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July 22, 1980

Mr. Donald Nussbaumer, Director
Material Safety and Licensing
Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Nussbaumer:

As discussed with you by Marshall Little, we would appreciate very much the assistance of the Nuclear Regulatory Commission in providing us a nuclear criticality safety analysis for the Waste Isolation Pilot Plant project (WIPP).

There is attached an outline of the specific information of interest to us. This includes background information describing the wastes planned for WIPP, the type of packaging, and content of fissile material. Should you have questions or wish further background information, please contact Marshall Little at FTS 476-5481.

Sincerely,

Jack M. Hoolley
-for-

Robert H. Neill
Director

RHN:lg

Enclosure

THIS DOCUMENT CONTAINS
POOR QUALITY PAGES

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Marshall S. Little
7/18/80

NUCLEAR CRITICALITY SAFETY ANALYSIS
FOR THE
WASTE ISOLATION PILOT PLANT PROJECT

Remote Handled Wastes

Required Analyses

1. Evaluate the reactivity of a linear array of eleven RH waste containers with full loading under the following conditions:

   a) Dry storage with reflection from the concrete pit wall.

   b) Fully moderated and fully reflected

   c) Determine the reactivity of the worst case rearrangement with full moderation and reflection.

   d) Determine impact of replacing moderator and reflector with brine or salt.

2. Determine the reactivity of a single RH waste canister over a range of values of H/Pu-239.

3. Determine the minimum critical number of close packed RH waste canisters over a range of values of H/Pu-239.

Required Analyses

1. Evaluate the reactivity of each type of CH waste storage array at the maximum and the average fissile loading over a range of H/Pu-239 values.

2. Evaluate the reactivity of a crushed array of CH waste representing a full underground storage array with maximum and average fissile content over a range of H/Pu-239. Crushing is defined as an 80-percent reduction in the compactible volume of the waste.

3. Determine the minimum critical array sizes at maximum and average loading over a range of H/Pu-239.

4. Evaluate reactivity of crushing the maximum waste hoist load of CH waste at various values of H/Pu-239.

Fire Water Collection Trenches

Criticality safety associated with fighting fires is to be addressed by considering an incident involving a full forklift load (24) of drums (the maximum fire in the CH Waste Handling Area). Each drum is assumed to contain the maximum fissile loading. It is further assumed that all of the (24) drums are ruptured and the fissile content of each is drained into a fire water collection trench.

SECTION 2
DESCRIPTION OF THE WASTES

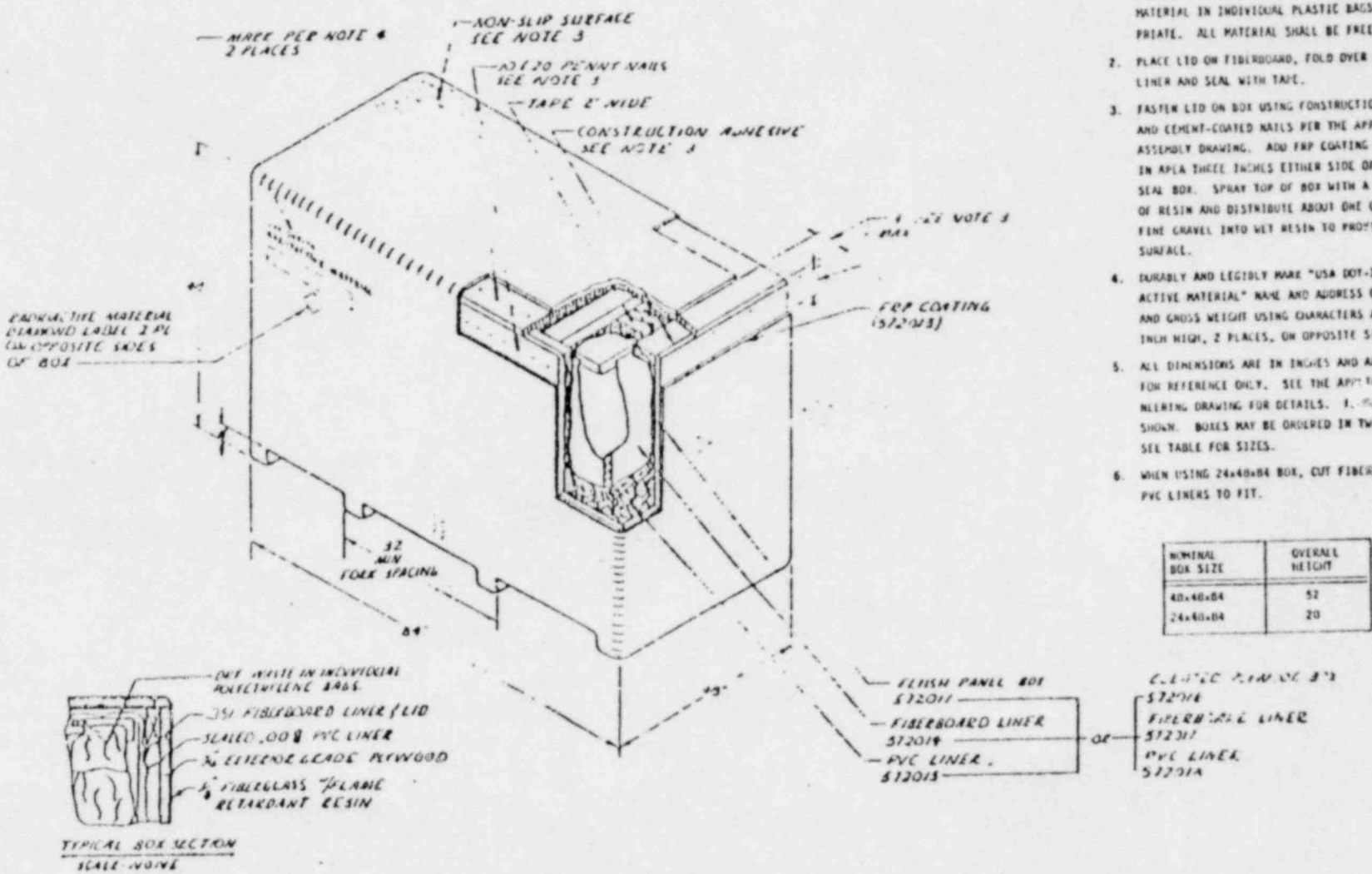
Two types of transuranic wastes, contact handled and remote handled, will be received at WIPP. The wastes will be received packaged in drums and boxes contained within licensed shipping containers.

2.1 Contact Handled Wastes

Contact handled (CH) wastes are defined as those packages which have a surface dose rate less than 200 mrem/hr. The waste planned for storage consists of material packaged in the DOT-specification [1] drums and boxes, shown in Figures 2-1 to 2-6, which will arrive at the site packaged in licensed shipping containers. A listing of the CH waste containers and the maximum allowable fissile content of each is given in Table 2-1. The drums received at WIPP are planned to be packaged in either the steel banded package shown in Figure 2-7 or over-packed in the sealed steel container shown in Figure 2-8. Both containers are referred to as six packs.

The isotopic compositions shown in Table 2-2 have been assumed as the anticipated typical fissile content and isotopic breakdown [2] of the drums and DOT-specification 7A boxes.

The materials packaged in the drums and boxes are both combustible and non-combustible. Combustible materials include paper, cardboard boxes, wooden boxes, plastic bags, rubber scrap, rags, surgical gloves, clothing, etc. It may be assumed that 25 percent of the waste is combustible [2]. The non-combustible wastes include residues from chemical processing, building rubble, metal, glassware and dry sludges.

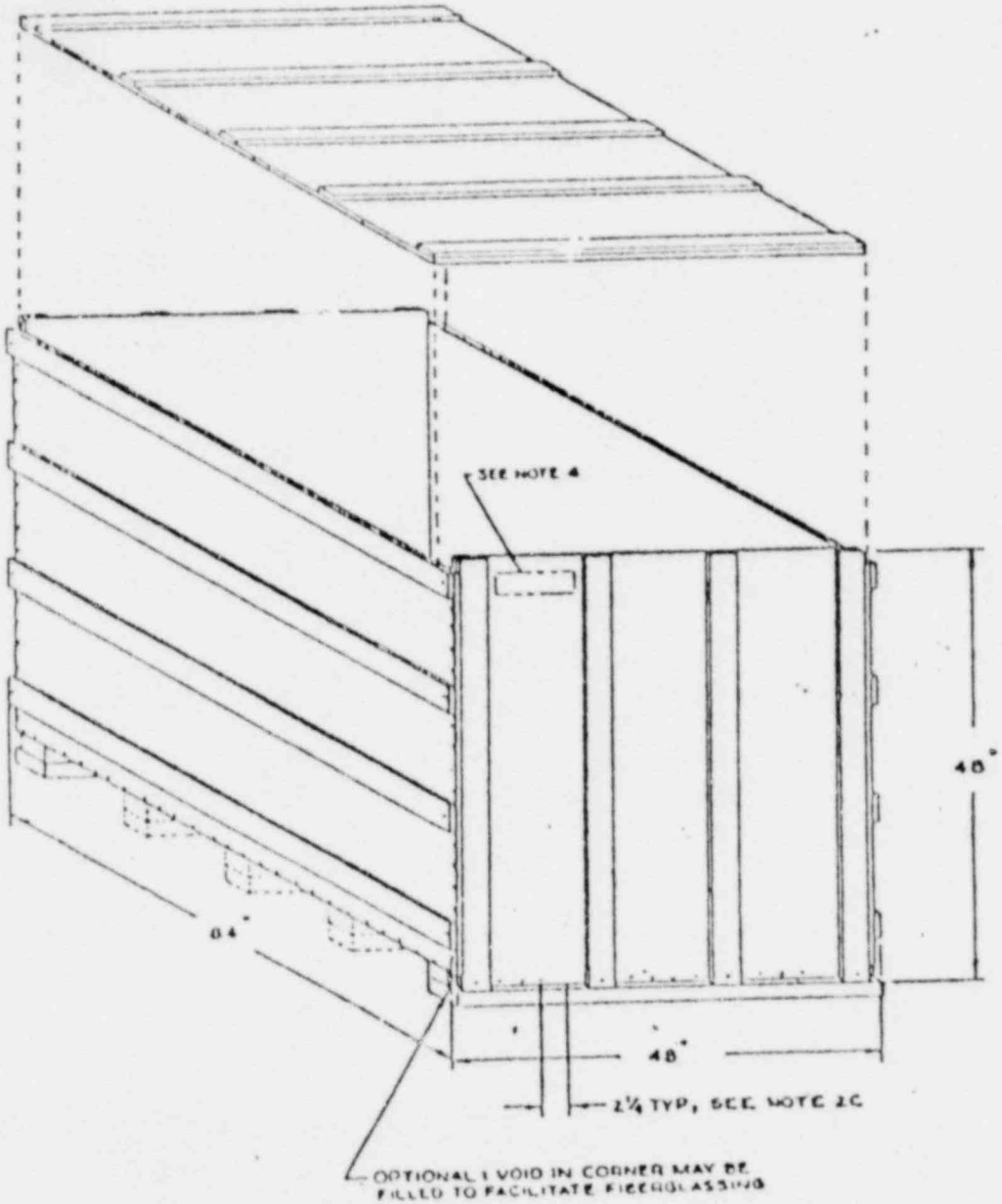


NOTES:

1. SECURELY BLOCK LARGE, HEAVY ITEMS WITHIN THE BOX TO PREVENT MOVEMENT. TIGHTLY PACK OTHER MATERIAL IN INDIVIDUAL PLASTIC BAGS AS APPROPRIATE. ALL MATERIAL SHALL BE FREE OF LIQUID.
2. PLACE LID ON FIBERBOARD, FOLD OVER PVC LINER AND SEAL WITH TAPE.
3. FASTEN LID ON BOX USING CONSTRUCTION ADHESIVE AND CEMENT-COATED NAILS PER THE APPLICABLE BOX ASSEMBLY DRAWING. ADD FRP COATING PER S72013 IN APEA THREE INCHES EITHER SIDE OF JOINT TO SEAL BOX. SPRAY TOP OF BOX WITH A LIGHT COAT OF RESIN AND DISTRIBUTE ABOUT ONE QUART OF FINE GRAVEL INTO WET RESIN TO PROVIDE A NON-SLIP SURFACE.
4. DURABLY AND LEGIBLY MARK "USA DOT-7A", "RADIOACTIVE MATERIAL" NAME AND ADDRESS OF USER, AND GROSS WEIGHT USING CHARACTERS AT LEAST 1.0 INCH HIGH, 2 PLACES, ON OPPOSITE SIDES OF BOX.
5. ALL DIMENSIONS ARE IN INCHES AND ARE GIVEN FOR REFERENCE ONLY. SEE THE APPLICABLE BOX ENGINEERING DRAWING FOR DETAILS. FLUSH PANEL BOX, SHOWN. BOXES MAY BE ORDERED IN TWO HEIGHTS. SEE TABLE FOR SIZES.
6. WHEN USING 24x48x84 BOX, CUT FIBERBOARD AND PVC LINERS TO FIT.

NOMINAL BOX SIZE	OVERALL HEIGHT
48x48x84	52
24x48x84	20

Figure 2-1 DOT 7A Fiberglass Reinforced Flush Panel or Cleated Plywood Box Assembly



NOTES:

1. BOX DIMENSIONS BEFORE FIBERGLASSING:

   OUTSIDE: 84L x 48W x 49-1/2D x 115 FT³
   INSIDE: 81L x 45W x 42-1/2D x 90 FT³

2. ASSEMBLE BOX WITH THREE-WAY CORNERS AS FOLLOWS:

   A. APPLY ELASTOMERIC CONSTRUCTION ADHESIVE (B.F. GOODRICH PL-200 OR APPROVED EQUIVALENT) IN A CONTINUOUS BEAD OF 1/4 INCH MINIMUM DIAMETER ALONG EACH PLYWOOD-TO-PLYWOOD JOINT. REMOVE EXCESS ADHESIVE FROM OUTSIDE OF BOX.

   B. EACH END OF EACH CLEAT SHALL BE FASTENED WITH AT LEAST ONE 16 PENNY CEMENT-COATED BOX NAIL.

   C. APPLY 8 PENNY CEMENT-COATED BOX NAILS OR 2 INCH PLASTIC COATED STAPLES THRU THE PLYWOOD INTO THE APPROPRIATE CLEAT OR STRINGER AS SHOWN. FASTENERS SHALL BE FLUSH TO 1/16 INCH BELOW SURFACE. STAPLE CROWNS SHALL CROSS GRAIN OF FIRST PLY AT NOT LESS THAN A 40° ANGLE. INTERIOR OF BOX SHALL BE FREE OF PROTRUDING FASTENERS.

3. FIBERGLASS BOX AND ASSEMBLE SKIDS PER S72013. COATING MAY BE DONE ON INDIVIDUAL PANELS OR ON ASSEMBLED BOX.

4. DURABLY AND LEGIBLY MARK MANUFACTURER'S NAME OR SYMBOL AND DATE OF MANUFACTURE 2 PLACES ON OPPOSITE ENDS OF BOX, USING CHARACTERS AT LEAST 1/4 INCH HIGH. A PAPER LABEL WITH RESIN COVERCOAT ACCEPTABLE.

5. WHEN THE PURCHASE ORDER SPECIFIES A NON-FIBERGLASSED BOX, OMIT ASSEMBLY STEPS PER NOTE 3. ATTACH SKIDS PER SHEET 2 OF THIS DRAWING SERIES. TEMPORARILY SECURE LID WITH DOUBLE-HEADED NAILS OR OTHER SUITABLE FASTENERS TO RESIST BLOWING IN HIGH WINDS DURING STORAGE OR TRANSPORATION.

6. FINAL LID CLOSURE BY USER SHALL BE MADE USING CONSTRUCTION ADHESIVE AND 8 PENNY CEMENT COATED NAILS OR 2 INCH PLASTIC COATED STAPLES.

Figure 2-2 DOT 7A Cleated Plywood Box Assembly

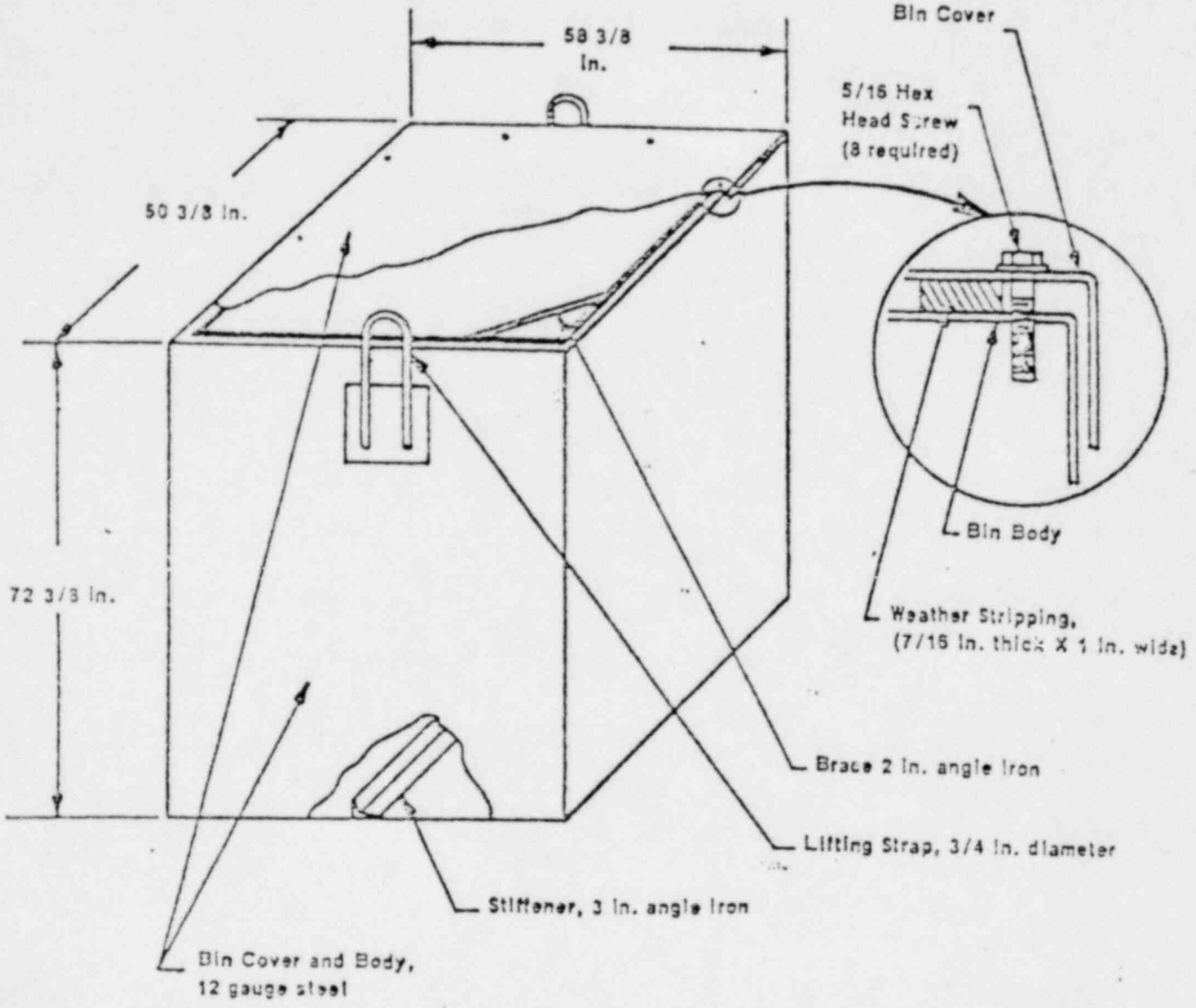


Figure 2-3 DOT Specification 7A Steel Box

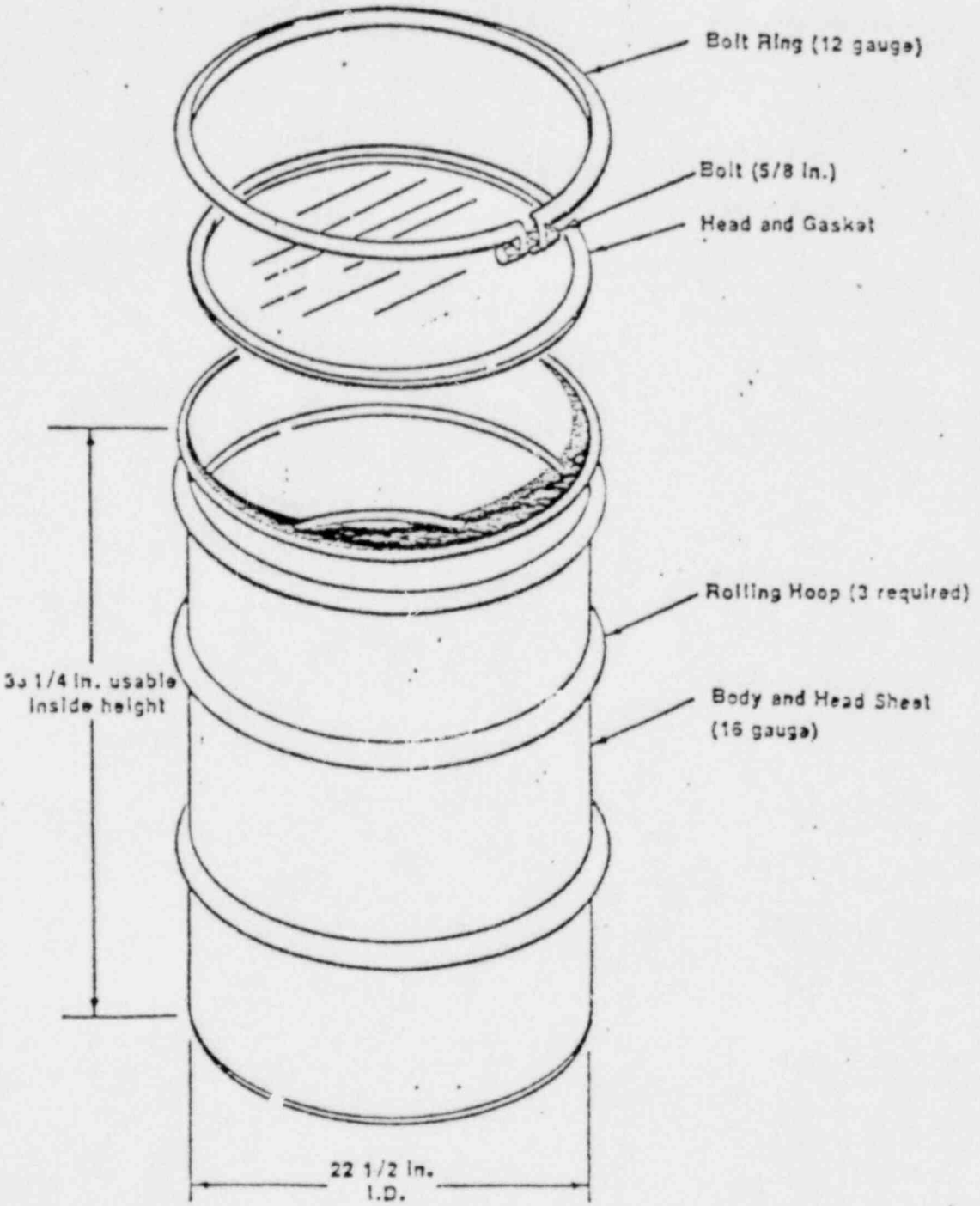


Figure 2-4 DOT Specification 17C Steel Drum (55 Gallon)

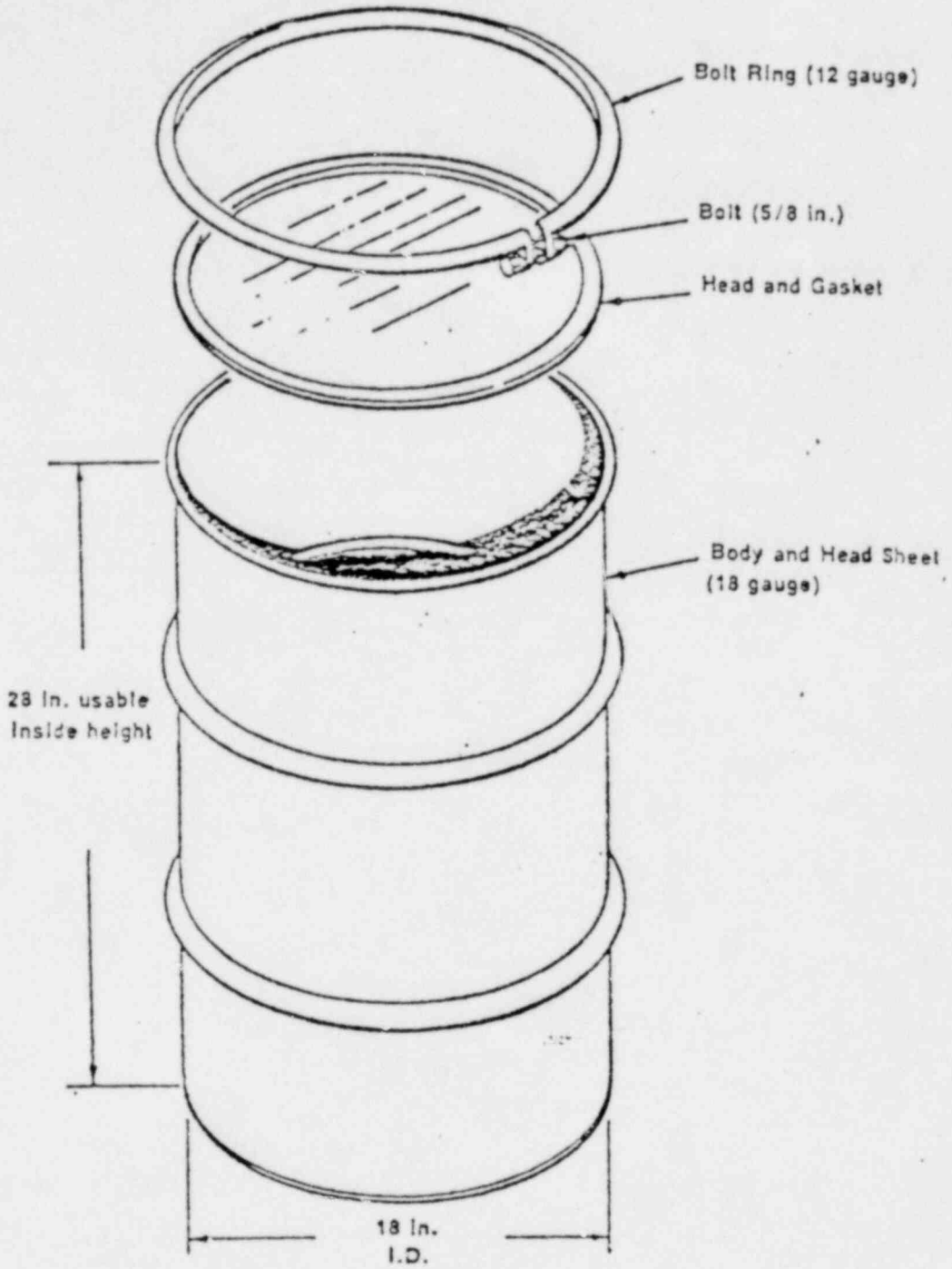


Figure 2-5 DOT Specification 17H Steel Drum (30 Gallon)

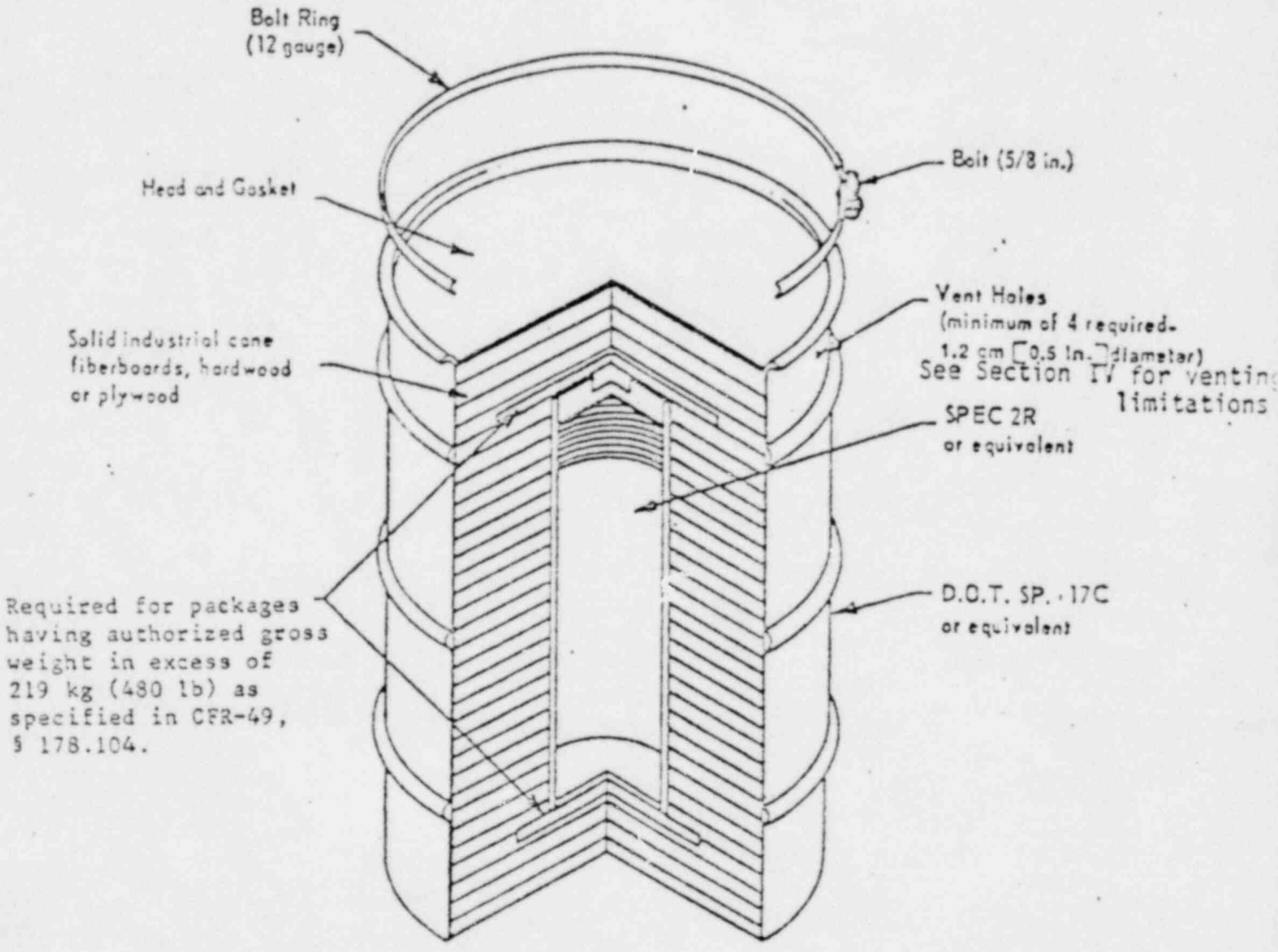


Figure 2-6 DOT Specification 6M Packaging

NOTES

1. CONTAINS 6 EACH 55 GALLON DRUMS.
   VOLUME OF EXTERNAL CONFIGURATION - 75 CU. FT.
   VOLUME OF 6 DRUMS - - - - - - - - -48 CU. FT.
   WEIGHT OF DRUMS - - - - - - - - - - 333 LBS.
   WEIGHT OF FRAME - - - - - - - - - - 199 LBS.
   WEIGHT OF CONTENTS - - - - - - - 5713 LBS.*
   TOTAL WEIGHT - - - - - - - - - - 6245 LBS.

   * 90% FULL AT 138 LBS./CU. FT.

2. FRAME 2" X 2" X .250" ANGLE AND
   2" X 2" X .250 TEE.

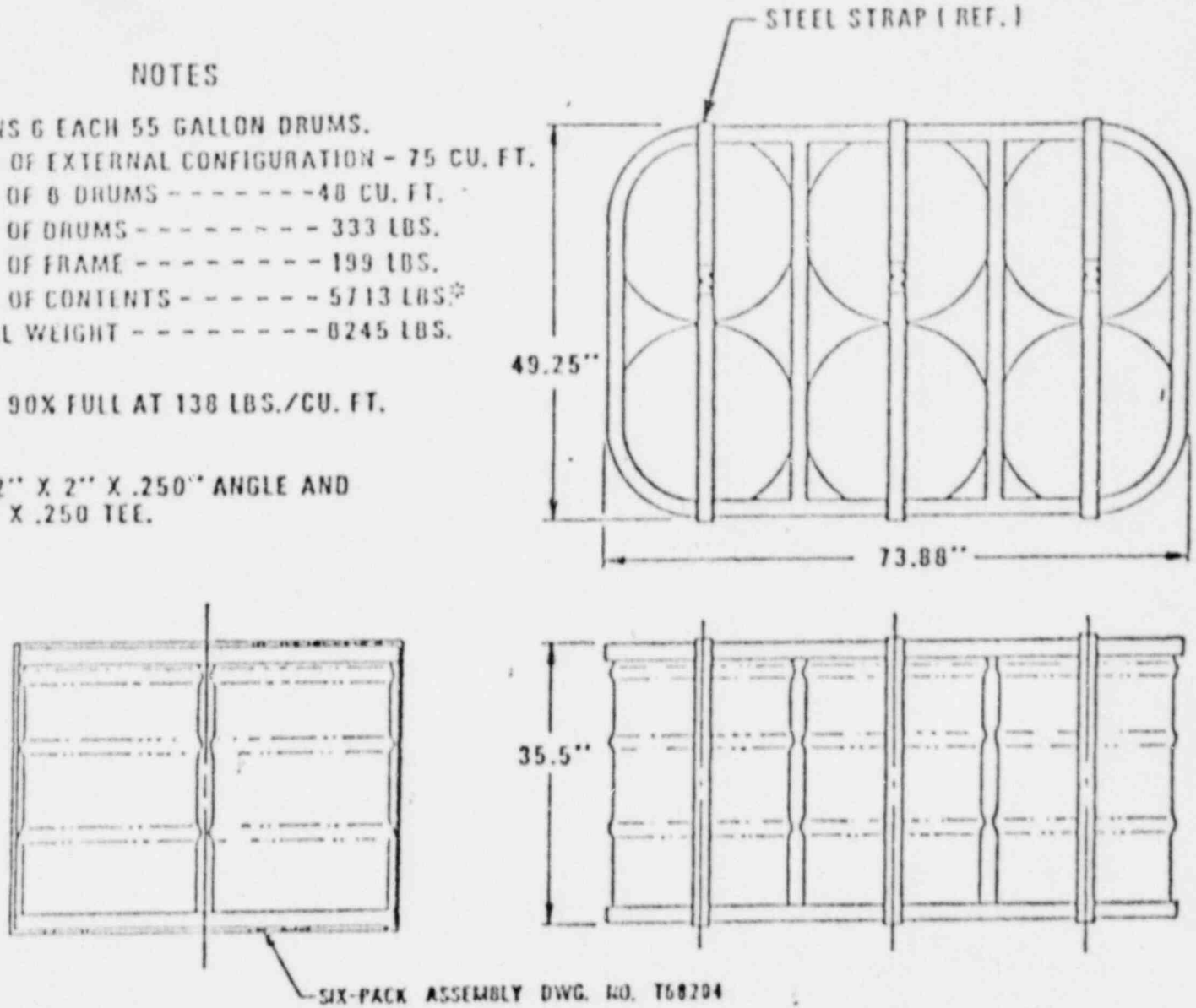


Figure 2-7 Steel Banded Six-Pack

NOTES

1. Weight of Container- - - - - - - 326 lbs.
   Weight of Contents - - - - - - - 8942 lbs.*
   Total Weight - - - - - - - 9268 lbs.
   *90% Full at 138 lbs./cu ft.
2. 18 Ga. (.0478) Steel Cover and Bottom
   16 Ga. (.0598) Steel Sides

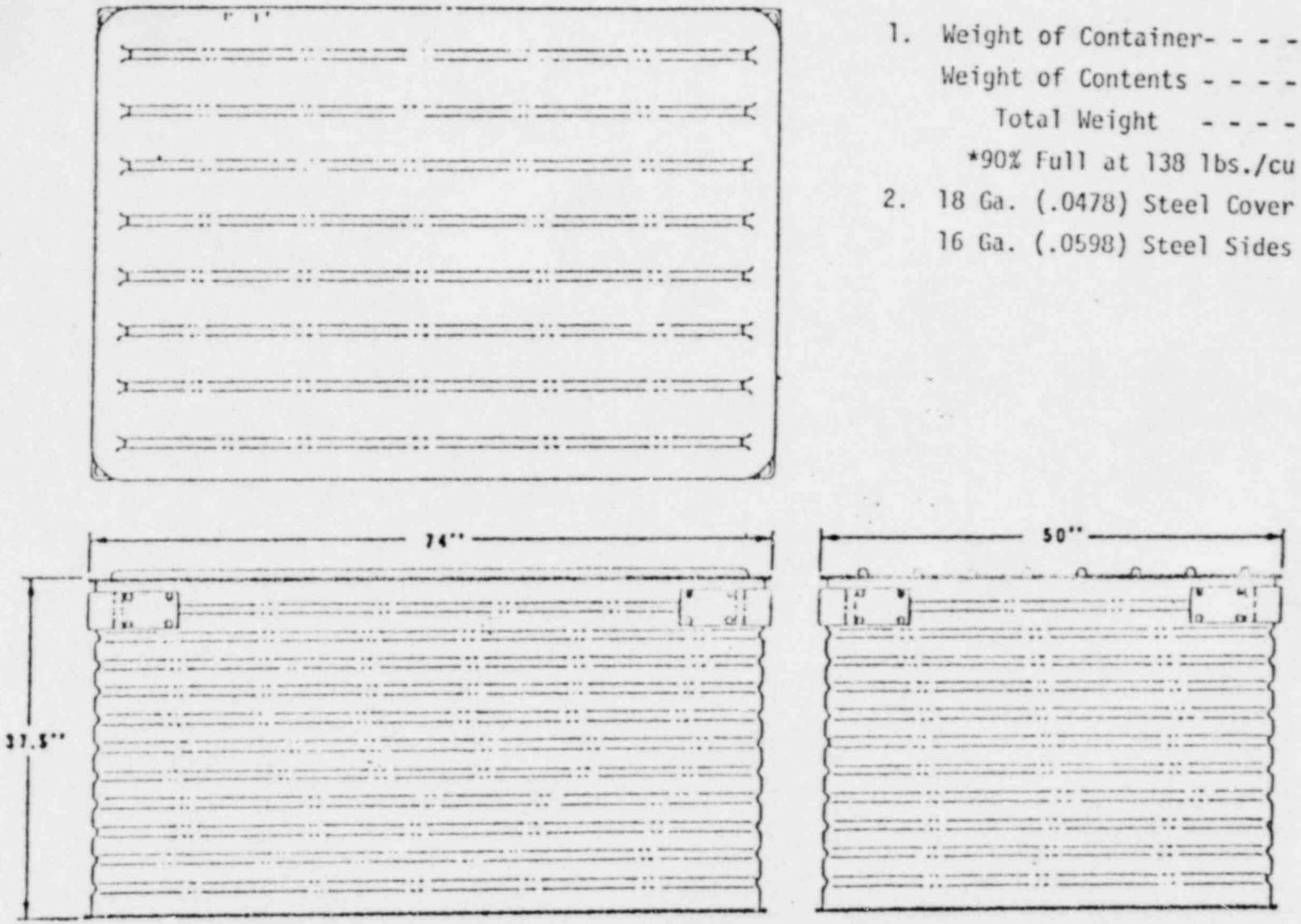


Figure 2-8 Steel Six Pack

2.2 Remote Handled Wastes

Remote handled (RH) wastes will also be received for storage at WIPP. All RH wastes will be received at WIPP contained in metal canisters placed within licensed shipping containers. The canister is a 24-inch outside diameter, 3/8-inch thick carbon steel pipe of welded construction and is 10 feet long including the lifting pintle. Some canisters will be overpacked within the WIPP hot cell with a 26 inch outside diameter, 11-foot long, 3/8-inch thick carbon steel overpack. The waste canister is designed to satisfy the requirements for a Type A container as described in 49 CFR 173.398 [1]. Design and fabrication of the canisters will be controlled by a WIPP approved specification. All canisters will be smooth-sided or corrugated cylinders and will have no protrusions that extend beyond their nominal outside diameter. The reference RH waste canister is shown in Figure 2-9.

The actual RH waste may be assumed to be in one of three noncombustible forms. One form of waste may be termed non-fixed and consists of contaminated concrete and steel, dry process sludges, etc. The two fixed waste forms may include borosilicate glass and wastes fixed in ordinary concrete. The assumed isotopic content of RH wastes regardless of form is shown in Table 2-3 [2].

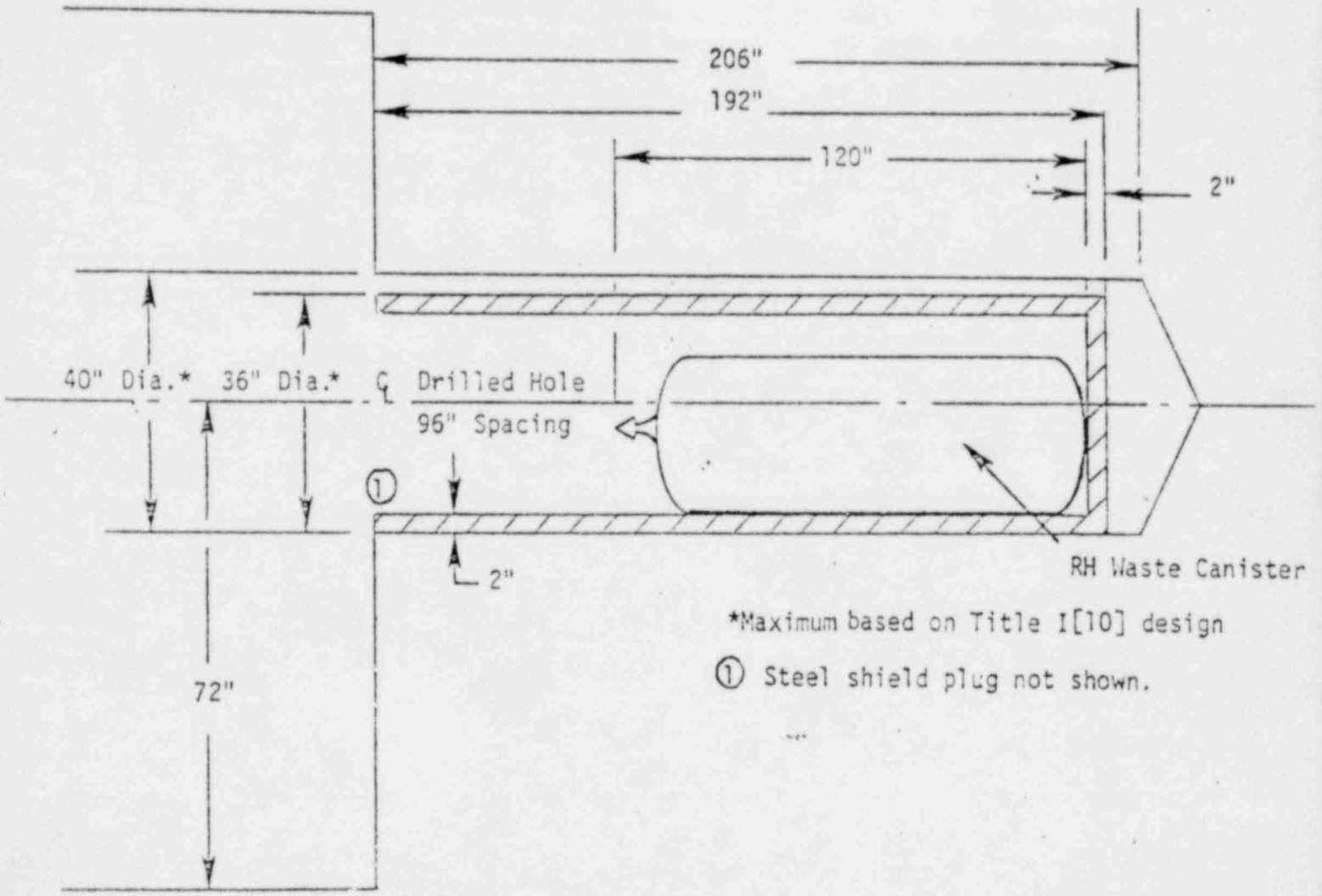


Figure 2-9 Remote Handled Waste Canister Storage Configuration (Not to Scale

TABLE 2-1

CONTACT HANDLED WASTE CONTAINERS

Package Description	Dimensions	Maximum Fissile Content (grams)
DOT-7A Boxes†		
a. FRP-coated plywood	4' x 4' x 7'	350*
b. Cleated plywood	Random	*
c. Steel boxes (M3-Bins)	50" x 58" x 72"	*
Drums		
a. 55-gallon, 17C	24" dia. x 35" length	200
b. 30-gallon, 17H	19" dia. x 29" length	100
c. 55-gallon, DOT 6M	24" dia. x 35" length	500
d. 83-gallon**	26" dia. x 43" length	200

† Packaged in steel overpack for storage.

* Limited to 5 grams in any cubic foot.

**Used as overpacks for 55-gallon drums.

TABLE 2-2

ISOTOPIC CONTENT OF CONTACT HANDLED WASTE DRUMS AND BOXES

Isotope	Total Mass Per Drum, grams	Total Mass Per Box, grams
Pu-238	2.5×10^{-3}	4.0×10^{-3}
Pu-239	7.5	12.0
Pu-240	0.5	0.81
Pu-241	2.7×10^{-2}	4.4×10^{-2}
Pu-242	2.4×10^{-3}	3.9×10^{-3}
Am-241	1.5×10^{-3}	2.5×10^{-3}
Total	8.03	12.86
Typical Fissile Content, grams	7.5	12.0
Typical Plutonium Content, grams	8.0	12.8
Maximum Allowable Fissile Content, grams	200.0	350.0

TABLE 2-3

REMOTE HANDLED WASTE ISOTOPIC CONTENT

Isotopes	Mass in Waste, grams
Co-60	0.093
Sr-90/Y-90	59.3
Ru-106/Rh-106	2.0×10^{-8}
Cs-137/Ba-137m	0.5
Eu-152	0.1
Eu-154	3.1×10^{-2}
Pu-238	0.042
Pu-239	126.7
Pu-240	8.7
Pu-241	0.46
Am-241	2.5×10^{-2}
Total	195.95

TABLE 3-1

27 ENERGY GROUP STRUCTURE

GROUP	E_U (eV)	E_L (eV)
1	1.733 + 7	1.221 + 7
2	1.221 + 7	1.000 + 7
3	1.000 + 7	7.408 + 6
4	7.408 + 6	5.488 + 6
5	5.488 + 6	3.679 + 6
6	3.679 + 6	2.231 + 6
7	2.231 + 6	1.353 + 6
8	1.353 + 6	8.208 + 6
9	8.208 + 5	4.979 + 5
10	4.979 + 5	3.020 + 5
11	3.020 + 5	1.832 + 5
12	1.832 + 5	1.111 + 5
13	1.111 + 5	4.087 + 4
14	4.087 + 4	1.503 + 4
15	1.503 + 4	5.531 + 3
16	5.531 + 3	2.035 + 3
17	2.035 + 3	7.485 + 3
18	7.485 + 3	2.754 + 3
19	2.754 + 2	1.013 + 2
20	1.013 + 2	3.727 + 2
21	3.727 + 1	1.371 + 1
22	1.371 + 1	5.044
23	5.044	1.855
24	1.855	6.826-1
25	6.826-1	4.140-1
26	4.140-1	1.000-1
27	1.000-1	1.000-5

TABLE 3-2

EXPERIMENTAL DATA FOR THERMAL SYSTEM: UNREFLECTED PLUTONIUM NITRATE SOLUTION IN ALUMINUM SPHERE

Measured Volume	:	949.1 liter
Container Material	:	Al
Al Thickness	:	0.77 cm
Temperature	:	23 $\pm$ 0.5°C

Chemical Analysis $Pu(NO_3)_4$ Water Solution

Pu Concentration	:	9.43 g/liter
Specific Gravity	:	1.053
Free Acid Molarity	:	1.105 M

Isotopic Analysis (wt%)

Pu-238	Pu-239	Pu-240	Pu-241	Pu-242
0.004	97.386	2.521	0.075	0.014

TABLE 3-3

EXPERIMENTAL DATA FOR FAST SYSTEM: SPHERICAL CORE OF Pu-239 IN SPHERICAL REFLECTOR

Core

Material	Pu-239
Diameter, cm	10.084
Mass, kg	8.386
Density, gm/cm^3	15.62*
Enrichment, wt-%	*

Reflector

Material	Enriched Uranium-235
Thickness, cm	1.656
Density, gm/cm^3	18.8**

*Density is for Pu. This contains 4.9 atom-% Pu-240 and 0.31 atom-% Pu-241.

**93% enriched uranium-235.

TABLE 4-2

COMPOSITIONS OF CONCRETE AND BOROSILICATE GLASS

Concrete		Borosilicate Glass	
Element	Weight Percent	Element	Weight Percent
Aluminum	4.6	Aluminum	0.91
Calcium	8.3	Boron	7.69
Hydrogen	0.6	Magnesium	0.12
Magnesium	0.3	Oxygen	55.37
Nickel	1.2	Potassium	0.84
Oxygen	49.8	Silicon	31.64
Potassium	1.9	Sodium	3.43
Silicon	31.5		
Sodium	1.7		
Sulfur	0.1		

SECTION 8

REFERENCES

1. Title 49, Code of Federal Regulations, Department of Transportation.

2. H.C. Shefelbine, "Preliminary Evaluation of the Characteristics of Defense Transuranic Wastes," SAND-78-1850, November 1978.

3. R.A. Soltesz and R.K. Disney, "Nuclear Rocket Shielding Methods, Modification, Updating and Input Data Preparation", Volume 4: WANL-PR-(LL)-034, Westinghouse Electric Corporation, August 1970.

4. W.W. Engle, Jr., "A User's Manual for ANISN, A One-Dimensional Discrete Ordinates Transport Code with Anisotropic Scattering," Union Carbide Co., Nuclear Division, K-1693 (1967).

5. N.M. Greene, et al., "AMPX-A Modular Code System for Generating Coupled Multigroup Neutron-Gamma Libraries from ENDF/B," ORNL/TM-3706, March 1976.

6. R.W. Roussin, et al., "The CTR Processed Multigroup Cross Section Library," ORNL/RSIC-37 (1976).

7. D. Garber, Compiler, "ENDF-201, ENDF/B Summary Documentation," BNL-17541 (ENDF-201) (1975).

8. E.D. Clayton et al., "Limiting Critical Concentration and Eta for Pu-239," Trans. Am. Nucl. Soc., 28 , 292, 1978.

9. "Reactor Physics Constants", ANL-5800, July 1963.

10. Waste Isolation Pilot Plant Safety Analysis Report, Draft, January 1980.

11. WIPP Project Office Letter, DW:79:02942, October 12, 1979.