DOT HAZMAT RADIOACTIVE SHIPPING FOR ACADEMIC AND MEDICAL FACILITIES

This document is meant as an aid only, and is intended for the most common radioactive materials likely to be shipped by academic or medical facilities. No representation of any kind is made with respect to accuracy or correct interpretation of the U.S. Department of Transportation Regulations (Code of Federal Regulations) Title 49, Transportation, Subchapter C, Hazardous Materials Regulations. This is the work of the author only excepting those indicated below that assisted in reviewing this document. It is not an official publication of the Eastern Colorado Health Care System or the Department of Veterans Affairs.

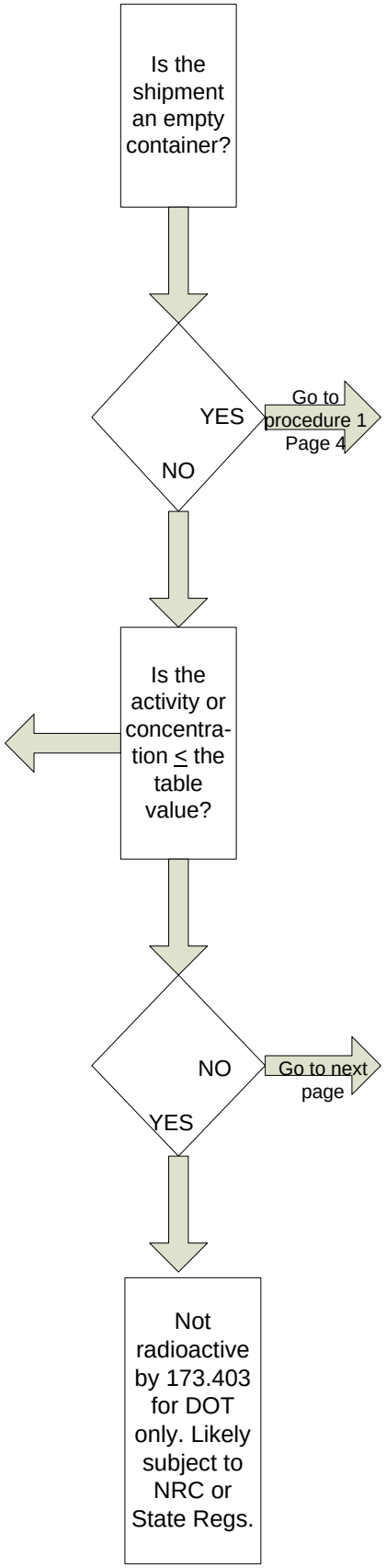
This document is an MS Word Form and as such you can add isotopes to the tables if the ones you ship are not listed. Be sure that you check the units in the table, they are not necessarily the ones used in 49 CFR and in the case of the table for limited quantities [second one] calculations are made. I strongly suggest you have somebody double check your work and you triple check it.

Subpart H – Training – Requires Hazmat employees (personnel that ship hazardous materials) to be trained initially and every three years. This document does not address training.

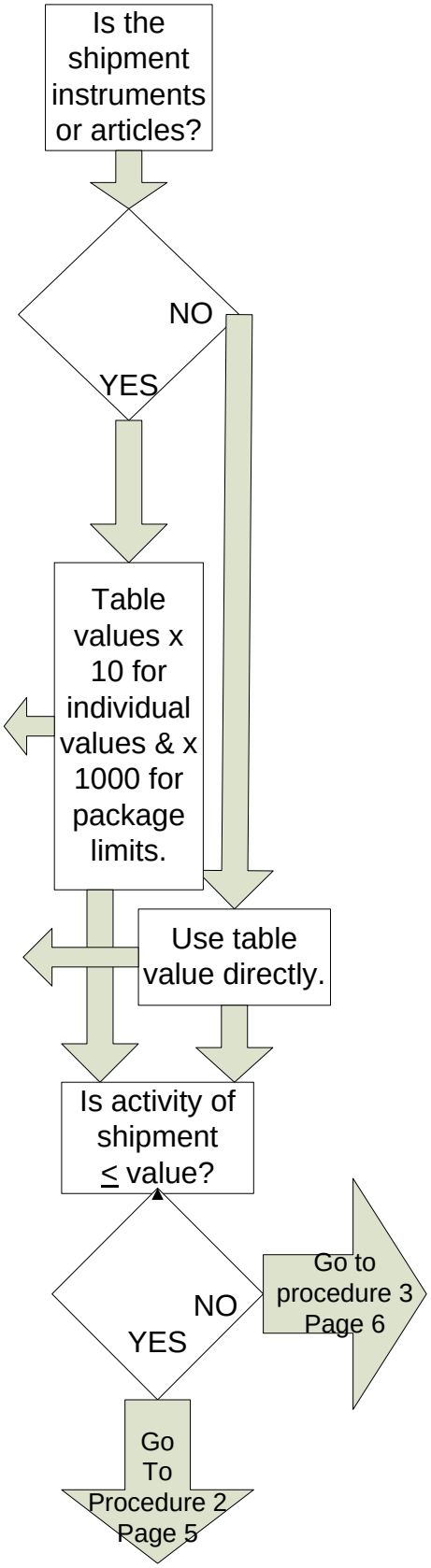
I would like to thank Jim Herrold of the University of Wyoming, Laramie, Paul Ward, Federal Emergency Management Agency [FEMA], Karen Sheehan, Fox Chase Cancer Center, Philadelphia, Susan Masih, University of Missouri at Kansas City, and Walter (Buddy) Furr, VA Durham, NC for their expert help in reviewing and preparing this manual.

Peter G. Vernig,
RSO, Eastern Colorado HCS

173.403 Radioactive Materials Definition (Consignment) and 173.433. Values taken from Table 173.436		
Isotope	Conc. Bq/g [Ci/g] (nCi/g)	Act. MBq (uCi)
H-3	1×10^{6} [2.7×10^{-5}](27uCi)	1000 (27 mCi)
C-14	1×10^{4} [2.7×10^{-7}] (270)	10 (270)
F-18	10 [2.7×10^{-10}] (0.27)	1.0 (27)
Na-22	1×10^{1} [2.7×10^{-10}] (0.27)	1.0 (27)
P-32	1×10^{3} [2.7×10^{-8}] (27)	0.1 (2.7)
P-33	1×10^{5} [2.7×10^{-6}] (27 uCi)	100 (2.7 mCi)
S-35	1×10^{5} [2.7×10^{-6}] (27 uCi)	100 (2.7 mCi)
Ca-45	1×10^{4} [2.7×10^{-7}] (270)	10 (270)
Cl-36	1×10^{4} [2.7×10^{-7}] (270)	1.0 (27)
Co-57	1×10^{2} [2.7×10^{-9}] (2.7)	1.0 (27)
Co-60	1×10^{1} [2.7×10^{-10}] 0.27)	0.1 (2.7)
Ga-67	1×10^{2} [2.7×10^{-9}] (2.7)	1.0 (27)
Sr-85	1×10^{2} [2.7×10^{-9}] (2.7)	1.0 (27)
Sr-89	1×10^{3} [2.7×10^{-8}] (27)	1.0 (27)
Mo-99	1×10^{3} [2.7×10^{-9}] (2.7)	1.0 (27)
Tc-99m	1×10^{2} [2.7×10^{-9}] (2.7)	10 (270)
In-111	1×10^{2} [2.7×10^{-9}] (2.7)	1.0 (27)
I-123	1×10^{2} [2.7×10^{-9}] (2.7)	10 (270)
I-125	1×10^{3} [2.7×10^{-8}] (27)	1.0 (27)
I -131	1×10^{2} [2.7×10^{-9}] (2.7)	1.0 (27)
Ba-133	1×10^{2} [2.7×10^{-9}] (2.7)	1.0 (27)
Cs-137	10 [2.7×10^{-10}] (0.27)	0.01 (0.27)
Xe-133	1×10^{3} [2.7×10^{-8}] (27)	0.01 (0.27)
Sm-153	1×10^{2} [2.7×10^{-9}] (2.7)	1.0 (27)
Tl-201	1×10^{2} [2.7×10^{-9}] (2.7)	1.0 (27)
U-238	10 [2.7×10^{-10}] (0.27)	0.01 (0.27)
$U_{\text{nat or dep}}$	1.0 [2.7×10^{-11}] (0.027)	0.001 (0.027)



173.425 Activity Limit for Limited Quantities…(Pkg) Values excerpted from Table 4 and 173.435 A_2 values.		
Isotope	Act. GBq (mCi)	Conc. GBq/g (mCi/g)
H-3	37 (1 Ci)*	
C-14	3.0 (81)	0.16 (4.5)
F-18	0.6 (16)	3.5×10^{6} (9.5×10^{7})
Na-22	0.5 (14)	230 (6300)
P-32	0.5 (14)	1.1×10^{4} (2.9×10^{5})
P-33	1.0 (27)	5.8×10^{3} (1.6×10^{5})
S-35	3.0 (81)	1.6×10^{3} (4.3×10^{4})
Ca-45	1.0 (27)	6.6×10^{2} (1.8×10^{4})
Cl-36	0.6 (16)	1.2×10^{-3} (3.3×10^{-2})
Co-57	10 (270)	3.1×10^{2} (8.4×10^{3})
Co-60	0.4 (11)	42 (1.1×10^{3})
Ga-67	3.0 (81)	2.2×10^{4} (6.0×10^{5})
Sr-85	2.0 (54)	8.8×10^{2} (2.4×10^{4})
Sr-89	0.6 (16)	1.1×10^{3} (2.9×10^{4})
Mo-99	0.6 (16)	1.8×10^{4} (4.8×10^{5})
Tc-99m	4.0 (110)	1.9×10^{5} (5.3×10^{6})
In-111	3.0 (81)	1.5×10^{4} (4.2×10^{5})
I-123	3.0 (81)	7.1×10^{4} (1.9×10^{6})
I-125	3.0 (81)	6.4×10^{2} (1.7×10^{4})
I -131	0.7 (19)	4.6×10^{3} (1.2×10^{5})
Ba-133	3.0 (81)	9.4 (2.6×10^{2})
Cs-137	0.6 (16)	3.2 (87)
Xe-133	10 (270)	6.9×10^{3} (1.9×10^{5})
Sm-153	0.6 (16)	1.6×10^{4} (4.4×10^{5})
Tl-201	4.0 (110)	7.9×10^{3} (2.1×10^{5})
U-238	Unlimited	1.2×10^{-8} (3.4×10^{-7})
U_{nat}	Unlimited	2.6×10^{-8} (7.1×10^{-7})
* As tritiated water.		



Procedure 1, EMPTY PACKAGE

Limitations –
(173.428 – 173 421 (2) (3) &(5))

- Radiation at surface < 0.5 mrem/h (0.005 mSv/h)

- Removable Contamination [173.443(a)]

< 220 dpm/cm^2 (For beta/gamma & low toxicity alpha if not divide by 10. If you have not established the efficiency of your wipe procedure you must assume an efficiency of 10%. (Alternately use 22 dpm/cm2 as the limit) [173.443 (a) (1)]

- No fissile material see 173.453 for possible exception.

- Unimpaired securely closed.

- Internal contamination < 22,000 dpm/ cm^2.

- Previous shipping labels removed or obliterated & "EMPTY" w/1 inch lettering and 6 x 6 inch size (172.450) must be applied

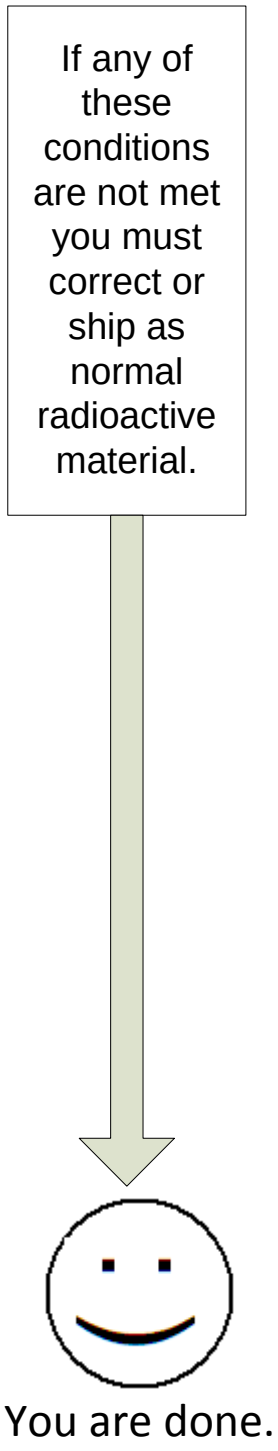
- "UN 2908" label required (173.422 (a)

- If a hazardous substance or waste, shipping papers required.(172 subpart C)

Packaging – N/A

Labeling – "EMPTY" and "UN 2908" as above.

Shipping papers – Not required unless hazardous substance or waste.



- Shipping papers – Not required unless hazardous substance or waste.

Procedure 2 - EXCEPTED PACKAGE SHIPPING

Limitations – 173.421

- Activity limits listed on page 3 and were determined from 173.425 table 4 and 173.435 Activity Limits… with suitable adjustments. (a)
- Package can be easily handled, has smooth surface, can withstand vibration and acceleration and for air shipments can withstand temperature range of -40 C (-40 F) to 55 C (131 F) and containers of liquids can withstand pressure differential of 95 kPa (13.8 lb/in^2) 173.410
- Radiation level at surface does not exceed 0.5 mrem/h (0.005 mSv/h). Not explicit but implied no detectable radiation @ 1 m. 173.403
- Removable radioactive material does not exceed 220 dpm/cm^2 (4 Bq/cm^2) for beta, gamma and low toxicity alpha emitters or 1/10th for other isotopes. If you have not established the efficiency of your wipe procedure you must assume an efficiency of 10%. (Alternately use 22 dpm/cm2 as the limit) [173.443 (a) (1)]. 173.443 contains additional requirements for exclusive use vehicles not generally used in academic or medical facilities.]

If hazardous material or waste must meet 172 subpart C shipping papers.

- Additional requirements for excepted instruments and articles.
  - Radiation level at 10 cm (4 in) of unpackaged instrument is not > than 10 mrem/h (0.1 mSv/h) 173.424 (d)
  - Radioactive material is completely enclosed. A sealed source may not be considered an article. 173.424 (e)
- Packaging – IP 1 package 173.410
- Marking – The outside of the inner package or if none the package is marked “Radioactive”. 173.421(4)
- The package does not contain fissile material unless excepted by 173.453.
- Outside marked with “UN 2910” (173.421(6) → 173.422 (a) → 172.101)

If any of these conditions are not met you must correct or ship as normal radioactive material.

Procedure 3 NORMAL RADIOACTIVE SHIPMENT
Limitations – For Type A Packages – Type B Packages are not covered here.

Activity Limits -

173.431 Activity Limits for Type A… Values excerpted from 173.435 A_2 values.		
Isotope	Act. TBq (Ci)	Conc. TBq/g (Ci/g)
H-3	40 (1,100)	360 (9700)
C-14	3.0 (81)	0.16 (4.5)
F-18	0.6 (16)	3.5×10^{6} (9.5×10^{7})
Na-22	0.5 (14)	230 (6300)
P-32	0.5 (14)	1.1×10^{4} (2.9×10^{5})
P-33	1.0 (27)	5.8×10^{3} (1.6×10^{5})
S-35	3.0 (81)	1.6×10^{3} (4.3×10^{4})
Ca-45	1.0 (27)	6.6×10^{2} (1.8×10^{4})
Cl-36	0.6 (16)	1.2×10^{-3} (3.3×10^{-2})
Co-57	10 (270)	3.1×10^{2} (8.4×10^{3})
Co-60	0.4 (11)	42 (1.1×10^{3})
Ga-67	3.0 (81)	2.2×10^{4} (6.0×10^{5})
Sr-85	2.0 (54)	8.8×10^{2} (2.4×10^{4})
Sr-89	0.6 (16)	1.1×10^{3} (2.9×10^{4})
Mo-99	0.6 (16)	1.8×10^{4} (4.8×10^{5})
Tc-99m	4.0 (110)	1.9×10^{5} (5.3×10^{6})
In-111	3.0 (81)	1.5×10^{4} (4.2×10^{5})
I-123	3.0 (81)	7.1×10^{4} (1.9×10^{6})
I-125	3.0 (81)	6.4×10^{2} (1.7×10^{4})
I -131	0.7 (19)	4.6×10^{3} (1.2×10^{5})
Ba-133	3.0 (81)	9.4 (2.6×10^{2})
Cs-137	0.6 (16)	3.2 (87)
Xe-133	10 (270)	6.9×10^{3} (1.9×10^{5})
Sm-153	0.6 (16)	1.6×10^{4} (4.4×10^{5})
Tl-201	4.0 (110)	7.9×10^{3} (2.1×10^{5})

Procedure 3 Normal Radioactive Shipment continued next page.

Radiation Limits – See Labeling page 8.

Removable radioactive material may not exceed 220 dpm/cm^2 (4 Bq/cm^2 for beta, gamma and low toxicity alpha emitters or 1/10^{th} for other isotopes. (3) (e) wipe procedure you must assume an efficiency of 10%. (Alternately use 22 dpm/cm2 as the limit) [173.443 (a) (1)]
[173.443 contains additional requirements for exclusive use vehicles not generally used in academic or medical facilities.]

If hazardous material or waste must meet 172 subpart C shipping papers.

Shipping Papers –
173.433 (g) → 172.203(d)

- Must include the name or abbreviation of each nuclide.
- A description of the physical and chemical form.
- The activity in SI units or abbreviations.
- The category of label, "Radioactive White I; Radioactive Yellow II; or Radioactive Yellow III.

Material pertaining to fissile materials left out. 172.203 (d)(7)
Material on the use of type B containers left out (8)
Material on the use of exclusive use left out (9)
Material on highway route controlled quantities left out (10)

Certification – One of the following certifications must be entered on the shipping papers –

- ***This is to certify that the above named [herein-named] materials are properly classified, described, packaged, marked and labeled, and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.***

- I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, described, packaged, marked and labeled, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. 172.204

- Emergency response telephone number – An emergency response telephone number must be supplied that is monitored at all times by a person who is knowledgeable in radiation safety, emergency response, and incident mitigation or by a person who has access to a similarly knowledgeable person must be entered on the shipping papers. A number that requires a callback is not sufficient. 172.604

- Marking – Package must be marked either "USA Type A" or "Type A" and "USA". Marking must be 0.5 inches (13 mm) high. 173.310

- Labeling – 172.403 Exceptions 173.421 Exempt quantities and 427 LSA

Transport Index	Maximum Radiation at Surface mrem/h (mSv/h)	**Label Category**
0	≤ .5 (0.005)	***White I***
≥ 0 but ≤ 1	≥ 50 (0.5) but ≤ 200 (2)	***Yellow II***
> 10	≥200 (2) but ≤ 1000 (10)	***Yellow III***
Any highway route control quantities must be Yellow III If measured value is less than 0.05 then it may be considered 0 Transport Index is = dose in mrem/h (mSv x 100) at 1 meter. 173.403 (b) & (c)		

- Two of the above labels are required placed on opposite sides. (f)
- The labels are standard and are described in 172.436 White I, 172.438 Yellow II, and 172.440 yellow III.
- The following is entered on the labels
    - Isotope (abbreviations)
    - Activity in SI units
    - Transport Index for Yellow II and Yellow III labels.
- Cargo only Aircraft label is required for Yellow II and III labeled shipments where the transport index is > 3.0.

175.700 (a) & 172.448.

    - Transport Index on Yellow II & III

(172.403 (g) (1), (2), &(3) Information on over pack (g) is omitted.)
(172.407 Placement of labels omitted.)

- Radioactive Labels must be 100 mm [4 in] on a side. Label specs 172.407 largely taken care of by using standard adhesive labels.
- The shipper must insure that the package meets the design requirements, the effectiveness of shielding and containment and is proper for shipment and unimpaired physically. 173.474 and 475. Detail is omitted.
- For shipment by air, packages should be labeled additionally with “Cargo Only” label. 172.402 (c), 172.448
- All White Label I packages and Yellow II and III packages which have transport indexes ≤ 3 can be shipped by passenger airplane. It is not recommended unless essential. Such packages need not be labeled with “Cargo Only”. 175.700

- Packaging –

173.410, 411, 412

    - Package must meet the tests specified in 173.465 & 466 and shipper must retain a copy of test documentation. 173.415 (a)
    - Smallest external dimension must be > 4 inches (10 cm). 173.412 (b)
    - Must have a seal or other feature that provides evidence that the package has not been opened in transit. 173.412 (a)