THE VOLUME DISTRIBUTION OF CANS USED IN TRU WASTE MEASURED BY VE AND ITS POSSIBLE ECONOMIC IMPLICATIONS

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ABSTRACT

One of the prohibited items inside a Transuranic Waste container to be shipped to WIPP is a sealed container with a volume greater than 4 liters. RTR examination cannot be used to distinguish if adhesive tape was used for sealing a can and estimated can volume is imprecise. Therefore, if a can lid is on and the estimated volume is greater than 4 liters, it must be considered sealed, a Prohibited Waste Report (PWR) is written, and the waste container is forwarded to Visual Examination and Repacking (VE). This creates a costly and hazardous process, and its avoidance could bring important savings in hazard, time, effort and waste to the WIPP waste certification process. We have used the Visual Examination database to determine the volume distribution for cans used in transuranic waste packaging, and to evaluate overlaps with the WIPP limitations. Note that the 4 liter limit is a little bit bigger than the volume of one gallon (3.785412 liter) and our evaluation of RTR volume estimation uncertainty makes standard one gallon cans indistinguishable from 4.5 liters in maximum volume. This results in elimination of all one gallon cans. The US packing industry produces a large amount of one gallon and larger cans, which were cheap and effective containers for radioactive materials and wastes.

A possible solution to this conflict between common interior packaging cans and the regulatory limits would be to examine the implications of a limit that is 30% larger (5.25 liters). This requires evaluation of the potential impact for volumes of contained gas and explosion, which propagates through safety and transportation analyses. For Los Alamos National Laboratory, the Visual Examination database indicates that such a volume limit increase would decrease by at least 8% the number of cans requiring PWRs. This could result in a reduction in the number of drums sent prohibited item disposal or for visual examination, with substantial enhancement of worker safety and avoidance of costly activities.

This paper will discuss the RTR capability and enhancement in dimensional measurements and how this is used in the WIPP qualification process. The evaluation constrains of the 4-liter WIPP limit for sealed containers will be presented, and the consequences of a increase on LANL project efficiency and costs.

INTRODUCTION

The Los Alamos National Laboratory (LANL) Risk Reduction and Environmental Stewardship (RRES) Division manages characterization, repackaging, certification, and transportation of transuranic waste for shipment to the Waste Isolation Pilot Plant (WIPP) for disposal. Two primary characterization techniques used in this process are nondestructive evaluation of waste container contents using Real-Time Radiography (RTR) and direct examination of waste container contents using Visual Examination (VE). VE serves as a quality control process for RTR, through statistical selection of a number of waste containers, opening the containers, directly examining the contents, and evaluation of miscertification rates for prohibited items. The statistical selection of waste containers is based on accuracy of RTR results from the previous year, determined using the miscertification rates defined from VE.

One of the prohibited items inside a Transuranic (TRU) waste container to be shipped to WIPP is a sealed container with a volume greater than 4 liters. Sealed containers of interest are generally steel paint cans used to package waste materials for placement in the TRU waste container, and a one gallon paint can corresponds to approximately 4 liters. RTR examination cannot distinguish if adhesive tape was used for sealing a can and estimated can volume is imprecise. Therefore, if a can lid is on and the estimated volume is greater than 4 liters, it must be considered sealed, a Prohibited Waste Report (PWR) is written, and the waste container is forwarded to Prohibited Item Disposition (PID). PID, while operationally faster than VE, does involve time, effort and exposure hazards associated with opening and repackaging TRU waste containers.

It is assumed that miscertification rates for RTR should be approximately 2%. Initial rates determined at LANL were 11%, while other shipping sites have maintained rates within a factor of 2 of 2%. Examination of documentation and processes showed that there had been difficulty over time with RTR operators being able to recognized sealed containers greater than 4 liters in the waste. Retraining operators, and making evaluations for prohibited items with more restrictive pass/fail criteria, has resulted in LANL miscertification rates of less than 2%. However, minimizing the miscertification rate meant increasing the "conservationism degree" that made the cans with actual volumes smaller than 4 liters receive a "Prohibited Item Report" and to be sent for PID, with an associated cost and hazard exposure increase.

This paper reports on an engineering assessment, focused on the uncertainties involved in volume measurements for potentially sealed containers for RTR and VE.

VOLUME MEASUREMENT EVALUATION

It is apparent that 1 gallon cans are a significant component of the LANL miscertifications and subsequent prohibited item dispositions. We hypothesize that this results from substantial volume contributions from small-scale operations and research processes that have, at least in part, been packaged in 1 gallon steel paint cans in the LANL heterogeneous waste streams.

We focused our efforts on finding where the RTR errors are generated. We have developed a method for measuring the volume and volume uncertainty of the objects in closed volumes by RTR. This led to examination of the association between the 4 liters WIPP limit value and 1 gallon can volume, to determine the certification process, economic and safety implications.

We have started by using the Visual Examination Group database. This provides direct measurement results for steel cans within the TRU waste containers. The data is not directly correlated with RTR measurements because the radiography results are not be made available to VE operations until after the visual examination is completed. This provides statistics for approximately 150 cases, with the measurements done by VE operators using the inner ruler. The distribution of results is shown in Fig. 1.

In the figure we observe that the peaks are grouped above the exact multiples of gallons or quarts, being a specific pattern to US packing industry production. One contribution to this distribution above nominal volumes is the necessity to provide a headspace for product expansion, and to provide for access and use of the product contained in the can (e.g. paint).

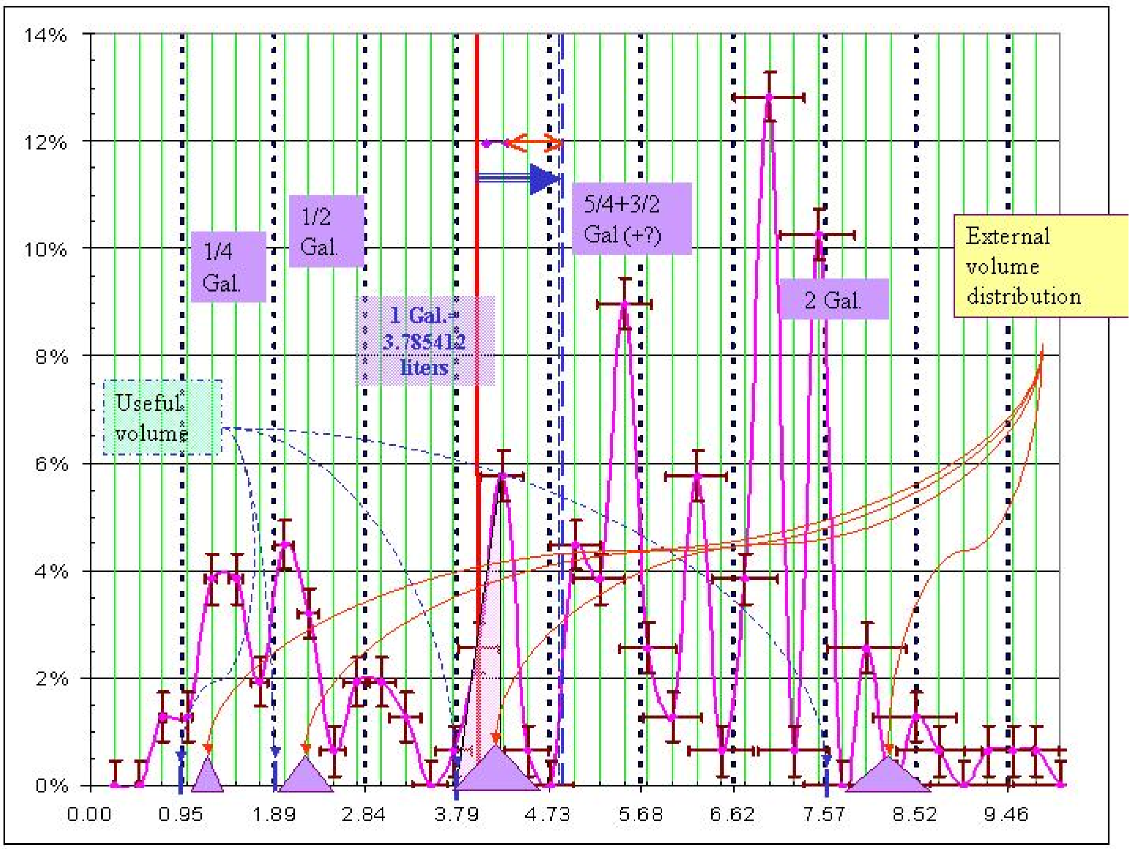

Fig. 1 The distribution of cans and volume distribution that results from grouping the cans in classes of ¼ liters. The red vertical line represents the 4 liter limit.

From the positioning of the cutoff value (4 liters) in the can volume distribution analysis, it is obvious that the prohibited item limits defined for WIPP were intended to make the 1 gal cans pass characterization and certification unopened, even if they were apparently sealed, and to avoid related supplementary time, effort and hazards of repackaging efforts. However, the distribution for 1 gallon cans peaks at about 4.25 liters, meaning that with infinite accuracy only very few of the 1 gallon cans can be passed directly by the VE operation (most 1 gallon cans will be prohibited items if apparently sealed, requiring the can lids to be removed).

The RTR procedure is inherently less accurate than the VE procedure, when used to measure linear sizes and evaluate volumes. The image size on the RTR display system is variable due to divergence of the X-ray beam from source to detector. Variation of placement of an object of interest in the TRU waste container changes the object location between the detector and X-ray source, which is further varied by rotation of the container platform in the instrument. Therefore, variation of the apparent object volume with position in the container relative to the X-ray to detector axis is approximately 40%. A volume calculator and procedure has been developed that decreases this variation by half, using the image size and rotation of the container in the space near the X-ray source where the magnification is maximized. Application of this procedure can drive the measurement uncertainty down to a few percent, but this still results in large uncertainties in the estimated volume.

To further evaluate the volume evaluation process, we need to examine the techniques use to measure, their uncertainties and how those uncertainties impact comparison against the 4 liter threshold.

Visual Examination Measurements

The most accessible measurable value is the external volume. The inner volume is less accessible in the conditions of hazard risk of VE operations. A measurement of the cans in the waste container is performed using rulers with accuracy 0.1"-0.05". This results in uncertainties of the calculated volume of 10-20%. The process of measurement involves overlapping the objects inside the glovebox with a ruler and reading the ruler through the window. This is a difficult process when done inside the glowsbox, with objects containing various waste materials and weights.

In Fig. 2, the view of a ruler based measurement is presented. Careful statistical acquisition in order to eliminate the fluctuations and to obtain a gaussian distribution would result in the distribution curves show in the figure. The calculated volume value does not have gaussian distribution, it becomes an asymmetric distribution with higher probability for lower values, an advantage as it reduces the volume-spread domain for a certain risk factor. A VE operator does not, however, make statistical measurements, so these curves represent the ideal envelope for random uncertainties of the measurements and calculated volumes.

From Fig. 2, there are several ways to figure the limits for the measurement error domain.

Empirically, picking up a value from the ruler, experimentally considered that is the minimum unit that might be correctly read, and considering that the real value might be anywhere between these limits. This distorts into a histogram the distribution curve, but the shape is maintained.

Statistically, operationally defining and applying a calibration process for VE measurements that fix individual miscertification impact factors.

In addition to direct measurement uncertainties, other aspects of the system impact the total uncertainty:Choosing the right location of the measurement point, affected by shape and constructive factors (i.e. canning, sealing, soldering, chamfers, etc.).

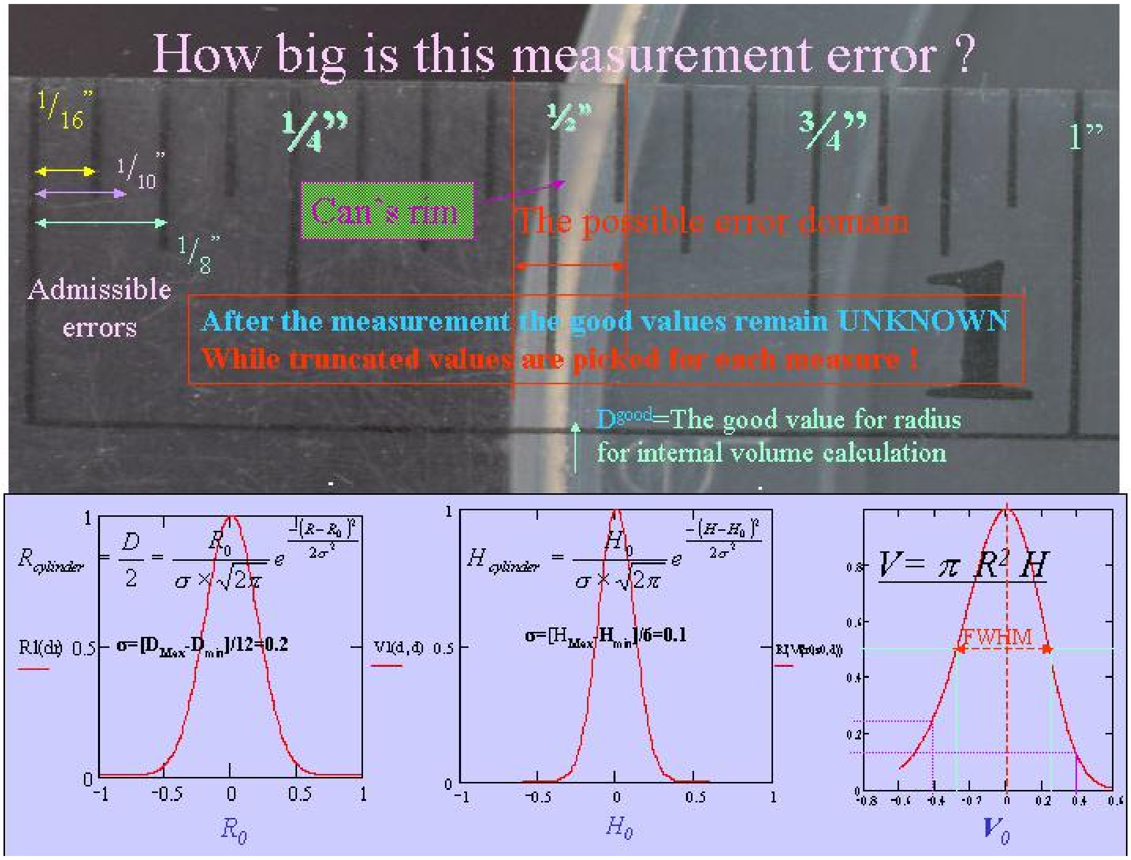

Fig. 2 The ruler overlapping measurement view and results

Effort involved in lifting cans and effort of getting synchronization with the ruler at both ends
Refraction and parallax in the glove box windows
Truncation when communicating a dimensional result

In our simulation we have picked a error value for length measurement of 0.1", and considered that will give insight on what a such measurement means. The red border in Fig. 3 represents the domain of usual cans. Outside this range are special constructive geometries. On the right hand side there is the scale representing the measurement uncertainty. The values have been considered as having attached the tolerances so they are written as $V \pm \Delta V$ The program which plotted the error distribution has the following algorithm:

picked a volume $V \in (0.5 - 12)$ liters, step 0.1 liters, then
pick a height $H \in (0.5 - 10)$", with the step of 0.1"
calculate the radius R= Square Root(v/(PI*H))
read the tolerances and calculate the extrems:
Vmin= PI*(R-t(R))^2*(H-tH)
Vmax=PI*(R+t(R))^2*(H+tH)
Calculate the relative error using:ε=(Vmax-Vmin)/V

Plot ε (H,V) for {H=[1;10], V=[1;12] }, convert LG>Color; Show legend bar and color code on right.

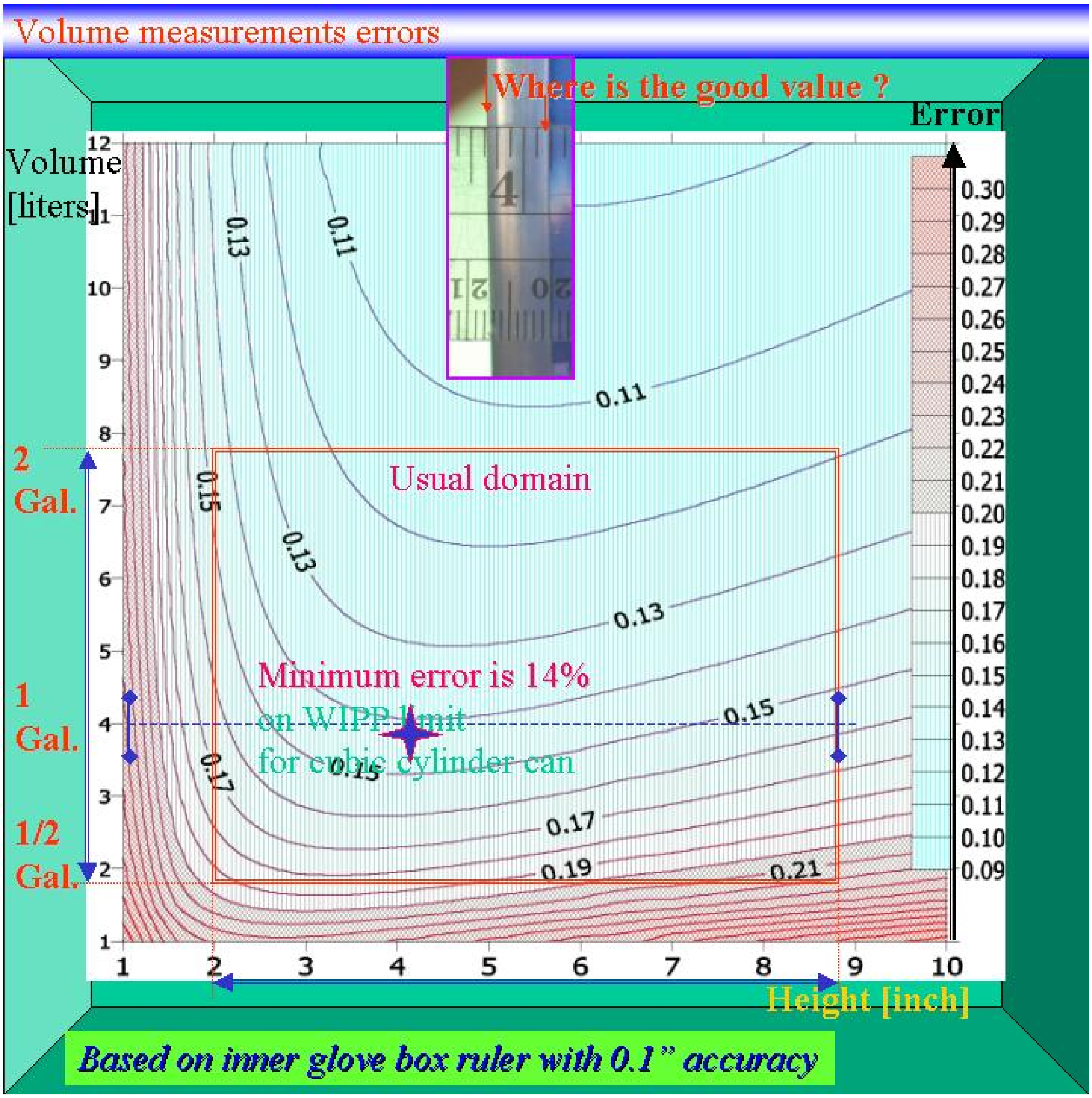

Fig. 3 The error distribution for a preset tolerance after the problem with selecting the good measurement point on the object have been resolved correctly.

Discussion

The main components contributing to the final can volume are shown in Fig. 4, and compared to the 4 liter threshold. In Fig. 4, the upper-left quadrant focuses in on a section of Fig. 1 chart from 3.5 liters to 4.9 liters and from 0-6% volume distribution. This is the 1 gallon can volume distribution and main reference points. The distribution around the 4 liter volume for a tolerance value of 0.1" was considered to be equivalent with σ in the R and H formulas of Fig. 2, resulting upper right quadrant plot of volume distribution. The lower part of the chart illustrates the components of volume build up, for technology and ending with measurement problems. We see that the evolution to actual can volume is the following:

We have a can with the useful commercial declared (nominal) volume of 1 gallon.

This is the volume of a certain liquid type the manufacturer guaranties can be contained without problems, if used according to the can's book of charges and performances.

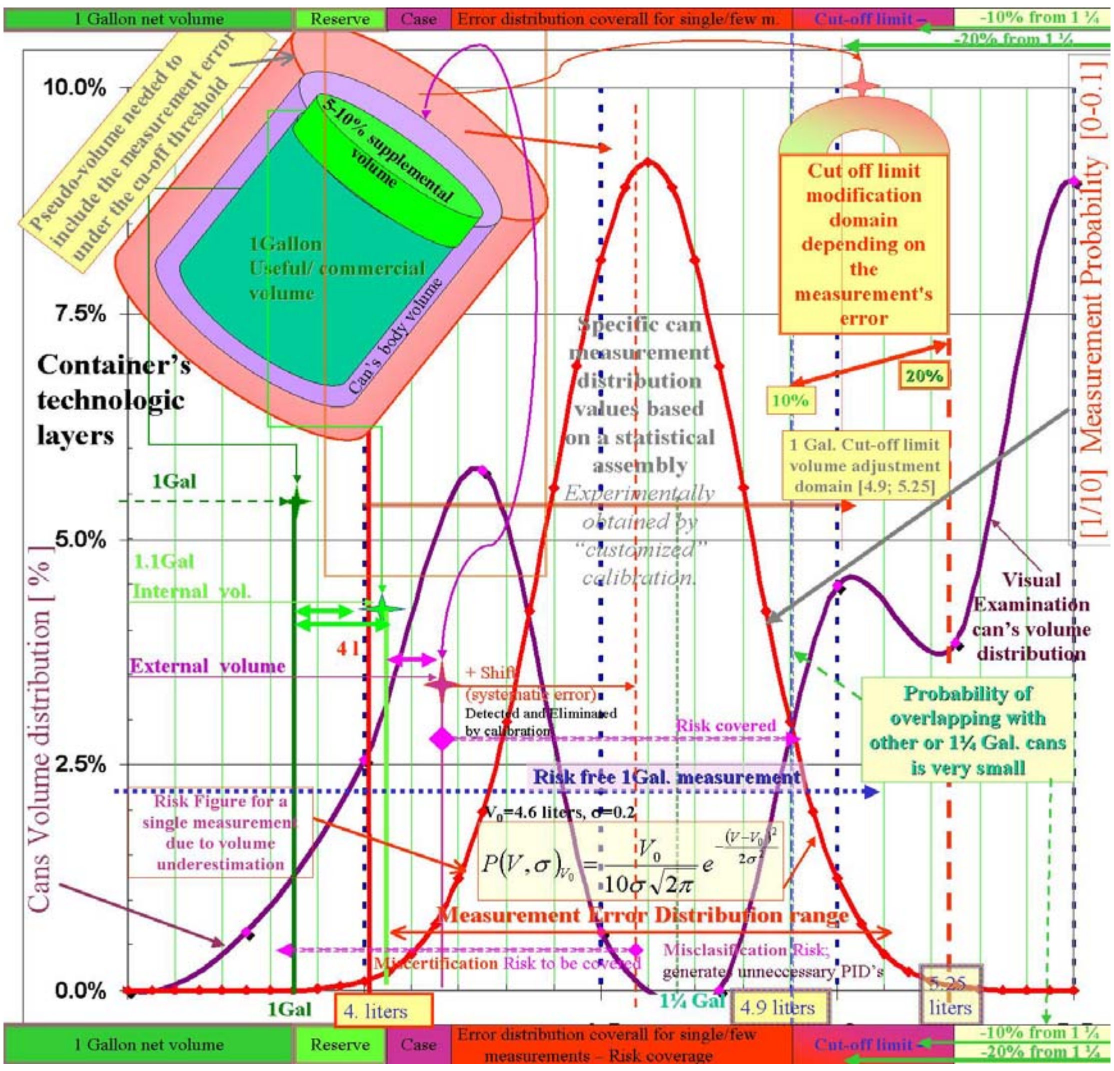

Fig. 4 Measurement and volume contributions to uncertainty and comparison to evaluation of prohibited item threshold.

It is known that the real volume is greater than 1 gallon, with an amount established by the manufacturer which mainly have to comply in mainly 5 situations:

Liquid dilatation and pressure increase if sealed
Displacement accelerations at less than 1/10-1/20 g
Tilting of an angle of 5^o-10^o .
Pouring error of 1-5 %
Lid increased border and volume

From these primary factors, a manufacturer creates an design volume. The design volume is somewhere between 105-110% of the nominal volume, driving a 1 gallon (3.79 liter) nominal volume to 1.05-1.10 gallons (3.97-4.16 liters). Thus, the gross 1 gallon can volume, which is measured by VE or RTR processes is greater than 4 liters. The can itself occupies a further volume component. Wall thickness will vary for can designs, but for most usual cases can be approximated as a 5%. The net total volume of a 1 gallon can is therefore 1.10-1.16 gallons (4.17-4.37 liters). In this result, we have calculated the minimum, smooth volume required to contain a can and not included the evaluation uncertainty defined for VE in Fig. 3. This is the minimum external volume that is presented to an operator of VE or RTR for evaluation relative to the 4 liter sealed container standard, and for a 1 gallon can would always exceed the limit.

How large would the tolerance have to be for conventionally manufactured 1 gallon cans to consistently pass the prohibited item threshold and what other impacts might ensue? In addition to the can size issues developed above, the answer depends on the capabilities of the actual equipment in use, particularly measurement precision. Assuming that RTR measurements can be made to allow volume estimation at the 20% uncertainty level, a threshold level of 5.25 liters would just allow the most restrictive evaluations to be applied and yet pass 1 gallon cans.

From LANL database of VE statistics, the calculated number of TRU waste drums that would not have to be opened and repackaged is about 2%, due to the fact that RTR identifies multiple issues for most of the drums. This results in the following rough estimate of cost avoidance for the Los Alamos Site:

Cost = 17,000 [drums] x 2% x 1.1 [k$/Drum] = **374 [k$]** This is cost decrease would be accompanied by other decreases in certification and operations areas:

Increase of productivity with about 340 drums and decreasing PID processing
Decreasing the miscertification rate and additional drums sent to VE.
Hazard exposure reduction for the PID and VE operators.

CONCLUSION

The actual limit of 4 liters practically eliminates all the 1 gallon cans, in spite the initial intention of WIPP regulations to allow 1 gallon cans to pass certification. This classification as Prohibited Items sending them to PID or VE, producing higher hazards, effort and expenses. This analysis using the LANL database of VE measurements and evaluation of the components of actual volumes for manufactured cans indicates that a threshold of at least 5.25 liters is likely required to consistently pass 1 gallon cans. The consequences of such a WIPP threshold modification for cost, productivity and hazard exposure can be evaluated. Changing this threshold would also require evaluation of the potential for larger volumes of contained gas in a sealed can within the TRU waste container.