# Fill/Headspace by Weight

## Scope and Application

**Wine:**

| Standards of Fill<br>27 CFR 4.72(a) and (b) | Fill Tolerance<br>27 CFR 4.72 (c) and 27 CFR 24.255(b)(1) |
|---|---|
| ≥ 15 L in 1 L increments | ± 1.0% (≥ 15 L) |
| 3 L to 14 L in 1 L increments,<br>2.25 L, 1.8 L, 1.5 L, 1 L | ± 1.5% (1.0 L to 14.9 L) |
| 750 mL, 720 mL, 700 mL,<br>620 mL, 600 mL,<br>568 mL, 550 mL | ± 2.0% (550 mL to 750 mL) |
| 500 mL, 473 mL | ± 2.5% (473 mL to 500 mL) |
| 375 mL, 360 mL, 355 mL, 330 mL,<br>300 mL | ± 3.0% (300 mL to 375 mL) |
| 250 mL, 200 mL | ± 4.0% (200 mL to 250 mL) |
| 187 mL, 180 mL, 100 mL | ± 4.5% (100 mL to 187 mL) |
| 50 mL | ± 9.0% |

A liter of wine is defined at 20°C (68°F) in 27 CFR 24.10.

Wine container sizes without a fixed tolerance are to be filled according to good commercial practice (27 CFR 4.37(d)(1)).

The fill tolerances and standards of fill in 27 CFR Part 4 apply to wine that contains not less than 7 percent alcohol by volume. They do not apply to cider, perry, or mead that contain less than 7 percent alcohol by volume nor sake. Where there is no TTB regulation, containers beyond the limits listed above are Flagged in the LIMS database.

Headspace is defined as the volume of the container occupied by air after closure.
27 CFR 4.71(a)(3):
(i) *187 mL or more.* If the net contents stated on the label are 187 milliliters or more, the headspace must not exceed 6 percent of the container's total capacity after closure.
(ii) *Less than 187 mL.* If the net contents stated on the label are less than 187 milliliters, except as described in (a)(3)(iii) of this section, the headspace must not exceed 10 percent of the container's total capacity after closure.
(iii) *Exception.* Wine bottled in clear containers with the contents clearly visible, with a net content stated on the label of 100 milliliters or less, may have a headspace that does not exceed 30 percent of the container's total capacity after closure.

**Distilled Spirits:**

| Standards of Fill<br>27 CFR 5.203(a) | Fill Tolerance<br>27 CFR 19.356(b) |
|---|---|
| 3.75 L. 3 L, 2 L,<br>1.8 L, 1.75 L, 1.5 L, 1.0 L | ± 1.5% (≥ 1L) |
| 945 mL, 900 mL,<br>750 mL, 720 mL, 710 mL, 700 mL,<br>570 mL, 500 mL,<br>475 mL | ± 2.0% (376 mL to 999 mL) |
| 375 mL, 355 mL, 350 mL, 331 mL,<br>250 ml, 200 mL,<br>187 mL | ± 3.0% (101 mL to 375 mL) |
| 100 mL, 50 mL | ± 4.5% (≤100 mL) |

Proof spirits is defined at 60°F in 26 U.S.C. 5002(a)(10), so fill is accordingly determined at 60°F.

Headspace is defined as the volume of the container occupied by air after closure. Headspace for containers 200 mL or greater must be no more than 8% of the total bottle capacity. (27 CFR 5.202(b))

**Malt Beverages:**
Filling shall be conducted in accordance with “good commercial practice” (27 CFR 25.142(d)). Historically, the TTB laboratories have considered good commercial practice as ± 2% of the labelled fill for malt beverages, beyond which samples are Flagged in the LIMS database.

A gallon is defined for malt beverages at 4°C (39.1°F) in 27 CFR 7.1.

Mandatory label information for malt beverages requires net contents ( 27 CFR 7.70), except when blown, branded, or burned, in the container, and must be displayed on the brand label (27 CFR 7.63(a)(5)).

## Levels and Limitations

This method is preferable for opaque containers and cans. It is also suitable for translucent containers.

## Supplemental Documents

**Form:SSD:516:001** Calculation for Fill/Headspace by Volume
(Formerly BAL:Form:516)

**Form:SSD:517:001** Calculation for Fill/Headspace by Weight
(Formerly BAL:Form:517)

**WG:SSD:1040:003** Sub-sampling
(Formerly SSD:WG:112)

**WG:Balance:001** Balance and Weights Verification Procedure
(Formerly SSD:WG:304a**)**

**SSD:TM:102** Ethanol Determination by Specific Gravity

**SSD:TM:516** Fill / Headspace by Volume

## Equipment

Top loading balance with 0.01 g accuracy (or better)

Density Meter with 0.0001 g/cm$^3$ accuracy (or better), set at 20 °C

Waterproof Marker

## Reagent and Sample Preparation and Handling

No sample prep is necessary. Homogenization is accomplished using **WG:SSD:1040:003**.

## Procedures

**Note:** All procedures for fill in carbonated samples begin with an unopened bottle or can, and in most cases for non-carbonated samples. Sometimes the sample closure is subject to damage by the process of opening the container. This is particularly evident with wine corks where the closure may break apart. In those instances, the analyst may determine that it is better to open the non-carbonated sample prior to weighing to avoid errors due to closure removal or destruction. The sample is immediately stoppered to prevent loss or damage to the contents.

1. For samples in a translucent container, mark the container with a waterproof marker at the Fill Level, and the bottom edge of the closure.
2. Weigh full bottle, with closure, ($W_f$) after stripping all extraneous attachments from the bottle on the top loading balance.
3. Distilled Spirits and Wine:

Determine the true specific gravity ($S_{20°C}$) of the liquid contents at 20 °C using the densitometer.

For Malt Beverages:

Determine the true specific gravity ($S_{20°C}$) of the decarbonated beverage at 20°C.

4. After analysis of sample is completed, drain the bottle or can by inverting for at least 1 minute after the stream of liquid breaks and drops form.
5. Rinse empty bottle with water and dry, inverted at room temperature, for at least 1 hour.
6. Weigh the empty can or bottle with closure ($W_e$).
7. For headspace, fill bottle to the brim with water (or to the mark made at the bottom edge of the closure), replace closure and re-weigh ($W_{bc}$).
8. Note the label volume ($V_o$).

Note: For translucent containers, violative results are confirmed using fill by volume test method (**SSD:TM:516**) or by filling the container with room temperature water to the mark made in Step 1, reweighing, and using 1.0000 for the sample density. This value is then used to confirm the one determined.

## Quality Control

1. Prior to weighing: Confirm top loader operating condition by recording two standard weights, for example a 100 g weight and a 1000 g weight. Weight tolerances should be as defined by laboratory protocol, WG:Balance:001.
2. Top loading balances should be recalibrated annually and the calibration results should be filed with the balance log book. All weight measurements should be recorded in the logbook.
3. Quality control of density meter should be performed according to SSD:TM:102

## Sources of Uncertainty

1. The main source of uncertainty may originate from improper use of a top loading balance. Therefore, particular care should be taken in assuring the proper and timely maintenance and calibration of the balances.
2. Accuracy and precision of the density meter may also be a factor of uncertainty. The density meter should be calibrated and results of laboratory control sample run in duplicate should be within established tolerance range.

## Calculations

### Fill

Absolute fill at temperature T, $V_T = (W_f – W_e) / D_T$ *equation 1*

where $D_T$ = density of beverage at temperature T

$D_T / D_{20°C} = D_{H2O\ T} / D_{H2O\ 20°C}$

where $D_{H2O\ T}$ = density of water at temperature T

solving for $D_T = D_{20°C} * D_{H2O\ T} / D_{H2O\ 20°C}$ *equation 2*

by definition $S_{20°C} = D_{20°C} / D_{H2O\ 20°C}$

solving for $D_{20°C} = S_{20°C} * D_{H2O\ 20°C}$ *equation 3*

substituting the expression for $D_{20°C}$ from equation 3 into equation 2:

$D_T = S_{20°C} * D_{H2O\ 20°C} * D_{H2O\ T} / D_{H2O\ 20°C}$

$D_{H2O\ 20°C}$ cancels out to give: $D_T = S_{20°C} * D_{H2O\ T}$ *equation 4*

substituting the expression for $D_T$ from equation 4 into equation 1:

$V_T = (W_f – W_e) / (S_{20°C} * D_{H2O\ T})$ *equation 5*

Wines are reported at 20°C, so use $D_{H2O\ 20°C} = 0.99823$ in equation 5 to get:

$V_{20°C} = (W_f – W_e) / (S_{20°C} * 0.99823)$ *equation 6*

Distilled spirits are reported at 60°F, so use $D_{H2O\ 60°F} = 0.99902$ in equation 5 to get:

$V_{60°F} = (W_f – W_e) / (S_{20°C} * 0.99902)$ *equation 7*

Malt beverages are reported at 4°C, so use $D_{H2O\ 4°C} = 1$ in equation 5 to get:

$V_{4°C} = (W_f – W_e) / S_{20°C}$ *equation 8*

Fill as % of label contents = $V_T \times 100 / V_0$ *equation 9*

### Headspace

Volume of the bottle, $V_b = (W_{bc} - W_e) / D_{H2O\ T}$ *equation 10*

Wines are reported at 20°C, so use $D_{H2O\ 20°C} = 0.99823$ in equation 10 to get:

$V_b = (W_{bc} - W_e) / 0.99823$ *equation 11*

Distilled spirits are reported at 60°F, so use $D_{H2O\ 60°F} = 0.99902$ in equation 10 to get:

$V_b = (W_{bc} - W_e) / 0.99902$ *equation 12*

Headspace % = $[(V_b - V_T) / V_b] \times 100$ *equation 13*

## Reporting Results

Fill is reported as % of label contents with one decimal, i.e. xxx.X% and as mL with no decimal place, i.e. XXX mL. Headspace is reported as % with one decimal place, i.e. xxx.X%.

Compliance is assessed on wine and distilled spirits based on the fill tolerances given in the 27 CFR. Compliance is not assessed on malt beverages, rather any container filled beyond ± 2% of the labelled volume is noted in the "Summary of Findings" narrative section of the results report and called out in the LIMS Findings test by selecting "Warning" under Fill Compliance along with "Flagged" under Summary Determination (when there are no other compliance issues being reported).

## Safety Notes

Normal laboratory safety protocol should be followed.

## References

| | Standards of Fill | Fill Tolerances | Fill Temperature | Headspace |
|---|---|---|---|---|
| Wine | 27 CFR 4.72 (a) & (b) | 27 CFR 24.255(b) | 27 CFR 24.10 | 27 CFR 4.71(a)(3) (i), (ii) & (iii) |
| Distilled Spirits | 27 CFR 5.203(a) (1) & (2) | 27 CFR 19.356(b) | 26 U.S.C. 5002 (a)(10) | 27 CFR 5.202(b) |
| Malt Beverages | None | 27 CFR 25.142(d) | 27 CFR 7.1 | none |

27 CFR 30.67 for correction of volume of spirituous liquors to 60°F.

*Official Methods of Analysis* (2019) 21st Ed., AOAC INTERNATIONAL, Rockville, MD**, Method 990.17** (*Calculation from Measured Net Weight*). www.eoma.aoac.org [accessed on March 25, 2021]
(Note: Similarities – calculation and weighing/measuring steps; Differences – TM-517 does not include the $CO_2$ density correction referenced in OMA 940.17, does not follow same method of degassing, and does not dry using an oven).

ASBC Methods of Analysis. 8th Revised Ed., 1992**. Method Fills-1**. *Total Contents of Bottles and Cans by Calculation from Measured Net Weight*. Issued 1992. American Society of Brewing Chemists, St. Paul, MN, USA.
(Note: Similarities – calculation and weighing/measuring steps; Differences – TM-517 is different from Fills-1 in terms of the drying method and correction for residual $CO_2$ after degassing).

## Location of Validation Package

Quality System Files

## Required Training, Certification and Re-certification

1. In-house training by a certified chemist.
2. Demonstrate competency by taking written test and by performing the technique.
3. Recertification every 5 years.

## Revision History

Rev. 3 -- Allows for verifying noncompliant results using water; Changes calculation for malt beverages to use SG rather than density (8/21/2009)

Rev. 4 – Edits for consistency and clarity. Addition of compliance statement.

Rev. 5 – Changed section 3 under Procedures from Apparent Specific Gravity to True Specific Gravity. (08/30/2017)

Rev. 6 – Added regulatory references, changed wine reporting to 20°C, corrected and explained calculations, and clarified compliance reporting.

Rev. 7 – Changes to regulations and references. Change to balance readability. No changes were made to the method procedure.

Rev. 8 – Updated CFR references for 27CFR parts 5 and 7.

Rev. 9 – Changed document IDs to the new ID structure.

Rev. 10 – Updated standards of fill.