

cork

technical manual for the correct use of cork stoppers



**cork** (cork) [prob – Du., LG. kork (whence G. kork) . Sp. alcorque  
cork sole of shoe, perh. of Arab. origin (see AL – pref.).]  
1. The bark or periderm of the cork-oak 1570. 2. Anything  
made of cork; ... 3. The cork-tree or cork-oak (*Quercus*  
*suber*) 1601. 4. To stop (a bottle, etc.) with, or as with, a cork





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“Cork is part of our history and culture”, writes Helena Pereira in her latest book [1], and while this noted Portuguese cork researcher is referring to her own country here, it is a comment that also applies to many other Mediterranean countries, including Italy. Her assertion is corroborated by the discovery of numerous archaeological finds from the Roman and Greek periods and even earlier, as well as by quotations from numerous ancient literary works.

In the past, cork was exploited for its thermal insulation properties, resistance to impact, flotation in water and ability to seal recipients, and all these uses remain virtually unchanged today, despite the progress that has been made in the various fields of human endeavour. The production of cork closures for various types of beverage continues to be an important economic driver in some countries. In winemaking, cork enjoyed a virtually unchallenged monopoly for centuries until the development of alternative closure systems in recent decades. The success of cork in winemaking is explained by the fact that the gradual industrialisation of wineries starting in

the 18th Century revealed just how flexible this material is and how well it was able to adapt to faster, more precise and increasingly highly automated bottling lines. Today the cork industry has the at times difficult task of transforming a natural material like cork so that it can be used in modern wineries and of guaranteeing performance that preserves the quality of the wine until bottles are opened. To achieve this goal, cork stopper producers need to introduce increasingly strict controls in the various stages of production, but we should also remember that cork stoppers perform their task best when used in carefully controlled conditions.





The purpose of this Manual is to examine in detail how cork stoppers are used in the wine-making industry, from delivery and corking through to bottles distribution and consumption. Ample space is devoted to examining possible problems relating to the use of cork closures, their causes and troubleshooting procedures to resolve them. Troubleshooting information is provided in table form for easy

consultation and use directly in wineries. All the aspects considered are discussed for still, sparkling and semi-sparkling wines. This Manual draws on multidisciplinary competences in the cork and winemaking fields, and while addressed primarily to a technical audience, it is also for students and producers who are looking for specific information about the correct use of cork closures in a single, comprehensive study.

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# 01

# 1

## THE VARIOUS TYPES OF CORK STOPPER

The cork stoppers available on the Italian market can be classified as follows:



one-piece natural cork stopper



one-piece colmated natural cork stopper treated using cork dust and glue to eliminate surface defects



multi-piece or bonded natural cork stopper comprising two or more pieces of cork joined together by glue. The cork is obtained from low thickness, slow-growing planks to produce high density stoppers



agglomerated stopper (\*)



agglomerated stopper with discs (1+1, 0+1 or 0+2 depending on the number of discs and their position in relation to the two ends of the cork stopper) (\*)



new generation agglomerated stopper, obtained by means of the agglutination of cork granules treated with glue and that contains at least 75% cork granules (by weight) (\*)

(\*) these stoppers are also known as "technical cork stoppers", in accordance with ISO 633:2007 Cork – Vocabulary

The choice of stopper is based on:

- Characteristics including diameter/length/visual class, determined as described in "Nuovo Disciplinare sulle metodiche analitiche per il controllo del tappo di sughero ad uso enologico" [2]
- Overpressure inside bottle, as follows:
  - A) natural cork stopper (any type), for still wines
  - B) agglomerated stopper, for still, semi-sparkling and sparkling wines
  - C) agglomerated stopper with discs, for still (0+1 or 1+1), semi-sparkling and sparkling wines (with discs only on the end inside the bottle)
- Insertion line with respect to bottle mouth, as follows:
  - A) Straight cork: insertion of maximum 1 mm sink, for still or semi-sparkling wines

B) Mushroom shaped corking: insertion of the cork to about half of its length, leading to the characteristic mushroom shape after securing in place by muselets, for semi-sparkling and sparkling wines.

### Usual pressure inside bottle

Generally speaking, the overpressure values inside the bottle (at 20°C) for the various categories of wine are:

- still and fortified wine: slight depression/overpressure compared with atmospheric pressure, depending on the bottling system used
- semi-sparkling wine: internal overpressure between 1.5 and 2.5 bar
- sparkling wine: internal overpressure between 3.5 and 6 bar.

# 01 BOX A

## DEFINITIONS

(from the INTERNATIONAL CODE OF CORK STOPPER MANUFACTURING PRACTICE – C.E. Liège, 6th Edition, 2011)

## FINISHED PRODUCTS

**Stopper** | product obtained from cork and/or agglomerated cork, made up of one or several pieces and intended to seal bottles in order to preserve their contents.

**Multi-piece cork stopper** | cork stopper made from several pieces of natural cork glued together.

**Agglomerated cork stopper made by extrusion/moulding (\*)** | cork stopper obtained by means of the agglutination of cork granules, with a granulometric size between 0.25 and 0.8 mm, bonded with flexible glue using a process of extrusion or moulding.

**Agglomerated straight cork stopper with natural cork discs for still and semi-sparkling wines** | stopper having a body made of agglomerated cork with one or more natural cork discs glued on one or on both ends. The agglomerate may be obtained from treated cork granules.

**Agglomerated cork stopper with natural cork discs for semi sparkling and sparkling wines (\*)** | agglomerated cork stopper with one or more natural cork discs glued on one end.

**Agglomerated cork stopper with natural cork discs for traditional method sparkling wines (\*)** | agglomerated cork stopper with one or more natural cork discs glued onto the same end. The disks may not be less than 4 mm thick and the combined height of the discs must be between 10 and 13 mm. The agglomerate may be obtained from treated cork granules.

(\*) these stoppers are also known as “technical cork stoppers”, in accordance with ISO 633:2007 Cork – Vocabulary

## SEMI-FINISHED PRODUCTS

**Body** | natural cork cylinder made from one or more pieces, or from agglomerated cork, and obtained by extrusion or moulding

**Granulated cork** | cork fragments of variable size obtained by grinding prepared cork and/or by milling manufactured cork stoppers or cork cut pieces, with dimensions generally between 0,25 mm and 8 mm, and already classified by grain size and bulk density.

**Disc** | cylindrical piece of natural cork with variable diameter and thickness, manufactured by cutting cork planks perpendicularly to the growth rings.

**Treated granulated cork** | granulated cork produced with a method that tends to improve organoleptic neutrality and is used in the production of «agglomerated treated granulated cork stoppers».





#### WINEMAKING PRODUCT CATEGORIES

(Attachment I to European Council Regulation no. 491/2009, 25 May 2009)

**Wine** | produced exclusively from the total or partial alcoholic fermentation of fresh crushed or uncrushed grapes or grape must. Has a total alcohol content of  $\leq 15\%$  by weight (with exclusions).

**Fortified wine** | produced from partially fermented grape must or from ... wine with the addition of neutral wine-derived alcohols, distilled wine, concentrated grape must ... (with exclusions) ..., having an effective alcohol content between 15 and 22% by volume and a total alcohol content by volume of  $\geq 17.5\%$  (with exclusions).

**Sparkling wine** | produced from the first or second alcoholic fermentation of fresh grapes, grape must or wine. On uncorking, the carbon dioxide produced derives exclusively from fermentation. The cuvée from which sparkling wine is produced must have a total alcohol content of  $\geq 8.5\%$  vol. Bottles have an over pressure of  $\geq 3$  bar at 20°C.

**Fine sparkling wine** | produced like sparkling wine from superior quality wines (e.g. designated origin). Bottles have an overpressure of  $\geq 3.5$  bar at 20° C.

**Aromatic fine sparkling wine** | produced using grape must or partially fermented grape must from specific aromatic varieties. This sparkling wine must have an effective alcohol content of  $\geq 6\%$  vol. and a total content of  $\geq 10\%$  vol. Bottles have an overpressure of  $\geq 3$  bar at 20° C.

**Semi-sparkling wine** | produced with an effective alcohol content of  $\geq 7\%$  vol. and obtained from wine with a total alcohol content of  $\geq 9\%$  vol. Bottles have an overpressure due to endogenous dissolved carbon dioxide of between 1 and 2.5 bar at 20° C.

**Gasified sparkling wine / gasified semi-sparkling wine** | produced by adding carbon dioxide to wine. Overpressure in bottles must comply with the values indicated above in the respective category.

*Note: exclusions refer to various P.D.O. and P.G.I. wines*

# 02

## DELIVERY TO WINERY AND STORAGE OF CORKS BEFORE USE



# 1

### Cork stopper purchasing

Choose the most suitable cork based on:

- style of wine
- wine pressure
- shipment conditions
- the internal diameter of the bottle neck. It should be remembered that not all bottles are the same and that even bottles of the same type (e.g. standard Bordeaux bottle), but of differing weights and produced by diverse suppliers, may have a different internal diameter
- the instructions and technical specification provided by the supplier.

# 2



### Delivery of cork stoppers

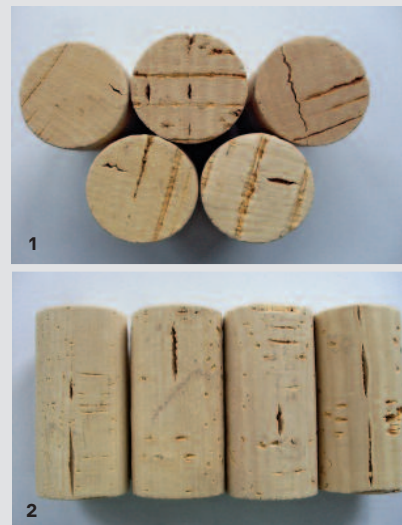
When the cork stoppers are delivered to the winery, the following parameters must be checked:

- conditions of the vehicles used, which must be dry, free of odours and not also be carrying, together with cork stoppers, other material that may in some way contaminate them (e.g. paint, solvents, detergents, food products with distinctive aromas, etc.)
- state of packaging, which must be sealed, undamaged and dry and placed on plastic pallets or HT treated wooden pallets according to commercial agreements defined with the supplier
- correspondence of the material delivered to the material ordered (type of cork, printing and quantity)
- quality controls performed according to the "Nuovo Disciplinary sulle metodiche analitiche per il controllo del tappo di sughero ad uso enologico" [2]
- check the level of quality agreed by supplier and customer.

# 02 BOX C

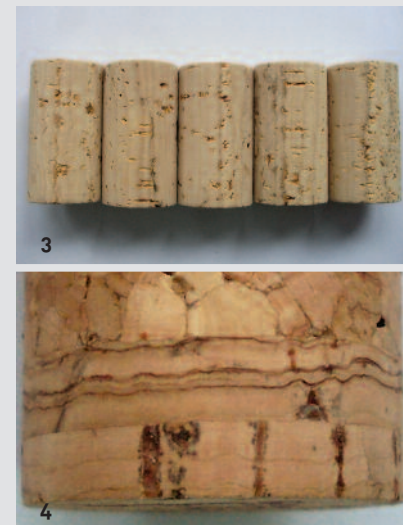
- 1/2) Examples of blown cork
- 3) Example of dry year in a one-piece cork
- 4) Example of dry year in a sparkling wine cork (detail)
- 5/6) Examples of corkwood cork
- 7/8) Examples of insect galleries
- 9) Example of longitudinal cracking
- 10) Example of transversal cracking

## SOME CRITICAL DEFECTS IN CORK STOPPERS (8, 9)



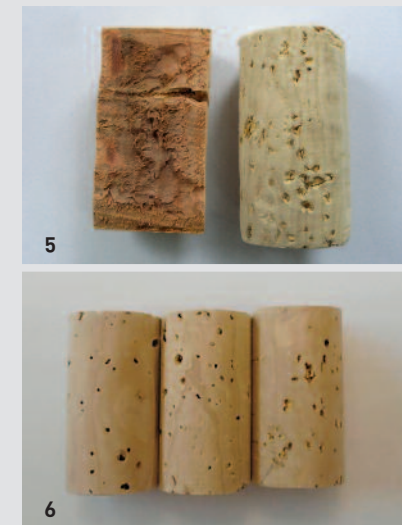
### BLOWN CORK

A structural discontinuity in a year of growth, generally caused when trees lose all their leaves, causing the formation of one or more layers of small, flat cells. Sometimes this defect is visible macroscopically in the form of cracking on the lateral surface or ends of the stopper, but sometimes it is completely invisible. The defect results in total or partial detachment of the two layers at the site of the cracking.



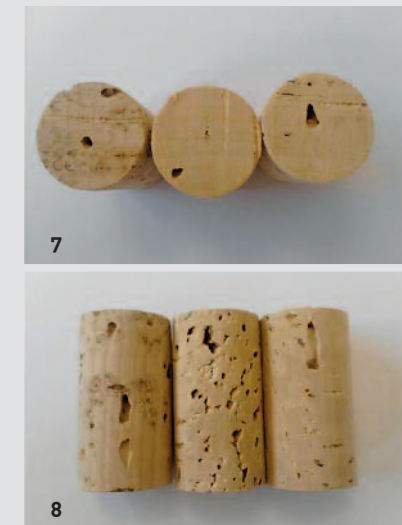
### DRY YEAR

A woody discontinuity inside the suberose tissue, caused by the inclusion in a layer of cork of the underlying conducting cells (phloem tissue) as a result of a period of intense aridity; this discontinuity may be almost total (in this case a dry year is the cause) or partial, generating woody nodules or inclusions.



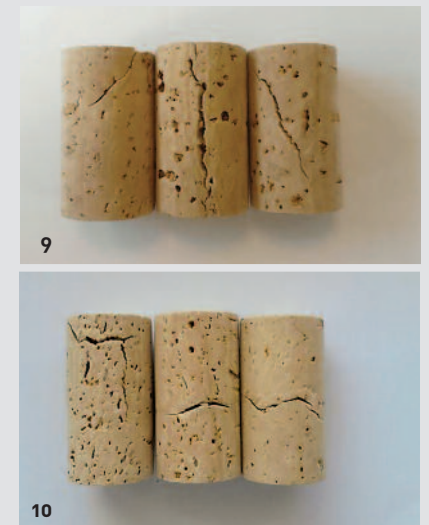
### CORKWOOD

Cork stopper with one or more areas of suberose tissue which have not matured completely, in which cells have a translucent and brownish appearance. During storage of planks, this tissue becomes lighter in colour and shrinks, causing deformation.



### INSECT GALERIES

Cork with one or more insect galleries. Generally these holes extend along one growth ring and can affect both the diameter and length of the cork stopper entirely or in part. The cork has two holes on the surface of the stopper.



### LONGITUDINAL OR TRANSVERSAL CRACKS

Corks with one or more openings of irregular shape and length on the backside. A crack can be longitudinal if it develops vertically along the height of the cork, or transversal if it develops horizontally.

### Cork stopper storage

Packaged cork stoppers should never be left outdoors and immediately transferred to a proper indoor storage area. This area must be:

- clean, well-aired and dry
- at the ideal temperature and relative humidity of 15-25°C and 50-70% respectively (lower temperatures down to 5°C are acceptable, as long as the corks are conditioned for at least 24 hours at the optimum temperature before use)
- free of odours which could contaminate the product

- used exclusively for storing cork stoppers if possible, but in any case must never contain chemical substances of any type (paint, hydrocarbons, cleaning products, vineyard treatment products, etc.)
- cleaned using chlorine-free detergents
- free of wood or woody material (pallets, posts, planks, etc.) treated with chemical substances and particularly with halophenols

- we advise analysing the air in storage areas periodically to check for any chemical pollutants (halophenols and haloanisoles) in accordance with current legislation
- we recommend painting walls with mould resistant paints and which do not release substances responsible for sensory anomalies (Standard UNI 11021:2002)

- corks must always be stored in their original, sealed and undamaged bags (in the event of opening for sampling purposes, containers must be resealed immediately)
- the bags must be raised above ground and never exposed to sunlight, even through glass
- cork stoppers must be used before the date recommended by the manufacturer
- stocks must be used on a FIFO basis (First In First Out)



# 03 BOX<sup>D</sup>

## CORK STOPPERS USE

### REQUIREMENTS OF BOTTLE

(extract from the Technical Specification for the supply of Standard Wine Bottles, Assovetro and Unionvini, 1st revision, November 2009)

Bottles must be manufactured with glass suitable to contain food products (type A sodium-calcium glass in accordance with the Italian Ministerial Decree dated 21/03/1973, as amended) and in compliance as regards heavy metals with Legislative Decree no. 22, dated 05/02/97 (ratifying European Council Directive 94/62, 21/12/1994) as amended on 19/02/2001 and 08/05/2006.

The technical characteristics of the bottle and mouth and limitations on the use of containers are set out in the technical documents provided by each glass manufacturer. The dimensions of the container must be as per the technical drawing.

The tolerances of diameter, height, verticality, and mouth parallelism must comply with CE.T.I.E. regulation DT2.

The capacity of bottles "Measuring containers" must comply with the requirements of Decree Law 451, 03/07/76 and Law no. 416, 19/08/76.

The official control method is set out in ISO 8106:2004.

For use with sparkling wine, the bottles must be suitable and certified for bottling wine with an internal overpressure of  $\geq 3,5$  bar. For semi-sparkling wines, bottles must be suitable and certified for bottling with an internal overpressure of between 1.5 and 2.5 bar.

# 1

### Bottle checks

In addition to the requirements given in Box D, bottles must also be free of the defects defined in point 4.1.3 of the Technical Specification for the supply of Standard Wine Bottles (Assovetro and Unionvini, 1st revision, November 2009) and specifically:

#### Class B:

this class includes all non-conformities which fail to ensure the correct storage and consumption of the wine

- Edge cutting
- Flat bubbles at mouth
- Mouth parallelism in respect of maximum tolerance pursuant to CE.T.I.E. DT2 regulation (if precludes a correct corking)
- Out of vertical in respect of maximum tolerance pursuant to CE.T.I.E. regulation DT2 (if precludes correct corking)
- Crease on mouth
- Internal profile of mouth out of specification

#### Class C:

this class includes all non-conformities that affect filling line productivity:

- Narrow necks (if they cause filling or corking problems)
- Bottles out of dimensional specifications
- Resistance to internal pressure out of specification
- Mixed bottles in pallet (the presence of only one different container requires the entire delivery batch to be temporarily set aside. This non-conformity is managed by common agreement between the parties)





#### Preliminary corking machine checks

- Check that the jaws are in good condition and clean
- Ensure adequate cleaning of the corking turret, the cork elevators and the feeding hoppers
- Check the point of maximum compression of the corking jaws (optimum diameter 15.5 mm)
- Maintain adequate cork orthogonality
- Check that the bottle advancing systems are suitable for the used bottles
- Adjust the height of the corking head in accordance with the bottle used
- Check that the compensation spring, if present, is in good condition
- Check saturation system operation, if present
- Check vacuum system operation, if present

1) Example of cork deformation caused by incorrect cork insertion into the bottle

#### System operating checks

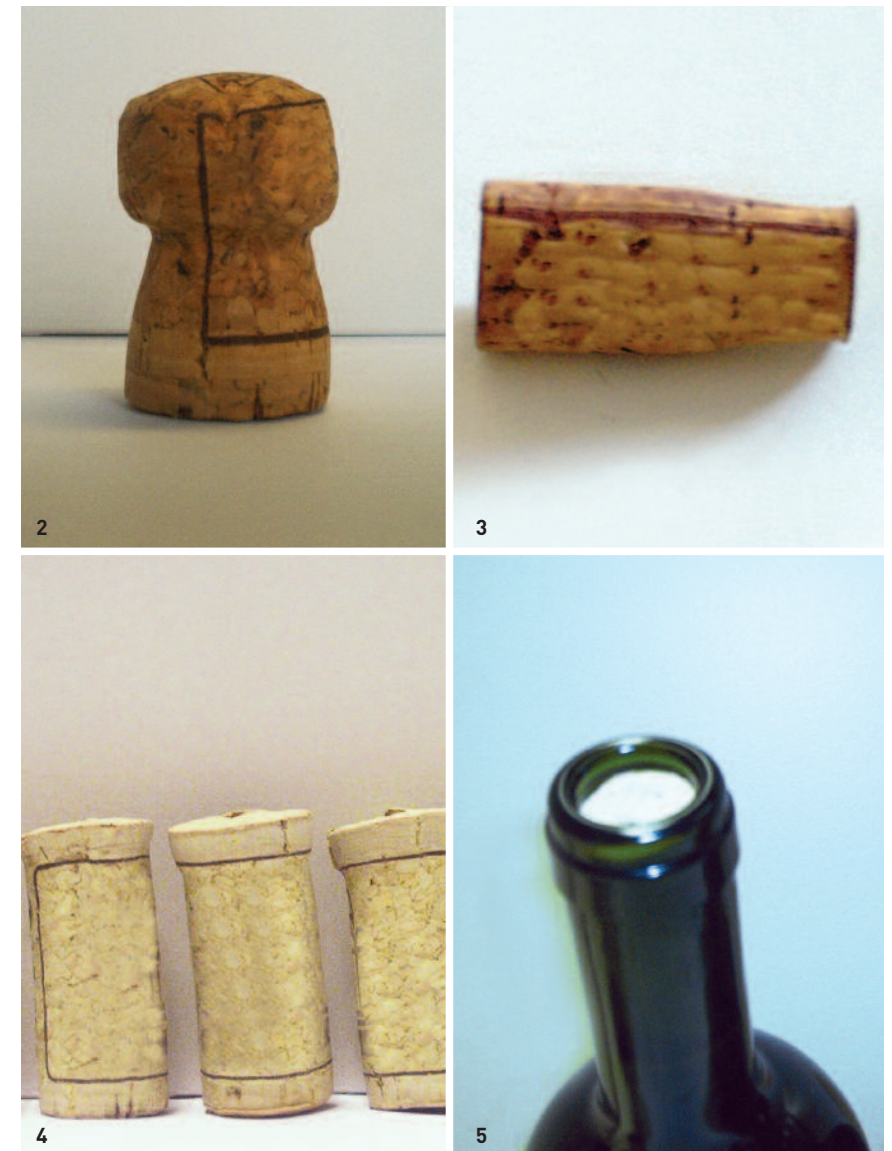
##### Bottle filling:

- Check the filling level and adjust if necessary based on filling temperature and/or subsequent heat treatment of the wine
- Check that there is no liquid layer in the section of the neck between cork and glass (essential in the case of fortified or dessert wines)
- Check for any pressure in the bottle due to transport gas (for still wines)
- Check the depression value (for still wines)
- Check auto-level system operation, if present

##### Bottle corking:

- Check that the cork is perfectly inserted into the compression chamber and does not protrude outside it
- Check that the compressing system does not cause any deformation or alteration to the cork structure
- Check the precise level of cork insertion (for straight cork stoppers bottling between 0 to 1 mm range)

- 2) Example of sparkling wine cork deformation
- 3) Example of scratching caused by incorrect corking machine operation
- 4) Example of still wine cork deformation
- 5) Example of over-insertion





# 03

# 3

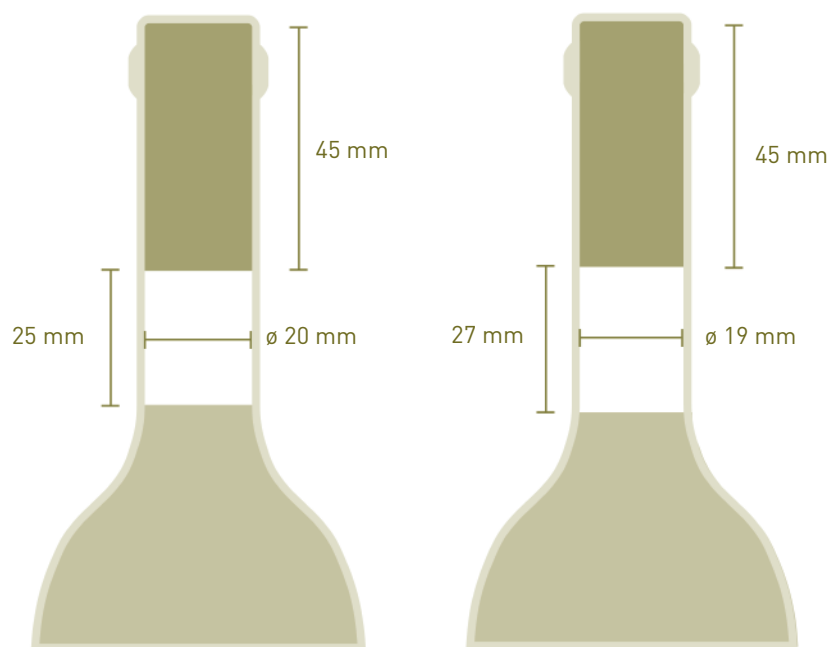
## • Check the volume of the headspace

- The free volume between the base of the cork and the wine must be about 1% of the volume of the wine at a temperature of 20°C [3], in order to limit the increase in internal pressure due to the dilation of the wine as a result of an increase in temperature. For example, in a 0.75 l bottle, the volume of the headspace must be about 8 ml. This volume can be calculated using the formula  $V = \pi r^2 h$

- In practice, the height of the headspace is often used; however, this measurement is indicative and should be assessed according to the characteristics of the bottle
- Check that there are no vibrations and avoid sudden stops during corking
- Do not exceed the maximum number of bottles/hour per corking head recommended by manufacturer (for still wines)
- Check that the cork shows no signs of self-expulsion (for mushroom shaped corking)

## Muselet application (for sparkling and semi-sparkling wines):

- Check muselet positioning and application
- Check that muselet does not affect cork orthogonality
- Check the length of the cork wire muselet after application ( $24 \pm 1$  mm). This measurement refers to the 0+2 cork; for other types (e.g. 0+1) please refer to the manufacturer's specifications. Make sure that the length is correct ensures a good seal as a result of the crown effect (see BOX E)



Example of headspace height, equal to a free volume of 1% of the wine volume, in two types of 0.75 Bordeaux bottle

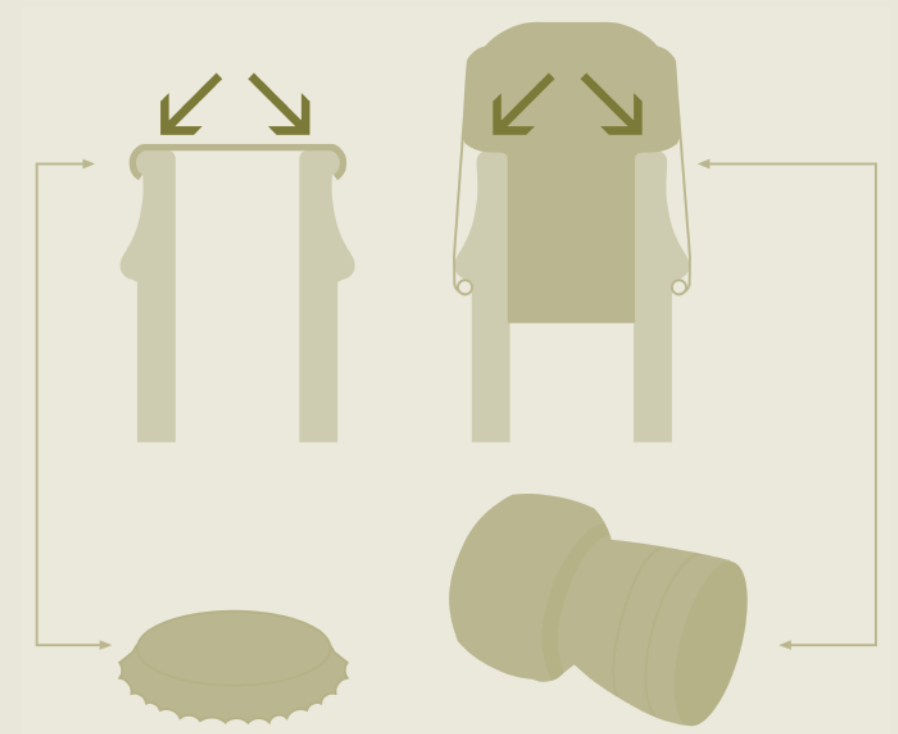
# BOX E

## CROWN EFFECT

(Excerpt from: "Manuale di tappatura per vini spumanti") [4]

When the muselet is tied under the bottle's mouth, it causes an elastic deformation of the section of cork stopper that is left outside the bottle's neck during corking. This elastic deformation produces the so-called crown cap effect. The crown cap effect is produced by metal crown caps that are crimped onto the bottle mouth in such a way as to compress a thin seal between the metal part and the surface

of the bottle mouth. Muselets obtain the same effect by exploiting the flexibility and deformability of a cork stopper, which is compressed axially onto the bottle mouth. The creation of this area of maximum compression of the material blocks the micro pores in the cork agglomerate by elastic deformation, so achieving the crown cap effect.



The picture illustrates the vertical cross-sections of two bottle necks, the first closed with a crown cap and the second with a crown cap effect cork stopper with muselet. The arrows indicate the contact areas between the crown cap effect cork and the bottle.

**End of line checks**

- Check the positioning of the cork at standard temperature (20°C)
- Check the liquid level at standard temperature (20°C)
- Check that the overpressure inside the bottle is less than 0.5 bar (for still wines)
- Check that there is no water or moisture on the external surface of the cork before capsuling (for still wines)
- Check for damp corks before packaging in cartons
- Keep bottles upright at the end of the line for as long as possible (minimum time recommended: 3 hours) (see Box <sup>F</sup> too)

BOX <sup>F</sup>**BEHAVIOUR OF ONE-PIECE CORK STOPPERS AFTER COMPRESSION AND RELEASE**

After compression by the corking machine jaws and release, one-piece cork stoppers have the following dimensional recovery rates:

- a) instantaneous: 85% of original diameter
- b) after three hours: 95% of original diameter
- c) after 24 hours: 99% of original diameter



# 04

# 1

# 2

## CELLAR STORAGE OF BOTTLED WINES



Example of insect damage to a cork stopper. Also note signs of wine leakage

### Suitability of the cellar

- Cork easily absorbs odours and cellar storage areas for bottles must be free of substances which have a negative sensory impact, including halophenols and haloanisoles
- Storage areas must be free of insects whose larva can damage cork (the most frequent are, for example, moths from the Tineidae and Oecophoridae families)
- Current food and health regulations must be applied

### Temperature

The temperature of storage areas is a crucial variable in ensuring the best possible seal between cork and bottle and must be kept in the range 15 to 18°C. Rises in temperature cause the volume of the wine to increase (about 0.2 ml/°C), reducing the headspace and increasing the internal pressure. This puts the cork seal at risk.  
See Box <sup>6</sup> for further information

# BOX <sup>6</sup>



### STOPPER/BOTTLE SEAL SYSTEM (5, 6)

The leakage of wine from corked bottles mainly affects one-piece cork stoppers, but also other types, although less frequently. Although the phenomenon is generally referred to as leakage, there is a distinction between:

- “leakage”, which is a more serious defect, with the percolation of wine through the cork or along a crease; the loss of wine does not stop and in general the bottle is unsaleable

- “Staining”, or the process by which wine leaks between the glass and the cork, causing a minimal loss of product; the staining may be momentary

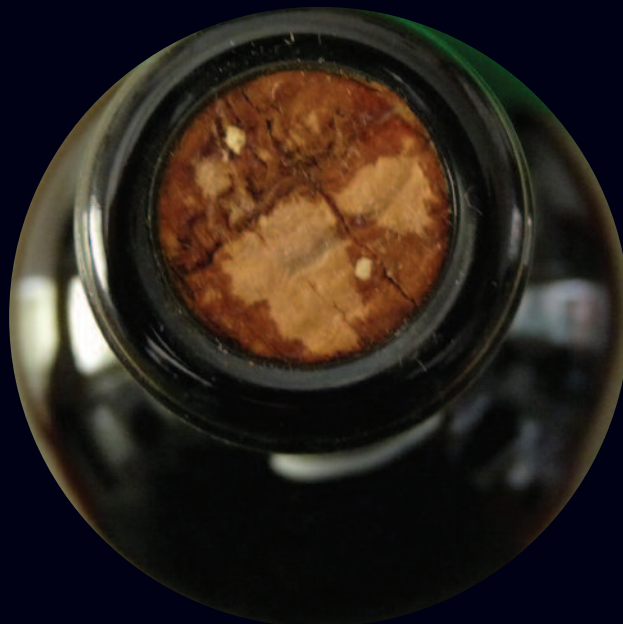
Apart from the appearance of the bottle, even a small seepage of wine can increase the humidity on the outer face of the cork or in the space between the cork and the capsule, which risks improving fungal growth.

# 04

Example of wine seepage on the outer surface of a cork



Example of mould proliferation on the outer surface of a cork



°C	
0	1,85
1	1,80
2	1,74
3	1,68
4	1,64
5	1,59
6	1,54
7	1,45
8	1,68
9	1,64
10	1,36
11	1,32
12	1,28
13	1,24
14	1,20
15	1,16
16	1,13
17	1,09
18	1,06
19	1,03
20	1,00
21	0,97
22	0,95
23	0,93
24	0,91
25	0,88

# 2

## Temperature

Wines bottled with straight cork may have a risk of partial rising of the cork. For semi-sparkling wines, temperature rises cause an increase in the internal overpressure as indicated in the conversion table given in the table alongside. This may cause a loss of internal overpressure.

Tabella: Ratio between the overpressure (expressed in Pascal) of a semi-sparkling wine at 20°C and the overpressure at a temperature t

# 3

## Humidity

If the air is too dry, it can cause the outer surface of the cork to dry out excessively, causing a loss of elasticity and seal problems. In overly damp environments, on the other hand, mould can proliferate on the outer surface of the cork, accompanied by the risk of transmitting unpleasant flavours to the wine. The relative humidity must be between 60% and 80%.

Example of leakage and consequent growth of mould on a sparkling wine cork



# 4

## Bottle position during storage

In the past, the vertical or horizontal storage of bottles of still wine was regarded as a variable able to control the ingress of oxygen into bottles. Recent studies tend to minimise the impact of the position of bottles on the evolution of the wine they contain, as no quantitative differences between the amount of oxygen to enter in the two cases have been found [7]. So far as concerns the effect on the elasticity of the cork (with the possibility of wine staining) and on the increased risk of contamination through wine/cork contact, the choice of bottle position must take account of the correlation between internal neck profile and cork stopper dimensions, type of stopper used and style of wine.

# 05

# 1

# 2

# 3

## SHIPMENT, STORAGE BEFORE AND AFTER SALE, CONSUMPTION

### Bottle shipment

During shipment, the quality of corking can be ensured if:

- the containers and trucks used are in a good sanitary state and have not been contaminated by previous loads
- the bottles of wine have not been subjected to temperatures over 40°C
- the bottles of wine have not been subjected to temperature swings of more than 30°C

### Storage of bottles before sale

The distributor/retailer's storage area for bottles before sale should have the following characteristics:

- no anomalous odours or substances that can contaminate the product from a sensory point of view
- controlled temperature (15-18°C) and humidity (60-80%); the bottles must never be subjected to temperatures over 40°C or temperature swings of more than 30°C
- ambient conditions must be such as to guarantee uniform conservation of the batch

### Conservation of bottles after sale and consumption

The factors to take into consideration for the purposes of preserving the characteristics of the product are:

- storage time before consumption
- storage conditions (high temperature environments)
- consumption temperature (for sparkling wines)
- stopper freezing
- correct corkscrew use
- cleanliness of glasses



# 06

## TROUBLESHOOTING GUIDE

Important information for the correct use of this troubleshooting guide:

- the table below lists causes, checks and precautions relating to problems affecting bottled wine resulting from the cork, bottle, filling, capping, storage or consumption

- also indicated are various problems affecting bottled wine, the causes of which may be different from those mentioned above. Only the most frequent problems are presented in this table, the causes of which relate to production steps prior to the wine coming into contact with the cork. Other issues relating to good winemaking practice are outside the scope of this manual
- cork stoppers for sparkling wine are intended as type 0+2

- the "references" column indicates where further information can be found in the Manual
- for analytical methods of checking cork stoppers consult "Nuovo disciplinare sulle metodiche analitiche per il controllo del tappo di sughero ad uso enologico" [2]
- checks and precautions are only indicated if they can be performed by users

1 STILL WINE  
2 SEMI-SPARKLING WINE  
3 SPARKLING WINE

ISSUE	ORIGINS	CAUSES	CHECKS/PRECAUTIONS	REFERENCES	1	2	3	
CORK BREAKAGE	CORK	- anomalies in cork	- check that there are no critical defects	BOX <sup>C</sup>	●			
		- non-compliant agglomerated body	- assess in advance the apparent relative density, state of agglomeration and torsion test of the body	NUOVO DISCIPLINARE		●	●	
- insufficient lubrication		- check in advance cork dimensions	NUOVO DISCIPLINARE	●	●	●		
	CONSUMPTION	- unsuitable corkscrews and/or incorrect technique used for uncorking	- use suitable corkscrews and/or correct manual uncorking technique	SECTION 5.3	●	●	●	
CORK PUSHED ABOVE BOTTLENECK LINE	CORK	- non-compliant agglomerated body	- assess in advance the apparent relative density and state of agglomeration of the body	NUOVO DISCIPLINARE		●	●	
		- diameter insufficient in relation to the internal diameter and profile of the bottle neck	- determine in advance optimum cork dimensions based on the internal diameter and profile of the bottle neck	SECTION 2.1		●	●	
		- excessive lubrication	- check in advance lubrication state by assessing extraction force	NUOVO DISCIPLINARE	●	●	●	
	BOTTLE	- internal neck profile non-compliant or unfit for use	- check in advance the internal profile of the bottle neck and that there is no reverse tapering	SECTION 3.1/BOX <sup>D</sup>	●	●	●	
	CORKING	- high overpressure:						
		■ poor corking machine jaw compression	- check jaw compression diameter	SECTION 3.2	●	●	●	
		■ cork inserted too slowly	- check cork insertion speed	SECTION 3.3	●	●	●	
■ insufficient headspace volume		- check headspace volume	SECTION 3.3	●	●	●		
	■ incorrect muselet application	- check correct muselet positioning	SECTION 3.3		●	●		
STORAGE	- temperature rise during bottle storage and/or shipment	- check bottle storage and/or shipment conditions	SECTION 5/BOX <sup>G</sup>	●	●			
DISC BREAKAGE	CORK	- anomalies in disc cork	- check that there are no critical defects	BOX <sup>C</sup>	●	●	●	
		- diameter larger than the acceptable tolerance above the nominal value	- check in advance cork dimensions	NUOVO DISCIPLINARE	●	●	●	
		- diameter unsuitable in relation to the internal diameter and profile of the bottle neck	- determine in advance optimum cork dimensions based on the internal diameter and profile of the bottle neck	SECTION 2.1	●	●	●	
	BOTTLE	- internal neck profile non-compliant or unfit for use	- check in advance the internal profile of the bottle neck	SECTION 3.1/BOX <sup>D</sup>	●	●	●	
CORKING	- excessive cork stopper compression	- check jaw compression diameter	SECTION 3.2	●	●	●		

ISSUE	ORIGINS	CAUSES	CHECKS/PRECAUTIONS	REFERENCES	1	2	3
DISC DETACHMENT	CORK	- diameter larger than the acceptable tolerance above the nominal value	- check in advance cork dimensions	NUOVO DISCIPLINARE	●	●	●
		- diameter unsuitable in relation to the internal diameter and profile of the bottle neck	- determine in advance optimum cork dimensions based on the internal diameter and profile of the bottle neck	SECTION 2.1	●	●	●
		- poor disc/body adhesion	- perform in advance a boiling resistance test	NUOVO DISCIPLINARE	●	●	●
	BOTTLE	- internal neck profile non-compliant or unfit for use	- check in advance the internal profile of the bottle neck	SECTION 3.1/BOX <sup>D</sup>	●	●	●
	CORKING	- excessive cork stopper compression	- check jaw compression diameter	SECTION 3.2	●	●	●
EXCESSIVE ABSORPTION / LEAKAGE / SEEPAGE	CORK	- diameter smaller than the acceptable tolerance below the nominal value	- check in advance cork dimensions	NUOVO DISCIPLINARE	●	●	
		- diameter insufficient in relation to the internal diameter and profile of the bottle neck	- determine in advance optimum cork dimensions based on the internal diameter and profile of the bottle neck	SECTION 2.1	●	●	
		- anomalies in cork	- check that there are no critical defects	BOX <sup>C</sup>	●	●	●
		- inadequate surface coating treatments	- perform liquid seal capacity	NUOVO DISCIPLINARE	●	●	
		- uncorrect cork stopper conservation	- check length and conditions of cork stopper storage	SECTION 2.3	●	●	
	BOTTLE	- internal neck profile non-compliant or unfit for use	- check in advance the internal profile of the bottle neck	SECTION 3.1/BOX <sup>D</sup>	●	●	●
	FILLING	- moisture present on neck between cork and glass	- check filling process	SECTION 3.3	●	●	●
	CORKING	- scratching, folding or flaring present	- check correct corking machine jaw operation	SECTION 3.2	●	●	●
		- cork skewed	- check correct bottle position with respect to insertion punch	SECTION 3.3	●	●	●
		- excessive cork compression	- check jaw compression diameter	SECTION 3.2	●	●	●
		- poor cork stopper insertion	- check that cork is inserted $24 \pm 1$ mm after muselet application	SECTION 3.3		●	●
		- incorrect muselet positioning	- check correct muselet positioning	SECTION 3.3		●	●
		- high overpressure:					
		■ poor corking machine jaw compression	- check jaw compression diameter	SECTION 3.2	●		
		■ cork inserted too slowly	- check cork insertion speed	SECTION 3.3	●	●	●
■ insufficient headspace volume	- check headspace volume	SECTION 3.3	●	●	●		
STORAGE	- incomplete stopper dimensional recovery: insufficient vertical storage of bottles	- wait at least three hours before laying bottles down	SECTION 3.4	●	●	●	
	- bottles stored in an environment that is too dry	- check that storage area humidity is between 60% and 80%	SECTION 4.3	●	●	●	
	- temperature rise during bottle storage and/or shipment	- check bottle storage and/or shipment conditions	SECTION 5	●	●	●	

ISSUE	ORIGINS	CAUSES	CHECKS/PRECAUTIONS	REFERENCES	1	2	3
HARDWOOD CORK	CORK	- anomalies in disc cork	- check that there are no critical defects	BOX <sup>c</sup>		●	●
	CORKING	- insufficient cork insertion	- check that cork is inserted 24 ± 1 mm after muselet application	SECTION 3.3			●
	BOTTLE	- internal neck profile cylindrical (virtually no taper)	- check in advance the internal profile of the bottle neck	SECTION 3.1		●	●
	WINE	- wine pressure too high	- check wine pressure in bottle	SECTION 3.3			●
	STORAGE	- high pressure due to incorrect bottle shipment and/or storage - bottles stored for very long periods	- check bottle conservation and/or shipment conditions	SECTION 5		●	●
	SUNDRY	- fall in internal overpressure	- see "loss of internal overpressure" section				●
HARD TO UNCORK	CORK	- density too high	- check in advance the apparent relative density of the cork	NUOVO DISCIPLINARE	●	●	●
		- diameter larger than the acceptable tolerance above the nominal value	- check in advance cork dimensions	NUOVO DISCIPLINARE	●	●	●
		- diameter too large in relation to the internal diameter and profile of the bottle neck	- determine in advance optimum cork dimensions based on the internal diameter and profile of the bottle neck	SECTION 2.1	●	●	●
		- bad choice of lubricant or insufficient amount used	- check in advance lubrication state by assessing extraction force	NUOVO DISCIPLINARE	●	●	●
	BOTTLE	- internal neck profile non-compliant (e.g. mouth with overhang) or unfit for use	- check in advance the internal profile of the bottle neck	SECTION 3.1/BOX <sup>d</sup>	●	●	●
		- anti-scratch coatings inside neck	- check in advance for widespread defects using bottling test		●	●	●
	CORKING	- over-insertion of cork stopper	- check that cork is inserted no more than 24 ± 1 mm after muselet application	SECTION 3.3		●	●
		- unsuitable wine pressure	- check wine pressure on corking; if it is correct, there may be a subsequent loss of pressure (see "loss of internal overpressure")	SECTION 3.3		●	●
		- wine pasteurised in bottle or bottled with an hot filling machine	- inform the cork supplier about the bottle treatment process		●	●	●
	STORAGE	- unsuitable cork stopper conservation	- check cork conservation conditions and period	SECTION 2.3	●	●	●



ISSUE	ORIGINS	CAUSES	CHECKS/PRECAUTIONS	REFERENCES	1	2	3	
IRREGULAR EVOLUTION OF WINE	CORK	- loss of cork seal:						
		■ anomalies in cork	- check that there are no critical defects	BOX <sup>C</sup>	●	●	●	
		■ diameter smaller than the acceptable tolerance below the nominal value	- check in advance cork dimensions	NUOVO DISCIPLINARE	●	●	●	
		■ diameter insufficient in relation to the internal diameter and profile of the bottle neck	- determine in advance optimum cork dimensions based on the internal diameter and profile of the bottle neck	SECTION 2.1	●	●	●	
	■ oxidising substance residues on cork	- assess in advance the release of oxidising substances	NUOVO DISCIPLINARE	●	●	●		
	BOTTLE	- loss of cork seal:						
		■ internal neck profile non-compliant or unfit for use	- check in advance the internal profile of the bottle neck	SECTION 3.1/BOX <sup>D</sup>	●	●	●	
	CORKING	- loss of cork seal:						
		■ scratching, folding or flaring present	- check correct corking machine jaw operation	SECTION 3.2	●	●	●	
		■ poor cork stopper insertion	- check that cork is inserted $24 \pm 1$ mm after muselet application	SECTION 3.3		●	●	
		■ moisture present on neck between cork and glass	- check filling process	SECTION 3.3	●	●	●	
		■ cork skewed	- check correct position of bottle with respect to insertion punch	SECTION 3.3	●	●	●	
	■ incorrect muselet application	- check correct muselet positioning	SECTION 3.3		●	●		
	WINE	- contamination by grapes in bad sanitary state	- do not use grapes in bad sanitary state			●	●	●
		- contact with containers or equipment that are not sufficiently clean	- clean containers and equipment that come into contact with wine using chlorine-free products			●	●	●
		- contact with contaminated wood	- check in advance for the presence of contaminants			●	●	●
- contamination of cellar environment		- store wine in areas free of contaminating substances			●	●	●	
STORAGE	- unsuitable cork stopper usage and conservation	- store corks in a suitable area and do not leave in open sacks or hoppers	SECTION 2.3		●	●	●	
	- temperature rise during storage and/or shipment of bottles	- check bottle storage and/or shipment conditions	SECTION 5		●	●	●	

ISSUE	ORIGINS	CAUSES	CHECKS/PRECAUTIONS	REFERENCES	1	2	3
LOSS OF INTERNAL OVERPRESSURE	CORK	- non-compliant agglomerated body	- assess in advance the relative density and state of agglomeration of the body	NUOVO DISCIPLINARE		●	●
		- diameter smaller than the acceptable tolerance below the nominal value	- check in advance cork dimensions	NUOVO DISCIPLINARE		●	●
		- diameter insufficient in relation to the internal diameter and profile of the bottle neck	- determine in advance optimum cork dimensions based on the internal diameter and profile of the bottle neck	SECTION 2.1		●	●
	BOTTLE	- internal neck profile non-compliant or unfit for use	- check in advance the internal profile of the bottle neck	CAPITOLO 3.1/BOX <sup>D</sup>		●	●
	CORKING	- scratching, folding or flaring present	- check correct corking machine jaw operation	SECTION 3.2		●	●
		- cork skewed	- check correct position of bottle with respect to insertion punch	SECTION 3.3		●	●
		- cork inserted too far	- check that cork is inserted $24 \pm 1$ mm after muselet application	SECTION 3.3		●	●
- incorrect muselet positioning		- check correct muselet positioning	SECTION 3.3		●	●	
MOULD GROWTH ON OUTER SURFACE OF CORK	CORKING	- moisture or liquids present on the outer surface of cork before capsule application	- check that the outer surface of the cork is dry and without fungal growth before capsule application	SECTION 3.3	●	●	
	STORAGE	- moisture or wine present on outer surface of cork before corking	- check that on corking the outer surface of the cork is dry and without fungal growth	SECTION 3.3	●	●	
		- bottles stored in overly damp environment	- check that storage area humidity is between 60% and 80%	SECTION 4.3	●	●	●
PRESENCE OF CORK DUST OR FRAGMENTS IN WINE	CORK	- anomalies in cork	- check that there are no critical defects	BOX <sup>C</sup>	●	●	●
		- residual processing dust present	- check in advance for determination of dust	NUOVO DISCIPLINARE	●	●	●
	CORKING	- corking machine not sufficiently clean	- adequately clean the entire corking system before and during operation	SECTION 3.2	●	●	●
		- cork damaged by corking machine jaws or feed system	- check correct corking machine jaw operation and the feed system	SECTION 3.2	●	●	●
		- flaring and/or chipping with cork fragmentation due to bad centering	- check correct bottle position with respect to insertion punch	SECTION 3.3	●	●	●

ISSUE	ORIGINS	CAUSES	CHECKS/PRECAUTIONS	REFERENCES	1	2	3
SELF-EXPULSION OF CORK	CORK	- incorrect choice of lubricant or excessive amount used	- check in advance lubrication state by assessing extraction force	NUOVO DISCIPLINARE		●	●
	BOTTLE	- internal neck profile non-compliant or unfit for use	- check in advance the internal profile of the bottle neck	SECTION 3.1/BOX <sup>D</sup>		●	●
	CORKING	- poor cork stopper insertion	- check that cork is inserted 24 ± 1 mm after muselet application	SECTION 3.3		●	●
		- high wine pressure	- check wine pressure on corking	SECTION 3.3	●	●	
STORAGE	- temperature rise during storage and/or shipment of bottles	- check bottle storage and/or shipment conditions	SECTION 5		●	●	
SENSORY TAINING DUE TO CONTAMINATION BY MICROBIAL METABOLITES	CORK	- contamination of cork in forest environment	- sensory and/or instrumental analysis on corks	NUOVO DISCIPLINARE	●	●	●
		- contamination of cork during processing	- sensory and/or instrumental analysis on corks	NUOVO DISCIPLINARE	●	●	●
	WINE	- contamination by grapes in bad sanitary conditions	- do not use grapes in bad sanitary conditions		●	●	●
		- contact with containers or equipment that are not sufficiently clean	- clean containers and equipment that come into contact with wine using chlorine-free products		●	●	●
		- contact with contaminated wood	- check in advance for the presence of contaminants		●	●	●
		- contamination of cellar environment	- store wine in areas free of contaminating substances		●	●	●
	STORAGE	- unsuitable cork stopper usage and conservation	- store corks in a suitable area and do not leave in open bags or hoppers	SECTION 2.3	●	●	●
		- unsuitable bottle storage	- check bottle storage conditions	SECTION 5	●	●	●

ISSUE	ORIGINS	CAUSES	CHECKS/PRECAUTIONS	REFERENCES	1	2	3
TOO EASY TO UNCORK / CORK SPINNING INSIDE THE BOTTLENECK	CORK	- poor density	- check in advance the apparent relative density of the cork	NUOVO DISCIPLINARE	●	●	●
		- diameter smaller than the acceptable tolerance below the nominal value	- check in advance cork dimensions	NUOVO DISCIPLINARE	●	●	●
		- diameter insufficient in relation to the internal	- determine in advance optimum cork dimensions based on the internal diameter and profile of the bottle neck	SECTION 2.1	●	●	●
		- bad choice of lubricant or excessive amount used	- check in advance lubrication state by assessing extraction force	NUOVO DISCIPLINARE	●	●	●
	BOTTLE	- internal neck profile non-compliant or unfit for use	- check in advance the internal profile of the bottle neck	SECTION 3.1/BOX <sup>D</sup>	●	●	●
	CORKING	- insufficient cork insertion	- check that cork is inserted $24 \pm 1$ mm after muselet application	SECTION 3.3		●	●
		- structural damage to cork	- check the position of the insertion punch and the muselet	SECTION 3.3	●	●	●
- high wine pressure		- check wine pressure on corking	SECTION 3.3		●	●	

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