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WEA NZ CONFERENCE
Barrel Cellar-Process Design

September 2008

Barrel Cellar –Process Design

- Key process design aspects should be addressed when selecting and designing a barrel cellar

- Three key process conditions that should be designed for and controlled
  - Temperature
    - Control fermentation
    - Minimise risk of spoilage
  - Humidity
    - Minimise wine losses
  - Carbon Dioxide (CO_2)
    - Health and safety

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Temperature Control In Barrel Cellars

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- Typically achieved using fancoil heat exchangers
- Fancoils sized based of calculation of heat load
  - Heat infiltration through walls
  - Air infiltration through doors, extract fans etc
  - Fermentation (exothermic reaction)
  - People respiration
  - Equipment-forklifts, fans, lights
  - Product temperature change
- There is not a good industry understanding on temperature change in wine barrels
  - Heat transfer through wine barrel
- Transfield Worley have completed a series of trials to better understand heat transfer through a wine barrel

Temperature Change In Wine Barrel

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- Structure of a wine barrel means that it behaves like an insulated vessel
  - 23mm layer of oak insulation
- Rate of heat transfer through the barrel wall is slow
  - 0.01kW per ºC per barrel
- Often results in winemakers setting unrealistic performance requirements for fancoil units
  - Performance requirements are never met
  - Results in oversized fancoils

Temperature Change In Wine Barrel

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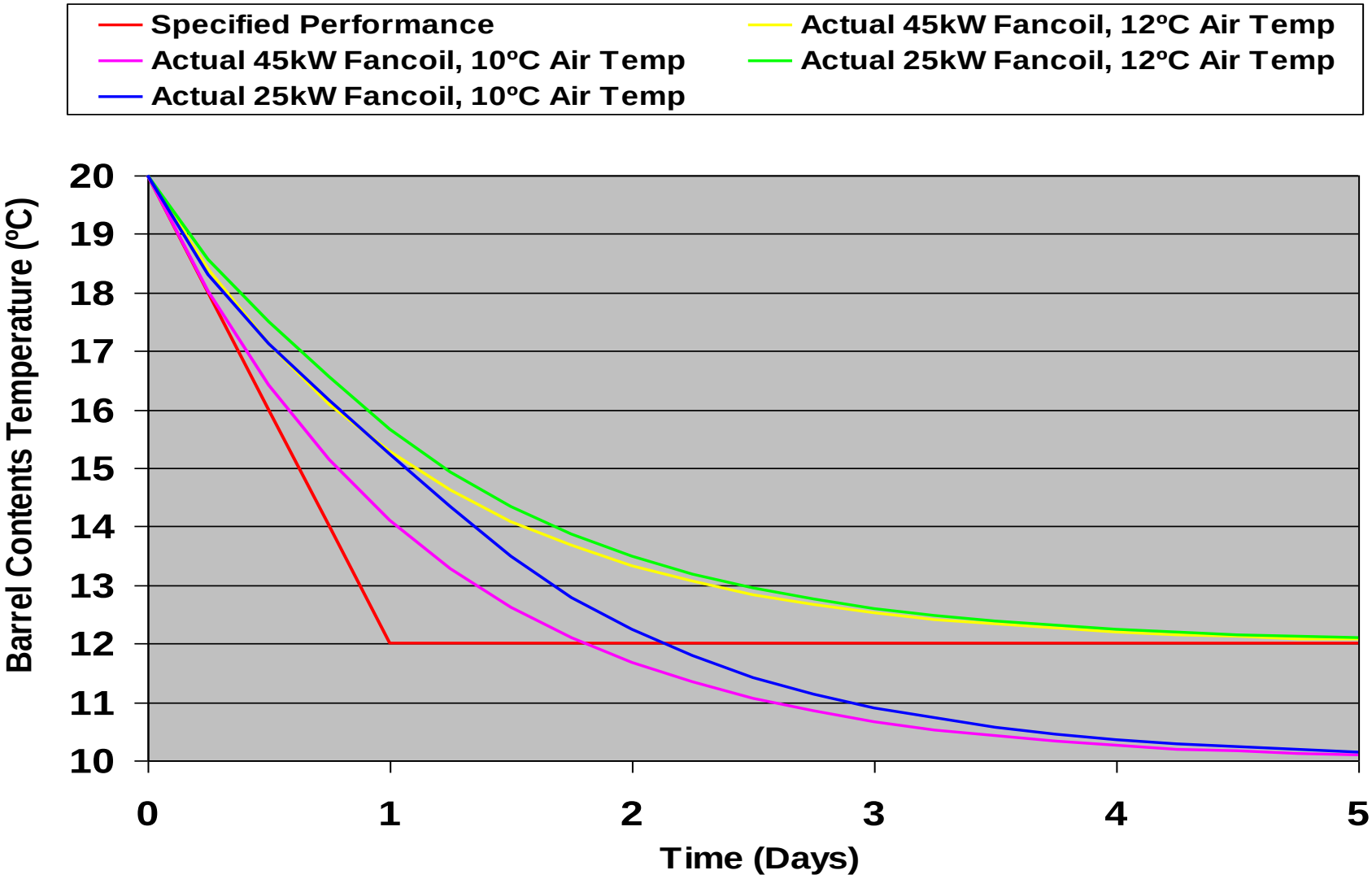
- Winemakers cooling requirements
  - To cool 500 barrels from 20ºC to 12ºC in 24hrs with a barrel cellar temperature of 12 ºC

- Traditional heat load calculation

$$\frac{500 \text{ barrels} \times 225\text{kg/barrel} \times 4.3\text{kJ/kgºC} \times (20\text{-}12\text{ºC})}{24\text{hrs} \times 3600 \text{ sec/hr}}$$

- = 45kW fancoil cooling load

Temperature Change In Wine Barrel



Temperature Change In Wine Barrel

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- Rapid change in barrel temperature is not practically achievable due to the thermal properties of the wine barrel

- Need to consider actual heat transfer properties of barrel or will oversize fancoils
  - Minimal increased performance
  - Wasted capital cost

- To achieve temperature pull-down need barrel cellar temperature at least 2ºC colder than target temperature

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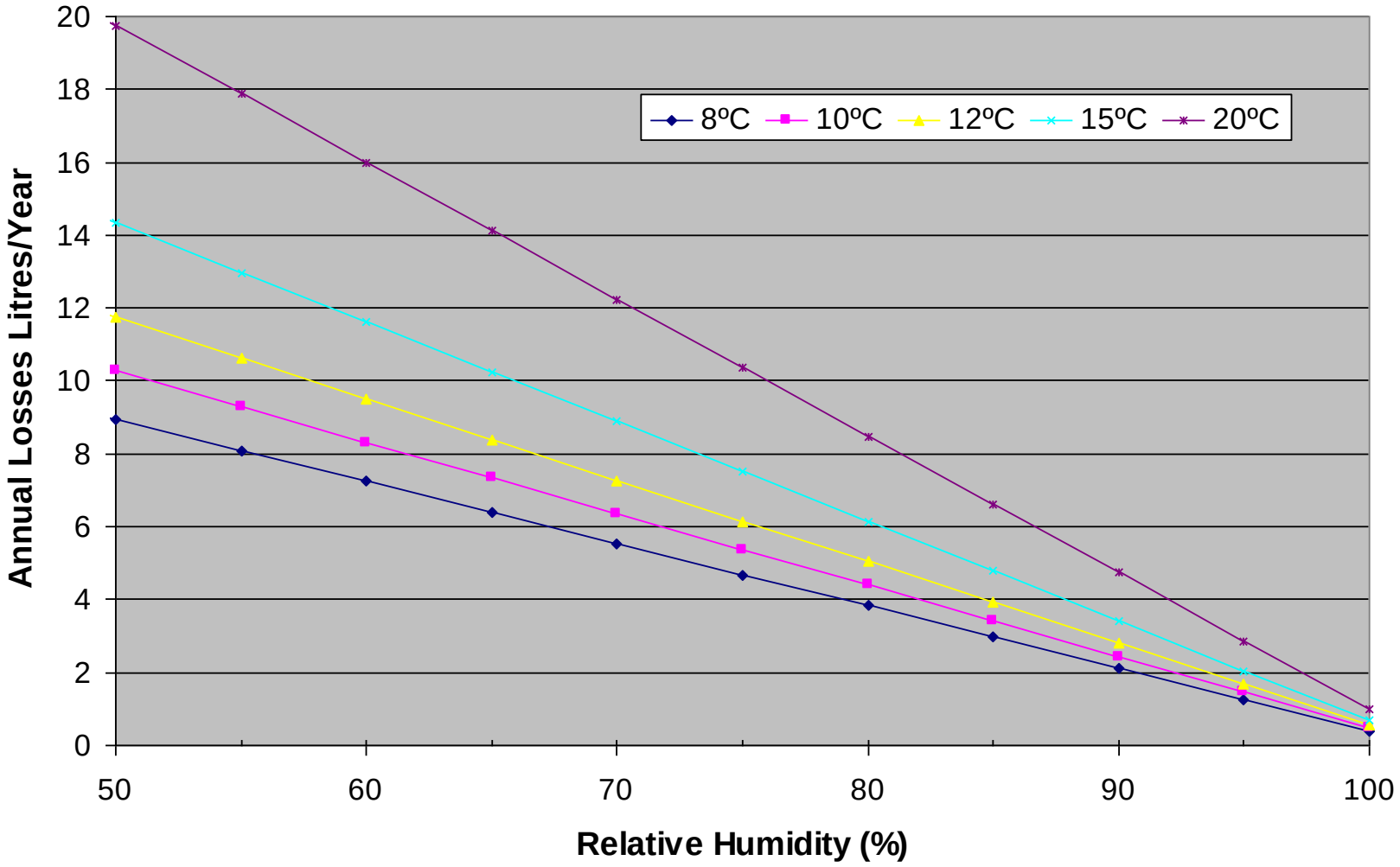
Annual Wine Evaporation Losses from 225L Barrel



Source: Prof. Roger Boulton, University of California

Example: Losses from a Barrel Cellar

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- 500 barrels
- Barrel cellar @12ºC, 60% relative humidity
  - 9.5 litres of wine losses per barrel per year
  - 4,750 litres wine losses per year
- Barrel cellar @12ºC, 85% relative humidity
  - 3.9 litres of wine losses per barrel per year
  - 1,950 litres wine losses per year
  - Reduction of 2,800 litres of wine per year
  - @$10 per litre equates to $28,000 saving per year
- Make sure you have good control over the humidity in your barrel cellar

Humidity Control In Barrel Cellars

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- Our experience is that 85% RH is a reasonable target
  - Minimises evaporative losses
  - Does not cause condensation of cellar walls and barrels (minimises mould)
  - Practically achievable and controllable

- Correct fancoil selection is critical
  - Fancoils naturally dehumidify when in cooling mode
  - The colder the fancoil surface temperature the more water that will condense on the fancoil and the greater the rate of dehumidification
  - Cold glycol temperature should not be below 6-8ºC

- Humidification
  - Range of solutions including:
    - Fogging (Compressed air and water)
    - Misting (high pressure water)
    - Steam

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CO_2 Generation In Barrel Cellar

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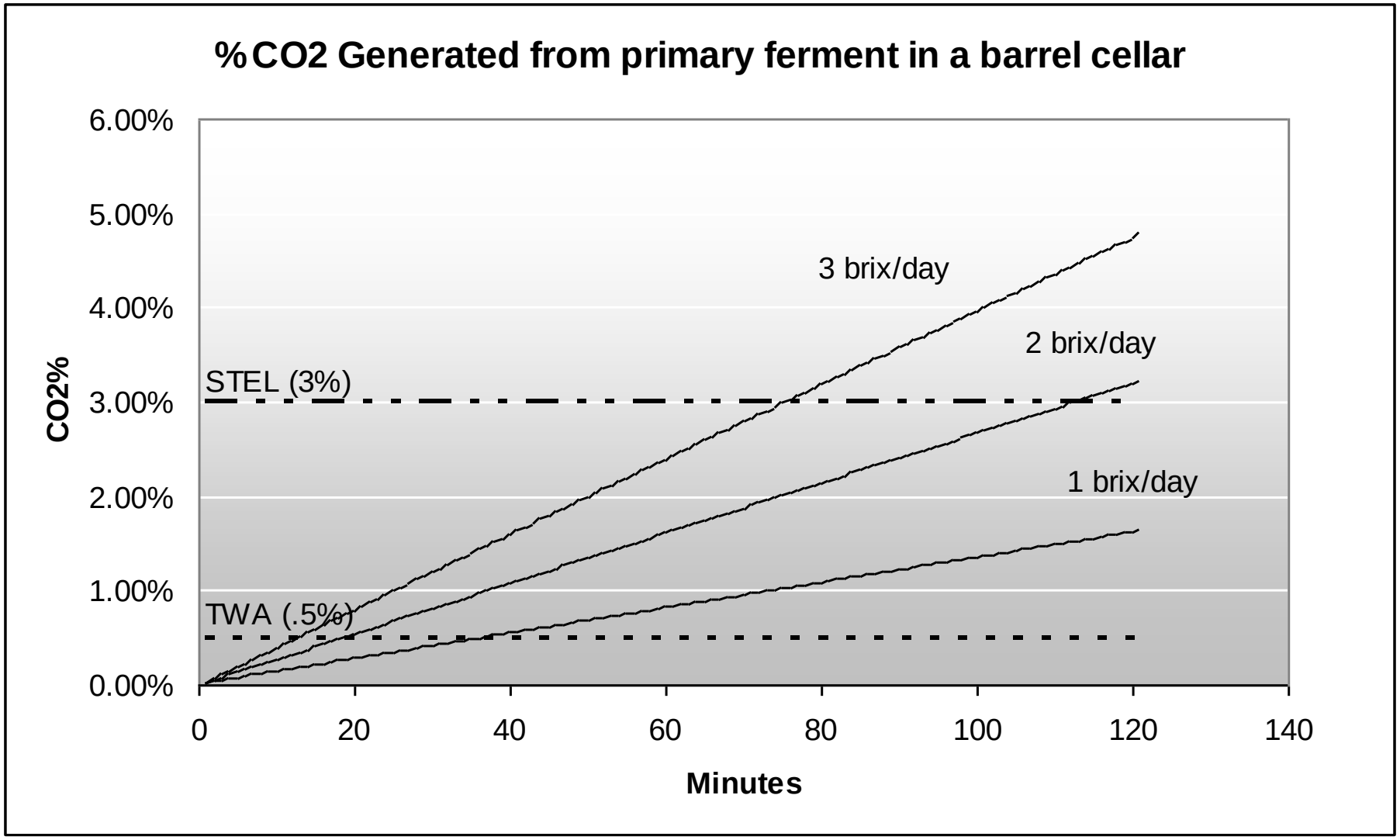
$C_6H_{12}O_6$	→	$2C_2H_5OH$	+	$2CO_2$
180 grams		92 grams		88grams

- 3.0 litres of CO_2 per litre juice per brix per day
- A 225 litre barrel over the primary ferment period approximately 16,000 litres of carbon dioxide
- Department of Labour (OSH) Workplace Exposures Standard
  - Normal concentration of CO_2 in air is 0.03%
  - TWA (time weighted average) exposure limit for 8hrs continuous work is 0.5%
  - STEL (short term exposure limit) 15min in a 24hr period is 3%
  - Above 10% unconscious in a few minutes
  - Above 15% lethal expose limit

CO_2 from 500 Barrels in Cellar



CO_2 from 500 Barrels

- Ferment rate of 1 brix/day without adequate ventilation
  - Unsafe for staff to work in little over 3 ½ hours,
  - Lethal after approximately 20hrs
- Requires an automated extraction and alarm system
  - Extraction rates of 5 air changes per hour would be required to maintain the Time Weighted Average exposure limit of 0.5% of CO_2
  - These rates are often not achievable using passive air circulation such as leaving the cellar door open prior to entry
- Need to correctly size extraction fans
- CO_2 sensors need to be reliable and located in correctly positions
  - Safety integrity level ratings (SILs)

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Summary

- Temperature
  - Rapid pulldown is not practically achievable
  - Need to consider thermal properties of wine barrel
    - Otherwise fancoil units will be oversized
- Humidity
  - Evaporative losses from wine barrels are significant
    - $28K per year from 500 barrels
    - Run glycol at no less than 8ºC
  - Good business case for installing humidification
- Carbon Dioxide (CO_2)
  - Carbon Dioxide in barrel cellars is a real health and safety hazard
  - CO_2 levels can increase above safe working levels very quickly
    - Unsafe to work in after 3 ½ hrs
  - Passive circulation will not provide adequate fresh air circulation

Finishing Message

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- Barrel cellar design is more complex than often thought
- Not getting it right has significant implications
  - Quality
  - Cost
  - Health and safety
- Transfield Worley can assist you in developing the optimum barrel cellar design that is tailored to your specific needs