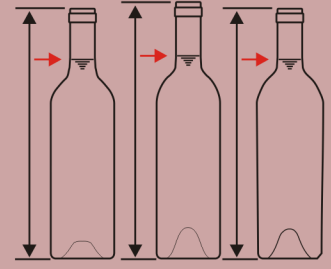


# Bottling Handbook for Proper Closures



## Know Your Bottle

Recent developments in wine packaging have introduced a number of new sources for premium wine bottles. Along with the benefits of these diverse resources, we have seen an increase in the occurrence of mismatched corks and bottles - often leading to unfortunate consequences.

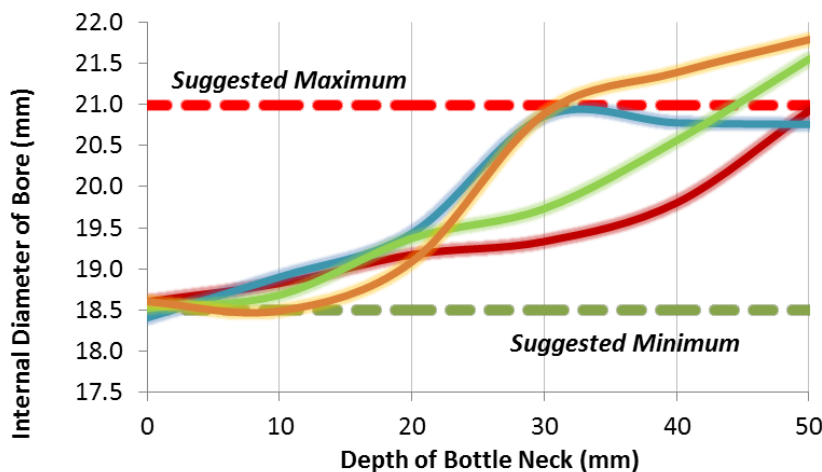
When most glass companies report internal diameter they refer to the “C dimension”. This is basically the top 5mm from the mouth of the wine bottle. Their typical quality control procedures are targeted at this value. Diameter measurements from further down the neck sometimes exhibit wildly different dimensions. Different bottles have different rates of taper. This can be a matter of design, or sometimes a matter of manufacturing variance.

Irregular diameter or excessive taper can be quite detrimental to long-term wine aging. Problems occur when the bottleneck is too wide at the bottom of the cork. When this case, the seal at the bottom of the cork can be compromised, and wine may seep around the sides. This will weaken the overall sealing capacity of the cork and is likely to cause leakage.

The table below compares the internal dimensions of four commercially available wine bottles. Bottles "A" and "B" have internal dimensions with suggested guidelines for the entire 50mm range. Bottle "C" starts at 18.5mm and expands to more than 21mm at a depth of 50mm. Bottle "D" will be a problem as its diameter exceeds 21mm at a depth of only 40mm.

A maximum diameter of 20.5mm is recommended. Internal diameter at the bottom of the cork should not exceed 21mm.

### Comparison of Bore Diameters at Depth



	0mm	10mm	20mm	30mm	40mm	50mm
Bottle A	18.6	18.8	19.2	19.3	19.8	20.9
Bottle B	18.4	18.9	19.4	20.9	20.8	20.8
Bottle C	18.5	18.7	19.4	19.7	20.6	21.6
Bottle D	18.6	18.5	19.1	20.9	21.4	21.8

## Calculating Ullage

Leaking wine bottles are often erroneously blamed on poorly performing closures, but unless the closure has serious physical defects, the reason for leakage is usually due to improper bottling practices and excess bottle pressure after bottling.

Wine bottle drawings from glass manufacturers show the suggested fill point for wine at 68°F. The fill point is measured as the distance from the top of the bottle to the correct wine level in the bottle. These figures do not absolve the winery from their requirement to have a legal fill. They do, however, provide a good idea as to where the correct fill point should be. Generally, the fill point on the 750 ml bottle at 68°F will be approximately 64mm from the top. It is always best, however, to consult the drawing as a +/-3mm variance is possible.

The throat diameter of a standard, American 750ml bottle will vary slightly in the ullage area. On average, however, it is fair to say that the ullage with a 49mm cork and a 64mm fill height will average 4.8 ml. in volume. For a 45mm cork the correct volume would be 6.5 ml.

If the winery bottles at legal fill heights and with adequate vacuum to assure that there will be no more than 2 pounds relative pressure in the bottle at 68°F, it is very unlikely that the customer will ever complain about leaking corks.

The classic reason wines develop excess pressure in the bottles is that the bottles were overfilled in the first place. When this is combined with pressures of warming and expanding wine, leaking can become inevitable.

## Calculating Ullage...

### Temperature Effects

Based upon figures from "Principles and Practice of Winemaking" by Boulton et al, the thermal expansion of wine between 20°C [68°F] and 40°C (104°F) is .08%. This doesn't sound like much. It does, however, convert to .166 ml in volume per degree Fahrenheit. Thus, if a winery bottles at 58°F with 4.5 ml in ullage, that ullage will be reduced to under 3 ml at 68°F and internal bottle pressure will have risen significantly.

There are three ways to achieve proper ullage levels and bottle pressure.

1. Bottle wine at 68°F and fill to the level designated by the bottle manufacturer and confirmed by the winery.
2. Adjust the fill level to compensate for temperature differences. A good rule of thumb is to adjust the fill level by 0.55mm for every degree Fahrenheit above or below 68°F.
3. Adjust vacuum levels to compensate for temperature differences. This method seems less reliable than adjusting fill levels because it places so much responsibility on the performance of bottling equipment. Internal bottle pressure needs to be equivalent to less than 2psi (relative) at 68°F.

### Management Suggestions

One way of dealing with ullage calculations is for bottling managers to chart out target fill heights and internal bottle pressures by bottle type in advance of bottling. Though this will not eliminate their responsibility for a "legal fill", it will provide an excellent guideline for good bottling.

It is also critical that wineries keep good ongoing records during the bottling day. At a minimum, the following protocols should be observed.

- Freshly corked wines from each corker head should be checked at a minimum every hour for internal pressure [suggested interval is every 30 min].
- Quality control should not rely on the temperature gauge at the filler. A thermometer should be dropped into one bottle ex-filler every half hour.

## Ullage and Fill Height by Bottling Temperature

Wine Temperature	Ullage		Fill Height		Comp PSI for Base 68°F
	(ml)	(mm)	45mm	49mm	
72°F	5.5	16.0	62.0	66.0	3.7
71°F	5.6	16.4	62.4	66.4	3.2
70°F	5.7	16.6	62.6	66.6	2.8
69°F	5.9	17.2	63.2	67.2	2.4
<b>68°F</b>	<b>6.0</b>	<b>17.5</b>	<b>63.5</b>	<b>67.5</b>	<b>2.0</b>
67°F	6.1	17.8	63.8	67.8	1.6
66°F	6.2	18.1	64.1	68.1	1.3
65°F	6.4	18.7	64.7	68.7	1.0
64°F	6.5	19.0	65.0	69.0	0.6
63°F	6.6	19.3	65.3	69.3	0.3
62°F	6.7	19.6	65.6	69.6	0.1
61°F	6.8	19.9	65.9	69.9	-0.2
60°F	6.9	20.1	66.1	70.1	-0.5
59°F	7.0	20.4	66.4	70.4	-0.7
58°F	7.1	20.7	66.7	70.7	-0.9
57°F	7.2	21.0	67.0	71.0	-1.1
56°F	7.3	21.3	67.3	71.3	-1.3
55°F	7.4	21.6	67.6	71.6	-1.5
54°F	7.5	21.9	67.9	71.9	-1.7
53°F	7.6	22.2	68.2	72.2	-1.9
52°F	7.7	22.5	68.5	72.5	-2.1

- 1 Ullage is determined by calculating the thermal expansion of a dry wine with 14% alcohol, compared to a base of 6mL at 68°F. Ullage distance is calculated in mm, based on the neck diameter observed in a standard straight sided claret 750mL bottle. Different bottles may have different conversion ratios of mL:mm. Here, the conversion factor is 2.9 mm/mL and is based on an average neck diameter of 20.90mm in the ullage area.
- 2 Fill height assumes corks are recessed 1mm below the bottle top. Calculations are based on specific dimensions for Bottle Type: 750ml Claret Premier (Cal Glass / Owens Brockway) - other bottles may differ.
- 3 Maximum Internal bottle pressure is measured in psi relative to sea level air pressure of 14.7. The maximum reflects the value of pressure that would yield a psi of 2.0 when the bottle comes to rest at 68°F.

## Calculating Ullage...

- If bottling line Q.C. tests bottles that are out of spec for fill or vacuum at a specific temperature, the associated product should be quarantined, [preferably] flipped upright and checked out. Only when the problem is resolved, should cases be returned to regular inventory.
- Q.C. should always check out the readings on cork probe gauges against one another in the morning and again at noon.
- These gauges should also be used to check the functioning of the corker gauge [not vise versa].
- If there is a problem with the vacuum on one or more of the corker heads, the line should be stopped until it is cleared. This should not be done "on the fly".

## Maintaining Legal Volume

Legal fill levels are an important requirement. We recommend the following process:

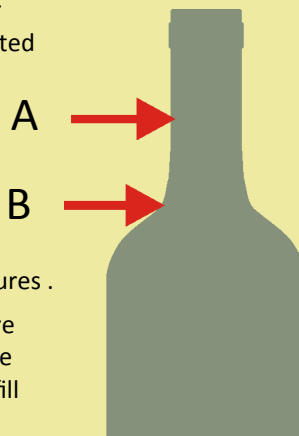
- Consult the bottle drawing.
- Calculate the approximate fill height based upon the actual temperature of the wine.
- Weigh one case of bottles empty. Record the empty weight of each together with its mold number. Run them through the filler. Weigh each individual bottle. Calculate the net difference [full versus empty]. In order to convert this figure to mLs at 68°F, divide the net by .9982g/mL [the specific gravity of water at 68°F].
- If testing with wine you should re-calculate the specific gravity based on the wine used. Wine typically has a lower specific gravity than water.
- Adjust fill heights as required.
- If legal requirements force the ullage to be smaller than indicated by the internal pressure table, increasing the bottling vacuum can be used to compensate.

## For Large Format Bottles...

The ullage tables in this bulletin are designed for 750ml bottles, and calculations need to be adjusted for different bottle sizes. In particular, large format bottles can exhibit tremendous expansion under high temperatures.

For bottling conducted at 68°F, the CQC suggests allowing 8ml of ullage for every Liter of wine. For a 3L bottle—that is 24ml. This target would be adjusted for different temperatures .

To determine the volume, place a mark (A) where the bottom of the cork is expected. Fill the bottle with water. Subtract 24ml and mark the target fill height (B).



## CQC Technical Specs

These specifications outline the general physical and chemical characteristics of cork stoppers as reviewed by the CQC. Specifications are reviewed for compliance by a combination of facilities in California and Europe.

### Dimensions

Dimensions are measured to ensure the correct specification is maintained as agreed with the Buyer. It is important to ensure the function of sealing the wine and adequate extraction of the cork stopper. Method: ISO 9727-1

Specification:

Diameter  $\pm 0.5$  mm

Length  $\pm 1.0$  mm

Ovality  $\leq 0.7$ mm

*Note: Ovality is the mathematical difference between two measurements of diameter taken perpendicularly to each other.*

### Moisture content

At high moisture values may promote microbial growth. Method: ISO 9727-3. Specifications for 1+1 corks are measured at the disk.

Incoming: Average Moisture < 7% or samples <8% at AQL 4.0

Outgoing: Moisture between 4-8%

### Recovery after compression

Good resilience enhances good corking impermeability. Method: ISO 9727-4

Specification: Greater than 90% recovery by diameter after five minutes.

*Note: For a 24mm diameter natural cork stopper the compression target is a diameter of 15.8mm.*

CQC Technical Specs...

**Extraction force**

To ensure adequate extraction force is applied so that the cork stopper can be easily removed. The stoppers' hold should easily allow the normal insertion of the corkscrew. Method : ISO 9727-5

Specification: The amount of force required to remove a 45 x 24 mm cork shall be between 15–45 daN.

*Note: extraction measurements at 24 hours after bottling, based on standard CETIE internal neck dimensions.*

**Peroxide residues**

Where used, a high level of residual peroxide may impact adversely on the level of sulfur dioxide in the wine.

Method: qualitative analysis involving the reaction of potassium iodide with residual oxidants in the presence of a starch indicator.

Specification: No positive results.  
*Note: MDL at 0.2mg/L per cork.*

**Dust**

High levels of dust may have an impact on equipment performance and appearance. Method: ISO 9727-7

Specification: Dust as defined by fine particles of natural cork material will not exceed 3mg/cork.

**Cork Quality Council  
Members**

- Amorim Cork America
- Cork Supply USA
- Lafitte Cork & Capsule
- M.A.Silva USA
- Portocork
- Scott Laboratories

[www.corkqc.com](http://www.corkqc.com)

Recommended Corking Practices

**Corker Jaw Type**

- The 4-segment, sliding jaw type cork compression system is recommended. Roller or iris type jaws tend to cause wrinkles in the cork that can cause leaking.

**Corker Maintenance to Ensure:**

- Corking machines are maintained to the manufacturer's recommended standards at all times.
- Maintain lubrication schedule.
- Smooth action in compression stage.
- No nicks or other damage to the jaw segments.
- Good alignment and seal of bottleneck in centering bell.
- Properly centered plunger.
- Daily cleaning and sanitation of handling surfaces; i.e. hopper, feed tube, orienter, and jaws.
- For a 24mm diameter natural cork stopper the compression target is a diameter of 15.8mm.

**Cork Handling and Storage:**

- Do not open plastic cork bags until immediately before loading corks into the loading machine. No bags containing corks should be left open for any reason.
- Corks recovered from the corking machine after the bottling is completed should be returned to the plastic bag or another closable container, "dosed" with sulfur dioxide gas (vapor) and sealed tightly.

- Corks should be stored in sealed containers in a cool dry location, not in a bottling room, barrel storage area, or chemical storage area. Temperature should be 55 to 70 ° F, humidity 50 to 70% and the atmosphere be free of haloanisole contamination.

**Moisture Content:**

- New shipments of cork as well as corks, which have been stored for extended periods of time, should be checked for moisture content before use. Corks should have an average moisture content between 4% and 8%.
- Corks below target moisture levels should be discarded or returned to the supplier for re-hydration and sterile packaging.
- Inner neck of the bottle must be dry.

**Internal Bottle Pressure:**

- Wine temperature should be between 60-70 ° F. If lower temperatures are used then the fill point should be adjusted down to compensate for expansion in the bottle when room temperature is reached. Be sure to maintain legal fill volume.
- If the fill point is too high, less vacuum can be achieved and internal pressure will increase.
- The vacuum system should be well controlled and maintained. Gauges that continuously display vacuum status at the corking head should be monitored. Frequent (each ½ hour) online QC of corked bottles (pierce test) are highly recommended.
- It is recommended that the above elements be combined to produce a net effect of no more than 2 psi internal bottle pressure at 68 °F.

**Storing Wines Neck-Up ?**

It takes a compressed cork about 5 minutes to achieve 90% of its expansion in the bottle. The balance of natural expansion takes place in a matter of hours. This is the reason why cork companies strongly suggest that freshly bottled wines remain neck-up for 5-10 minutes after bottling

When bottles are turned over immediately after bottling, the corks are at risk to develop seepage along the sides of the partially contracted cork. This problem is exacerbated with large diameter bottles or problems with high pressure in the bottle related to ullage calculations or temperature. CQC members encourage wineries to store wines neck-up if they have any doubts about glass size or bottling conditions.