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From: Meredith Brown <racer@lanl.gov>
Subject: Green Alert: Bulging Drum Video/Research Data

TITLE: Green Alert: Bulging Drum Video and Research Data

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LESSONS LEARNED STATEMENT: Since 1992, there have been 123 occurrences in DOE involving incompatible chemical mixing and pressurization of drums where drums became pressurized to unknown levels. Hazardous materials teams often have little or no training on how to respond or approach bulging drum incidents. An award winning video titled "Bulging Drums - What Every Responder Should Know" is now available to help educate waste workers, hazardous materials teams, fire fighters, etc. Copies of the video may be obtained by contacting Michael Larranaga, Los Alamos National Laboratory, at 505 665 9396.

DISCUSSION: Failure of a pressurized drum can cause a rapid release of pressure, possibly ejecting the drum top or bottom and releasing drum contents, which could result in personnel injury and environmental contamination. Currently, there is no quick, inexpensive, and reliable method for determining pressures inside drums. In an attempt to develop training criteria and a device for determining internal pressures in drums, research is being conducted at Los Alamos National Laboratory to explore the effect of pressure on new closed- and open-head metal and plastic drums and metal overpacks. The objectives of this research are (1) to determine at what pressures 20-, 30-, and 55-gallon drums and 85-gallon overpacks experience failure; (2) to quantify the amount of deformation 55-gallon metal drums experience at various pressures under separate treatments; (3) to determine if the data for the 55-gallon metal drums supports developing an instrument for determining internal pressures; and (4) to conduct a statistical analysis on the mean failure pressures of the collected data for 55-gallon drums.

ANALYSIS: Drums of different types were pressurized from zero pounds per square inch gauge (psig) to failure at 5.0 psig intervals. Linear deformation along the center line of metal drums was measured and recorded with corresponding pressures. Observations were made through a 30x60 magnification spotting scope approximately 75 feet from the test apparatus.

55-Gallon Metal Drums
The following observations are noted with respect to new closed- and open-head 55-gallon metal drums. There were notable differences in the failure characteristics among drum types:

1. Drums appear to vent immediately adjacent to the nut and bolt fastener on the ring.
2. 100% of drums tested vented at pressures at or below 32 psig.
3. Pinging was noticeable between 15 and 20 psig.
4. The 55-gallon metal open-head drums appear to bulge at only the top and bottom ends.
5. Body seams (top to bottom) experienced no visible distortion or apparent weakening.

55-Gallon Metal Closed-Head Drums

1. 95% of the drums tested failed explosively.
2. Of the catastrophic failures, 68% failed at the bottom end, making the entire drum a projectile.
3. 100% of the drums tested failed at the top or bottom ends.
4. When filled with liquid (½ or ¾ full), bottom failures appear to be increasingly violent with increasing water levels up to ¾-full.
5. Approximately 5.0 psig before failure, a significant amount of distortion of the drum chime is apparent.
6. The 55-gallon metal open-head drums appear to bulge at only the top and bottom ends.
7. Body seams (top to bottom) experienced no visible distortion or apparent weakening.
8. Pinging was noticeable between 15 and 20 psig, and increased dramatically immediately before drum failure.
9. T-test indicates a probability that 99% of the failures will occur above 48.7 psig.

The open- and closed-head top deformation averages are sufficient to use the data in developing a device to correlate pressure versus deformation for estimating the internal pressures of visibly bulging 55-gallon metal drums.

55-Gallon Plastic Drums

The five 55-gallon seamless high-density polyethylene drums tested failed explosively at pressures of 48, 48, 50, 30, and 58 psig. Four of five failures occurred through the sides of the drums at no particular or identifying location. One failed at 30 psig out of the top end of the drum. These are significant observations because they show the potential for seamless high-density polyethylene drums to fail out of the sides. Deformation was observed at the tops, bottoms and sides of the drum.

The two 55-gallon open-head high-density polyethylene drums failed explosively at 23 and 24 psig, ejecting the entire top off the drum. One 55-gallon plastic-lined metal drum self vented at 50 psig with a top bulge characteristic of the curve for the closed-head top deformation. A device for estimating internal pressures in 55-gallon drums will not be useful on plastic or plastic-lined drums because deformation was not measured or differences exist in construction between these drums.

The range of failure pressures for the plastic drums was 23-68 psig, and for the metal drums 13-125 psig (125 psig was the maximum test pressure). The pressure deformation curves generated from the data will assist the development of a device to estimate the internal pressure in 55-gallon metal drums.

85-Gallon Metal Overpacks

The six 85-gallon metal overpacks tested failed at or below 16 psig and appeared to self-vent immediately adjacent to the placement of the nut and bolt fastener on the ring. The overpacks appeared to bulge only at the top and bottom ends.

30-Gallon Metal Drums

The four 30-gallon metal drums (2 open-head, 2 closed-head) tested show that significant hazards exist when a 30-gallon metal container is pressurized. The high pressures associated with these containers present many hazards:

1. Extremely high pressures (>120 psig) were possible in 30-gallon metal closed-head drums.
2. These drums maintained extremely high pressures without venting.
3. The failure of these drums under these conditions can be anticipated as catastrophic and extremely

violent.
4. Other than bulge, no apparent failure indicators, such as pinging, were noted.
5. The 30-gallon metal closed-head drums appear to bulge at only the top and bottom ends.

30-Gallon Metal Open-Head Drums
1. Of the two 30-gallon metal open-head drums tested, one failed explosively, and one self-vented.
2. Both 30-gallon metal open-head drums tested maintained pressures greater than 50 psig.
3. Other than bulge, no apparent indicators, such as pinging, were noted.
4. The 30-gallon metal open-head drums appear to bulge at only the top and bottom ends.

20 and 30-Gallon High-Density Polyethylene Plastic Drums
1. The seam and seamless construction 20- and 30-gallon high-density polyethylene drums failed at pressures above 45 psig.
2. Both the seam and seamless construction 20- and 30-gallon high-density polyethylene drums can maintain high pressures for extended periods of time.
3. Four of five seamless construction 30-gallon high-density polyethylene drums failed explosively from the side at no particular location on the drum, making the entire drum a projectile.
4. The seam construction 20-gallon high-density polyethylene drums failed explosively along the bottom seam of the drum, making the drum a projectile.
5. The 20- and 30-gallon high-density polyethylene drums appear to bulge from the top, bottom, and sides of the drum.

RECOMMENDATIONS: Deformation of a drum indicates the drum has been subjected to internal pressure, not that it is under pressure at the time of inspection. The design of these containers makes them capable of violent rupture, and caution should be taken in approaching deformed drums. The following observations should be used as indicators of danger when approaching bulging drums.

1. The distortion of the chime on 55-gallon metal closed-head drums at approximately 5 psig before failure.
2. Intermittent pinging of 55-gallon open- and closed-head metal drums at 15-25 psig.
3. Rapid and intense pinging of 55-gallon metal closed-head drums immediately before drum failure.
4. A strong potential exists for closed-head 55-gallon and closed- and open-head 30-gallon metal drums to fail explosively.
5. All the 85-gallon and 55-gallon open-head drums tested self-vented.
6. 30-gallon metal closed-head drums can hold and maintain in excess of 120 psig.
7. One of two open-head 30-gallon metal drums tested failed explosively.
8. Four of five seamless 55-gallon closed-head high-density polyethylene drums failed explosively out of the side of the drum.
9. Two of four 30-gallon high-density polyethylene drums failed explosively out of the side of the drum, and two self-vented.
10. The seam construction 20-gallon drums tested failed explosively on the bottom seam.
11. Sealed containers of all types have the potential to become pressurized.

ORIGINATOR: Los Alamos National Laboratory
CONTACT: Michael Larranaga, 505 665 9396
AUTHORIZED DERIVATIVE CLASSIFIER: Meredith Brown, 505-667-0604, meb@lanl.gov
REVIEWING OFFICIAL: Michael Larranaga, 505 665 9396
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FOLLOW-UP ACTIONS: Information in this report is accurate to the best of our knowledge. As a means of measuring the effectiveness of this report, please contact the originator of significant action(s) taken as a result of this report or of any technical inaccuracies you find. Your feedback is appreciated.