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PLASTIC
DRUM
INSTITUTE

Plastic Drum Paneling Issues

PANELING

BACKGROUND

This report will explain the causes of paneling and suggest some possible ways to eliminate or minimize the paneling of plastic drums.

Drums are relatively thin walled packages whether they are steel, fiber or plastic. They are not intended to be pressure vessels. However, in some industrial applications they are subjected to pressure influences both internal and external. In many cases, the pressures exerted are within the tolerances acceptable for that package. When the pressures exerted on the package are *outside* the acceptable tolerance ranges, a distortion may be seen in the outer surface of the package. This phenomenon is usually referred to as **paneling**.

CAUSES OF CONTAINER PANELING

1. Changes in the temperature of the lading being packaged

2. Permeation of the lading into the wall of the container

3. Storage of an oxygen scavenger lading in the container

4. Changes in atmospheric pressure conditions

A container panels because ***the pressure inside the drum has become significantly less than the pressure outside the drum***. All of the above reasons for the paneling of containers have this same effect – they change the pressure differential across the container. The question then is, 'how much pressure difference is too much?' The results of the following Paneling Test for Plastic Containers provide the answers on a case-by-case basis.

SUMMARY

The problem of paneling has three possible causes: the temperature differential across the container is too great, the lading being package is a strong permeator, or the lading being packaged is a strong oxygen scavenger. A significant increase in atmospheric pressure (relative to the atmospheric pressure when the container was initially sealed) can cause a package that is relatively stressed near the point of paneling (by some other cause) to actually begin to panel.

All of the causes of paneling have solutions. If a temperature difference is causing the problem, use the results provided in the paneling test to determine a maximum temperature range for your container and either allow sufficient time for the lading to cool to an acceptable temperature or utilize plugs with venting systems in your containers. If you suspect a compatibility problem between your Lading and the container, please speak with your polyethylene material supplier. They can have your lading tested according to the DOT procedures provided in this report. A problem with oxygen scavenging is easily remedied by placing a blanket of nitrogen gas over the liquid being packaged.

PANELING TEST FOR PLASTIC CONTAINERS

TEST PURPOSE AND SCOPE:

The purpose of this test is to determine the amount of vacuum a given container can sustain before paneling occurs. Each type of container will be tested both empty and filled with water.

Equipment List:

Quincy air compressor Model QSI – 235
McDaniel Controls vacuum gauge (0 to 30 inch HG full scale)
Norgren air pressure regulator Model 11-018-100
Festo vacuum generator type VAD – 3/8

TEST PROCEDURE:

1. Perform this test at ambient conditions (c. 70 °F).

2. Obtain two samples of each type of container. Fill one of the samples with water to about five inches below the bung opening.

3. Plug the bung opening of the drum, as necessary. Using a punched out 2 in. NPT plug, attach the test apparatus to the drum. Connect the compressor air line to the test apparatus and set the initial vacuum to 1 inch HG using the pressure regulator

4. Once the vacuum in the drum reaches 1 inch of Hg, wait for two minutes. This will allow time for the sidewall of the drum to relax and adjust to the new pressure.

5. Using the pressure regulator, increase the vacuum in the drum by 0.25 inch Hg and again allow 2 minutes to pass.

6. Repeat Step 5 until the head of the drum draws in and record the pressure.

7. Continue to repeat Step 5 until paneling begins to occur and record this pressure.

8. Detach the compressor airline from the test apparatus and allow the vacuum in the drum to reach ZERO. Remove the test apparatus from the drum.

9. Repeat STEPS 3 through 8 for all containers that are to be tested.

RESULTS AND OBSERVATIONS

A filled container will always withstand a greater vacuum than an empty one because the lading places outward pressure on the container sidewall. This outward pressure counteracts a part of the vacuum applied to the container.

Once a given container begins to panel, it will continue to panel until the amount of the vacuum in the container decreases by approx. 0.5 psi. This reduction in vacuum normally occurs as the container walls panel. Paneling reduces the volume of the container and as a result, the vacuum inside the container. This means that a container will only panel to a limited degree, that is, until the vacuum inside the container drops just enough that paneling can no longer occur (in most cases this is approx. 0.5 psi). However, in this test we held a constant vacuum on the test container. This caused the container to continue to panel until severe distortion of the sidewall occurred. Also, once a container sidewall has buckled due to paneling, it will require less vacuum to cause the container to panel again. The reduction in paneling pressure is proportional to the severity of the previous paneling incident.

The paneling pressure is also dependent on the temperatures of the container's sidewall: if the container is hot, the sidewall is more ductile and will deform more easily.

PANELING DUE TO A TEMPERATURE DIFFERENTIAL

The following table and graph show the amount of vacuum induced within a drum as a function of the temperature differential between the drum's contents and surroundings (or inside and outside). This graph can be used in combination with the results from the paneling test to predict if a drum will panel given the temperature differential across the drum.

This cause of paneling can be eliminated in one of 4 ways.

1. Allow lading to cool longer before filling the container. (Using the results of the paneling test, one can determine a maximum temperature differential for a given container and calculate the maximum allowable temperature for the lading being packaged.

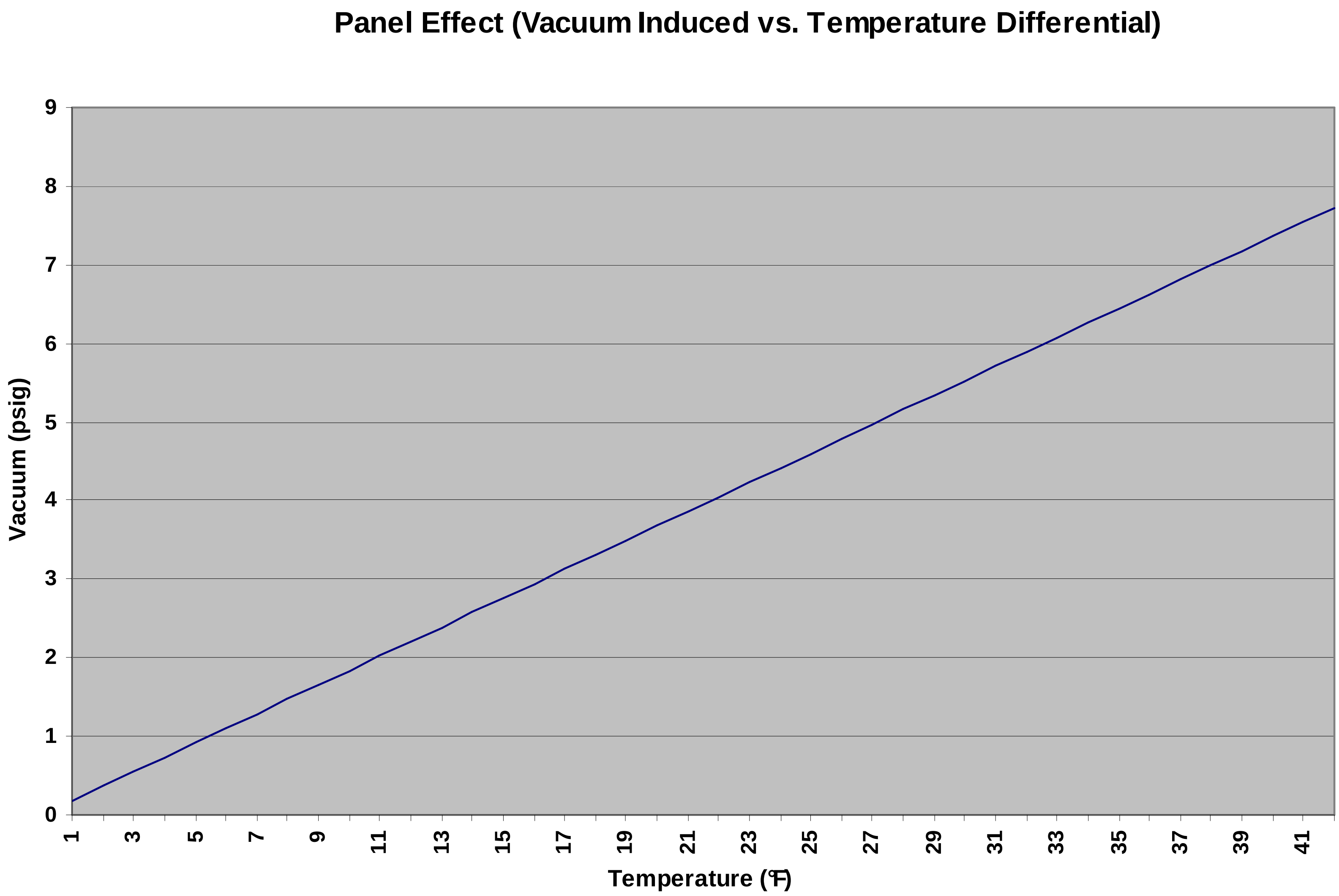
2. Allow lading to cool longer after filling but before sealing.

3. Do not store the packaged goods in a location that is cooler than the filling temperature by an amount exceeding the maximum temperatures.

4. Utilize a venting system.

VACUUM Vs. TEMPERATURE DIFFERENTIAL

Temperature (℉)	Vacuum (psig)
1	0.184
2	0.368
3	0.552
4	0.736
5	0.92
6	1.104
7	1.288
8	1.472
9	1.656
10	1.84
11	2.024
12	2.208
13	2.392
14	2.576
15	2.76
16	2.944
17	3.128
18	3.312
19	3.496
20	3.68
21	3.864
22	4.048
23	4.232
24	4.416
25	4.6
26	4.784
27	4.968
28	5.152
29	5.336
30	5.52
31	5.704
32	5.888
33	6.072
34	6.256
35	6.44
36	6.624
37	6.808
38	6.992
39	7.176
40	7.36
41	7.544
42	7.728


Panel Effect (Vacuum Induced vs. Temperature Differential)
Vacuum (psig)
0
1
2
3
4
5
6
7
8
9
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
Temperature (°F)

PANELING DUE TO STRONG PERMEATORS

Paneling can be caused by a chemical incompatibility between the lading and the container. The result is permeation of the lading into the walls of the container. This reduces the pressure inside the container and cause paneling. The Department of Transportation has a specific test to determine the compatibility of liquid materials packaged in plastic containers. A copy of the test is included on the next page.

D.O.T. PROCEDURE FOR TESTING CHEMICAL COMPATIBILITY AND RATE OF PERMEATION IN PLASTIC PACKAGING AND RECEPTACLES

Appendix B to Part 173

1. The purpose of this procedure is to determine the chemical compatibility and permeability of liquid hazardous materials packaged in plastic packaging and receptacles. Alternatives for this procedure are permitted as specified in part 173.24 (e) (3) (iii) of this subchapter.
2. Compatibility and rate of permeation are determined by subjecting full size plastic containers (or smaller containers as permitted in paragraph 4 of this Appendix) and hazardous material lading to Test Method 2: 28 days at a temperature no lower than 50 ℃ (122 ℉).
3. At least three sample containers shall be tested for each combination of hazardous material and size and design of container. Fill the containers to rated capacity with the specific hazardous material (at the concentration to be transported) and close as for shipment. For the first and last 24 hours of storage, place the containers with closures pointed downward, except that containers fitted with a vent are so placed on each occasion for five minutes only.
4. In those instances where it is not practicable to use full size containers, smaller containers may be used. The smaller container shall be manufactured by the same process as the larger container (e.g. using the same method of molding and processing temperatures) and be made of identical resins, pigments and additives.
5. Determine filled container weight or net weight of contents both before and after storage. Rate of permeation is determined from loss of hazardous materials contents, during the test exposure time, expressed as a percentage of the original weight.
6. After storage, the container shall be drained, rinsed, filled to rated capacity with water at ambient temperature, dropped from a height determined in accordance with part 178.603 (d) of this subchapter onto a rigid non-resilient, flat and horizontal surface.
7. Each of the following constitute test failure:
    a. Visible evidence of permanent deformation due to vapor pressure build-up or collapse of walls, deterioration, swelling, crazing, cracking, excessive corrosion, oxidation, embrittlement, leakage, rupture or other defects likely to cause premature failure or a hazardous condition.
    b. For materials meeting the definition of a poison according to this subchapter, a rate of permeation in excess of 0.5 % determined over the test period. For all other hazardous materials, a rate of permeation in excess of 2.0% determined over the test period.

PANELING DUE TO OXYGEN SCAVENGERS

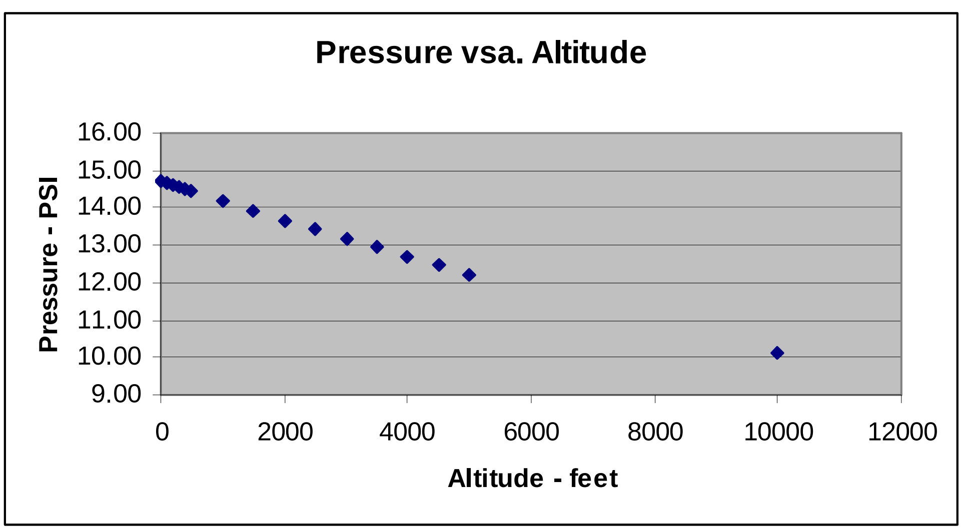
Another cause of paneling is storage of goods that deplete the oxygen inside the container. These types of liquids react with and consume the oxygen in the airspace between the liquid and the head of the container. As this occurs, the air pressure inside the container drops (due to loss of the oxygen into the liquid) and the container may panel. A simple solution to this problem is to displace the air above the liquid with a heavier inert gas (such as nitrogen), before sealing the container.

PANELING DUE TO PRODUCT ABSORPTION

Product absorption occurs from the inside of the drum in contact with the lading and generally will be present as a gradient across the wall thickness. Depending on the products tendency to cause swelling of the Polyethylene there will be a differential growth across the thickness resulting in the inner layer growing faster than the outer layers. Since the expansion is non-uniform across the wall inward deformation or paneling will take place to relieve the stress. Products that cause this effect are typically those similar to Polyethylene, e.g. Hydrocarbons, and do not evaporate from the exterior surface at an appreciable rate so there is no observed "permeation" loss.

PANELING DUE TO PRESSURE CHANGES

Paneling can occur due to change in atmospheric pressure. As noted above it does not take a large pressure difference to cause paneling. An increase in barometric pressure from time of filling can be enough to result in paneling. Another cause is a change in pressure due to altitude changes. For example a drum filled in Denver and shipped to Los Angeles would experience an increase in external pressure of about 2.5 psi, 5000 ft. to 0 feet altitude. See graph.



Paneling caused by any of the factors described above can be seen on drums anywhere in a storage situation e.g. any tier of a stacked array. Apparent paneling appearing only in the bottom layer of a stack is usually the result of poor stacking conditions. Most UN 1H1 drums are stack tested to a specific gravity of 1.8 or 1.9 meaning they were subjected to a top load of 2100 or 2300 pounds for 28 days at 40 ºC. In many cases observable deformation is reported in much shorter times and lower temperatures at lower top loading. In these cases the collapse is due mainly to point loading resulting from the use of poor pallet designs. Namely, pallets that are designed to be used with steel drums or other types of packagings do not support a plastic drum adequately. In a stack test the force is applied uniformly to the drums between parallel, usually steel, platens on a level surface. In practice the pallets used e.g. a 46" x 46" has three stringers and only three to five bottom deck boards and seven top deck boards. The stringers are typically on 22" centers so that they are out the outer edge of a drum with a 22.5" OD and therefore results in point loading. Collapse can be seen below the point of contact with the drum as shown in the photo. The deck boards can also sag and apply non-uniform loading to the drums. Another factor is the surface where stacks are stored. In many warehouses floors are slightly sloped to allow for drainage in case of spills. This can cause a slight tilt in a stack and shift the load to one side of a stack. The use of vented closures will also reduce the ability of a plastic drum to support a load. This is why UN marks are often indicating a specific gravity of 1.4 or 1.5 when vented compared with 1.8 or 1.9 non-vented. Taking these factors into account with those described above it can be seen that "paneling" can occur at lower than tested top load.

This paper was prepared and endorsed by the Plastic Drum Institute (PDI)

The Plastic Drum Institute (PDI) is a trade association, which represents manufacturers of industrial plastic containers, polyethylene resin manufacturers, closure and ring manufacturers, industrial container recyclers and equipment manufacturers in North America.