RAM Transportation and Radiation Safety

Federal Railroad Administration

Hazardous Materials Seminar

Reno, Nevada

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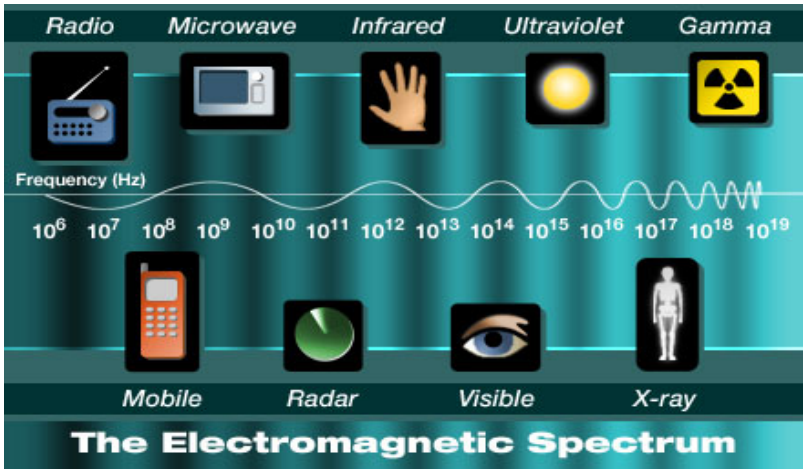
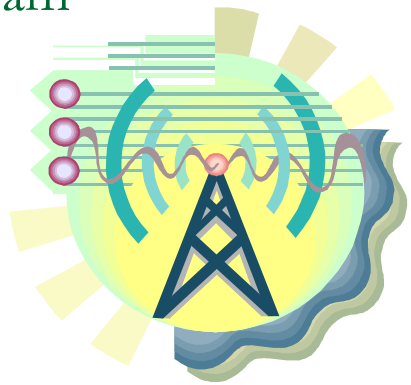
FRA Region 7 Hazmat/RAM Inspector

What is “Radiation”

- All parts of the electromagnetic spectrum are described as 'radiation', but not all radiation is the same.
  - At the top of the scale is **ionizing radiation**





“Ionizing Radiation”

- Has very high energy which can:
  - change a molecule's structure, or
  - can cause changes in human cells that potentially cause mutations and in some cases cancer.

“Ionizing Radiation” is produced by:

- radioactive decay,
- nuclear fission and nuclear fusion,
- extremely hot objects (thermal or blackbody radiation), and
- accelerated charges - X-rays, and gamma rays.

What are the three types of ionizing radiation?

Alpha Emission (α):

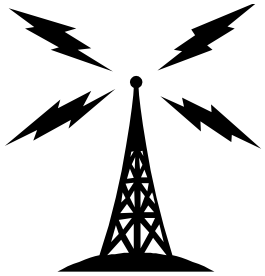
- A cluster of 2 neutrons and 2 protons, 4He2+, a helium nucleus
- Heavy, slow-moving (not of high energy), easily stopped by a sheet of paper or after a centimeters in air

Beta Emission (β):

- A fast moving, high energy electron, coming from a neutron decaying into a proton and an electron
- Can travel further than an alpha particle, a few meters in air or a sheet of aluminum is needed to stop it

Gamma Emission (γ):

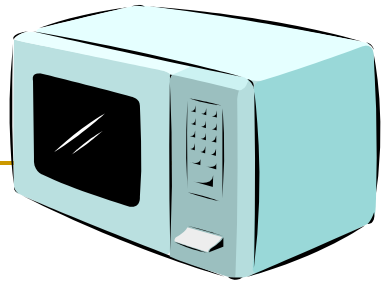
- Not a particle, but a burst of very high energy as electromagnetic radiation of a very high frequency
- Very dangerous, requires robust shielding such as thick/dense lead or concrete to drastically reduce exposure.



“Non-ionizing Radiation” includes:

- radio waves, such as in mobile phones, broadcast TV and radio stations,
- microwaves, like that produced by microwave ovens and used in radar (remember the Radar Range?).
- infrared, UV and visible light.

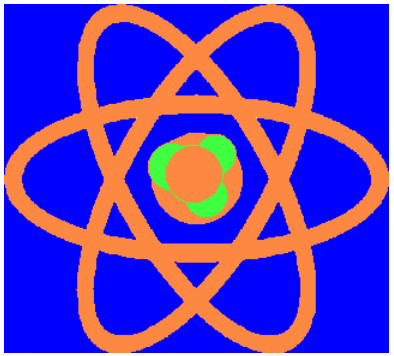
- These types of radiation are at the lower end of the spectrum.
- They have very low energies, and do not have the ability to alter matter, so they are classed as **non-ionizing radiation**.



"Radiation"

For purposes of this presentation, when the term "radiation" is used, it means

Ionizing Radiation.



Radiation Protection Principles

- You may be exposed to radiation in two general ways:
  - externally from being close to or in contact with radioactive material or sources;
    or
  - internally from radioactive material deposited in the body.

It is important to understand the difference between contamination and exposure when talking about radiation.

Radiation Protection Principles

Think of a bonfire as an analogy …

- Radioactive contamination occurs when radioactive material is deposited on or in an object or a person.
  - Radioactive materials released into the environment (like the smoke and embers from a bonfire) can cause air, water, surfaces, soil, plants, buildings, animals, or people to become contaminated.
  - A contaminated person has radioactive materials on or inside their body (like inhaling smoke or getting covered in soot from the bonfire.

What is Radiation Exposure?

- Radioactive materials give off energy that travels in waves or particles.
  - These waves or particles are called ***radiation.***
- When a person is **exposed** to radiation, the energy from the waves or particles penetrates the body.
  - For example, when a person has an x-ray, he or she is exposed to radiation.

    Think of the heat from a bonfire … this is like exposure …
  - the closer you get the hotter it is,
  - the bigger the fire the hotter it feels at the same place.

How Does Contamination Differ From Exposure?

- A person exposed to radiation is not necessarily contaminated with radioactive material.
- A contaminated person is exposed to radiation released by the radioactive material on or inside their body.
- An uncontaminated person can be exposed by being too close to radioactive material or a contaminated person, place, or thing.
- Ability to prevent contamination is why it is so important to prevent a NAR from occurring by ensuring that the package containing the radioactive material is securely closed, and will remain so, for transportation!!

More Definitions

- **REM** **R**oentgen **E**quivalent **M**an, a unit used in radiation protection.
  - It is used to measure the amount of damage to human tissue from a dose of ionizing radiation.
  - The REM incorporates the health risks from radiation.
  - It provides a common unit for measuring human radiation doses.
  - You will usually see it expressed as millirems.

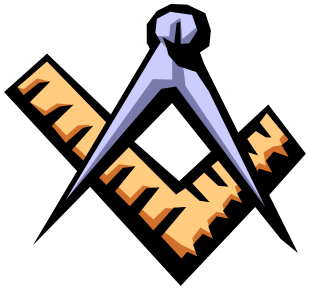
    1 REM = 1,000 millirems (also mrem).

Definitions (continued)

- **mrem/hr** or **mr/h** - millirem/hour
  - This is a measure of radiation exposure rate.
  - It tells us how fast you are being exposed.
- **Exposure Dose –** the term used to define exposure intensity over time.
  - Directly proportional to:
    - the "strength" of the radiation field at a particular location (as measured in mrem/hr), and
    - the time spent in that specific field.
- ***Exposure Rate at the Source***: One of the most important factors in defining exposure is the "strength" (activity, mR/hr, etc.) of the radiation source.
  - This is like the heat from the bonfire … the bigger (stronger)it is the more intense the heat.
  - When the strength or “activity” of the radioactive material or generator is low, the radiation dose received will be lower.

Radiation Protection Concepts

- The external dose a person receives when near a radioactive material or source depends on three factors:
  - Time.
  - Distance.
  - Shielding.



Radiation Protection Concepts

- ***Time:*** The total dose you get from an external source directly depends on the time of exposure to the source.

- ***Distance:*** By increasing the distance between you and the source of exposure, the dose you receive can be significantly reduced.

Radiation Protection Concepts

- ***Time – some examples:***
  Let's say you're standing in a location where the radiation activity level is measured at 20 millirem per hour (mrem/h), and;
  - You stay at that location for 1 hour, your dose would be 20 mrem.
  - If you stay in the same spot for only 15 minutes then your dose would be 5 mrem.

  Note: Any time spent near a source (***in a known radiation field)*** should be minimized and used effectively.

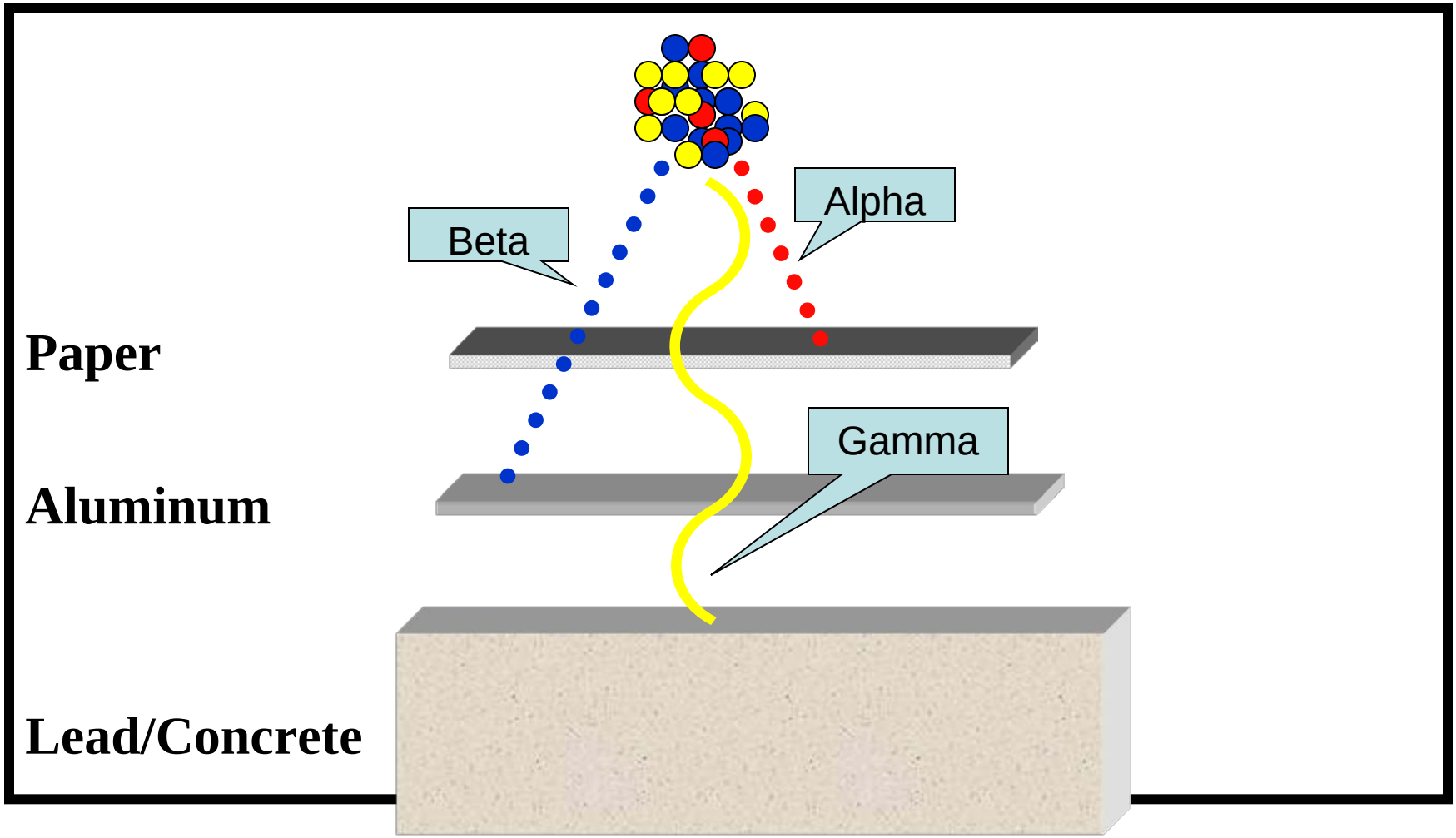
Radiation Protection Concepts

- ***Distance – some examples:***
  - When you double your distance from a radiation source, the dose rate at the further distance will drop to one-fourth the level that it would be at the closer distance. (The Inverse Square Rule)
    - if the level of gamma radiation 6 inches from the source, is 60 mr/h
    - the dose rate at 12 inches would be 15 mr/h.
    - at 24 inches the rate will be 3.5 mr/h.

Radiation Protection Concepts

- ***Shielding:*** When radiation sources are used, absorbing material or shields are usually used to reduce exposure levels.
  - Any material between the source and you causes some of the energy to be absorbed by that material (the shielding) so the energy doesn't reach you.
  - Keep in mind that some high energy ionizing radiation will always get through shielding.
  - The specific shielding material and thickness will be based on the intensity and type of radiation involved.
  - Packaging used for the transport of RAM offers some level of shielding.

What shielding is needed for the three types of radiation?



Radiation Safety Rules

- The basic objective of radiation protection measures are:
  - to limit entry into the body, or
  - exposure to external radiation,

  to quantities as low as reasonably achievable (ALARA) and always within established limits.

- The radiation safety rules that follow generally apply to potential exposures to RAM **as well as** other industrial chemicals and materials.

Radiation Safety Rules

1. Eating, drinking, smoking, and the application of cosmetics are prohibited in areas where RAM are suspected or known to be present.
2. Protective gloves shall be worn when handling contaminated or potentially contaminated items.
3. Hands should be washed thoroughly after handling or touching items that may be contaminated with RAM, especially before eating.
4. It is wise to wear Personal monitoring devices when working around radioactive materials or in areas where radiation fields (above background radiation) may exist.

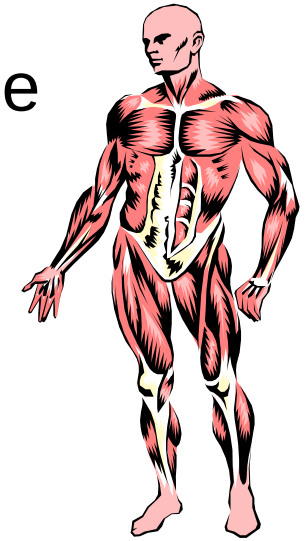
Radiation Safety Rules

5. Follow the established emergency procedures in the case of an accident involving RAM:

   - Get out of the area as quickly and safely as possible.
   - Get upwind of the accident scene if possible.
   - Consult the incident commander or other responders to determine if any contamination has escaped.
   - Notify your supervisor or appropriate on scene personnel if it appears you have been contaminated.

Radiation Safety

The OSHA maximum limit for exposure to the



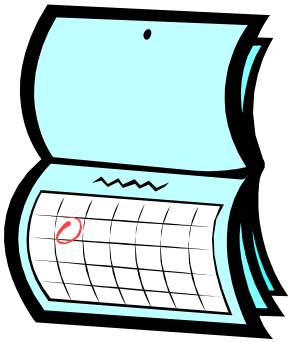
- whole body, head and trunk,
- active blood-forming organs(bone marrow),

Red Blood Cell

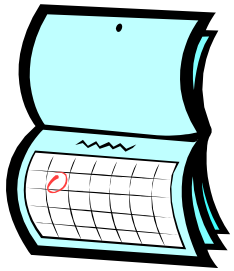
- lens of eyes,

- or gonads

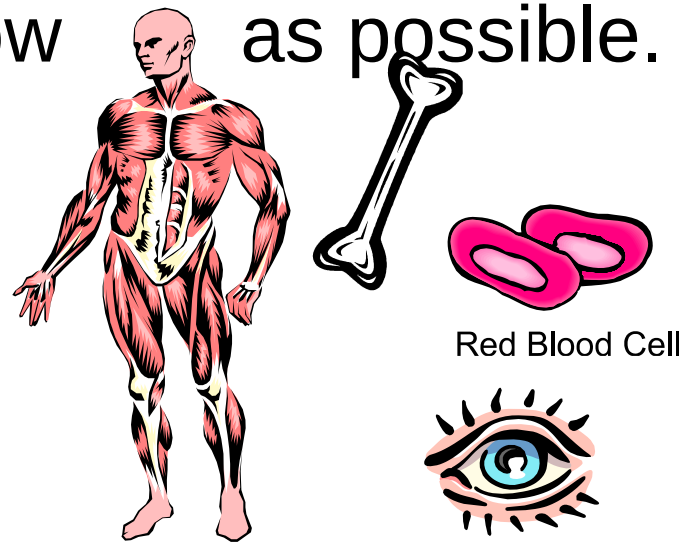
is 1250 mrem a quarter (90 days) / 5000 mrem (5 rem) a year.



Radiation Safety



Regardless of the OSHA maximum radiation exposure limits one should always practice ALARA and keep ones exposure limits as low as possible.



- The permissible radiation emission levels for the different categories of RAM shipments are based on the radiation level measured in mSv/hr (millisieverts/hour) or mrem/hour (millirem/hour) – 1mSv/hr = 100 mrem/hr

- The radiation levels that dictate which RAM category is applicable is based on the maximum radiation level at the surface of the package.

Packages are labeled based on the DOT radiation level limits at the package surface.

- **Radioactive White-1- less than or = to 0.005mSv/hr (0.5 mrem/hr) at package surface – No Transport Index (TI) - Almost no radiation**
- **Radioactive Yellow- II – greater than 0.005 mSv/hr (0.5 mrem/hr) but less than or = to 0.5 mSv/hr (50 mrem/hr) at package surface – TI of 1 or less at 1 meter (3.3 ft) -- Low radiation**
- **Radioactive Yellow- III – greater than 0.5 mSv/hr (50 mrem/hr) but less than or = to 2mSv/hr (200 mrem/hr) at package surface – TI of more than 1 but not more than 10 at 1 meter (3.3 ft.) - Higher radiation**

- The Transportation Index (TI) can be an indicator of how much radiation can be expected at 1 meter (3.3 ft.) from the package.

Some other marking that's important –

- If the RAM **packages** themselves are contained within a conveyance, then the outside of the conveyance; the container, the rail car, trailer or intermodal container, may have only a RAM placard on it that does identify specific contents, activity and TI, as the label does.

- **TIME**

  - **How long can you work in a known radiation field and still be safe?**
    - Lets take look at an example where you need to work near a package or railcar that has a Type III label (using the maximum 2 mSv/hr (200mrem/hr) limit at the package surface.
    - We know that the exposure rate decreases with distance and in this example the radiation level at one meter (3.3 feet) is 1 mSv/hr (10 mrem/hr).
    - You need to get within about 2 feet of the package.

- **Here is a little table of exposure rates versus distance.**
- **As we can see, when you get closer, your rate of exposure goes up.**
- **In this case at 2 feet it is up to about 27 mrem/hr.**

Distance vs Exposure Rate

meters	feet	mr/h
0.3048	1.00	107.64
0.5	1.64	40.00
0.6096	2.00	26.91
0.9144	3.00	11.96
1	3.28	10.00
1.524	5.00	4.31
2	6.56	2.50
3	9.84	1.11
3.048	10.00	1.08

- **Now, here is a little table of exposure dose versus time.**
- **Remember, you can limit your exposure dose by also limiting the time you spend at an exposure rate, in this case 27 mrem/h.**
- **If you spend 5 minutes in this location, your dose for that time is 2.25 mrem.**

Time vs Exposure Dose @27 mr/h

Time	Dose(mrem)
1 minute	0.45
2 minutes	0.90
3 minutes	1.35
5 minutes	2.25
10 minutes	4.50
15 minutes	6.75
20 minutes	9.00
30 minutes	13.50
45 minutes	20.25
60 minutes	27.00

How long can you work and still be safe?

- From our example, you could do the same task 133 times before reaching a quarterly limit of 300 mrem dose,

- … and if we use the OSHA quarterly limit of 1250 mrem, this same task could be done over 500 times and still be within the OSHA limit.

FRA HQ Radiation Safety Personnel

- Radiation Safety Officer
  - Alan Misiaszek - Sr. Industrial Hygienist
- Associate Radiation Safety Officer
  - Kevin Blackwell
    Hazardous Materials/Radioactive Materials
    Program Specialist

Transportation of Radioactive Materials by Rail

Shipping Paper Information

Waybill: 299973 Date: 5/02/07

****
* HAZARDOUS *
****

MHFX 5347 J J302 RR 1 5/02/07 299973
BPRRGS F10

5407

STOP
THIS
CAR
AT

20963 HENDERSON CO 39 WEST VALLEY NY

BPRR NEWCA CSXT CHGO BNSF S CSXT 83894 F9
RW07073 BM
BOL Date 3/29/07 BOL Time 10:29

CONSIGNEE
CAST TRANSPORTATION (ON BNSF)
VIA TRANSLOAD AT CAST
TRANSPORTATION
HENDERSON CO 80640

SHIPPER
WEST VALLEY NUCLEAR SERVICES ON
BEHALF OF US DOE
10282 ROCK SPRING RD
WEST VALLEY NY 14171

FREIGHT BILL PARTY
MHF LOGISTICAL SOLUTIONS, INC.
800 CRANBERRY WOODS DRIVE
SUITE 450
CRANBERRY TWP PA 16066

NH Do Not Hump

Shipper cert scale weight
Gross 247,510
Tare 57,100 Sec.7 NO

Net 190,410 Prepaid

IN-BOND TYPE: Blank

49 501 50
FAK - CONTAINS

FAK - CONTAINS / 30 TOTAL PACKAGES = 190410 LBS.
"EXCLUSIVE USE SHIPMENT" RW07073
SPECIFIC INSTRUCTIONS:
*THE TRANSPORT VEHICLE MAY NOT BE RETURNED TO
SERVICE UNTIL THE RADIATION DOES RATE AT EACH
ACCESIBLE SURFACE IS 0.5 MREM PER HOUR OR LESS, &
THERE IS NO SIGNIFICANT REMOVABLE (NON-FIXED)
RADIOACTIVE SURFACE CONTAMINATION AS SPECIFIED IN
PARAGRAGH (A) OF 49 CFR 173.443.
*WHEN TRANSFERING RAILCAR FROM ORIGINATING CARRIER
, A COPY OF THESE PROVISIONS IS REQUIRED FOR EACH
CONNECTING CARRIER.
*DO NOT LOAD OTHER PACKAGES INTO GONDOLA RAILCAR.
*IF THE CARRIER NEEDS TO CONTACT WVNSCO, CALL
WVNSCO SHIFT SUPERVISOR AT (716) 942-4400.

HAZARDOUS INFO
30 Package

MHFX 5347

HAZARDOUS INFO
190410 Pound
RADIOACTIVE MATERIAL,
LOW SPECIFIC ACTIVITY
(LSA-II)
7
UN3321
RQ(PU-239, AM-241, PU-240) (PU-238, PU-241, CM-245)
SOLID METAL OXIDES, FISSILE EXCEPTED
RADIOACTIVE YELLOW-III, DB0033: TI=7.6;
DB0058: TI=8.4; DB0093: TI-1.1; DB0102: TI=1.3;
DB0120: TI=3.3; DB0130: TI=4.2; DB0131: TI=3.2;
DB0156: TI=3.0; DB0160: TI=1.1; DB0162: TI=1.3;
DB0164: TI=1.1; DB0188: TI=3.0; DB0210: TI=8.2;
DB0211: TI=3.1; DB0216: TI=5.2; DB0220: TI=6.5;
DB0481: TI=5.3; DB0482: TI=6.9; DB0483: TI=2.5;
DB0484: TI=7.1; DB0485: TI=1.2; DB0486: TI=1.1;
DB0488: TI=1.4; DB0489: TI=1.1; DB0490: TI=4.8
DB0762: TI=2.9; DB0764: TI=2.9; DB0765: TI=3.0
DB0769: TI=2.4; DB0770: TI=3.1
93.2 GBQ PER PACKAGE/LIFT -LINER, TOTAL ACTIVITY:
2.80 TBQ
EMERGENCY CONTACT:
(716) 942-4400
HAZMAT STCC=4929137
****
********** END OF HAZMAT DATA **********

Notify party on arrival 1
ROB WOODBURN
PHONE NUMBER: (724) 772-9800 X 5534

Shipping Paper Information

49 CFR §172.101 Hazardous Materials Table

- **Authorizes 20 Proper Shipping Names for Radioactive Materials**

7//UN2909	**Radioactive material, excepted package-articles manufactured from natural uranium [or] depleted uranium [or] natural thorium**
7//UN2908	**Radioactive material, excepted package-empty packaging**
7//UN2911	**Radioactive material, excepted package-instruments [or] articles**
7//UN2910	**Radioactive material, excepted package-limited quantity of material**
7//UN2912	**Radioactive material, low specific activity (LSA-I) [non fissile or fissile-excepted]**
7//UN3321	**Radioactive material, low specific activity (LSA-II) [non fissile or fissile-excepted]**
7//UN3322	**Radioactive material, low specific activity (LSA-III) [non fissile or fissile excepted]**

Shipping Paper Information

7//UN2913	**Radioactive material, surface contaminated objects (SCO-I [or] SCO-II) [non fissile or fissile-excepted]**
7//UN2919	**Radioactive material, transported under special arrangement, [non fissile or fissile excepted]**
7//UN3331	**Radioactive material, transported under special arrangement, fissile**
7//UN3327	**Radioactive material, Type A package, fissile [non-special form]**
7//UN2915	**Radioactive material, Type A package [non-special form, non fissile or fissile-excepted]**
7//UN3332	**Radioactive material, Type A package, special form [non fissile or fissile-excepted]**
7//UN3333	**Radioactive material, Type A package, special form, fissile**
7//UN3329	**Radioactive material, Type B(M) package, fissile**
7//UN2917	**Radioactive material, Type B(M) package [non fissile or fissile-excepted]**
7//UN3328	**Radioactive material, Type B(U) package, fissile**

Shipping Paper Information

7//UN2916 Radioactive material, Type B(U) package [non fissile or fissile-excepted]

7//UN2978 Radioactive material, uranium hexafluoride [non fissile or fissile-excepted]

7//UN2977 Radioactive material, uranium hexafluoride, fissile

Shipping Paper Information

Entries on Shipping Papers

Entries Always Required

- **The basic description, in sequence: U.N. Identification Number, Proper Shipping Name, Hazard Class (7) -- § 172.202(a)&(b)**
- **Proper page numbering (i.e., Page 1 of 4) -- §172.201(c)**
- **24 hour emergency response telephone number (Use of a number that requires a call back - e.g., answering machine - is not authorized) -- §172.201(d) and 172.604**
- **The total quantity of the material described (mass, volume, or activity) in appropriate units (lbs, mL.) §172.202(a)(5)**
- **The number and type of packages -- §172.202(a)(7)**

Shipping Paper Information

- **The name of each radionuclide (as determined by §173.435). The activity must be in SI (Standard International) units (e.g., Bq,TBq), and may be in customary units (e.g., Ci, mCi) in parentheses following SI units. Abbreviations are authorized. -- §172.203(d)(1)&(3)**

- **If not special form, a description of physical and chemical form -- §172.203(d)(2)**

- **For each labeled package: -The category of label used; the transport index of each package with a Yellow-II or Yellow-III label [§172.203(d)(5)]; the criticality safety index of a package with a Fissile label -- §172.203(d)(6)**

- **Shipper's certification (not required for private carriers) and signature -- [§172.204]**

Shipping Paper Information

Entries Sometimes Required

Materials-Based Requirements:

- **If Hazardous substance (§171.8), "RQ" as part of the basic description -- §172.203(c)(2)**
- **"Highway Route Controlled Quantity" or "HRCQ", entered in association with the basic description -- §172.203(d)(10)**
- **For a package containing fissile material, the words "Fissile Excepted", if the package is excepted by §173.453 or otherwise the criticality safety index for that package -- §172.203(d)(6)**
- **If the material is considered hazardous waste and the word "waste" does not appear in the shipping name, then "waste" must precede the shipping name (e.g., Waste Radioactive material, Type A package, 7, UN2915) -- §172.101(c)(9)**

Shipping Paper Information

Package-Based Requirements:

- **Package identification marking for DOE or NRC Certified packages (see §173.471) -- §172.203(d)(7)**

- **IAEA Certificate of Competent Authority ID number for export shipments or shipments using foreign-made packaging (see §173.473) -- §172.203(d)(8)**

Shipping Paper Information

Administrative-Based Requirements:

- **"Exclusive Use-Shipment" [§172.203(d)(9)]**
- **If a DOT exemption is being used, "DOT-SP "followed by the exemption number [§172.203(a)]**
- **"Cargo Aircraft Only“ -- § 172.203(f)**
- **If subsidiary hazard is present, the hazard class or division number -- § 172.202(a)(3)**

Shipping Paper Information

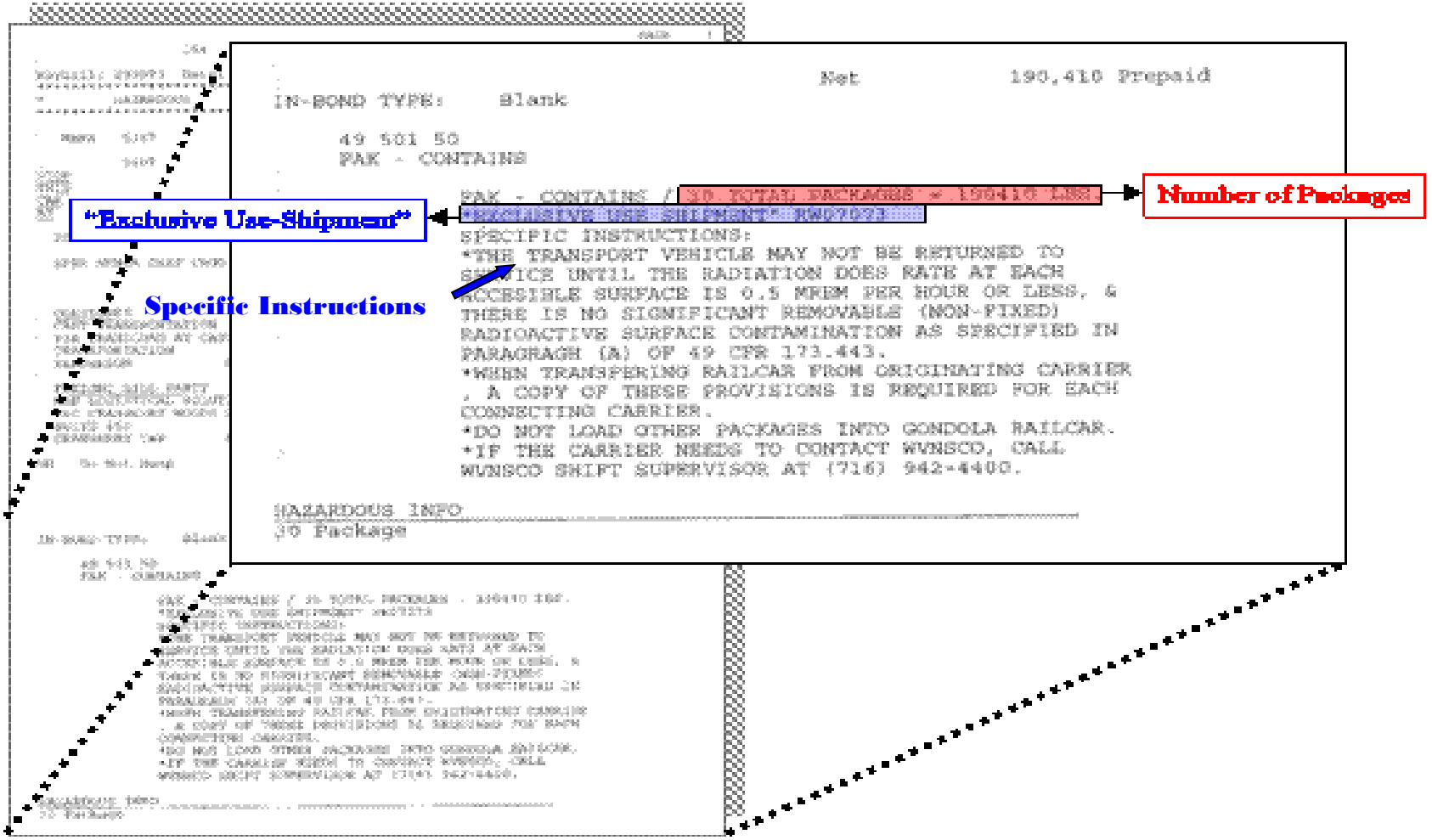
Optional Entries

- **Additional information is permitted (e.g., functional description of the product), provided it is not inconsistent with the required basic description -- §172.201(a)(4)**

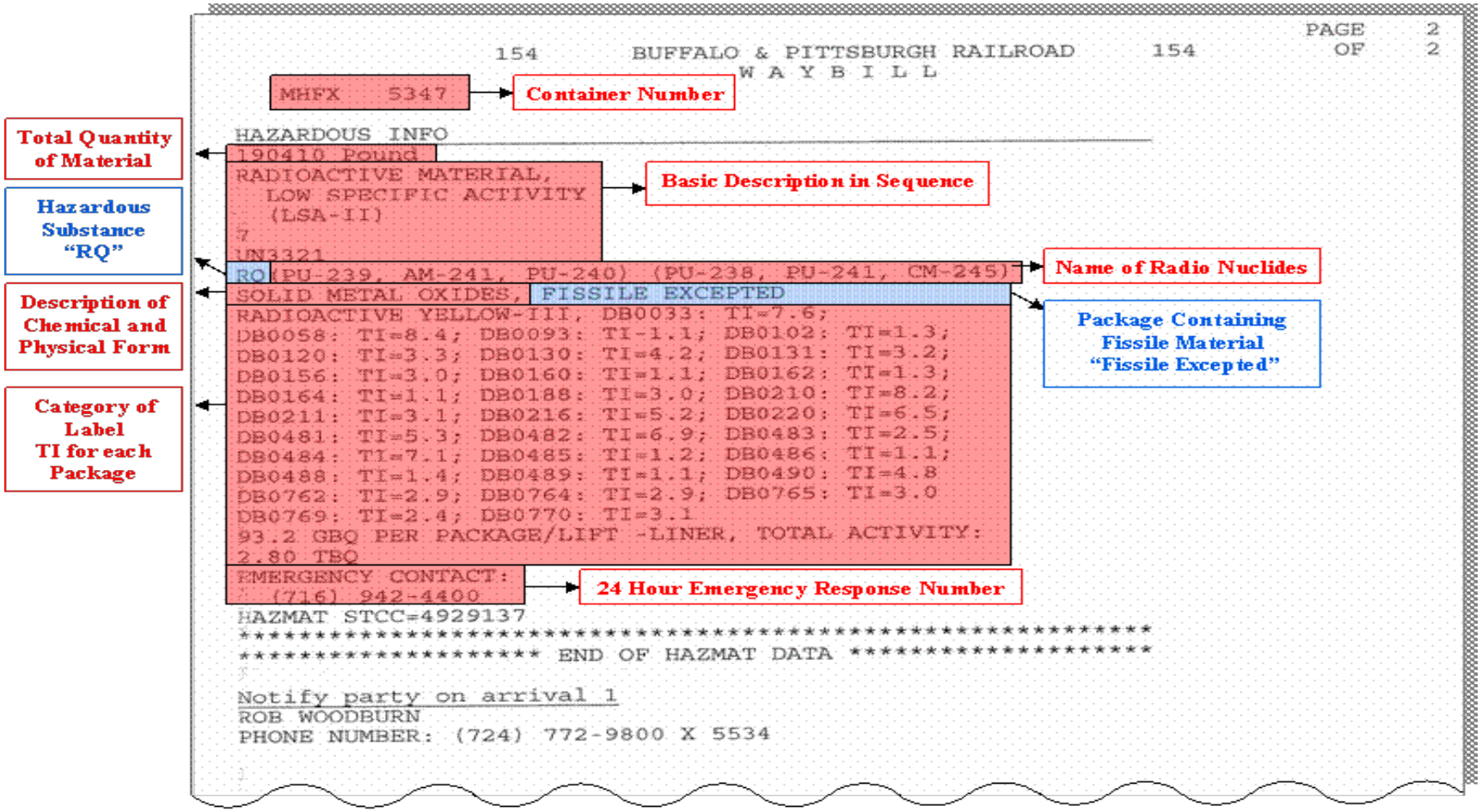
- **Except for Pu-239 and Pu-241,the weight in grams or kilograms of fissile radionuclide's may be inserted instead of activity units. For Pu-239 and Pu-241 the weight in grams of fissile radionuclide's maybe inserted in addition to activity units -- § 172.203(d)(3)**

- **Emergency response information must be entered on the shipping papers, or be a separate document carried with the shipping papers -- § 172.602(b)**

Shipping Paper Information



Shipping Paper Information



Marking Requirements

Marking Requirements

Package Markings

Markings Always Required

Bulk Packages

- **U.N. identification number on: - orange panels**
  §172.332(b)

- **White square-on-point display**
  §172.336(b)

Non-Bulk Packages

- **Proper shipping name**
  §172.301

- **U.N. identification number**
  §172.301

- **Name and address of consignor or consignee, unless truckload lot or freight container load, and entire contents of railcar, truck, or freight container are shipped from one consignor to one consignee**
  §172.301(d)

Marking Requirements

Excepted Packages

- **Proper shipping name**
  §172.301

- **U.N. identification number**
  §172.301

- **Name and address of consignor or consignee, *unless*: highway only and no motor carrier transfers, or part of carload or truckload lot or freight container load, and entire contents of railcar, truck, or freight container are shipped from one consignor to one consignee**
  §172.301(d)

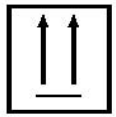
Marking Requirements

Additional Markings Sometimes Required

Materials-Based Requirements

- **Each package with a gross mass greater than 50 kg (110 lbs), must have its gross mass including the unit of measurement marked on the outside of the package**
  §172.310(a)

- **If non-bulk combination package containing liquid use, underlined double arrows indicating upright orientation (two opposite sides) [ISO Std 7801985 marking]**
  §172.312



Package-Based Requirements

- **The package type as TYPE IP-1, TYPE IP-2, TYPE IP-3, TYPE A, TYPE B(U) or TYPE B(M), as appropriate in letters 13 mm(0.5 in) high or greater**
  §172.310(b)

- **"USA DOT 7A Type A" for Specification 7A packagings**
  § 178.350 and markings required by § 178.3

Marking Requirements

- **For NRC approved Type B(U), B(M), or fissile material packages the package identification marking from the CoC (e.g., USA/9166/B(U), USA/9150/B(U)-85)**

  §173.471(b)

- **For Type B(U) or B(M) the trefoil symbol per 49CFR Part 172 App. B §172.310(d)**

- **Marked with the international vehicle registration code of the country of origin of the design, for IP-1,IP-2, IP-3, or a Type A package (e.g., USA)**

  §172.310(c)

- **For NRC certified packages, the model number, gross weight ,serial number, and package ID number 10 CFR 71.85**

Marking Requirements

Administrative-Based Requirements

- **If a DOT exemption is being used, the outside of the package must be marked "DOT-E", followed by the exemption number**

  §§172.301(c)) and 172.302(c)

- **Each Type B(U), B(M), or fissile material package destined for export, "USA" in conjunction with the specification markings or certificate identification**

  §172.310(e)

Special Considerations/Exceptions for Markings

- **Markings are required to be: (1) durable, printed in English on a package surface, label, tag, or sign; (2) displayed on a background of sharply contrasting color; (3) unobscured by labels or attachments; and (4) isolated from other marks (such as advertising)**

  §172.304

- **Shipment of LSA or SCO consigned as exclusive use by §173.427 are excepted from the marking requirements (i.e., proper shipping name and identification number) except that the exterior of each packaged or unpackaged material must be marked "Radioactive-LSA" or "Radioactive-SCO", as appropriate**.

Marking Requirements

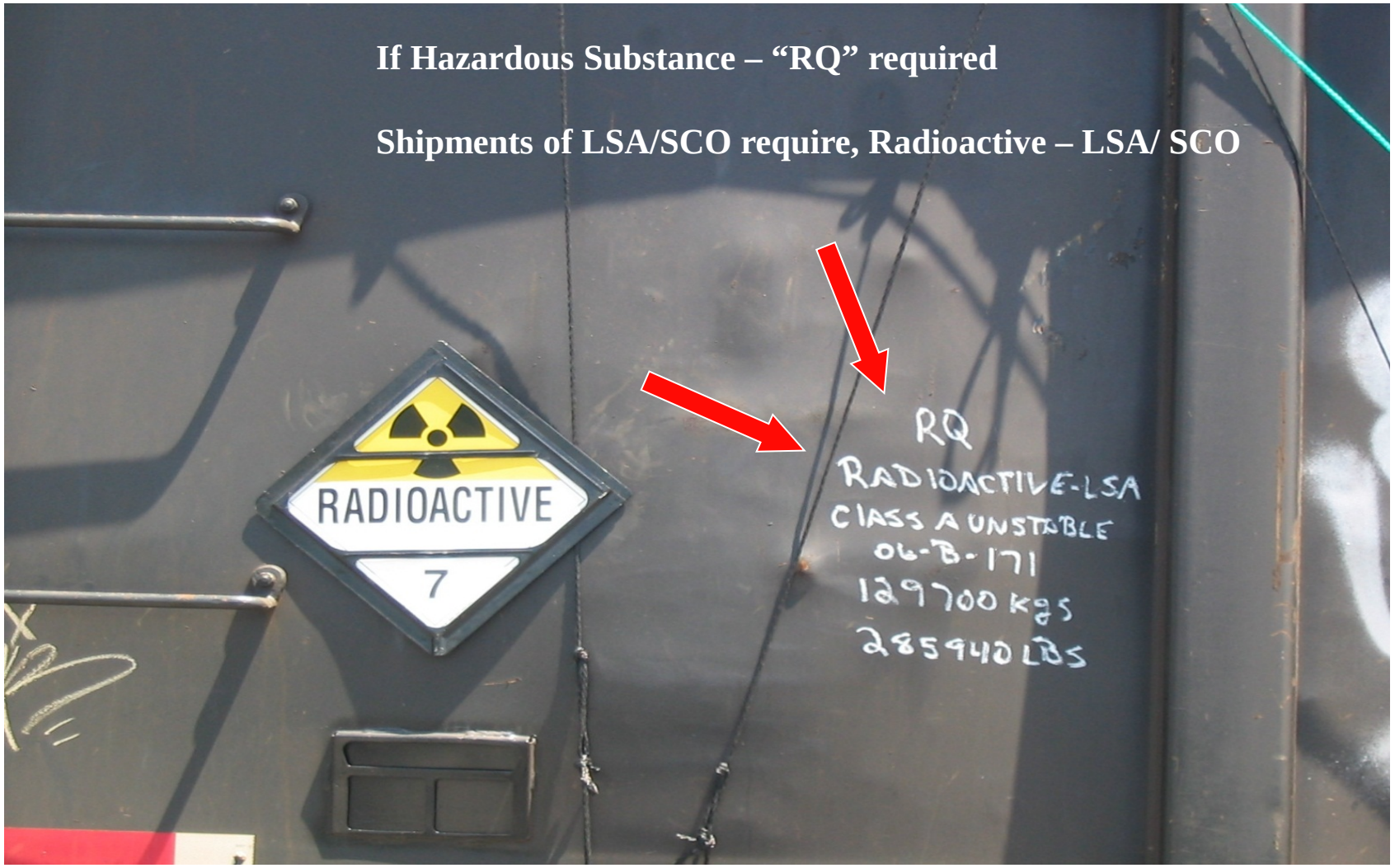
- **For bulk packages, marking (i.e., orange panels) may be required on more than one side of the package [§172.302(a), §172.331(c)]and must be displayed in proximity to any required placards §172.334(f)**

- **For an overpack, a statement that the contained packages comply with prescribed specifications §173.25(a)(4)**

Optional Markings

- **Both the name and address of consignor and consignee are recommended**

Marking Requirements



Placarding Requirements

Placarding Requirements

Visibility and Display of Radioactive Placard

- **Placards are required to be displayed:**

- Visible from the direction they face on each side and each end of the vehicle (i.e., four placards) §172.516(a)

- On the front of a motor vehicle instead of, or in addition to on the front of the cargo body (i.e., five placards) -- §172.516(b)

- Securely attached or affixed to the vehicle, or in a holder -- §172.516(c)(1)

- Clear of appurtenances and devices (e.g., ladders, pipes, tarpaulins) -- §172.516(c)(2)

- So far as practicable, be located so that dirt or water is not directed to it from the wheels of the transport vehicle -- §172.516(c)(3)

- At least 3 inches from any markings (such as advertisements) which may reduce placard's effectiveness -- §172.516(c)(4)

Placarding Requirements

- Upright and on-point such that the words read horizontally, left to right -- §172.516(c)(5)

- In contrast with the background, or have a solid or dotted line border which contrasts with the background -- §172.516(c)(7)

- **Placards must be maintained by carrier to maintain format, color, legibility, and visibility -- §172.516(c)(6)**

Conditions Requiring Placarding

- **Placards are required for any vehicle containing a package with a RADIOACTIVE Yellow-III label §172.504(e) Table 1**

- **Placards are required for shipment of LSA or SCO consigned as exclusive use -- § 173.427(a)(6)(v)**

Placarding Requirements

- **Placards are required for a Highway Route Controlled Quantity (HRCQ) of radioactive material, and,**

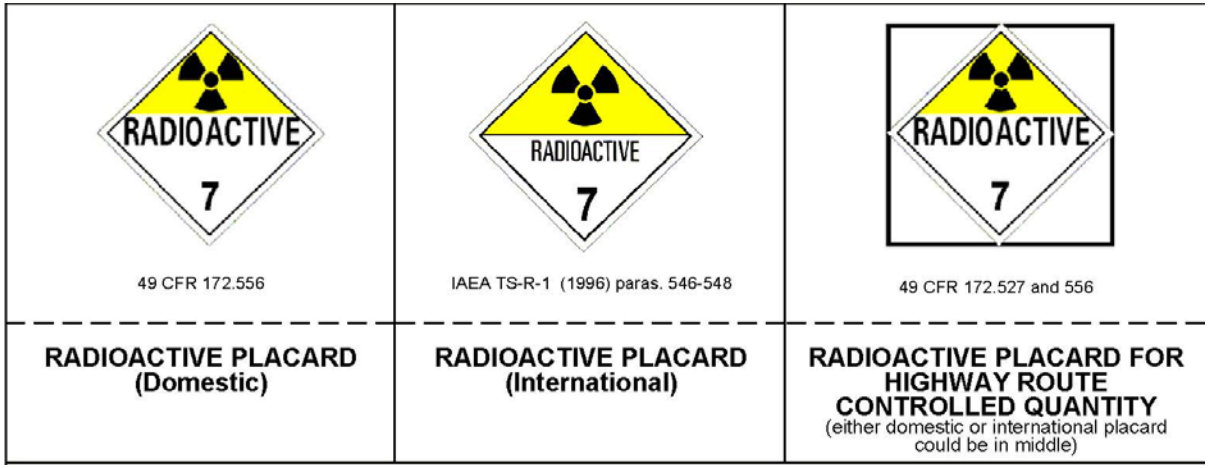
  - Must be displayed on a square background

  §§ 172.507 and 172.527

  - HRCQ packages must be labeled with RADIOACTIVE Yellow III labels

  §172.403(c)

Radioactive Active Placards



Placarding Requirements

Special Considerations/Exceptions for Placarding

- **Domestically, substitution of the UN ID number for the word "RADIOACTIVE" on the placard is prohibited for Class 7 materials**

  §172.503

  (However, some import shipments may have this substitution in accordance with international regulations §171.12)

- **If placarding for more than one hazard class, both placards must display the hazard class number [§172.519(b)(4)].**

- **Uranium Hexafluoride (UF6) shipments $ 454 kg (1001 lbs) gross weight require both RADIOACTIVE and CORROSIVE (Class 8), placards on each side and each end**

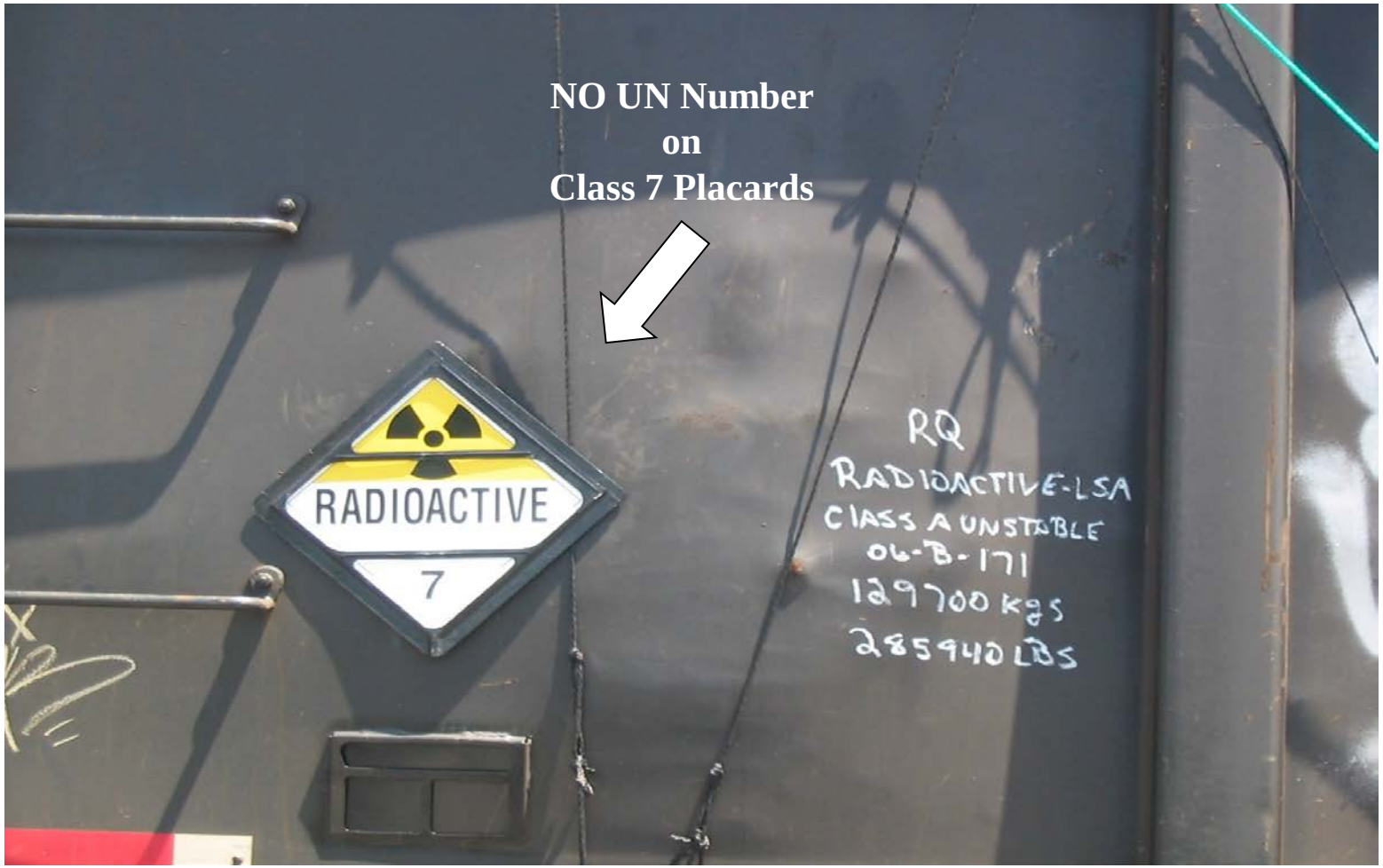
  §172.505(b)

- **For shipments of radiography cameras in convenience overpacks, if the overpack does not require a RADIOACTIVE - YELLOW III label, vehicle placarding is not required (regardless of the label which must be placed on the camera) §172.403(h)(5)**

- **A placard or placard holder may be hinged provided the required format, color, and legibility of the placard are maintained**

  §172.516(e)

Placarding Requirements



Placarding Requirements

Activity Level Limits

Activity Level Limits

Minimum Required Packaging - Package Based on Activity [1]

Category	Excepted Quantity [2]	Type A	Type B	Type B—HRCQ
Activity	≤ Table 4 [3]	≤A_1 or A_2	≤ A_1 or A_2	> 3000 A_1 or > 3000 A_9 or > 1000 TBq (whichever is least)
Packaging	Excepted Package [4]	Type A [5]	Type B [6]	Type B [6]

Notes

1 Material not defined as Class 7 is not regulated in transport - §173.403
2 Includes Limited Quantity - §173.421&Instruments and Articles §173.424
3 Activity limits for Limited Quantities and Instruments and Articles §
4 Excepted package must meet §173.410
5 Except for LSA/SCO, a Type A package may contain a quantity of radioactive material > A_1 or A_2 §173.431(a)
6 Type B(U) or B(M)

Activity Level Limits

Package Options for LSA/SCO [7, 8]

Packaging	Unpackaged LSA/SCO	Minimum Package [3, 3]	Industrial Packaging [4]	DOT Specification 7A Type A [5]	Type B(U), B(M)	Specification Tank cars [6]
Reference	§173.427(c) [1]	§173.427(b)(4)	§173.427(b)(1)	§173.427(b)(2)	§173.427(B)(3)	§173.427(B)(5)

Notes

1 See regulations in §173.427(c)
2 Only for domestic "Exclusive Use Shipments" and activity < A_2 quantity
3 The package must meet §173.24, §173.24a, and §173.410
4 Use of Industrial Package(IP-1,2, 3), must be in accordance with Table §173.427 and must meet §173.411
5 Except for LSA/SCO, a Type A package may not contain a quantity of radioactive material > A_1 or A_2 §173.431(a)
6 For "Exclusive Use Shipments", LSA-1liquid only, see specifications for tank cars or cargo tanks
7 For LSA/SCO that exceeds 1 rem/hr at 3 meters see 10CFR 71and NUREG 1608, sec. 4.1.3
8 LSA/SCO must comply with the conditions of §173.427(a)

Activity Level Limits

Package and Vehicle Radiation Level limits §173.441 [1]

Transport Vehicle Use	Non-Exclusive	Exclusive Use		
Transport Vehicle Type	Open or Closed	Open	Open w/Enclosure [2]	Closed
Package or Freight Container				
External Surface	200 mrem/hr	200 mrem/hr	1000 mrem/hr	1000 mrem/hr
Transport Index - TI [3]	10	No Limit		
Critical Safety Index - CSI [6]	50	No Limit		

Notes

1 The limits in this table do not apply to excepted packages §173.421, §173.426, §173.428

2 Security attached (to vehicle), access-limiting enclosure; package personnel barriers are considered as enclosures

3 The dimensionless number equivalent to maximum radiation level at 1 meter from the exterior Package surface, in millirem/hr rounded up to the next tenth §173.403

6 These provisions do not apply to shipment by vessel - see §§173.700 - 720 for vessel requirements

Activity Level Limits

Package and Vehicle Radiation Level limits §173.441 [1]

Transport Vehicle Use	Non-Exclusive	Exclusive Use		
Transport Vehicle Type	Open or Closed	Open	Open w/Enclosure [2]	Closed
Roadway or Railway Vehicle				
Any point on the outer surface	N/A	N/A	N/A	200 mrem/hr
Vertical planes projected from the outer edges		200 mrem/hr	200 mrem/hr	N/A
Top of Package		Load: 200 mrem/hr	Enclosure: 200 mrem/hr	Vehicle: 200 mrem/hr
2 meters from		Vertical planes 10 mrem/hr	Vertical planes 10 mrem/hr	Outer lateral surfaces: 10 mrem/hr
Underside		200 mrem/hr		
Occupied position	N/A [4]	2 mrem/hr [5]		
Sum of packages TI's	50	No limit		
Sum of packages CSI's [6, 7]	50	100		

Activity Level Limits

Notes

4 No dose limit is specified, but separation distances apply to Radioactive Yellow - III, or CSI labeled packages §177.842

5 Does not apply to carriers if operating under a state or federally regulated radiation protection program and if personnel wear radiation dosimetry devices §173.441(b)(4)

6 These provisions do not apply to shipment by vessel - see §§173.700 - 720 for vessel Requirements

7 The number of packages containing fissile material stored in transit in any one storage area must be limited so that the total sum of the CSI's is ≤ 50, and such groups of packages must be spaced at least 20 ft. from such groups §§173.457, 173.459

Activity Level Limits

	Maximum Permissible Limit		
Non-fixed Radioactive Contamination Limits for Packages §173.443(a) Table 9	**βγ 4 Bq/cm²**	**1 x 10 $^{-4}$ µCi/cm²**	**220 dpm/cm²**
	α 0.4 Bq/cm²	**1 x 10 $^{-5}$ µCi/cm²**	**22 dpm/cm²**

βγ means he sum of beta emmitters, gamma emitters, and low-toxicity alpha emitters

α means the sum of all other alpha emmitters (i.e., other than low-toxicity alpha emmitters)

Non-fixed (removable), contaimination must be kept, As Low As Reasonably Achievable (ALARA)

Applicable conditions which must be met:

In an exclusive use shipment, contamination on a package:

(1) may not exceed the values in §173.443(a) at the beginning of transport [§173.443(b)].

(2) may not exceed 10 times the values in §173.443(a) during transport [§173.443(b)].

Vehicle must not be returned to service until the radiation level is shown to be # 0.005 mSv/hr (0.5 mrem/hr) at any accessible surface, and there is no significant removable (non-fixed) contamination, as specified in §173.443(a)[§173.443(c)].

Activity Level Limits

In a closed transport vehicle used solely for transporting radioactive materials packages, the contamination levels on the packages may not exceed 10 times the values in §173.443(a).Additional conditions include:

(1) A survey of the interior surfaces of the empty vehicle must show that the radiation level at any point does not exceed 0.1 mSv/hr (10 mrem/hr) at the surface, or 0.02 mSv/hr (2 mrem/hr) at 1meter (3.3 ft).

(2) Exterior of vehicle must be conspicuously stenciled, "For Radioactive Materials Use Only" in letters at least 76 mm(3 inches) high, on both sides of the exterior.

(3) Vehicle must be kept closed except for loading and unloading §173.443(d).

Excepted package-empty packaging, §173.428, conditions include:

(1) Internal contamination may not exceed 100 times §173.443(a) (Table 9) §173.428(c).

(2) External contamination on the package may not exceed §173.443(a) (Table 9) §173.428(a).

(3) Radiation level must be # 0.005 mSv/hr (0.5 mrem/hr) at any external surface §173.428(a).

(4) Package must be marked with UN 2908 in accordance with §173.422(a).

(5) Packaging is in unimpaired condition and securely closed to prevent leakage §173.428(b).

(6) Labels are removed, obliterated, or covered, and the "Empty" label (§172.450) is affixed to the packaging §173.428(d).

(7) The package contains # 15 grams of U-235.

Thanks for your attention

Any Questions?