A COMPARATIVE STUDY OF TWO GEOMETRIC WASTE FORMS

ROUND VS. SQUARE

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ABSTRACT

The 55 gallon (7.5 cubic feet) round drum has been the essential standard container for low level waste disposal on the commercial side and at government facilities since the inception of the nuclear industry in this country. The advent of the recently developed 71 gallon (9.5 cubic feet) square drum provides a significant competitive challenge to the tried and true round drum as the waste container of choice.

This paper deals with the advantage of the 71 gallon (9.5 cubic ft.) square drum when compared with the 55 gallon (7.5 cubic ft.) round drum. Several scenarios are presented which clearly develop the case for square drums as the preferred container for nuclear waste disposal projects.

BACKGROUND

In the "olden days," your parents received the family milk supply in round glass containers, milk bottles. The package cost was of such significance that a "reward" was offered for the bottle's return. The package was expensive but the cost to deliver was relatively cheap. Today, you receive the family milk supply in square plastic or fiber cartons. The cost to deliver is so high that you must transport the milk yourself, but the package cost is trivial. And so it is with low level waste containers. The cost of the container, when compared to the storage, transport, and processing cost is trivial.

Clearly, it is prudent to optimize the packaging, placing the maximum quantity of material in the minimum storage volume.

With the advent of $30.00/cubic ft. burial charges and the probable escalation to $100.00, the economic pressure to hedge against rising costs has sent the industry looking for alternatives.

Historically, the waste container of choice has been the cylinder--the 55 gallon drum. It is relatively inexpensive, durable, easily transportable, available in a variety of suitable standards, and the technology is well developed.

There is, however, a fundamental relationship between package geometry and storage efficiency. Clearly, the advantage falls to the "square drum in the square hole" when compared with the "round drum in the square hole."

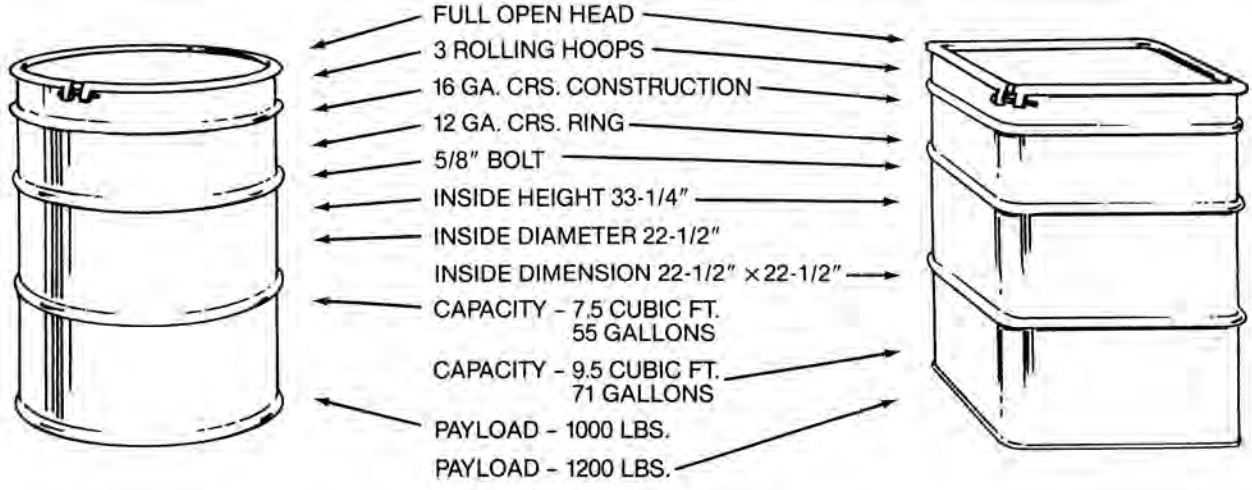


Fig. 1. Round Drum - Square Drum Comparison.

INTRODUCTION

Successful, alternative solutions to plans already underway must be reasonable. They must integrate conveniently into the existing parameters of the planned project. Such is the case with the 9.5 cubic ft. square drum. Configured to fit within the same space as the conventional 7.5 cubic ft., the square drum measures 22½" x 22½" on the inside by 33¼" inside height, identical dimensionally to the 7.5 cubic foot drum (Fig. 1). It fits within the same envelope ... the corners have simply been filled in.

Thousands of round 7.5 cubic ft. drums find their way to a final (or retrievable) resting place each year. It is, however, self-evident that the square drum is inherently more efficient than the conventional round drum. With few exceptions, the economics of waste disposal projects are enhanced by the simple geometric advantages of the square drum over the round (Fig. 2, Fig. 3, Fig. 4).

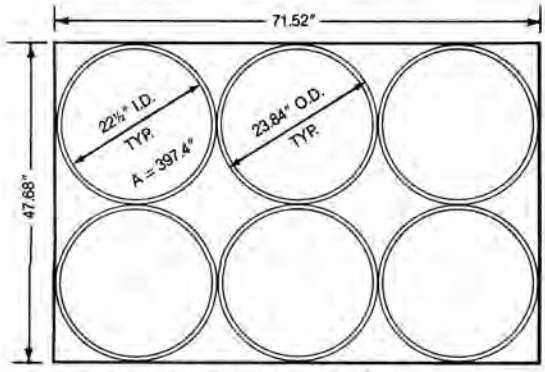
The "Geometric Advantages" begin to accrue as we cease to put round drums in square holes and begin to place square drums in square holes. If 9.5 cubic ft. square drums of equivalent dimensional size were used rather than the 7.5 cubic ft. round drums, at least the following could result:

- Approximately 26% more waste could be contained in the same place.
- The cost of storage facilities could be reduced by 26%.
- The size of storage facilities could be reduced by 26%.
- The number of drums processed could be reduced by 26%.
- The number of drums shipped could be reduced by 26%.

6-PACK ARRAY – ROUND DRUMS

Figure 2 displays a typical 6-pack array of drums normally seen at on-site storage facilities, and suggested as the waste form for the WIPP true-pack. (See Fig. 5).

This configuration will yield a storage efficiency of 69%. That is to say, the container and its waste will occupy 69% of the available space.

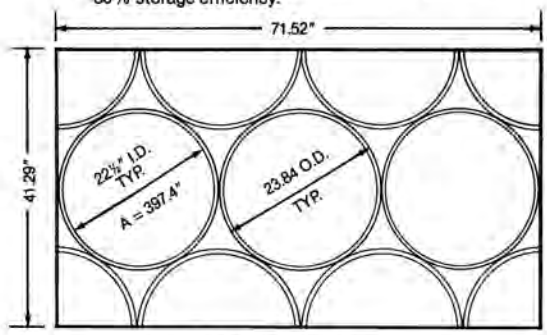


TOTAL STORAGE AREA = 3410 IN²
USEFUL STORAGE AREA = 6 (397.4) = 2384 IN²
STORAGE EFFICIENCY = $\frac{2384}{3410}$ = 69%
E = 69%

Fig. 2. "6-Pack" Array-Round Drums.

DENSE PACK ARRAY – ROUND DRUMS

Figure 3 displays a "dense-pack" array, typical of facilities which pyramid the containers horizontally, one upon the other. This arrangement will yield an 80% storage efficiency.

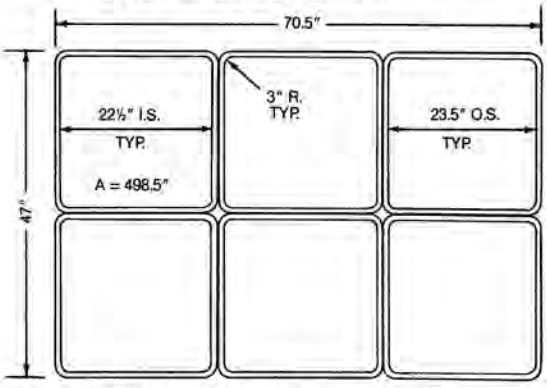


TOTAL STORAGE AREA = 2953 IN²
USEFUL STORAGE AREA = 6 (397.4) = 2384 IN²
STORAGE EFFICIENCY = $\frac{2384}{2953}$ = 80%
E = 80%

Fig. 3. Dense Pack Array - Round Drums.

DENSE PACK ARRAY – SQUARE DRUMS

Figure 4 displays the essence of this presentation. The Square Drum, equivalent dimensionally and in cross section to the drum, but containing 9.5 cubic ft. (see Fig. 1). This dense-pack square drum storage array will yield a 90% storage efficiency.



TOTAL STORAGE AREA = 3314 IN²
USEFUL STORAGE AREA = 6 (498.5) = 2991 IN²
STORAGE EFFICIENCY = $\frac{2991}{3314}$ = 90%
E = 90%

Fig. 4. Dense Pack Array - Square Drums.

WIPP
SQUARE DRUM COST BENEFIT

The "Waste Isolation Pilot Project" (WIPP) is located in Southeastern New Mexico at Carlsbad. This first-of-a-kind R & D facility is designed to receive and store "Contact Handled Transuranic Waste" (CH-TRU) and "Remote Handled Transuranic Waste" (RH-TRU) from the ten generating DOE sites throughout the country. This economic scenario deals solely with the Contact Handled Transuranic Waste.

At present, the container of choice is the conventional 7.5 cubic ft. open head drum. The containers will be delivered aboard a "transuranic waste package transporter (TRU-PACT)" or other authorized, appropriate conveyance. Each container of waste will be certified in accordance with "Waste Isolation Pilot Project Waste Acceptance Criteria" (WIPP-WAC).

The drums will be arrayed in "six packs", (Fig. 5) for automated handling. The WIPP facility is designed to receive and store approximately 6,200,000 cubic ft. of contact handled thru waste.

It is postulated here that if the waste received at WIPP were packaged in 9.5 cubic ft. square drums, (Fig. 6, Fig. 7) rather than the conventional 7.5 cubic ft. drum, a savings of $140,789,962.00 would accrue (Table I).

TABLE I
WIPP SQUARE DRUM COST BENEFIT

Assumptions

Facility capacity	6,200,000 cubic ft.
Facility cost	$690,000,000.00
Storage cost/cubic ft.	$111.00
Storage cost/round drum	$833.00
Storage cost/square drum.	$833.00
Drums required - round.	826,666
Drums required - square	652,631
Drum cost - round	$30.00
Drum cost - square	$45.00

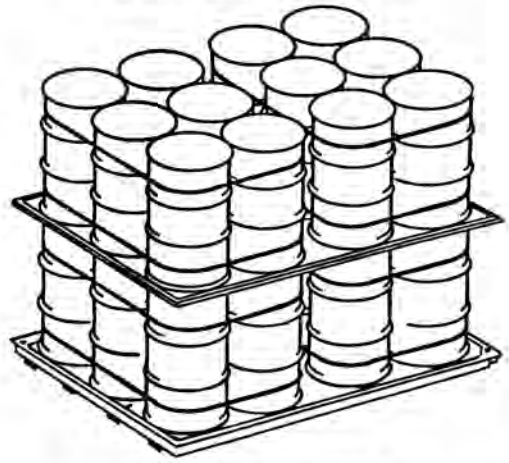
Conclusions

	Round Drum	Square Drum
Total storage cost	$689,000,000.	---
Total storage cost		$543,642,623.
Total drum cost	$ 24,799,980.	---
Total drum cost		$ 29,368,395.
	$689,000,000.	$543,642,623.

Square drum cost benefit $140,789,962.

Savings = 20%

STANDARD "6-PACK"



7½ CUBIC FT. PER DRUM
CAPACITY PER 6 DRUMS = 45 CUBIC FT.

Fig. 5. Standard "6-Pack".

SWEPP
SQUARE DRUM COST BENEFIT

The "Stored Waste Examination Pilot Plant" (SWEPP) at the Idaho National Engineering Laboratory (INEL) receives TRU-WASTE filled containers from DOE sites for inspection and certification prior to shipment to the DOE " Waste Isolation Pilot Project" (WIPP) at Carlsbad, New Mexico. Each container is non-destructively examined for fissile content, container integrity and internal contents to assure compliance with "Waste Acceptance Criteria" (WIPP-WAC). Non-certifiable containers are sent to the "Process Experimental Pilot Plant" (PREPP) facility at INEL for processing. To date, only 25%-35% of the containers surveyed are certifiable for WIPP.

The cost to examine each 7.5 cubic ft. drum is approximately $2,250.00 or $300.00 per cubic ft. of waste.

Some 4,500 - 6,500 7.5 cubic ft. containers are received at the SWEPP facility each year. It is postulated here that if the waste received at SWEPP were packaged in 9.5 cubic ft. square drums, rather than the conventional 7.5 cubic ft. drums (Fig. 1), a savings of $2,575,100.00 would accrue. (Table II)

TABLE II
SWEPP SQUARE DRUM COST BENEFIT

Assumptions

Drums processed - round	5,500
Drums processed - square	4,312
Drum cost - round	$30.00
Drum cost - square	$45.00
Cost to survey/cubic ft./round drum	$300.00
Cost to survey - round drum	$2,250.00
Cost to survey - square drum	$2,250.00

Conclusions

	Round Drum	Square Drum
Total drum cost	$ 165,000.	---
Total drum cost	. . . . .	$ 195,394.
Total survey cost	$ 12,375,000.	---
Total survey cost	. . . . .	$ 9,769,500.
	$ 12,540,000.	$ 9,964,894.
Square Drum Cost Benefit		$ 2,575,106.

Savings = 20%

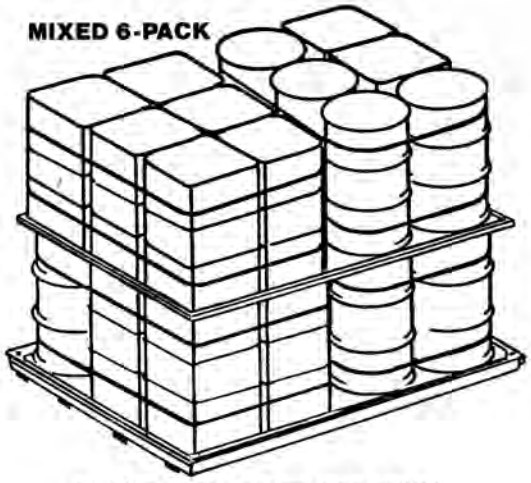


Fig. 6. Mixed "6-Pack".

PREPP
SQUARE DRUM COST BENEFIT

The Process Experimental Pilot Plant (PREPP) at the Idaho National Engineering Laboratory receives containers from the Stored Waste Examination Pilot Project (SWEPP) which are not certifiable for shipment to the Waste Isolation Project (WIPP) at Carlsbad, New Mexico.

At the PREPP facility, the waste and containers are shredded and incinerated. The ash and large particulates are classified and solidified in a concrete matrix within a conventional open-top 7.5 cubic ft. drum (Fig. 1).

At present, some 100,000 - 120,000 drums of waste are stored at the SWEPP facility awaiting survey for certification and shipment to WIPP. Based upon processing to date, it is anticipated *that only* 25%-35% of these waste containers will be certifiable in accordance with WIPP Waste Acceptance Criteria. The balance of 70,000 - 90,000 drums will be sent to the PREPP facility for processing.

It is postulated here that if the incinerated waste from the PREPP facility were solidified in 9.5 cubic ft. square drums rather than the conventional 7.5 cubic ft. round drums, a savings of $653,880.00 would accrue. (TABLE III)

NOTE: It has been reported that the waste container may be 7.5 cubic ft. stainless steel containers. For the purpose of this scenario, we have assumed the container of choice to be carbon steel.

TABLE III
PREPP SQUARE DRUM COST BENEFIT

Assumptions

Volume reduction ratio:	17:1
Waste to cement constituent ratio	1:1
Round drums processed	80,000
Processing cost per solidified drum	$300.00
Drum cost - Round	$ 30.00
Drum cost - Square	$ 45.00

Conclusions

	Round Drum	Square Drum
Drums solidified	9,411	---
Drums solidified	. . . . .	7430
Total processing cost	$11,763,750	---
Total processing cost	. . . . .	$ 9,287,500.
Total drum cost	$ 282,330.	---
Total drum cost	. . . . .	$ 334,350.
	$ 12,046,080.	$ 9,621,850.
Square drum Cost Benefit		$ 2,424,230.

Savings = 22%

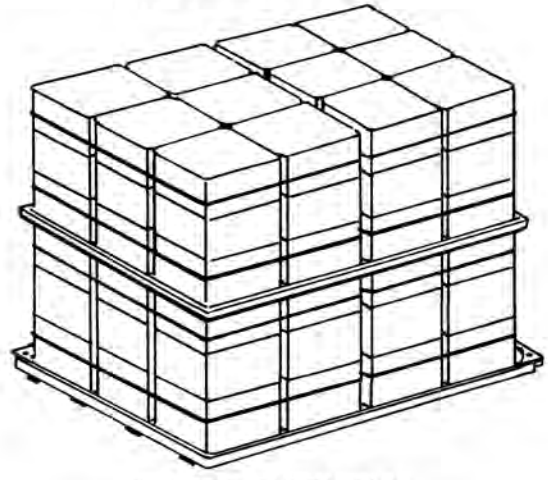


Fig. 7. Proposed "6-Pack".

WEST VALLEY DEMONSTRATION PROJECT
SQUARE DRUM COST BENEFIT

West Valley Nuclear Services (WVNS) under contract to USDOE has undertaken the decommissioning of a Nuclear Fuel Reprocessing Facility at West Valley, New York. Among the tasks to be completed is the solidification of some 500,000 gallons of supernatant liquid containing soluable fission products. This Class B & C waste will be combined with Portland cement in hi-shear mixers and discharged into 9.5 cubic ft. square drums. These hi-dose-rate, low-level waste drums will be remotely handled and placed in above ground earth mounded vaults (Fig. 8).

Originally intended for conventional 7.5 cubic ft. drums, the solidification system and disposal facility have been redesigned to accommodate approximately 17,500 9.5 cubic ft. square drums.

It is postulated here that if the facility were designed for 7.5 cubic ft. drums, the resultant facility cost increase would be approximately $450,806.00. (TABLE IV)

TABLE IV
WEST VALLEY SQUARE DRUM COST BENEFIT

Assumptions

Facility capacity-square drums	17,500
Equivalent facility-round drums	22,166
Facility cost	$2,500,000
Round drum cost	$ 40.00
Square drum cost	$ 63.00

Conclusions

	Round Drum	Square Drum
Facility cost	$ 3,166,666.	---
Facility cost		$ 2,500,000.
Total drum cost	$ 866,640.	---
Total drum cost		$ 1,102,500.
	$ 4,053,306.	$ 3,602,500.
Square Drum Cost Benefit		$ 450,800.

Savings = 11%

WEST VALLEY DRUM STORAGE

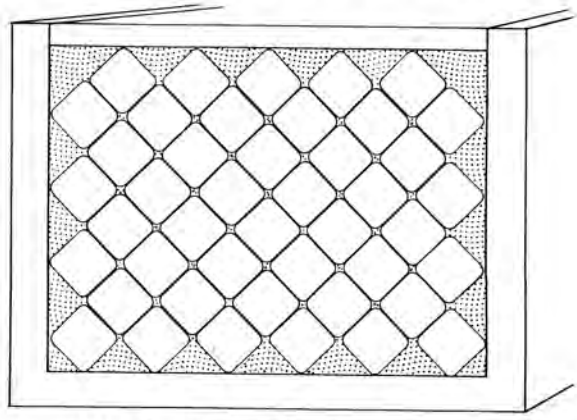


Fig. 8. West Valley Drum Storage.

CONCLUSION

Clearly, the advantage is on the side of the square drum. With few exceptions, waste processing and disposal projects are better served by the use of square drums. We have presented here scenarios which deal primarily with container and storage costs. Comparable savings can be realized in compaction, supercompaction, transportation, material handling, and back filling.

This industry can help itself to a significant cost reduction for waste disposal. Storage facilities can be smaller, fewer containers need be acquired, fewer containers need be handled. With few exceptions, waste disposal techniques are enhanced by the use of square drums (Fig. 9).

Fig. 9. 9.5 Cubic Ft. Square Drum.