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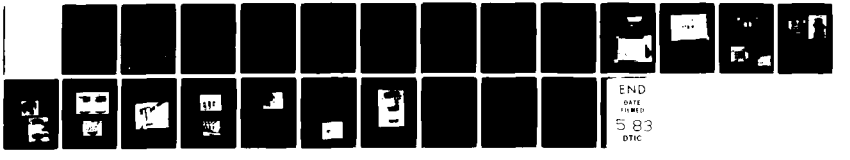

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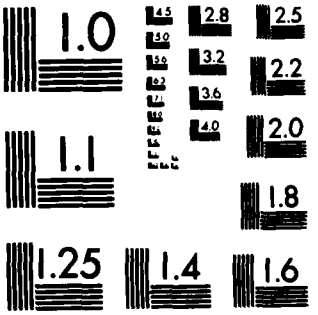

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PERFORMANCE EVALUATION OF METAL VERSUS NON-METAL ONE-QUART OIL CANS

HQ AFALD/PTP
Air Force Packaging and Evaluation Agency
Wright-Patterson AFB Ohio 45433

DECEMBER 1982

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

ABSTRACT: Composite (fiber/paper) cans were found to be an inadequate substitute for metal cans; high density polyethylene cans with metal tops were only slightly better; high density polyethylene cans with pour spouts were found to be superior to metal cans in all applicable performance characteristics with exception of the stacking resistance.

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ABSTRACT

Due to the lack of commercial use, the availability of metal oil cans is becoming scarce and thus more costly for utilization in procurements of petroleum products. As a result of this situation DLA/DFSC-TB requested that the Air Force Packaging and Evaluation Agency evaluate non-metal oil cans now being used.

Test results are as follows: Composite (fiber/paper) cans were found to be an inadequate substitute for metal cans; high density polyethylene cans with metal tops were only slightly better; high density polyethylene cans with pour spouts were found to be superior to metal cans in all applicable performance characteristics with exception to the stacking resistance.

An evaluation of the effect of the high density polyethylene can material on the composition and properties of oil during long term storage is an ongoing study at this agency to be completed in 3 to 5 years.

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INTRODUCTION

Due to the lack of commercial use, the availability of metal oil cans is becoming scarce and suppliers of engine oil are paying an average of $0.20 each for metal oil cans.

Due to this situation the Defense Fuel Supply Center (DFSC-TB), Cameron Station, Alexandria, VA., in support of the San Antonio Air Logistics Centers Directorate of Aerospace Fuels (SA-ALC/SFQ) and DARCOM Packaging, Storage and Containerization Center, Tobyhanna, PA., requested AFPEA to evaluate oil cans made of material other than metal.

The cost of high density polyethylene cans with metal lids was quoted as $0.13 each and the cost of the high density polyethylene pour spout can at $0.174 each.

Recent contracts for procurement of oil have averaged 10,000 cases (240,000 cans) per contract. Purchases of 240,000 high density polyethylene cans with metal tops would provide a $16,800 cost savings. Purchases of an equal quantity of the high density polyethylene cans with a pour spout would provide a $6,420 cost savings and a can superior to the type presently in use.

DESCRIPTION/INSPECTION OF TEST SAMPLES *

Metal cans. Metal cans identified as complying with PPP-C-96 were received from source "A". Quantity received: 12 cases, packed 24 cans to the case. Contents were marked NSN 9150-00-186-6699 (MIL-L-46152A). Inspection of the cans revealed minor dents in numerous cans; however, only a few cans were observed to leak.

Composite (fiber/paper) cans. Composite cans identified as complying with PPP-C-1581, Class 2, Type 1 were received from source "B". Quantity received: 12 cases, packed 24 cans to the case. Contents were marked diesel engine oil (MIL-L-2104). Inspection of the cans revealed only a few leaking cans. The side walls of a large number of cans were crushed near the top and bottom rims.

High density polyethylene cans. High density polyethylene cans (HDPE) received from source "C" were provided with metal lids attached to the side wall rim with a rolled rim seal. Quantity received: 24 cases, packed 24 cans to the case. Contents were identified as SAE 30 nondetergent engine oil service SA. Inspection revealed numerous cans oil stained with oil puddled between top and bottom cans. The oil stain appeared to originate at the rolled rim.

Four cans were emptied, cleaned, dried of all residue and weighed. The can complete with lid ranged from 64.5 to 68 grams with an average weight of 66.5 grams. The average weight of the HDPE material alone was determined to be 50.5 grams. Thickness measurements of the cans were as follows:

* Identification of sources of oil cans coded A through D, are available to U.S. Government agencies upon request.

	Minimum (inches)	Maximum (inches)	Average (inches)
Can side[1]	0.028	0.059	0.041
Can bottom	0.038	0.097	0.069
Can top	0.007	0.0085	0.0079

High density polyethylene pour spout can. This can type, fabricated entirely of high density polyethylene (HDPE) has a 2 1/2 inch spout protruding from the top of the can. The opening of the spout was covered with a foil cover which was heat sealed to the rim. A screw on plastic cap was used for the closure. The cans were designed with a recess that accommodated the spout of a can stacked on top (see Note 19). This facilitated stacking of the cans and reduced the potential cubic size of the 24 can case. The contents of 12 cases were marked as SAE 20W-50 aviation oil and 1 case as SAE 10W-40 API engine oil service SF-SE. Inspection of the cans revealed 7 leakers. These appeared to be due to the application of the foil seal off center on the pour spout. Four cans were emptied, cleaned, dried of all residue, and weighed. The total weight including the foil seal and screw on cap varied from 62.2 grams to 64.1 grams with average determined to be 63.1 grams. The average weight of the can without the screw cap was determined to be 60.7 grams. The thickness of the can walls varied as follows:

	Minimum (inches)	Maximum (inches)	Average (inches)
Can side[2]	0.037	0.065	0.0506
Can bottom	0.037	0.059	0.047
Can top	0.026	0.071	0.046
Can neck	0.032	0.057	0.049

TEST EQUIPMENT

The following test equipment was used in this study:

a. Free Fall Drop Tester, Gaynes Engineering Co., SN4693.

b. Vibration Test Machine, L.A.B. Corp., Type 5000-96B, SN56801.

c. Temperature Test Chamber (-100°F to +170°F), Tenney Engineering Co..

[1]Maximum thicknesses were obtained around the lower quarter of the can side wall.

[2]The thickness of the side material was observed to be greatest at the bottom and became thinner toward the top.

TEST PROCEDURES

Selection. Two hundred eighty eight oil cans of each type were selected and marked to identify any damage incurred in transportation. Each type of oil can was then repacked into new regular slotted containers (RSC) made of single wall V3C fiberboard. The interior dimensions of these containers were identical to the dimensions of the original shipping container the cans were received in.

Conditioning. Four sample cases of each type oil can were conditioned in three different temperatue environments: Ambient room temperatures of 72°, -40° and +120°F. When it was judged necessary, as for the free fall drop tests and stacking tests, cases not previously tested were allowed to condition at the test temperature for a minimum of 24 hours prior to testing.

Free Fall Drop Test. Free fall drop tests were performed at ambient temperature, -40°F and +120°F in accordance with Federal Test Method Standard No. 101B, Method 5007, procedures B and C using a 16-inch drop height for level B evaluation and 21-inch drop height for level A evaluation. New cases and cans were used in tests at each combination of drop heights and temperatures. The drop series consisted of one flat face drop on each of six sides, one corner drop, and one drop on each of the three edges radiating from the corner selected for the corner drop test.

Vibration Test. Vibration (repetitive shock) tests were performed in accordance with Federal Test Method Standard No. 101B, Method 5019. Each type can was packaged in the previously specified cartons of 24 cans and vibrated 30 minutes per face for a duration of 3 hours, or until failure occurred. These tests were conducted at ambient room temperature.

Stacking Tests. Stacking tests were performed at ambient temperature as well as -40°F and +120°F in accordance with Federal Test Method Standard No. 101B, Method 5016. The loads computed for the cartons of each type oil resulted in varying superimposed load values. These load values were found to be within 10%; therefore, the tests were performed using the maximum weight for testing level A (1,648 pounds) and level B (1,135 pounds). When a container sucessfully passed the level A test the level B test was not performed.

TEST RESULTS

Free fall drop test results are presented in Table 1 and described in Notes 1 through 24.

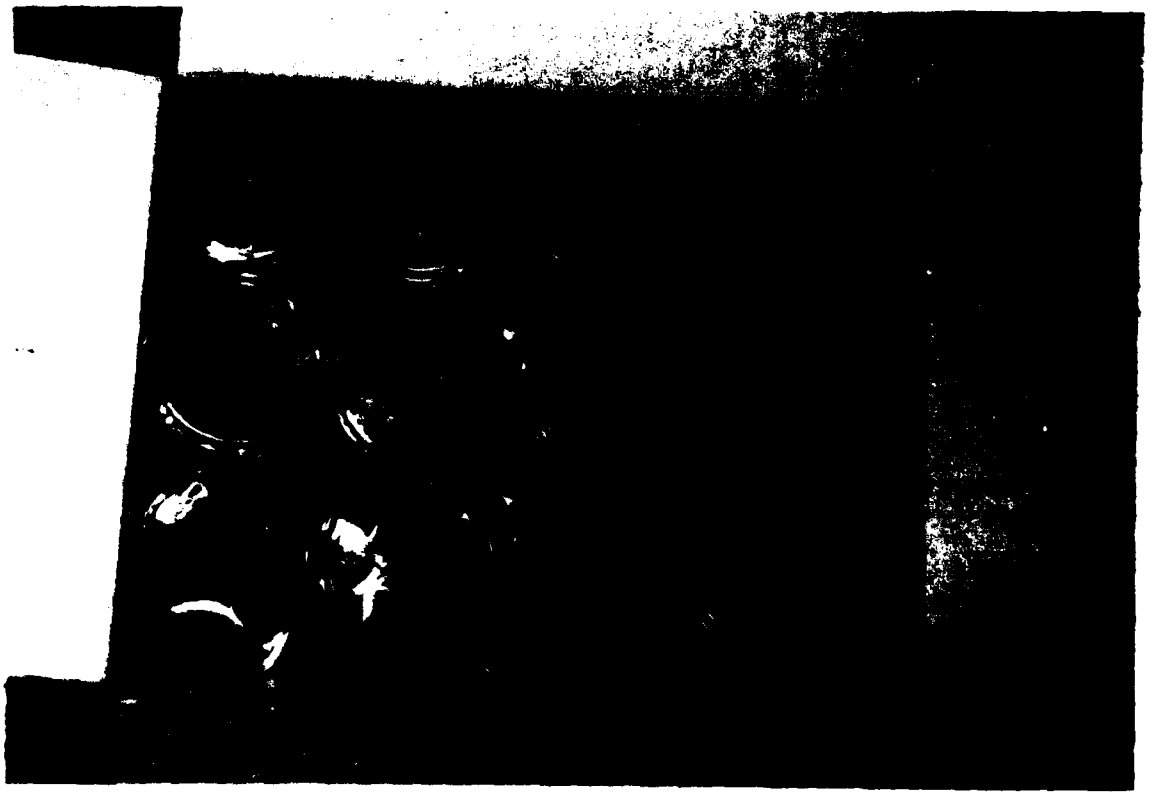
TABLE 1 - FREE FALL DROP TEST RESULTS

Can Composition	AMBIENT TEMP Level A 21" DH	AMBIENT TEMP Level B 16" DH	-40°F Level A 21" DH	-40°F Level B 16" DH	+120°F Level A 21" DH	+120°F Level B 16" DH
Metal	No leaks Note #1	No leaks Note #2	6 cans leaked Note #3	No leaks Note #4	1 can leaked Note #5	No leaks Note #6
Composite	18 cans leaked Note #7	11 cans leaked Note #8	19 cans leaked Note #9	21 cans leaked Note #10	20 cans leaked Note #11	13 cans leaked Note #12
High Density Polyethylene	19 cans leaked Note #13	6 cans leaked Note #14	5 cans leaked Note #15	5 cans leaked Note #16	8 cans leaked Note #17	3 cans leaked Note #18
High Density Polyethylene with pour spout	3 cans leaked Note #19	No leaks Note #20	1 can leaked Note #21	No leaks Note #22	No leaks Note #23	Not performed Note #24

FREE FALL DROP TEST NOTES

Metal Cans (Notes 1 through 6).

Note 1 - Level A, 21" drop height, ambient temperature: No cans leaked oil. Cans were dented to a depth of 5/8-inch. All rolled rims were deformed with some having a reversed curvature (see pictures below).



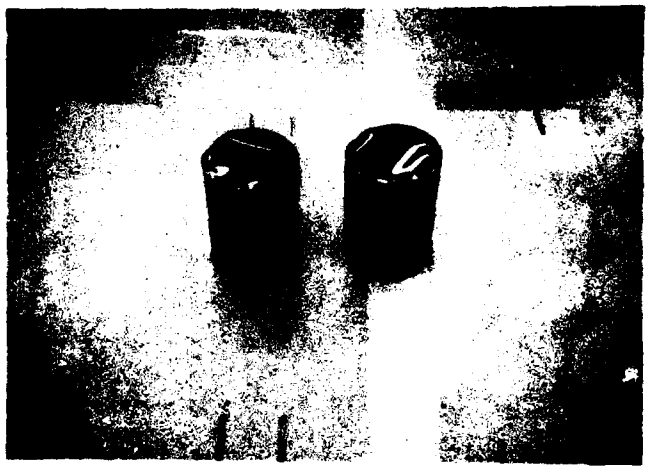
Note 2 - Level B, 16" drop height, ambient temperature: No cans leaked. Cans were dented to some degree primarily near the rolled rims. The rolled rims were out of round (see picture below).

Note 3 - Level A, 21" drop height, -40°F: Six cans leaked oil. Cans were dented to a depth of 31/64-inch. The rolled rims were slightly out of round.

Note 4 - Level B, 16" drop height, -40°F: No cans leaked oil. All cans were dented, some to a maximum depth of 1/4-inch. The rolled rims were slightly deformed, however, general appearance was not radically different from the original circular configuration.

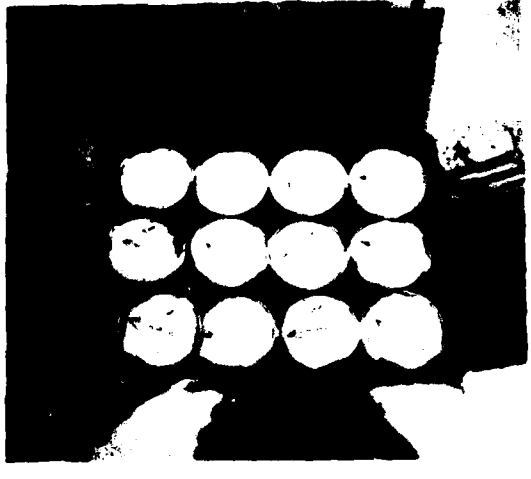
Note 5 - Level A, 21" drop height, +120°F: One can leaked oil. All cans were dented. Maximum depth of dents was measured to be 1/2-inch. The rolled rims were all deformed with the ends of most cans bulging.

Note 6 - Level B, 16" drop height, +120°F: No cans leaked oil. All cans were dented to some degree. Maximum depth of dents was 7/32-inch. Rolled rims deformed with some having a reverse curvature. Most cans had bulging ends (see picture below).

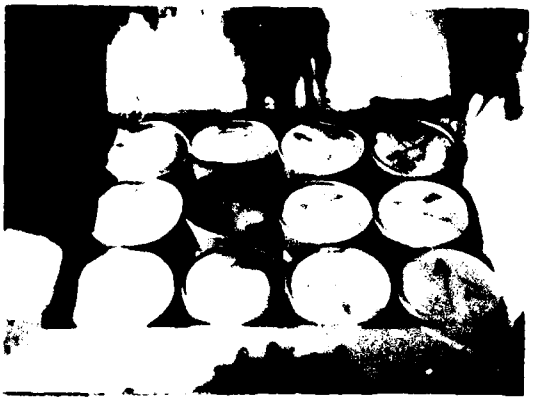


Composite Cans (Notes 7 through 12).

Note 7 - Level A, 21" drop height, ambient temperature: 18 cans leaked oil. The case was oil stained after the last flat face drop. The corner drop and one edge drop was completed prior to termination of the test due to oil exiting the case. Top picture shows top of can number 10 piercing side of can number 9. Bottom picture shows the composite material parted from 1/2 the circumference of the rolled rim of can numbers 9 and 14.



Note 8 - Level B, 16" drop height, ambient temperature: 11 cans leaked. The composite material was pushed from the grip of the rolled rim. The material was torn at the rolled rims of some cans (can number 2, picture below). The rolled edges of all cans were out of round at the top or the bottom.



Note 9 - Level A, 21" drop height, -40°F: 19 cans leaked. Due to oil leaking from the case this test was discontinued after completion of six flat face drops. The composite material was released from the rolled rims and pushed into the can. Most of the cans that have the rolled rim, curvature reversed in places on either the top/bottom or both.

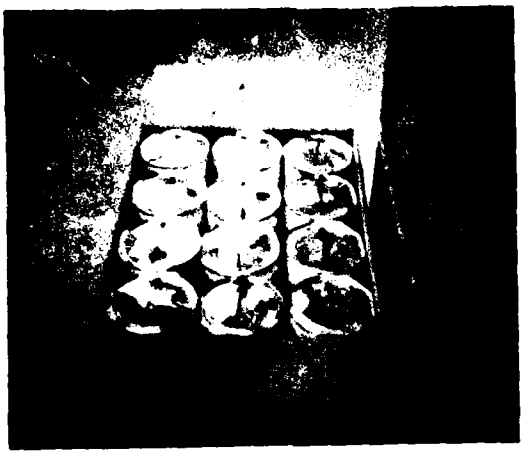
Note 10 - Level B, 16" drop height, -40°F temperature: 21 cans leaked. The case split upon the corner impact (seventh drop), spilling cans of oil onto the impact surface; the test was discontinued. The cans were deformed similar to those described for the Level A, -40°F temperature tests.

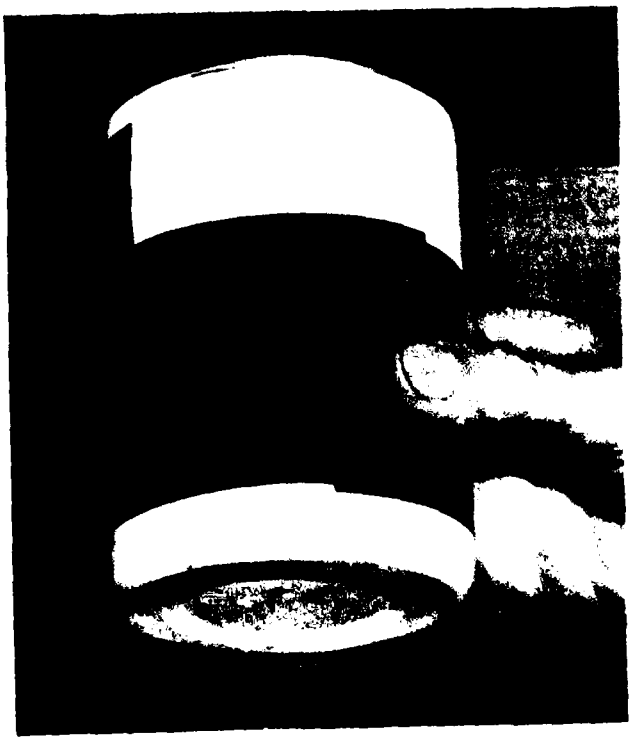
Note 11 - Level A, 21" drop height, +120°F temperature: 20 cans leaked. The tape separated from the fiberboard container on the seventh (corner) drop; the test was discontinued. The extent of damage was much more severe than that observed in the Level A, -40°F drop test. The fiber sides on some cans were separated from the rolled rims around more than three-quarters of the circumference. This was very similar to the damage observed from Level A, ambient temperature testing.

Note 12 - Level B, 16" drop height, +120°F temperature: 13 cans leaked. Tests were discontinued after completion of flat face drops due to oil running from the case. The composite material was found to be ruptured at the metal top or bottom rolled rim, but was less than that which occurred in the Level A test.

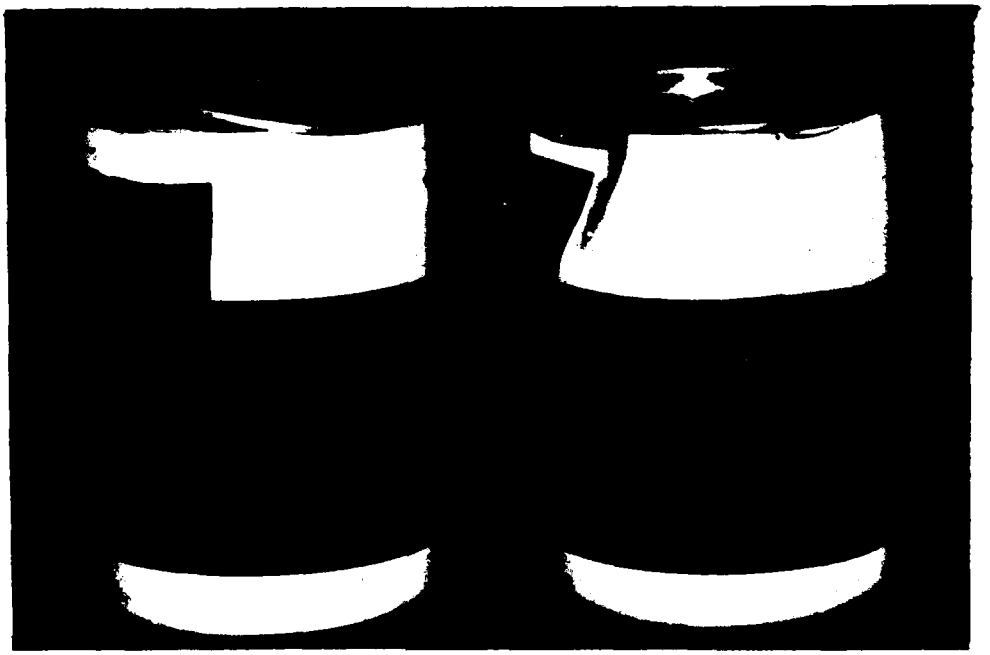
High Density Polyethylene (HDPE) (Notes 13 through 18).

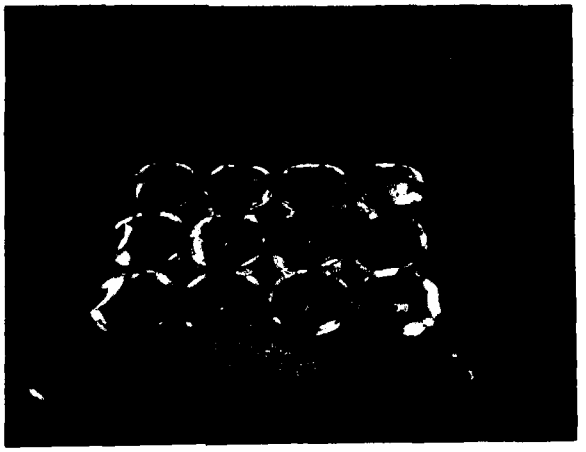
Note 13 - Level A, 21" drop height, ambient temperature: 19 cans leaked. No punctures of the HDPE material were observed; however, some cans had dents to a maximum depth of 25/64-inch. The HDPE material was pushed from the grip of the rolled rim on four cans. The maximum depth of these indentations was 1/2-inch; however, in some instances the pressure of the HDPE material pressing against the metal top retarded the flow of oil from the can. Most of the cans rolled rims were out of round and the metal tops bulged (see picture below).





Note 14 - Level B, 16" drop height, ambient temperature: 6 cans leaked. The HDPE material was pulled from the grip of the rolled rim around 25% of the cans' circumference on one can (see top picture below). The rolled rims of the exterior cans were more severely damaged with little difference noted between the damage incurred during Level A testing and Level B testing (see bottom picture below).



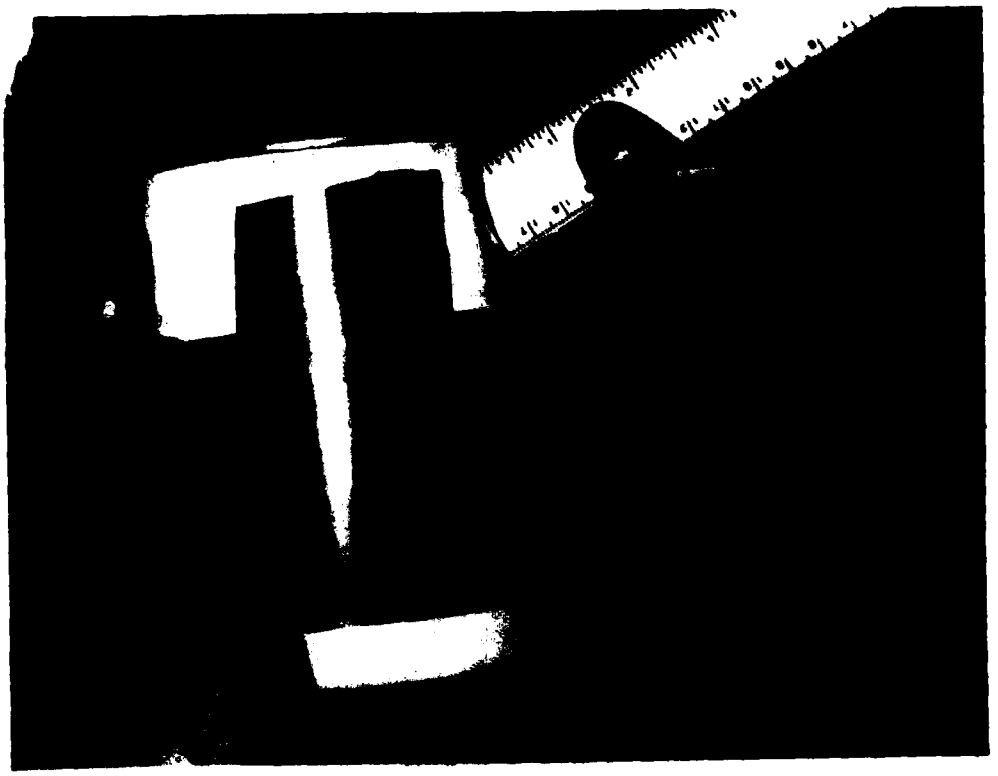


Note 15 - Level A, 21" drop height, -40°F temperature: 5 cans leaked. None of the cans had the HDPE material pulled from the rolled rim. Generally the cans were in better condition than those tested at Level A, ambient temperature.

Note 16 - Level B, 16" drop height, -40°F temperature: 5 cans leaked. Slight damage to rolled rims of all cans. No bulging tops were observed.

Note 17 - Level A, 21" drop height, +120°F temperature: 8 cans leaked. 3 cans had the HDPE material pulled from the rolled rims. The rolled rims of most cans were out of round.

Note 18 - Level B, 16" drop height, +120°F temperature: 3 cans leaked. 2 cans had the HDPE material pulled 5/8-inch from the rolled rims (see picture below). The general appearance of the remaining cans was good.



High Density Polyethylene (HDPE) Can with Pour Spout (Notes 19 through 24)

Note 19 - Level A, 21" drop height, ambient temperature: 3 cans leaked. Hairline cracks occurred in the center of the bottom, where the joining seam bridges a cavity designed in the base of the can. 2 caps were found loose in the case, however, the foil seal prevented an oil spill. Other damage was confined to the dents that occurred primarily at the base of the HDPE material (see picture below).

Note 20 - Level B, 16" drop heigh, ambient temperature: None of the cans leaked. The bottom of the HDPE cans were slightly dented in the vicinity of the recess for the spout (see picture below).

Note 21 - Level A, 21" drop height, -40°F temperature: 1 can leaked. The seam on the bottom of one can split from the center to the outside edge (see picture below). Slight denting was noted in the base area of the recess for the spout and also on the two perpendicular edges formed by this recess.

Note 22 - Level B, 16" drop height, -40°F temperature: None of the cans leaked. The HDPE cans were observed to have little or no evidence of damage.

Note 23 - Level A, 21" drop height, +120°F temperature: None of the cans leaked. The HDPE cans had little or no evidence of damage.

Note 24 - Level B, 16" drop height, +120°F temperature: Since this can passed Level A tests, Level B tests were not performed.

VIBRATION (REPETITIVE SHOCK) TEST RESULTS

The case of metal oil cans failed after being vibrated on faces 3, 1 and 2, in sequence, for a period of one and one-half hours. The case of composite oil cans failed after vibration on faces 3, 1, 2 and 4 for a period of two hours. The HDPE oil can with the metal top and the HDPE oil can with the pour spout satisfactorily completed the test program.

STACKING TEST RESULTS

The results of the stacking tests are set forth in Table 2. NOTE: Successful completion of the Level A stacking test was considered to negate the requirement for Level B testing.

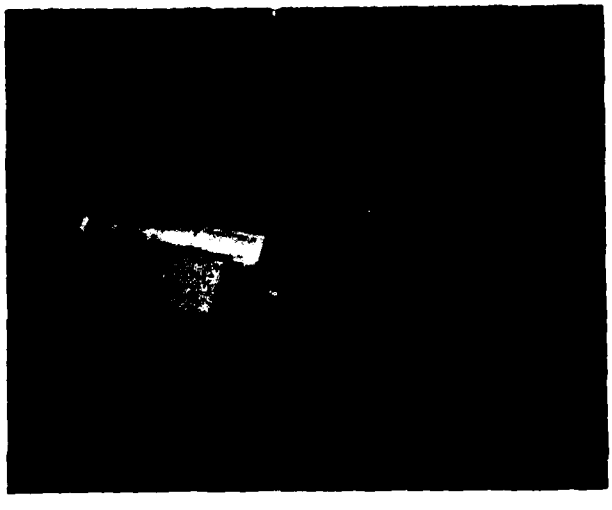
TABLE 2 - STACKING TEST RESULTS

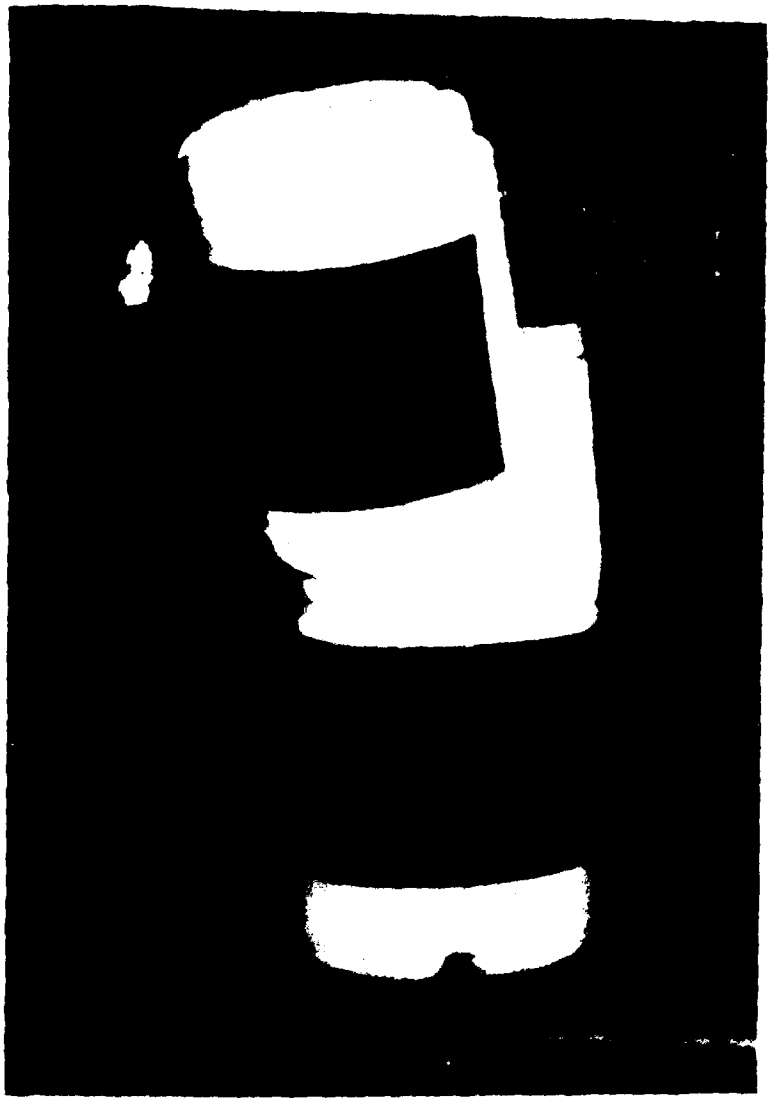
	Level A Packing (1,648 lbs) TEMPERATURE			Level B Packing (1,135 lbs) TEMPERATURE		
Can Composition	Ambient	-40	+120	Ambient	-40	+120
Metal	Pass	Pass	Pass	----	----	----
Composite	Pass	Pass	Pass	----	----	----
High Density Polyethylene (metal top)	Pass	Pass	Pass (Note 1)	----	----	----
High Density Polyethylene (pour spout)	Fail (Note 2)	Pass	Pass (Note 3)	Pass	----	Pass (Note 4)

Stacking test notes

Note 1 - The Level A load was leaning somewhat at the completion of test for HDPE oil can with the metal top.

Note 2 - The Level A load was noted to be slightly off center and after 48 minutes the load toppled spilling the load (see pictures below and on next page). Pour spout cans did not leak.





NOTE 2 (continued) Pour spout cans, distorted by failure of packaging level "A" stacking test.

Note 3 - Upon placing the Level A load on the case of HDPE pour spout cans, the load started to topple and the test was discountinued.

Note 4 - The level B load was supported by the case of pour spout cans, however, there was a list of approximately 10^{0} noted upon completion of the test.

DISCUSSION

Generally speaking level A testing caused more severe damage to the quart cans than the damage suspected to occur in the actual shipping environment and therefore it is not considered to be a realistic standard against which to evaluate the relative performance of oil can packs. For this reason, the following remarks relating to comparative pack performance are based on the results obtained in the Level B tests which are probably more representative of the actual logistics environment.

Results of the drop tests indicated the HDPE pour spout cans equaled or exceeded the performance of the metal oil can. An average of 19% of the HDPE cans with the metal tops leaked. An average of 63% of the composite oil cans leaked.

The results of the vibration (repetitive shock) tests indicated the metal oil cans provided the least amount of protection. Both oil cans made of HDPE material provided excellent protection against vibration with no leaking cans noted at the conclusion of the test.

Results of the stacking test indicated each type of oil can packed in cases of 24 cans will stack 40 cases to the pallet and four pallets high; however, a noticeable weakness was observed in the stacking strength of the HDPE pour spout cases.

Suppliers of each type can provided cost data for shipments FOB their facility as follows: Metal $0.193 each, Composite $0.142 each, HDPE (with metal lid) $0.115 each, HDPE (pour spout) $0.174 each. These costs do not include the cost of fiberboard cases, handling and filling the can.

Processors packaging oil in one-quart cans report similar costs for each type can with the exception of the HDPE can with a metal lid which was reported to average $0.15 each; this is 30% more than the cost the supplier of the can reported. Other comments of the processors indicate filling of the HDPE pour spout can, would be slightly more expensive, than the cans used at present. This is due to the slower filling rate required. They also stated that the composite can should not be used to package synthetic oils. This is due to the wicking action of the synthetic oil under the crimped rim of the can.

The effects on the composition of additives and oil due to packaging in HDPE cans over extended periods of time (3-5 years), will be determined by this agency. The manufacturers of HDPE cans indicate there will be no changes in the composition of the oil or the additives during long term storage; however, the oil additives may have some effect upon the HDPE material.

CONCLUSIONS

Based on the results of the rough handling and storage tests performed in this study it is concluded that the high density polyethylene (HDPE) can with pour spout is a suitable substitute for the metal cans currently used.

The HDPE can with pour spout will reduce product loss now being experienced with oil packaged in metal cans, and would also be expected to be far superior to the composite and HDPE cans with metal lids in this respect.

The HDPE can with a metal lid would provide the lowest initial cost; however, the loss of product due to leaking cans would negate this advantage.

RECOMMENDATIONS

Procurement, transportation, and storage of oil packaged in composite (fiber/paper) cans should only be considered when the product is not available in high density polyethylene or metal cans and then should only be shipped in palletized loads.

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