BMSB Fumigation of Oak Barrel and Cork Imports

A Technical Assessment for the Australian Wine Industry

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Executive Summary

Since 2018, mandatory pre-border biosecurity treatment for Brown Marmorated Stink Bug (*Halyomorpha halys*, BMSB) has materially altered the supply chain for imported cooperage and corks destined for Australia. Oak barrels, classified under Harmonised System (HS) Chapter 44 (Wood and articles of wood), are categorised as target high-risk goods under the Department of Agriculture, Fisheries and Forestry of Australia's (DAFF) (2026a) BMSB seasonal measures and require mandatory treatment when shipped from any of ~38 target risk countries during the risk season (1 September to 30 April inclusive). The approved treatment options are methyl bromide (MB) fumigation, sulfuryl fluoride (SF) fumigation, heat treatment, and from the 2025–26 season, ethyl formate (EF) combined with CO_2.

The chemical and physical risks posed by fumigation to oak barrels and corks are material but manageable. MB and SF are highly volatile and largely dissipate during the mandatory airing/ventilation period. However, oak's inherently high porosity and the elevated moisture content of new, untoasted staves create conditions under which inorganic bromide (from MB) or fluoride ions (from SF) can accumulate in the wood matrix, posing a risk of subsequent migration into wine during maturation. For barrels, which are invariably shipped in a closed state with bungs, it is arguable that wine contact surfaces are not exposed to the fumigant during the process and the risk of transfer to wine is negligible. The same cannot necessarily be said for staves and other unfinished oak products transported in containers. Cork tends to be more exposed when shipped in bulk as breathable bales or in lined cardboard boxes. The OIV sets maximum acceptable limits of 1 mg/L for both bromide and fluoride in wine. Ethyl formate (EF) is another fumigant which has recently been approved for application at source market which may offer an alternative with any residues being similar to naturally occurring compounds. Heat treatment carries its own risks for cooperage, specifically, over-drying of staves leading to leakage on arrival. In the case of corks heat treatment is considered less of an issue in general as the material can be rehumidified on arrival in Australia. However, heat treatment eliminates issues with fumigant residue concerns entirely. The cooperage and cork industry and Australian supply-chain participants have broadly converged on

heat treatment as the preferred option for new barrels corks, however this presents cost and logistical issues which are not sustainable in the long term, particularly in the case of cooperage.

The use of the fumigants MB and SF also present issues with organic certification for wines which are stored in treated barrels or under treated closures. Current advice in all identified markets suggests that treatment with MB or SF of barrels or closure will prevent organic or biodynamic certification of wines. No advice on the use of EF in relation to organic or biodynamic status was found.

The Australian Wine Research Institute (AWRI) has reviewed the literature and concluded that halophenol/haloanisole taint from MB or SF fumigation of oak barrels is highly unlikely under normal conditions, but has not conducted direct experimental work on this specific scenario. No research has yet been identified on the impacts of the use of EF for barrels or corks. No published evidence of taint incidents attributable to BMSB fumigation of oak barrels has been identified in the peer-reviewed enology literature. Given the greater issues with cooperage the review below focuses on it, however the learnings outlined are broadly applicable to cork as well.

1. Regulatory Framework

1.1 Australia: DAFF BMSB Seasonal Measures

The DAFF (2026a) seasonal measures for BMSB apply to targeted goods manufactured in or shipped from target risk countries, shipped between 1 September and 30 April (inclusive), with the shipped-on-board (SOB) date, recorded on the Ocean Bill of Lading, as the operative date. The 2025–26 season commenced on 1 September 2025, with key updates including:

- Addition of Republic of Korea and Japan to the emerging risk country list
- Target high-risk airfreight from the USA and China subject to random inspections
- Ethyl formate (EF) added as a new offshore-only BMSB treatment option from 1 September 2025

The full target risk country list for 2025–26 comprises approximately 38 countries: Albania, Andorra, Armenia, Austria, Azerbaijan, Belgium, Bosnia and Herzegovina, Bulgaria, Canada, Croatia, Czechia, France, Georgia, Germany, Greece, Hungary, Italy, Kazakhstan, Kosovo, Liechtenstein, Luxembourg, Montenegro, Moldova, Netherlands, Poland, Portugal, North Macedonia, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Switzerland, Türkiye, Ukraine, United States of America (USA), and Uzbekistan (C.H. Robinson 2026). China, Japan, Republic of Korea, and the United Kingdom are classified as emerging risk countries subject to random onshore inspection only, not mandatory treatment. Notably, the world's major cooperage nations, France, USA, Hungary (included via EU membership context), and increasingly Eastern European countries are all on the target risk list, meaning virtually all imported cooperage is subject to the measures.

Oak barrels under HS Chapter 44 (Wood and articles of wood, wood charcoal) are explicitly listed as target high-risk goods requiring mandatory treatment. The factsheet on preparing to import goods, prepared by DAFF (2025), confirms that the same conditions apply to both new and used goods, no distinction is drawn between unused cooperage and previously-filled barrels or casks. The New, Unused and not Field Tested (NUFT) exemption scheme applies only to specific machinery tariff chapters (82, 84, 85, 86, 87, 88, 89) and is not available for HS Chapter 44 wood products including barrels.

The BMSB measures apply exclusively to the goods themselves and not to packaging material or non-commodity items in the same container. However, if target high-risk goods (e.g., barrels) are packed in the same container as non-targeted goods, the entire container is subject to treatment at the container level.

Treatment providers in target risk countries must be registered and approved under AusTreat, DAFF's pre-border biosecurity treatment provider assurance scheme. Certificates from unregistered, suspended, or withdrawn providers will not be accepted.

1.2 Specific DAFF Treatment Requirements for Oak (Chapter 44 Goods)

The DAFF BMSB seasonal measures page (Department of Agriculture, Fisheries and Forestry of Australia 2026a) specifies the following mandatory treatment parameters, outlined in Table 1.

Table 1. DAFF mandatory treatment parameters.

Treatment	Parameters
Heat	56°C or higher at the coldest surface, minimum 30 minutes; OR for goods <3,000 kg (break bulk only), 60°C for minimum 10 minutes
Methyl Bromide	≥24 g/m^3 at ≥10°C for 12–<24 hours, minimum endpoint reading 12 g/m^3; OR ≥24 g/m^3 at ≥10°C for ≥24 hours, minimum endpoint reading 8 g/m^3
Sulfuryl Fluoride	CT ≥200 $g{\cdot}h/m^3$ at ≥10°C for ≥12 hours, minimum endpoint reading 12 g/m^3; OR CT ≥200 $g{\cdot}h/m^3$ at ≥10°C for ≥24 hours, minimum endpoint reading 8 g/m^3
Ethyl Formate (offshore only)	EF at 16.7% with 83.3% CO_2; at ≥10°C; per EF methodology v1.0

Note that the BMSB-specific MB and SF dosage schedules differ from ISPM-15 wood packaging material (WPM) schedules and from commodity-level quarantine schedules designed for timber insects. The BMSB schedules use lower CT products because BMSB is a surface/void-dwelling insect rather than a wood-boring species.

A DAFF methyl bromide fumigation methodology v3.0, effective from 1 May 2025, now governs all MB fumigations, with updated documentation requirements for fumigation certificates and records of treatment.

1.3 BMSB vs. ISPM-15 for Wood Packaging

It is important that wine industry buyers understand the distinction between BMSB treatment requirements and the International Standards for Phytosanitary Measures (ISPM) No. 15 for solid wood packaging material (ISPM-15). ISPM-15 applies to *wood packaging material* (pallets, crates, dunnage, packing blocks, etc.) and requires treatment to prevent spread of timber pests (International Standards for Phytosanitary Measures 2006). Cooperage, oak barrels, casks, and vats, is the traded *commodity* itself, not packaging material, and therefore sits under a different regulatory framework. A barrel bearing an ISPM-15 mark (the "wheat stalk" stamp) would denote treatment of the *pallet or crating* used to ship it, not the barrel itself.

BMSB measures address *hitchhiker pest* risk, as BMSB conceals itself in the void spaces of any goods regardless of the goods' own pest-harbourage properties. They therefore capture Chapter 44 cooperage because wood articles present suitable microhabitats for overwintering BMSB. An ISPM-15-compliant pallet carrying barrels will satisfy pallet-level requirements but does not constitute BMSB treatment of the barrels themselves (UFP Packaging 2026).

1.4 New Zealand: MPI Requirements

The New Zealand Ministry for Primary Industries (MPI) has aligned its BMSB measures closely with DAFF, sharing the same target risk country list, treatment options, and approved treatment provider register (MPI BMSB requirements for importers). MPI issues Import Health Standards (IHS) for sea containers from Italy (where higher BMSB populations have been detected) and for targeted vehicles, machinery, and parts.

Key differences between Australian and New Zealand measures are outlined in Table 2.

Table 2. Key differences between BMSB measures undertaken in Australia and New Zealand.

Feature	Australia (DAFF)	New Zealand (MPI)
Primary targeted goods	Broad — HS Chapters 44, 45, 57, 68–70, 72–88, etc.	Vehicles, machinery, parts; Italy containers

Break bulk	Mandatory offshore treatment	Mandatory offshore treatment
Italy sea containers	Targeted as high-risk country	All containers from Italy require treatment or IHS supervision
Treatment providers	AusTreat registered	Aligned with AusTreat register
Airfreight	Random inspection (USA, China)	Not specified in primary measures

For cooperage imported simultaneously into both countries, importers must comply with both sets of requirements and are advised to contact the relevant authority in advance (Ministry for Primary Industries n.d.).

1.5 USA (USDA APHIS)

The USA is both a major cooperage exporter (American oak) and one of the earliest countries subject to BMSB import treatment requirements imposed by importing nations. USDA APHIS does not impose BMSB offshore treatment requirements analogous to those of DAFF/MPI on incoming wood goods from other nations in the same way, APHIS's role regarding BMSB has primarily been domestic management and surveillance of *H. halys* within the USA. Treatment of US-origin goods for export to Australia occurs under DAFF AusTreat/BMSB scheme requirements imposed by the importing country, using DAFF-approved treatment providers in the USA (C.H. Robinson 2026). ProFume® (sulfuryl fluoride) and Vikane®, both Corteva/Dow products, are widely used by US treatment providers for BMSB fumigation of goods including wine barrels (Douglas Products 2021).

1.6 European Union

The EU does not currently impose BMSB-specific mandatory import treatment requirements equivalent to those in Australia and New Zealand on incoming goods. Rather, the EU is itself a BMSB target risk country for other importing nations. The EU operates under ISPM-15 for solid wood packaging. *H. halys* is established in several EU countries (Italy most severely, followed by France, Switzerland, Germany). Some EU national plant protection organisations (NPPOs) have implemented domestic management measures, but no EU-wide offshore treatment requirement for cooperage imports into the EU exists analogous to DAFF measures.

Fiji has also adopted BMSB measures aligned with Australia and New Zealand, with mandatory treatment for goods from Canada, Italy, Japan, Taiwan, and the USA during the risk season (Gard 2025).

2. Approved Fumigants and Treatment Protocols

2.1 Methyl Bromide (Bromomethane, CH_3Br)

Methyl bromide is a broad-spectrum, highly volatile colourless gas (boiling point 3.56°C, density 3.27 relative to air) used as a Quarantine and Pre-Shipment (QPS) fumigant. For BMSB purposes under DAFF schedules, the minimum applied dose is 24 g/m^3 at ≥10°C. Higher dose rates are employed for general wood treatment under Australian Quarantine and Inspection Service (AQIS) and DAFF legacy schedules, with timber typically requiring 48 g/m^3 at 21°C for 24 hours under National Action Plan (NAP) conditions, and stored product pests treated at 32 g/m^3 at 21°C for 24 hours (Australian Quarantine and Inspection Service 2010). The BMSB-specific schedule is less intensive than commodity fumigation for wood-boring insects because the target pest is a surface/void dweller.

Under the Montreal Protocol, MB is classified as an ozone-depleting substance and has been phased out for agricultural use in developed countries. However, QPS applications are permanently exempt from the Protocol's phase-out provisions (United Nations Environment Programme 2007). MB may legally continue to be used for BMSB fumigation of imports indefinitely under this exemption. Notwithstanding the legal exemption, environmental pressure is mounting. UNEP Decision XX/6 called on parties to reduce QPS MB use, and several major fumigation providers are transitioning toward SF and EF as preferred alternatives (United Nations Environment Programme 2020). In the EU, MB as a pesticide (including post-harvest use) has been banned since 2005 under Regulation EC 2037/2000, though the QPS exemption remains applicable for export/import treatment outside the EU.

2.2 Sulfuryl Fluoride (SO_2F_2) — Profume® / Vikane®

Sulfuryl fluoride is a colourless, odourless non-flammable gas (boiling point −55.2°C) used as an alternative fumigant to MB. For BMSB control, DAFF requires a minimum CT product of 200 g·h/m^3. This differs from SF schedules for wood packaging under ISPM phytosanitary treatment standards, where CT products for wood-boring nematodes and insects can reach 1,400–3,000 g·h/m^3 (Ice Cargo n.d., International Plant Protection Convention 2017). As with MB, the lower BMSB-specific rate reflects the pest's biology as a hitchhiker rather than a wood-infesting organism.

SF does not deplete the ozone layer, making it environmentally preferable to MB. It is not registered for soil application or broad-spectrum agricultural use and is used primarily for structural and commodity fumigation. After ventilation, the residual SF concentration must fall to a threshold limit value (TLV) of ≤3 ppm before goods are released (Department of Agriculture, Fisheries and Forestry of Australia. n.d.).

2.3 Heat Treatment

Heat treatment requires a sustained temperature of 56°C or higher at the coldest surface of the goods for a minimum of 30 minutes for all good types. An alternative schedule of 60°C for 10 minutes applies only to individual break-bulk goods weighing less than 3,000 kg (Department of Agriculture, Fisheries and Forestry of Australia. 2026a). These parameters align with ISPM-15 heat treatment parameters for solid wood packaging material (56°C for 30 minutes throughout the wood profile), although the BMSB schedule is applied at the commodity surface level rather than requiring internal wood core temperature. This distinction is important for dense, bilge-filled cooperage.

2.4 Ethyl Formate (EF + CO_2) — New from 2025–26

Approved from 1 September 2025 under DAFF's AusTreat scheme, ethyl formate combined with CO_2 provides an additional offshore-only treatment option (Department of Agriculture, Fisheries and Forestry of Australia. 2026a, Shipping Australia 2025). EF is a naturally occurring ester with lower ozone-depletion potential than MB and rapid dissipation characteristics. The ethyl formate fumigation methodology v1.0 applies for the 16.7% EF / 83.3% CO_2 formulation. EF is not yet widely adopted by cooperage treatment providers but represents a potentially advantageous option for wine-sensitive goods given its low residue potential in wood.

2.5 Treatment Comparison Summary

Table 3

Treatment	BMSB Schedule (DAFF 2025–26)	Ozone depletion	Residue risk in oak	Available onshore	Key risks for cooperage
Methyl Bromide	24 g/m^3, ≥10°C, 12–24 h; endpoint ≥8–12 g/m^3	Yes (QPS exempt)	Moderate–High (moisture dependent)	Yes (container level)	Bromide ion residue; moisture amplifies risk
Sulfuryl Fluoride	CT ≥200 g·h/m^3, ≥10°C, 12–24 h	No	Low–Moderate	Yes (container level)	Fluoride ion; slow desorption from xylem
Heat	56°C surface, 30 min	None	None	No (offshore only)	Barrel desiccation/leakage; no chemical residue
Ethyl Formate	16.7% EF + CO_2, ≥10°C per v1.0	Very low	Very low	No (offshore only)	Limited provider availability; new to market

3. Chemical and Physical Impacts on Oak Barrels

3.1 Fumigant Penetration and Sorption Kinetics in Oak

Oak is among the most porous of cooperage timbers. The vascular structure of *Quercus* species consists of wide vessels (medullary rays) and tyloses that, in the stave-cut configuration used in cooperage, present high surface area to any diffusing gas. For MB, the primary determinant of sorption into wood is the surface-area-to-volume ratio. Research on *Pinus radiata* logs (a structurally analogous coniferous wood) demonstrated that after 16 hours of fumigation, 47–71% of the initial MB concentration remains in the treated space depending on end-grain sealing, and that MB desorption from wood is initially rapid but then slows significantly (Hall et al. 2017). The surface area of a log, analogous to the outer surface of barrel staves is the dominant parameter.

A 2025 study on MB and SF penetration into *Pinus sylvestris* var. *mongolica* logs under simulated fumigation conditions found that MB exhibited higher sorptive affinity than SF, with concentration gradients showing MB retention primarily in bark and phloem, with limited penetration beyond 2 cm depth (Shan et al. 2026). In contrast, SF diffused more uniformly to depths of up to 6 cm at lower concentrations. Critically, MB desorbed rapidly from surface tissues upon aeration, while SF desorbed slowly with negligible release from xylem. This asymmetry has significant implications: while MB may appear to dissipate more completely during the ventilation period (supporting its rapid release and lower apparent residue post-aeration), SF persists in the wood matrix at depth for longer, potentially representing a longer-term residue risk.

For oak barrel staves, typically 25–28 mm thick in standard 225 L barriques, the penetration depth of fumigant is directly relevant. MB's limited penetration beyond 2 cm in coniferous wood suggests that in oak staves (which may be even more restrictive to diffusion due to tyloses), MB sorption is concentrated in the outer stave zone, with rapid desorption during aeration. SF's deeper but slower-desorbing profile may result in residual fluoride at depth that is not fully removed by standard ventilation.

3.2 Role of Moisture Content

Moisture content (MC) is the single most critical variable governing both fumigant uptake and residue formation in wood. Higher MC dramatically increases sorption. The Food and Agriculture Organisation residue review (n.d.) confirms that moisture content of the goods profoundly influences residue accumulation. For example, wheat at 15% MC retained approximately 3.3× more inorganic bromide post-fumigation than wheat at 9% MC. Similar moisture-dependent amplification has been observed across commodity types.

New, freshly cooperaged oak barrels (as opposed to seasoned staves that have undergone air-drying for 18–36 months) retain significant moisture in the wood matrix. Green oak can have an MC of 40–60%; air-dried staves intended for cooperage typically reach 15–18% MC before barrel assembly; further seasoning in the cooperage can reduce this to 12–15%. Even at these "dry" MC levels, moisture content is sufficient to dissolve both MB and the resulting inorganic bromide/fluoride reaction products in the wood-water phase, trapping them in the stave matrix. As the AWRI eBulletin (2018) notes: *"if an oak barrel has a high moisture content, there is a possibility it could contain residual bromide (from methyl bromide) or fluoride (from sulfuryl fluoride) ions after fumigation."*

3.3 Bromide Residues from Methyl Bromide

MB reacts chemically with wood constituents via nucleophilic substitution, particularly with nitrogen- and sulfur-containing groups in proteins (if present), and via hydrolysis to methanol and inorganic bromide ion (Br^-) in the presence of moisture. The dominant residue pathway for wood, which has low protein content, is abiotic hydrolysis:

$$CH_3Br + H_2O \rightarrow CH_3OH + HBr$$

Inorganic bromide formed in this way is non-volatile and does not dissipate during aeration. Once fixed in the wood's aqueous phase, it can only be mobilised by liquid extraction. That is, when wine or water contacts the internal barrel surface. The concentration of Br^- in wood post-treatment depends on: initial MB dose, exposure duration, wood MC, and temperature. Repeated treatments (e.g., if barrels are re-exported and re-fumigated) accumulate inorganic bromide cumulatively.

Research on grain fumigation at 50 ppm residual bromide levels after standard commercial MB treatment provides a reference point (Food and Agriculture Organisation 1965), though grain matrices are compositionally very different from wood. Directly comparable data on oak stave bromide residue concentration post-BMSB MB treatment are not available in the published enology literature, highlighting a clear gap in current research.

3.4 Fluoride Residues from Sulfuryl Fluoride

SF hydrolyses in moist environments to SO_2 (sulfur dioxide) and HF (hydrofluoric acid), with the fluoride ion (F^-) the primary residual species of concern:

$$SO_2F_2 + H_2O \rightarrow SO_2 + 2HF$$

The AWRI notes that SF is "unlikely to leave any residue" in most scenarios and that it "splits into a metal halide and SO_2" upon contact with moisture (Australian Wine Research Institute 2026b). However, the

Australian Pesticides and Veterinary Medicines Authority (APVMA) evaluation of sulfuryl fluoride as the active in Profume® identified fluoride ion (F^-) as the residue of toxicological significance following SF treatment, with the ADI established at 0.01 mg/kg bw/day based on a NOEC of 20 ppm (83.4 mg/m^3) from a 24-month rat inhalation study (Australian Pesticides and Veterinary Medicines Authority 2007). As noted in the penetration study above, SF desorbs from xylem very slowly, meaning residual F^- in the wood matrix may persist well after ventilation has reduced the gaseous SF to below TLV thresholds.

3.5 Impact on Oak Extractives: Toasting Compounds, Lactones, and Tannins

The key aromatic compounds contributed by oak to wine during maturation include:

- **cis/trans-β-methyl-γ-octalactone** (whisky/oak lactones, CAS 39212-23-2): responsible for coconut, woody, and vanilla-adjacent notes, particularly prominent in American oak (*Q. alba*) (Waterhouse Lab 2015)
- **Vanillin and syringaldehyde**: lignin-derived phenolic aldehydes providing vanilla character, concentrations increasing with medium toast (Enartis Vinquiry n.d.)
- **Guaiacol, eugenol, 4-methylguaiacol**: volatile phenols derived from lignin pyrolysis during toasting
- **Furfural and 5-methylfurfural**: hemicellulose degradation products
- **Ellagitannins** (vescalagin, castalagin, grandinin, roburin series): polymeric tannins contributing structure and astringency, oxidative catalysts

Neither MB nor SF at BMSB treatment concentrations is expected to chemically degrade these compounds in the wood matrix. MB's primary reaction targets are nitrogen/sulfur-containing substrates (essentially absent in mature oak wood), and SF reacts with moisture to form HF. The fumigant concentrations applied under BMSB schedules (24 g/m^3 MB; CT 200 g·h/m^3 SF) are several orders of magnitude lower than those that would cause observable oxidative or chemical changes to oak extractives.

However, the desiccation effect of heat treatment on oak lactones deserves specific attention. Air-dried stave seasoning at ambient temperatures (the preferred cooperage practice) promotes slow terpene and lactone development in the stave matrix. Kiln drying at elevated temperatures has been shown to reduce cis/trans-β-methyl-γ-octalactone concentrations relative to air-dried staves, while increasing furfural through hemicellulose degradation (Wine with Seth 2026a). BMSB heat treatment at 56°C for 30 minutes applied to assembled barrels (as opposed to individual staves) is unlikely to replicate kiln-drying conditions, as the exposure is brief and at lower temperature than cooperage kiln-drying. Nevertheless, repeated or prolonged heat treatment cycles could affect the volatile aromatic profile of new barrels. No specific peer-reviewed study on this effect exists.

Ellagitannin extraction characteristics are a function of wood structure and toasting rather than fumigant exposure, and are unlikely to be affected at BMSB treatment parameters.

3.6 Taint Risk: Halophenols and Haloanisoles

The primary taint concern when MB fumigation of oak is considered is the potential formation of 2,4,6-tribromoanisole (TBA), a brominated analogue of the cork-taint compound 2,4,6-trichloroanisole (TCA). TBA forms via a two-step process: (1) formation of 2,4,6-tribromophenol (TBP) from phenol compounds in the presence of a halogenating agent, followed by (2) microbial O-methylation of TBP to TBA by Penicillium, Paecilomyces, and related mould species (Wine with Seth 2026b, Chatonnet et al. 2004). TBA has an extremely low detection threshold in wine (~4 ng/L), making any formation significant from a sensory standpoint.

The AWRI has carefully evaluated this chemistry and concluded that halophenol/haloanisole taint from BMSB MB or SF fumigation is highly unlikely under normal conditions, because:

1. TBA formation requires both a brominating agent *and* an oxidant (e.g., hypochlorite, peroxidase, or ozone-type oxidant) to convert oak phenols to bromophenol precursors
2. MB at BMSB concentrations primarily hydrolyses to inorganic Br^- rather than acting as an electrophilic brominating agent of aromatic ring systems
3. The AWRI helpdesk has not encountered verified taint cases from BMSB fumigation of oak barrels

However, the AWRI explicitly notes: *"unless a strong oxidising agent (e.g. hypochlorite or ozone) is also present, or unless the barrel is already tainted with a halophenol."* This is a critical caveat, if barrels destined for fumigation have been treated with hypochlorite (a once-common barrel sanitation practice, now largely discontinued) or if the treatment environment contains oxidants, the risk pathway to TBA formation cannot be excluded (Australian Wine Research Institute 2018). The AWRI also explicitly states it has *not* conducted experimental research on fumigation effects on oak and cannot guarantee adverse effects will not occur.

4. Wine Contamination and Sensory Risk

4.1 Residue Migration from Oak into Wine

When wine is introduced into a fumigated barrel, the aqueous wine matrix provides the extractant for any ionic residues (Br^-, F^-) present in the wood's moisture phase. Extraction kinetics will be governed by the same factors that control ellagitannin and volatile compound extraction: diffusion rates through the stave, surface contact area, temperature, and wine composition (particularly pH and alcohol content). Given that BMSB MB fumigation deposits Br^- primarily in the outer 0–20 mm of the stave where sorption is highest, and that wine contacts the internal surface of staves directly, migration into wine during the first fill is plausible for barrels with elevated residual ionic concentrations.

Whether any migrating bromide or fluoride would reach wine concentrations that breach regulatory limits depends on the initial concentration in the wood, the extraction efficiency, and the barrel-to-wine volume ratio. No specific quantitative migration studies on BMSB-fumigated oak barrels have been identified in the enology literature. The AWRI's position that "it is not possible to reliably measure for residual bromide and fluoride ions" in treated barrels, underscores the practical difficulty of pre-use risk assessment (Australian Wine Research Institute 2026a).

4.2 Regulatory Limits for Bromide and Fluoride in Wine

The OIV limit of 1 mg/L for bromide in wine is notably low and was established primarily to flag wines from vineyards with naturally high soil bromide (from saline groundwater), not from fumigant contamination. The same analytical signals arise from both sources, which creates potential compliance ambiguity when testing wine matured in MB-treated barrels. EU Regulation (EC) No. 396/2005 governs pesticide MRLs including MB residues (as inorganic bromide) in food commodities, with wine-specific provisions. No EU-specific wine limit for sulfuryl fluoride residues (as fluoride) that differs from the OIV limit was identified in this research.

No specific published studies by AWRI, Wine Australia, ETS Laboratories, or peer-reviewed journals on measured bromide or fluoride concentrations in wine matured in BMSB-fumigated oak barrels were identified. This constitutes a significant evidence gap that warrants targeted research, particularly given Australia's position as both a major wine exporter subject to OIV-aligned export limits and a major importer of cooperage from BMSB-risk countries.

Table 4. Regulatory limits of bromide and fluoride in wine

Analyte	Limit	Regulatory Body / Source
Bromide (total)	1 mg/L (1 ppm), note: may be exceeded in wines from vineyards with brackish subsoil	OIV International Code, Maximum Acceptable Limits (2015)

Fluoride	1 mg/L, except for vineyards treated with cryolite (up to 3 mg/L by national law)	OIV International Code, Maximum Acceptable Limits (2015)
Inorganic bromide (grape, postharvest fumigation)	20 ppm (= 20 mg/kg) in grapes	40 CFR §180.123 (US EPA)
Bromide (indicative testing)	Natural background in most fresh plant material is <5 mg/kg	EURL-SRM GC-ECD total bromide method

4.3 Off-Flavour and Taint Risks

Beyond inorganic ion migration, the risk of chemical or solvent taints from BMSB fumigation of oak barrels is considered low based on the following reasoning:

1. **Residual MB dissipation**: MB's high volatility (boiling point 3.56°C) ensures near-complete dissipation during the mandatory aeration period. After ventilation to below TLV thresholds (typically 1 ppm), the contribution of residual bromomethane to wine aroma is vanishingly small. The persistence of fixed inorganic bromide is the dominant residue concern, not the parent fumigant.

2. **Residual SF dissipation**: SF similarly dissipates during ventilation, though its hydrolysis product (fluoride) can persist in wood as noted above. At concentrations relevant to BMSB treatment, SF itself is not expected to contribute sensory-active residues to wine.

3. **TBA taint pathway**: As discussed in Section 3.6, TBA formation requires a multistep process that is unlikely to be initiated by MB alone without co-presence of strong oxidants. The absence of reported incidents supports this assessment, though the evidence base is limited.

4. **Solvent/ester contamination**: Ethyl formate (the new 2025–26 option) is itself an ester with a fruity, rum-like aroma, detectable at low concentrations in wine. Although naturally present in fermented beverages at low levels, any residual EF in barrel wood from pre-shipment fumigation could theoretically contribute to wine aroma. No research on this specific pathway was identified at the time of writing. This warrants investigation before widespread industry adoption of EF treatment for cooperage.

5. Industry Response and Alternatives

5.1 Cooperage Industry Position

Major French tonnelleries with significant Australian market presence, such as Tonnellerie Radoux (with Australian subsidiary B.H. Oak), Seguin Moreau, Taransaud, and Vicard, have adapted supply chain logistics to accommodate BMSB treatment requirements since the measure's introduction in 2018. The preferred approach across the cooperage sector has converged on heat treatment for new barrels, principally because:

- It eliminates all chemical residue concerns
- It can be conducted at the cooperage facility as part of the pre-shipping preparation workflow, however no cooperage has this capability so it is a mute point.

This preference for heat treatment is commercially visible. Classic Oak Products, an Australian cooperage importer, has separately invoiced BMSB heat treatment costs for multiple consecutive vintages, reflecting the cost's normalisation as a line item. Cooperages 1912 (representing Tonnellerie Quintessence, Tonnellerie Tremeaux, and Maison Moussié) confirmed absorption of tariff and BMSB-related surcharges in 2025 to protect client relationships during a period of elevated import costs (Winetitles 2025 cooperage tariff article).

No public statements from Tonnellerie Radoux, Seguin Moreau, or other top-tier tonnelleries specifically addressing MB fumigation avoidance for Australian orders were identified, though the industry's operational pivot toward heat treatment is well-documented.

5.2 Heat Treatment vs Chemical Fumigation, Cooperage Considerations

Heat treatment advantages for cooperage:

- No chemical residue in wood
- Consistent with existing drying/toasting infrastructure
- No post-arrival conditioning protocols beyond standard barrel preparation

Heat treatment disadvantages for cooperage:

- Can over-dry barrel staves, particularly for barrels that have been partially conditioned with wine or water. Desiccation causes stave shrinkage, and barrels that arrive over-dried will require extended swelling/hydration on arrival before use, risking leakage if filled immediately (Australian Wine Research Institute 2018)
- Post-treatment 120-hour window for containerisation adds logistical constraint
- For new barrels, desiccation risk is less severe as staves have already been kiln/air dried; the risk is greater for previously used barrels being re-exported

Chemical fumigation (MB or SF) is logistically simpler for large-volume, containerised shipments and can be applied onshore in Australia for FCL/FCX containers if offshore treatment was not obtained. This makes fumigation the default fallback for consignments that arrive untreated. The availability of onshore fumigation means that buyers of barrels who do not specify treatment at origin have access to a remediation pathway, albeit one that introduces the residue risks discussed above.

5.3 ISPM-15 Heat Treatment as a Dual-Compliance Strategy

When cooperage is shipped on ISPM-15-compliant pallets or in ISPM-15 treated wooden crating, the crating/pallet treatment does not constitute BMSB treatment of the barrels. However, where the shipping configuration involves each individual barrel undergoing heat treatment as part of the BMSB process, the documentation can be structured to satisfy both BMSB and any commodity-level phytosanitary requirements simultaneously. DAFF's guidance notes that where one treatment is conducted to meet two separate requirements (e.g., BMSB and commodity treatment), the highest of each parameter must be met.

5.4 Container Load vs LCL Considerations

For Full Container Load (FCL) shipments of barrels directly from cooperage, offshore treatment (preferably heat) and containerisation prior to the 120-hour post-treatment window is the most efficient pathway. The sealed container prevents re-infestation and provides the required documented supply chain integrity.

For Less than Container Load (LCL) or Freight of All Kinds (FAK) containers – increasingly common for small-to-medium Australian winery barrel orders from multiple cooperages – the container is assessed at the container level for BMSB risk prior to deconsolidation. If any goods in the container are target high-risk and untreated, the entire container is subject to onshore treatment before goods are released. This means that a single untreated consignment of barrels in a mixed LCL can impose fumigation costs on all other consignees in the container, creating supply chain friction. Wineries should specify offshore treatment of their barrel consignments to avoid this risk.

5.5 Montreal Protocol Phase-Out Context

The QPS exemption for MB means that its continued use for BMSB fumigation of cooperage imports is legally secure for the foreseeable future. However, commercial and environmental pressures are driving market substitution. The treatment provider industry's adoption of ProFume/Vikane (SF), and from 2025–26, ethyl formate, reflects a gradual transition. For the Australian wine industry, the directional travel toward heat treatment and EF, both residue-minimal options, is the commercially and scientifically preferable trajectory.

6. Practical Risk Management for Wineries

6.1 Recommended Specifications When Ordering Barrels

Australian wineries sourcing imported cooperage should incorporate BMSB treatment specifications into purchase orders and negotiations with cooperages. The recommended specification hierarchy, in order of preference, is:

1. Offshore heat treatment by an AusTreat-registered provider; this eliminates chemical residue risk entirely and is the industry-standard approach for premium cooperage. Wineries should specify "Heat treatment per DAFF BMSB methodology, ≥56°C at coldest surface for ≥30 minutes, by an AusTreat-registered provider with treatment certificate."
2. Ethyl formate (EF + CO_2) offshore fumigation; for the 2025–26 season onwards, where available from AusTreat-registered providers. This has a low residue risk and is ozone-neutral.
3. Sulfuryl fluoride offshore fumigation; lower residue risk than MB in dry-wood scenarios; wineries should specify adequate ventilation/aeration period before shipping, and request aeration confirmation on certificate.
4. Methyl bromide fumigation only if no other option is available. Wineries should apply the AWRI-recommended post-arrival protocol (below).

Explicit specification of avoidance of methyl bromide for premium new barrels is commercially achievable given the cooperage sector's existing capability for heat treatment. This should be specified in the barrel purchase order alongside cooperage origin, grain specification, seasoning duration, and toast level.

6.2 Quarantine, Airing, and Off-Gassing Procedures on Arrival

For fumigated barrels arriving in Australia (whether treated onshore or offshore), the following procedures are appropriate:

- Inspect treatment certificates on arrival: verify the treatment type, provider registration status, applied dose/temperature, endpoint reading, and treatment date relative to SOB date (treatment must be within 120 hours of SOB for shipments prior to 1 December, with exceptions)

- Ventilate the container on opening: allow 30–60 minutes of passive ventilation before entering. This is particularly important for SF-fumigated consignments, as SF itself (though not residual F^-) can persist at low concentrations
- Air barrels in a well-ventilated space for a minimum of 48–72 hours after container opening before introducing any water or wine
- For MB-treated barrels: do not rely solely on airing to remove ionic residues; proceed with the water conditioning protocol below

6.3 Pre-Use Conditioning Protocols for Fumigated Barrels

The AWRI recommends that for MB- or SF-fumigated barrels, these should be filled with chlorine-free water (treated water, with chlorine removed) for 48 hours after airing, to minimise residual bromide or fluoride ions (Australian Wine Research Institute 2018; Australian Wine Research Institute 2026a). The rationale for chlorine-free water is important, as municipal potable water containing residual chlorine could theoretically provide the oxidant precondition for halophenol formation if MB residues are also present (AWRI flags hypochlorite as a co-factor in the TBA formation pathway).

The practical protocol for MB/SF-treated new barrels is outlined below:

1. Inspect exterior for any odour anomalies (MB has a faint musty/sweet odour at high concentrations)
2. Air in well-ventilated space for ≥48–72 hours
3. Rinse with hot dechlorinated water (60–80°C), rolling to coat all internal surfaces
4. Fill with cold dechlorinated water and soak for 48 hours; check for leakage
5. Drain and assess, repeat water fill if concerned about residuals
6. Optional: send water soak sample (200 mL) to a laboratory for bromide and fluoride ion analysis before first wine fill
7. For heat-treated barrels that arrive dry, conduct standard swelling protocol with hot dechlorinated water. This is sufficient as there is no additional fumigant residue concern

Not that for previously used barrels (ex-wine or ex-spirit) that are subject to BMSB fumigation, they will contain residual wine/spirit in the wood matrix. MB hydrolysis under these conditions may produce bromomethanol and other organic derivatives in addition to Br^-. Given the absence of specific research on this pathway in wine-saturated wood, additional caution is warranted for used-barrel refumigation and heat treatment is strongly preferred for used cooperage.

6.4 Testing Protocols for Bromide and Fluoride Residues

Analytical testing of water used in the barrel conditioning soak protocol provides the most practical and representative assessment of ionic residues mobilisable by an aqueous-phase extractant (a reasonable proxy for wine, though wine's alcohol and pH will modify extraction kinetics). Recommended testing methods for relevant analytes are outlined below.

- Total inorganic bromide in aqueous samples: GC-ECD after propylene oxide derivatisation (EURL-SRM method) or IC (ion chromatography) (Community Reference Laboratory 2008); limit of determination ~0.5 mg/L in wine matrices
- Fluoride in aqueous samples: ion-selective electrode (ISE) or IC; widely available
- Wine testing post-first fill: send a representative sample (200 mL) from the first few weeks of maturation in a fumigated barrel for bromide and fluoride analysis; compare against OIV limits (1 mg/L each)
- Recommended laboratories: Affinity Labs, ETS Laboratories (USA; with AWRI collaboration noted), Eurofins (Australia), or other NATA-accredited laboratories with ion chromatography capability

Note: the AWRI cautions that *"it is not possible to reliably measure for residual bromide and fluoride ions"* directly in treated wood. Solution-phase (water extract or wine) testing is more analytically tractable and directly relevant to food safety.

7. Implications for Organic and Biodynamic Wine

For wineries certified to organic or biodynamic standards, BMSB fumigation of imported oak barrels or corks creates further complications beyond food safety or taint concerns. Organic wine standards operate on process-based positive lists, where a substance is prohibited unless it appears on an approved input list, and physical contact between an organic product (or the surfaces/containers that hold it) and a prohibited synthetic substance can compromise the organic status of the resulting wine. Methyl bromide and sulfuryl fluoride are synthetic fumigants and do not appear on any major organic-standard positive list.

7.1 Are Containers in Contact with Synthetic Fumigants Are Prohibited?

The USDA National Organic Program rule 7 CFR §205.272(b) (Legal Information Institute n.d.) is the most explicit statement of the principle and is widely mirrored in other jurisdictions. It prohibits, in the handling of any organically produced product, the use of *"(1) Packaging materials, and storage containers,* *or bins that contain a synthetic fungicide, preservative, or fumigant; (2) The use or reuse of any bag or container that has been in contact with any substance in such a manner as to compromise the organic integrity of any organically produced product or ingredient placed in those containers, unless such reusable bag or container has been thoroughly cleaned and poses no risk of contact of the organically produced product or ingredient with the substance used."*

An oak barrel is unambiguously a storage container under this definition. A barrel that has been fumigated with MB or SF therefore falls within §205.272(b)(1) and is, at face value, prohibited for use with NOP-certified wine unless the operation can demonstrate, to the satisfaction of its certifying agent, that residues have been removed and no risk of contact with the prohibited substance remains (U.S. Department of Agriculture n.d.). This determination is made by the certifier on a case-by-case basis; the regulation does not specify a numerical residue threshold.

7.2 Australian Standards: ACOS, NASAA and the National Standard

Australia operates a dual-tier organic system. The National Standard for Organic and Bio-Dynamic Produce administered by DAFF (2022) governs exports, while domestic certification is delivered against private standards including the Australian Certified Organic Standard (ACOS) owned by Australian Organic Limited and the NASAA Organic & Biodynamic Standard. Both private standards are aligned with, and stricter in some respects than, the National Standard.

ACO Certification, the principal Australian certifier, has stated explicitly that MB treatment causes loss of organic status: *"Methyl Bromide is a very common treatment fumigation method for Australian Quarantine and it's not an allowable input under organic standards, so that organic product would lose its organic status and could not be sold as certified organic"* (Kialla Pure Organics 2024). The same logic applies, by extension, to any container that has been fumigated with MB and subsequently contacts certified-organic product. The Australian Certified Organic Standard 2023 (Australian Organic Limited 2023) operates as a positive list, where only substances listed in its annexes are permitted. Synthetic fumigants for processing-facility application are not listed. Section 6 (Processing/preparation) and Section 7.9 (Wine production) of ACOS 2023 together require operators to prevent contamination of certified product from prohibited substances at all stages.

The National Association for Sustainable Agriculture Australia's (NASAA) (2026) standard similarly excludes synthetic fumigants and requires that storage and processing facilities prevent contact between certified product and prohibited substances.

7.3 EU Organic Wine (Regulation 2018/848)

The EU organic wine regime under Regulation (EU) 2018/848 (European Commission n.d.) operates on the same positive-list philosophy. Only substances and oenological practices explicitly listed in the implementing regulation (notably Annex V of the implementing acts on permitted oenological products and processing aids) may be used in the production of organic wine. Synthetic fumigants do not appear on this list. The CERES certification body's interpretive guide to organic wine under 2018/848 notes that all materials in contact with organic wine must themselves be free of prohibited substances, and that documentation of input compliance is the certified operator's responsibility (CERES 2022). A barrel that has been MB- or SF-fumigated would not satisfy this requirement without documented evidence of complete residue removal.

7.4 Biodynamic Standards: Demeter

Demeter's processing standard is the most explicit of the major standards on this point. The Demeter Processing Standard (Demeter Association 2017) requires that pest management in processing facilities be undertaken *"mechanical[ly] or with CO_2 fumigation, freezing, or with non-toxic materials"*, and explicitly states that *"all packaging must be free of fungicides, preservatives, fumigants, insecticides, and not be a contamination source of any materials prohibited by this Standard"*. The transport clause further prohibits the use of carriers that have been *"fumigated within 72 hours"* of transporting Demeter-certified product. Under Demeter, an MB- or SF-fumigated oak barrel would be categorically incompatible with biodynamic wine production, and even heat-treated barrels would need to satisfy general Demeter input requirements.

7.5 Heat Treatment as the Only Organic-Compatible BMSB Option

Of the four DAFF-approved BMSB treatments, only heat treatment is compatible with organic and biodynamic wine production without further conditions. Heat is a physical process that leaves no residue and does not introduce any synthetic substance into contact with the barrel. The remaining options each present problems, as outlined in Table 5.

Table 5. Compatibility of BMSB treatments with organic wine standards.

BMSB treatment	Compatibility with organic wine standards	Additional commentary
Heat treatment (56°C/30 min)	Compatible.	Physical process, no residue, no synthetic input. The default option for organic-certified wineries.

Methyl bromide	Prohibited in practice.	Synthetic fumigant; barrel falls under NOP §205.272(b)(1), ACOS contamination provisions, EU 2018/848 positive-list exclusion, and Demeter packaging/transport prohibitions. ACO has stated that MB-treated product loses organic status.
Sulfuryl fluoride	Prohibited in practice.	Same regulatory logic as MB — a synthetic fumigant in direct contact with a storage container. F^- residues are particularly persistent in oak xylem.
Ethyl formate (EF + CO_2, from Sept 2025)	Status unclear and unresolved.	Ethyl formate occurs naturally (it is a recognised volatile in some fruits and is present in trace amounts in wine itself) and CO_2 fumigation is explicitly permitted under Demeter and is generally accepted under NOP and ACOS for pest control. However, the synthetic-vs-natural status of commercial EF (typically synthesised from ethanol and formic acid for fumigation use) and its formulation with carrier gases has not, at the time of writing, been formally addressed in published guidance by ACO, NASAA, Demeter, or the EU. Certified operators should seek written confirmation from their certifier before accepting EF-treated barrels.

7.6 Practical Implications for Organic-Certified Wineries

The practical position for any Australian winery holding organic, biodynamic or organic-export certification (NOP, EU 2018/848, JAS) is unambiguous. Wineries should specify heat treatment in cooperage purchase orders, in writing, with documentary evidence from the supplier and the registered AusTreat treatment provider. This specification should be embedded in the order itself and should require:

- Identification of the registered AusTreat treatment provider
- Treatment certificate stating heat treatment per the DAFF schedule (56°C core temperature ≥30 minutes)
- Explicit written confirmation that the barrels have not been fumigated with MB, SF, or any chemical fumigant at any point in transit

- Retention of these documents in the organic handling plan (OHP) audit file for review by the certification body

Where a shipment arrives with documentation indicating MB or SF treatment, either because the supplier substituted treatment methods without notification or because onshore treatment was applied to the container after arrival, the barrels should be quarantined and not used for certified-organic wine until the certifying body has been notified and provided a written determination. The default certifier position, based on the ACO precedent and the explicit prohibitions in NOP §205.272 and Demeter standards, is that such barrels are no longer eligible for certified-organic product use. The barrels may still be used for conventional wine production, but the organic wine pathway is closed for that vessel.

For wineries operating split (organic and conventional) production, this creates an inventory-management requirement. Fumigated barrels must be physically segregated, clearly marked, and tracked through the OHP to prevent inadvertent use with certified product, a commingling failure that would itself trigger non-conformance under both NOP and ACOS.

Finally, there is an important parallel-production dimension. Under both ACOS 3.6 and NOP §205.201, an operation that handles both organic and conventional wine must maintain procedures sufficient to prevent contamination. For example, a winery that routinely receives fumigated barrels and uses them for conventional wine in the same cellar as organic barrels would need to address this risk explicitly in its organic system plan.

8. Evidence Gaps and Research Priorities

The following specific knowledge gaps were identified during this review and represent priorities for research, particularly for AWRI and Wine Australia:

1. Direct measurement of Br^- and F^- in water-extracts or wines from BMSB-fumigated oak barrels: No published experimental data exist quantifying the migration of ionic residues from BMSB-treated cooperage into wine under realistic maturation conditions. This is the most critical gap.

2. EF fumigation residues in wood and wine: EF has been approved as a BMSB treatment option only from September 2025. No peer-reviewed or industry data on EF sorption in oak, residue persistence, or potential sensory impact on wine exist. Given EF's ester character (rum/pineapple aroma at threshold concentrations), this warrants specific investigation before widespread adoption for cooperage treatment.

3. Used barrel re-fumigation pathways: The chemistry of MB hydrolysis products in wine-saturated oak has not been characterised. Given the chemical complexity of residual wine compounds in used barrels, bromide reaction pathways may differ from those in dry, new wood.

4. Cooperage supplier transparency: No public statements were identified from major tonnelleries specifically disclosing their BMSB treatment methodology for Australian-bound shipments. Industry guidance from Australian Grape & Wine, Wine Australia, and AWRI on requiring suppliers to disclose treatment type would be valuable.

This report was prepared based on publicly available information current as of June 2026. All regulatory schedules should be verified directly with DAFF (agriculture.gov.au/biosecurity-trade/import/before/brown-marmorated-stink-bugs) prior to each season, as country lists, treatment parameters, and approved providers are subject to annual review.

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