VISTA Technologies, Inc.
Radiation Safety Program

PROCEDURE - 21

PROTECTION OF THE PUBLIC AND ENVIRONMENT

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TABLE OF CONTENTS

Appendix B

(In Reference to 10 CFR 20 Appendix B Tables and Columns)

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage

ABBREVIATIONS AND ACRONYMS

α	-	Alpha
ß	-	Beta
γ	-	Gamma
μ	-	Micro
^{241}Am	-	Americium-241
^{137}Ce	-	Cesium-137
^{234}Pa	-	Protactinium-234
^{210}Pb	-	Lead-210
^{210}Po	-	Polonium-210
^{214}Po	-	Polonium-214
^{218}Po	-	Polonium-218
^{232}Pu	-	Plutonium-232
^{226}Ra	-	Radium-226
^{228}Ra	-	Radium-228
^{219}Rn	-	Radon-219 (Actinium Series)
^{220}Rn	-	Radon-220 (Thorium Series)
^{222}Rn	-	Radon-222 (Uranium Series)
^{89}Sr	-	Strontium-89
^{90}Sr	-	Strontium-90
^{230}Th	-	Thorium-230
^{232}Th	-	Natural Thorium
^{238}U	-	Uranium-238
μCi	-	MicroCurie
μCi/hr	-	MicroCuries per hour
μCi/ml	-	MicroCuries per milliliter
μM	-	Micrometer
μR/hr	-	MicroRoentgen per hour
μg/mg	-	Microgram per milligram
ALARA	-	As low as reasonably achievable
ALI	-	Annual limit on intake
ANSI	-	American National Standards Institute
APR	-	Air-purifying respirator
Bq	-	Becquerel
Bq/m^3	-	Becquerels per cubic meter of air
BZ	-	Breathing Zone
C	-	Coulomb
C/kg	-	Coulombs per kilogram
CDE	-	Committed Dose Equivalent
CEDE	-	Committed Effective Dose Equivalent

CFR	-	Code of Federal Regulations
Ci	-	Curie
CIH	-	Certified Industrial Hygienist
CFM	-	Cubic feet per minute
CLIA	-	Clinical Laboratories Improvement Act
CLP	-	Contract Laboratory Program
cm	-	Centimeter
cm/sec	-	Centimeters per second
cpm	-	Counts per minute
CPR	-	Cardiopulmonary resuscitation
CSE	-	Certified Safety Executive
(D)	-	Duplicate count
DAC	-	Derived air concentration
DAC-h	-	DAC hours
DCA	-	Double Contingency Analysis
DDE	-	Deep Dose Equivalent
DI	-	De-ionized water
DOT	-	U.S. Department of Transportation
dm^2	-	Square Decimeter; one square decimeter equals 100 square centimeters
dpm	-	Disintegrations per minute
dpm/cm^2	-	Disintegrations per minute per square centimeter
dpm/dm^2	-	Disintegrations per minute per square decimeter
dps	-	Disintegrations per second
DRD	-	Direct reading dosimeter
DU	-	Depleted uranium
EPA	-	U.S. Environmental Protection Agency
eV	-	Electronvolt
FE	-	Feces sample
FIDLER	-	Field instrument for detection of low energy radiation
FR	-	Filter ratio
FSP	-	Field Sampling Plan
ft^2	-	Square foot
γ	-	Gamma ray
GA	-	General area
GeLi	-	Germanium - Lithium
G-M	-	Geiger-Mueller
GMC-H	-	Mine Safety Appliances Company, full-facepiece, dual ..combination filter cartridges for an APR
GPD	-	Gaseous Diffusion Plang
h	-	hours
He-3	-	Helium Three (3)

HEPA	-	High efficiency particulate air
HNO_3	-	Nitric acid
HP	-	Health Physics
hr	-	Hour
HS	-	Hot spot (radiation)
HSP	-	Site-specific Health and Safety Plan
HWP	-	Hazardous Work Permit
ICRP	-	International Commission on Radiological Protection
ID	-	Identification
IDLH	-	Immediately dangerous to life or health
IDW	-	Investigation derived waste
IP	-	Ionization potential
IVC	-	Independent verification contractor
keV	-	Kiloelectronvolt
kg	-	Kilogram
LANL	-	Los Alamos National Laboratory
lpm	-	Liters Per Minute
MCA	-	Multi-channel analyzer
MDA	-	Minimum detectable activity
meV	-	Millielectronvolt
m	-	Meter
m^2	-	Squared Meters
m^3	-	Cubic meters
mCi	-	MilliCurie
MSHP	-	Manager, Vista Safety and Health Program
mil	-	1/1000 inch
ml	-	Milliliter
mm	-	Millimeter
mR	-	MilliRoentgen
mR/hr	-	MilliRoentgens per hour
mrem	-	Millirem
mrem/hr	-	Millirems per hour
MSA	-	Mine Safety Appliances Company
MSDS	-	Material Safety Data Sheet
MSHA	-	Mine Safety and Health Administration
NaI	-	Sodium iodide
NCA	-	Nuclear Criticality Analysis
NCS	-	Nuclear Criticality Safety
NCRP	-	National Council on Radiation Protection and Measurements
NEA	-	Nuclear Energy Agency
NIST	-	National Institute of Science and Technology

NIOSH	-	National Institute for Occupational Safety and Health
n. o. s.	-	Not otherwise specified
NPDES	-	National Pollutant Discharge Elimination System
NRC	-	U.S. Nuclear Regulatory Commission
NS	-	Nose swipe
NTIS	-	National Technical Information Service
NVLAP	-	National Voluntary Laboratory Accreditation Program
OHSO	-	On-Site Health and Safety Officer
ORNL	-	Oak Ridge National Laboratory
ORPO	-	On-Site Ionizing Radiation Protection Officer
OSHA	-	U.S. Occupational Safety and Health Administration
pCi	-	PicoCurie
pCi/gm	-	PicoCuries per gram
pCi/l	-	PicoCuries per liter
P.E.	-	Professional Engineer
PF	-	Protection Factor
PIC	-	Pocket Ionization Chamber
PM	-	Project Manager
PMT	-	Photomultiplier Tube
PPE	-	Personal Protective Equipment
PRP	-	Potentially Responsible Party
PRS	-	Portable ratemeter/scaler
PVC	-	Polyvinyl chloride
QA	-	Quality assurance
QC	-	Quality control
R	-	Roentgen
RA	-	Restricted (radiation) area
rad	-	Radiation absorbed dose
RAS-1 -		Kurz air sampling pump flow calibration kit
REM	-	Roentgen equivalent man
RHSC	-	Radiation Health and Safety Committee
RSO	-	VISTA Radiation Safety Officer
RWP	-	Radiation work permit
SAP	-	Sampling and Analysis Plan
SCBA	-	Self-contained breathing apparatus
SRD	-	Self-reading dosimeter
TODE	-	Total Organ Dose Equivalent
TLD	-	Thermoluminescent dosimeter
TWA	-	Time-weighted average

U^{nat}	-	Natural uranium
UR	-	Urine sample
U.S.	-	United States
VISTA	-	Vista Technologies, Inc.
VSHP	-	VISTA Safety and Health Program
VRSP	-	VISTA Radiation Safety Program
WL	-	Working Level
WP	-	Work Plan

PROTECTION OF THE PUBLIC AND ENVIRONMENT

The following sections discuss the requirements for waste water discharges to a sanitary sewer, discharge of water contaminated with radioactive materials other than to a sanitary sewer, air concentrations in Unrestricted Areas, and the total dose equivalent above background radiation levels for the general public.

1 WASTE WATER DISCHARGES TO A SANITARY SEWER

Waterborne radioactive materials discharged to a sanitary sewer system must be within the limits provided in Table 3 of Appendix B to 10 CFR 20. Section 20.2003 of 10 CFR 20, as well as local waste water control ordinances, provide additional requirements.

2 DISCHARGE OF WATER CONTAMINATED WITH RADIOACTIVE MATERIALS OTHER THAN TO A SANITARY SEWER

Discharges of contaminated water onto the ground, to ground water, and to surface water are generally forbidden. The allowable concentrations of radionuclides in effluent waste water discharges will reflect the following considerations:

- Applicable state and local regulations or waste water control ordinances;
- Discharges must not have the potential to cause a measurable degradation of any ground-water resources; and
- Concentration limits imposed by National Pollutant Discharge Elimination System (NPDES) permits, if applicable.

3 AIR CONCENTRATIONS IN UNRESTRICTED AREAS

Airborne concentrations for public access areas should be controlled to the limiting values provided in Column 1, Table 2 of Appendix B to 10 CFR 20.

4 TOTAL DOSE EQUIVALENT ABOVE BACKGROUND FOR THE GENERAL PUBLIC

The total annual dose equivalent for members of the public is obtained by summing the annual external dose equivalent and the committed effective dose equivalent for intakes resulting during the year. The total annual dose equivalent cannot exceed 100 mrem (0.1 rem or1 millisievert) in a year exclusive of the dose contributions from background radiation, any medical administration the individual has received, voluntary participation in medical research programs, for the most exposed person as a result of Vista field activities. The field operation controls will make sure that the dose in any unrestricted area from external sources does not exceed 0.002 rem (0.02 mSv) in any one hour.

By abiding by the procedures and regulations in;

- 10 CFR 71 "Packaging and Transportation of Radioactive Material";
- 10 CFR 20 "Standards for Protection Against Radiation";

- 49 CFR 1-179 "Hazardous Material Regulations, Department of Transportation (DOT)";
- " A review of the DOT for the Transportation of Radioactive Materials".

Vista provides a means to minimize exposures to individuals of the public as required in subpart D of 10 CFR 20. This will be accomplished by complying with the annual dose limit specified in subpart D of 10 CFR 20 by:

- Demonstrating by measurement or calculation that the total effective dose equivalent to the individual likely to receive the highest dose from the licensed operation does not exceed the annual dose limit; or
- Demonstrating that--

  (i) The annual average concentrations of radioactive material released in gaseous and liquid effluents at the boundary of the unrestricted area do not exceed the values specified in Table 2 of Appendix B to part 10 CFR 20 and

  (ii) If an individual were continually present in an unrestricted area, the dose from external sources would not exceed 0.002 rem (0.02 mSv) in an hour and 0.05 rem (0.5 mSv) in a year.

Appendix B -- Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage

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Introduction

For each radionuclide Table 1 indicates the chemical form which is to be used for selecting the appropriate ALI or DAC value. The ALIs and DACs for inhalation are given for an aerosol with an activity median aerodynamic diameter (AMAD) of 1 μm and for three classes (D,W,Y) of radioactive material, which refer to their retention (approximately days, weeks or years) in the pulmonary region of the lung. This classification applies to a range of clearance half-times of less than 10 days for D, for W from 10 to 100 days, and for Y greater than 100 days. The class (D, W, or Y) given in the column headed ``Class" applies only to the inhalation ALIs and DACs given in Table 1, columns 2 and 3.

Table 2 provides concentration limits for airborne and liquid effluents released to the general environment. Table 3 provides concentration limits for discharges to sanitary sewer systems.

Notation

The values in Tables 1, 2, and 3 are presented in the computer "E" notation. In this notation a value of 6E-002 represents a value of $6x10^{-2}$ or 0.06, 6E+002 represents $6x10^{-2}$ or 600, and 6E+00 represents $60x10^{0}$ or 6.

Table 1 "Occupational"

Note that the columns in Table 1, of this appendix captioned "Oral Ingestion ALI," "Inhalation ALI," and "DAC," are applicable to occupational exposure to radioactive material.

The ALIs in this appendix are the annual intakes of a given radionuclide by "Reference Man" which would result in either (1) a committed effective dose equivalent of 5 rems (stochastic ALI) or (2) a committed dose equivalent of 50 rems to an organ or tissue (non-stochastic ALI). The stochastic ALIs were derived to result in a risk, due to irradiation of organs and tissues, comparable to the risk associated with deep dose equivalent to the whole body of 5 rems. The derivation includes multiplying the committed dose equivalent to an organ or tissue by a weighting factor, w_T. This weighting factor is the proportion of the risk of stochastic effects resulting from irradiation of the organ or tissue, T, to the total risk of stochastic effects when the whole body is irradiated uniformly. The values of w_T are listed under the definition of weighting factor in 10 CFR 20. The non-stochastic ALIs were derived to avoid non-stochastic effects, such as prompt damage to tissue or reduction in organ function.

A value of w_T=0.06 is applicable to each of the five organs or tissues in the "remainder" category receiving the highest dose equivalents, and the dose equivalents of all other remaining tissues may be disregarded. The following parts of the GI tract -- stomach, small intestine, upper large intestine, and lower large intestine -- are to be treated as four separate organs.

Note that the dose equivalents for extremities (hands and forearms, feet and lower legs), skin, and lens of the eye are not considered in computing the committed effective dose equivalent, but are subject to limits that must be met separately.

When an ALI is defined by the stochastic dose limit, this value alone, is given. When an ALI is determined by the non-stochastic dose limit to an organ, the organ or tissue to which the limit applies is shown, and the ALI for the stochastic limit is shown in parentheses. (Abbreviated organ or tissue designations are used: LLI wall = lower large intestine wall; St. wall = stomach wall; Blad wall = bladder wall; and Bone surf = bone surface.)

The use of the ALIs listed first, the more limiting of the stochastic and non-stochastic ALIs, will ensure that non-stochastic effects are avoided and that the risk of stochastic effects is limited to an acceptably low value. If, in a particular situation involving a radionuclide for which the non-stochastic ALI is limiting, use of that non-stochastic ALI is considered unduly conservative, the licensee may use the stochastic ALI to determine the committed effective dose equivalent. However, the licensee shall also ensure that the 50-rem dose equivalent limit for any organ or tissue is not exceeded by the sum of the external deep dose equivalent plus the internal committed dose to that organ (not the effective dose). For the case where there is no external dose contribution, this would be demonstrated if the sum of the fractions of the nonstochastic ALIs (ALI_{ns}) that contribute to the committed dose equivalent to the organ receiving the highest dose does not exceed unity (i.e., Sum (intake (in μCi) of each radionuclide/ALI_{ns}) <1.0). If there is an external deep dose equivalent contribution of H_d then this sum must be less than 1-(H_d/50) instead of being <1.0.

The derived air concentration (DAC) values are derived limits intended to control chronic occupational exposures. The relationship between the DAC and the ALI is given by: DAC=ALI(in μCi)/(2000 hours per working year x 60 minutes/hour x 2 x 10^4 ml per minute)=[ALI/2.4x10^9] μCi/ml, where 2 x 10^4 ml is the volume of air breathed per minute at work by "Reference Man" under working conditions of "light work."

The DAC values relate to one of two modes of exposure: either external submersion or the internal committed dose equivalents resulting from inhalation of radioactive materials. Derived air concentrations based upon submersion are for immersion in a semi-infinite cloud of uniform concentration and apply to each radionuclide separately.

The ALI and DAC values relate to exposure to the single radionuclide named, but also include contributions from the in-growth of any daughter radionuclide produced in the body by the decay of the parent. However, intakes that include both the parent and daughter radionuclides should be treated by the general method appropriate for mixtures.

The value of ALI and DAC do not apply directly when the individual both ingests and inhales a radionuclide, when the individual is exposed to a mixture of radionuclides by either inhalation or ingestion or both, or when the individual is exposed to both internal and external radiation. When an individual is exposed to radioactive materials which fall under several of the translocation classifications (i.e., Class D, Class W, or Class Y) of the same radionuclide, the exposure may be evaluated as if it were a mixture of different radionuclides.

It should be noted that the classification of a compound as Class D, W, or Y is based on the chemical form of the compound and does not take into account the radiological half-life of different radioisotopes. For this reason, values are given for Class D, W, and Y compounds, even for very short-lived radionuclides.

Table 2

The columns in Table 2 of this appendix captioned "Effluents", "Air," and "Water", are applicable to the assessment and control of dose to the public, particularly in the implementation of the provisions of 10 CFR 20.1302. The concentration values given in Columns 1 and 2 of Table 2 are equivalent to the radionuclide concentrations which, if inhaled or ingested continuously over the course of a year, would produce a total effective dose equivalent of 0.05 rem (50 millirem or 0.5 millisieverts).

Consideration of non-stochastic limits has not been included in deriving the air and water effluent concentration limits because non-stochastic effects are presumed not to occur at the dose levels established for individual members of the public. For radionuclides, where the non-stochastic limit was governing in deriving the occupational DAC, the stochastic ALI was used in deriving the corresponding airborne effluent limit in Table 2. For this reason, the DAC and airborne effluent limits are not always proportional as was the case in Appendix B to 10 CFR 20.1-20.601.

The air concentration values listed in Table 2, Column 1, were derived by one of two methods. For those radionuclides for which the stochastic limit is governing, the occupational stochastic inhalation ALI was divided by 2.4×10^9 ml, relating the inhalation ALI to the DAC, as explained above, and then divided by a factor of 300. The factor of 300 includes the following components:

- a factor of 50 to relate the 5-rem annual occupational dose limit to the 0.1-rem limit for members of the public;
- a factor of 3 to adjust for the difference in exposure time and the inhalation rate for a worker and that for members of the public; and
- a factor of 2 to adjust the occupational values (derived for adults) so that they are applicable to other age groups.

For those radionuclides for which submersion (external dose) is limiting, the occupational DAC in Table 1, Column 3, was divided by 219. The factor of 219 is composed of a factor of 50, as described above, and a factor of 4.38 relating occupational exposure for 2,000 hours per year to full-time exposure (8,760 hours per year). Note that an additional factor of 2 for age considerations is not warranted in the submersion case.

The water concentrations were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by 7.3×10^7. The factor of 7.3×10^7 (ml) includes the following components:

- the factors of 50 and 2 described above and a factor of 7.3×10^5 (ml) which is the annual water intake of "Reference Man."

Note 2 of this appendix provides groupings of radionuclides which are applicable to unknown mixtures of radionuclides. These groupings (including occupational inhalation ALIs and DACs, air and water effluent concentrations and sewerage) require demonstrating that the most limiting radionuclides in successive classes are absent. The limit for the unknown mixture is defined when the presence of one of the listed radionuclides cannot be definitely excluded either from knowledge of the radionuclide composition of the source or from actual measurements.

Table 3 "Sewer Disposal"

The monthly average concentrations for release to sanitary sewers are applicable to the provisions in 10 CFR 20.2003. The concentration values were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by 7.3×10^6 (ml). The factor of 7.3×10^6 (ml) is composed of a factor of 7.3×10^5 (ml), the annual water intake by "Reference Man," and a factor of 10, such that the concentrations, if the sewage released by the licensee were the only source of water ingested by a reference man during a year, would result in a committed effective dose equivalent of 0.5 rem.

List of Elements

		Atomic			Atomic			Atomic
Name	**Symbol**	**No.**	**Name**	**Symbol**	**No.**	**Name**	**Symbol**	**No.**
Actinium	Ac	89	Germanium	Ge	32	Radium	Ra	88
Aluminum	Al	13	Gold	Au	79	Radon	Rn	86
Americium	Am	95	Hafnium	Hf	72	Rhenium	Re	75
Antimony	Sb	51	Holmium	Ho	67	Rhodium	Rh	45
Argon	Ar	18	Hydrogen	H	1	Rubidium	Rb	37
Arsenic	As	33	Indium	In	49	Ruthenium	Ru	44
Astatine	At	85	Iodine	I	53	Samarium	Sm	62
Barium	Ba	56	Iridium	Ir	77	Scandium	Sc	21

		Atomic			Atomic			Atomic
Name	Symbol	No.	Name	Symbol	No.	Name	Symbol	No.
Berkelium	Bk	97	Iron	Fe	26	Selenium	Se	34
Beryllium	Be	4	Krypton	Kr	36	Silicon	Si	14
Bismuth	Bi	83	Lanthanum	La	57	Silver	Ag	47
Bromine	Br	35	Lead	Pb	82	Sodium	Na	11
Cadmium	Cd	48	Lutetium	Lu	71	Strontium	Sr	38
Calcium	Ca	20	Magnesium	Mg	12	Sulfur	S	16
Californium	Cf	98	Manganese	Mn	25	Tantalum	Ta	73
Carbon	C	6	Mendelevium	Md	101	Technetium	Tc	43
Cerium	Ce	58	Mercury	Hg	80	Tellurium	Te	52
Cesium	Cs	55	Molybdenum	Mo	42	Terbium	Tb	65
Chlorine	Cl	17	Neodymium	Nd	60	Thallium	Tl	81
Chromium	Cr	24	Neptunium	Np	93	Thorium	Th	90
Cobalt	Co	27	Nickel	Ni	28	Thalium	Tm	69
Copper	Cu	29	Niobium	Nb	41	Tin	Sn	50
Curium	Cm	96	Osmium	Os	76	Titanium	Ti	22
Dysprosium	Dy	66	Palladium	Pd	46	Tungsten	W	74
Einsteinium	Es	99	Phosphorus	P	15	Uranium	U	92
Erbium	Er	68	Platinum	Pt	78	Vanadium	V	23
Europium	Eu	63	Plutonium	Pu	94	Xenon	Xe	54
Fermium	Fm	100	Polonium	Po	84	Ytterbium	Yb	70
Fluorine	F	9	Potassium	K	19	Yttrium	Y	39
Francium	Fr	87	Praseodymium	Pr	59	Zinc	Zn	30
Gadolinium	Gd	64	Promethium	Pm	61	Zirconium	Zr	40
Gallium	Ga	31	Protactinium	Pa	91			

Locate the data for Appendix B tables using the Atomic Numbers below:

Atomic #	Atomic #	Atomic #	Atomic #	Atomic #
1-17	37-39	51-52	65-69	81-84
18-25	40-42	53-55	70-72	85-90
26-29	43-45	56-58	73-75	91-92
30-33	46-48	59-61	76-77	93-95
34-36	49-50	62-64	78-80	96-101