a person, represented by Reference Man, to the limit set by the regulatory agency for each year of occupational exposure.

4.3 Approval - An act of endorsing or adding positive authorization or both.

4.4 Bioassay - Measurement of amount or concentration of radioactivity in the body or in material excreted or removed from the body for purposes of estimating the quantity of radioactive material in the body.

4.5 Committed Dose Equivalent - The dose equivalent to an organ or a tissue that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

4.6 Committed Effective Dose Equivalent - The sum of the committed dose equivalents to individual tissues resulting from an intake of a radionuclide multiplied by the appropriate weighting factors (w_T):

$$\sum w_T H_T \leq H_{wb}$$

where w_T = the weighting factor representing the ratio of the stochastic risk resulting from irradiation of tissue (T) to the total risk when the whole body is irradiated uniformly; H_T is the dose equivalent received by tissue (T); and H_{wb} is the stochastic dose-equivalent limit for uniform irradiation of the whole body.

4.7 Direct bioassay - In-vivo measurements to estimate the quantity of radioactive material in the human body using instrumentation that detects radiation emitted from the radioactive material.

4.8 Half-life, biological (T_b) - The time in which half the quantity of a material in a compartment, in an organ, or in the whole body is eliminated by biological processes.

4.9 Half-life, physical (T_p) - The time taken for the activity of a radionuclide to lose half its value by radioactive decay.

4.10 Half-life, effective (T_e) - The time taken for the activity of a radioactive material in a compartment, in an organ or in the whole body to be reduced to half its value by a combination of biological elimination and radioactive decay:

$$\frac{1}{T_e} = \frac{1}{T_b} + \frac{1}{T_R}$$

where T_e = the effective half time; T_b = the biological half time; and T_R = the radiological or physical half time.

4.11 Health Physics Professionals (HPP) - Individuals who, by virtue of their education and experience, approve and provide oversight for work involving or pertaining to radioactivity. The HPP shall be Certified by the American Board of Health Physics (Comprehensive).

4.12 Indirect bioassay - Estimate of amount of radioactive material in the human body based on measurements of radioactive material in excreta or in other biological materials from the body, and on a biological model for movement of the material in body tissues and organs.

4.13 Intake - Amount of radioactive material entering the body through the nose, mouth, or skin.

4.14 Internal dosimetry - Specification, analysis, and interpretation of bioassay measurements that result in an estimate of internal dose equivalent or dose commitment.

4.15 May - The word **may** is used to denote permission.

4.16 Monitoring - The measurement of activity in the whole body, in a region of the body, in material eliminated from the body or in the air to help estimate the intake of radioactive material. The term monitoring also includes interpretation of the measurements.

- Routine monitoring is monitoring carried out at regular intervals during normal operations.
- Special monitoring is monitoring carried out in actual or suspected abnormal conditions.
- Confirmatory monitoring is monitoring carried out in situations where workers are unlikely to be exposed to significant intakes, in order to demonstrate satisfactory conditions.

4.17 Organ - A differentiated part of the body that performs a special function.

4.18 Radiation Safety Officers (RSO) - Individuals who, by virtue of training and/or experience, have been authorized to develop, administer and implement a radiation protection program. Fixed facility RSOs shall be specified by federal or state license requirements, and are authorized to use or directly supervise the use of radioactive materials under the specifications of a specific radioactive materials license. Project RSOs shall be selected by the HPP.

4.19 Reference Man - A person with the anatomical and physiological characteristics defined in the report of the ICRP Task Group on Reference Man (ICRP Report No. 23).

4.20 Retention Function - A mathematical expression for that fraction of the initial body content of radioactive material retained in the organ of reference at time t after intake. The retention function is represented by the expression R(t).

4.21 Shall - The word **shall** is to be understood as a requirement.

4.22 Should - The word **should** is to be understood as a recommendation.

5 EQUIPMENT/MATERIALS REQUIRED

5.1 Sample Collection Kits

5.2 Chain of Custody Forms

5.3 Request for Analysis Forms

6 METHODOLOGY

6.1 Administrative Dose Limits

6.1.1 Engineered controls shall be used and control shall be applied to contamination at the source to minimize internal exposures. This contamination control program will be implemented by the RSO and Project Manager and will rely on engineeered controls as much as practicable, with the use of respiratory protection being minimized to the extent that the job task/site allow.

6.1.2 Individual internal doses shall be administratively controlled to not exceed those associated with intake of radioactive materials at 10% of the Annual Limit of Intake (ALI) referenced in 10 CFR 20.

6.1.3 Approval by the RSO and HPP is required for any employee, visitor, or contractor to exceed this limit.

6.1.4 The RSO shall take the following steps if there occurs an intake of radioactive materials that exceeds the administrative dose limits:

A. Inform the HPP of the occurrence.

B. Investigate the incident immediately.

C. Determine the root cause(s) and identify corrective actions to prevent recurrence.

D. Inform the HPP of the results of the investigation and any corrective actions taken.

E. Deny the individual involved further access into radiologically controlled areas pending assessment of internal dose and investigation of the circumstances involved in this intake.

6.1.5 For cases in which administrative dose limits have been exceeded, the RSO shall estimate the internal radiation dose. The results of the dose estimate shall be approved by the HPP, and retained permanently in the individual's dosimetry record.

6.2 Direct Bioassay Program

6.2.1 In-vivo bioassay (whole body counting) equipment may be used to monitor personnel for radionuclides that emit gamma rays or x-rays.

6.2.2 The capability for in-vivo bioassay should be provided by an approved contractor as deemed necessary by the RSO.

6.2.3 Whole body counting equipment shall be sensitive enough to detect 10% of the ALI at the 95% confidence interval for those radionuclides expected to be encountered by personnel.

6.2.4 Abnormal results identified in any calibration or system check shall be reported to the HPP and RSO for review and corrective action.

6.2.5 When an outside contractor performs WBC services, the RSO shall ensure that the requirements listed herein are included in the purchase order with the contractor.

6.3 Indirect Bioassay Program

6.3.1 *In-vitro* bioassay may be used to monitor personnel for internal deposition of radionuclides that cannot be detected using whole body counting equipment, or when measurement of individual elimination rates is desired.

6.3.2 The capability for *in-vitro* bioassay analyses shall be provided by a contractor as deemed necessary by the RSO.

6.3.3 Analyses shall be performed when a potential intake of alpha- or beta-emitting radionuclides is suspected.

6.3.4 To assure the quality of the results of the *in-vitro* bioassay program, the RSO shall require that the radioanalytical laboratory used for processing of biological samples comply with the recommendations of USNRC Regulatory Guide 4.15.

6.4 Monitoring Frequency

6.4.1 Baseline bioassays shall be performed upon assignment with potential internal exposures or at the discretion of the RSO or when project requirements dictate this need.

6.4.2 The RSO shall obtain the results of termination bioassays from previous employers.

6.4.3 If a baseline bioassay is deemed necessary, the type of sample and analysis shall be determined by the RSO or HHP or client HP department.

6.4.4 Routine bioassays shall be performed as stipulated in each project's health and safety plan, or in license requirements for IT fixed facilities. Where no such plan exists, routine bioassays shall be performed in accordance with the following guidance:

A. Prior to, and upon termination of work within a radiologically controlled zone or area where airborne activity was > 10 percent of a DAC.

B. Throughout the work period at a frequency determined by the RSO.

6.4.5 Special or non-routine bioassays shall be performed when it is suspected that an individual may have received an internal deposition that potentially exceeds 1 percent of the 10 CFR 20 dose limit, or as deemed necessary or prudent by the RSO or HPP.

6.5 Validation of Bioassay Results

6.5.1 The RSO shall determine the validity of bioassay results prior to their inclusion in the internal dose assessment process.

6.5.2 The RSO shall evaluate the following items to ascertain the validity of monitoring results:

- Sample collection errors;
- Radiation background interference during counting;
- Calibration errors;
- Computer software errors;
- Errors due to counting geometry; and/or

- Statistical errors.

6.5.3 Only valid bioassay results, as determined by the RSO shall be used for assessment of internal radiation dose. If the data are not valid, the RSO shall document the basis for that conclusion and include the documentation in the individual's dosimetry record. The RSO shall also estimate the internal dose to the individual via other means and include the estimate in the individual's exposure history.

6.5.4 The HPP shall review and approve all internal dose estimates prior to their becoming a part of the workers' exposure history.

6.6 Interpretation of Bioassay Results

6.6.1 The RSO should complete the top of the form entitled "Interpretation of Bioassay" (See Attachment 1).

A. The RSO shall identify the route of entry (i.e., inhalation, ingestion, etc.), which should be the most likely route based upon current knowledge of exposure conditions. However, this selection can and should be modified as further information becomes available.

B. The ALI for the radionuclide in question should be obtained from 10 CFR 20, Appendix B, Table 1.

C. The solubility class is only applicable to intake by inhalation and should be based upon current knowledge of the chemical form and/or particle size.

6.6.2 Using available bioassay results, the RSO should complete the table on Attachment 1 per instructions provided with that attachment.

6.6.3 The HPP shall review all forms for correct input values and calculations. They shall also review all data that support the internal dose estimate.

6.7 Action Levels

6.7.1 Selection and conduct of follow-up actions by the RSO should include consideration of the following:

A. The dosimetric significance of all involved radionuclides;

B. The presence of indicator radionuclides;

C. The likely routes of entry of the radionuclide(s) into the body;

D. Suspected biokinetic processes at times shortly after intake;

E. The time required for absorption and elimination to occur;

F. The expected retention or excretion of the radionuclides;

G. The availability of analytical services;

H. The required sensitivity and measurement turnaround time; and/or

I. The required sample size.

6.7.2 The Investigation Level should be set at the following:

$$IL = 0.3 \times f \times ALI$$

Where IL = the Investigation Level, f = the fraction of the year to which a particular routine monitoring result applies, and ALI is the Annual Limit on Intake for the radionuclide in question.

6.7.3 Follow-up actions for deposited radionuclides detected at levels in excess of one IL may include the following, at the discretion of the RSO:

A. Additional measurements; and/or

B. Acquisition of other data necessary to describe the retention of the radionuclide(s) in the body.

7 RECORDS

7.1 All Records pertinent to this procedure shall be maintained pursuant to RPP-010 DT

7.2 Individual Monitoring Records:

7.2.1 Internal radiation exposure received during prior employment.

7.2.2 Internal exposure received at other installations during current employment by IT.

7.2.3 Results of individual whole body counts and bioassay results

7.3 Internal Radiation Monitoring Program Records

7.3.1 Procedures and methods for interpretation and evaluation of individual exposure data

7.3.2 Capabilities of bioassay services

7.3.3 Program review and audits

7.3.4 Investigation reports for instances in which significant internal depositions occur

7.3.5 Procedures and records associated with *in-vitro* and *in-vivo* bioassay techniques including set-up, testing, calibration, and daily and weekly response checks of whole body counting equipment

7.3.6 Internal dose assessments, including the bases for the dose assessment

8 ATTACHMENTS

8.1 Attachment 1 - "Interpretation of Bioassay"

ATTACHMENT 1
INTERPRETATION OF BIOASSAY

Subject:	Route of Intake:
Date of Intake	Annual Limit on Intake:
Radionuclide:	Dose Conversion Factor:
Solubility Class: ☐ D ☐ W ☐ Y	

t (days)	Volume (Mass)	Activity	O (corrected)	(a) IRF	(b) O x IRF (needed only for least squares fit)	(c) IRF^2 (needed only for least squares fit)	(d) Intake
					(e)	(f)	

(g) Intake = Average of (d) =

or

(g) Intake = (e)/(f) =

(h) H_{50} = (g)/(ALI) x 5 =

or:

(i) H_{50} = (g) x DCF =

Dosimetrist / Date

* Needed only if least-squares fit is required.

ATTACHMENT 1 (cont'd)

INSTRUCTIONS FOR THE COMPLETION OF INTERPRETATION OF BIOASSAY FORM

1. The value listed for "t" should be the number of days between the suspected date of intake and the date of sample collection for indirect bioassay, or the date of measurement for direct bioassay.

2. Values for "Volume" or "Mass" are applicable to indirect bioassay measurements only.

3. The "Activity" should be the actual activity reported from the bioassay measurement.

4. The values for "O(corrected)" are "Activity" values corrected to reflect the appropriate units of activity in the applicable bioassay compartment. For example, a single 200 ml urine sample is analyzed and found to contain 25 pCi of "Activity". This value must be corrected to reflect the activity in a twenty-four-hour void. Therefore, "O(corrected)" is equal to (25 pCi × 1400 ml) ÷ 200 ml, or 175 pCi.

5. Values for "IRF" shall be selected from those contained in ICRP Publication 54.

6. For a single bioassay result or to obtain the average intake from multiple bioassay results:

   6.1 Values entered in column (c), labeled "Intake", are obtained by solving the equation: "O(corrected)" × "IRF".

   6.2 It is not necessary to complete columns (a) and (b).

   6.3 For multiple bioassay results, the average of the column (c) values is computed and entered in slot (d) below, marked "Intake"

7. To obtain a least-squares fit for multiple bioassay data:

   7.1 Columns labeled (a) and (b) should be completed, with the totals for each column entered in slots (e) and (f), respectively.

   7.2 The best estimate of intake should be obtained by solving for (e) ÷ (f), and entering the result in (g).

8. An estimate of Committed Dose Equivalent, or "H_{50}", in units of rem, should be obtained by one of the following means:

   8.1 Divide the value entered in either (d) or (g) by the ALI, multiply the result by 5, and enter the result in (h).

   8.2 Multiply the value entered in either (d) or (g) by an appropriate Dose Conversion Factor (Federal Guidance Report #11), and enter the result in (i).

9. Since the H_{50} is assigned in the year in which the dose is received, the value of (h) or (i) can be added to the external dose for that year and compared directly to administrative or legal dose limits in order to guide follow-up actions.