

An Engineer's View of Wine Cellar Environmental Monitoring

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Wine cellar owners are rightfully concerned over maintaining ideal storage conditions to avoid risk of damage to their delicate and perhaps costly investments. An engineer designing an appropriate monitor needs to know which parameters are to be measured along with their range and precision. In addition the data format, communication and presentation must be chosen. We have listened to the wine experts and advocates, who have a strong presence on the Internet, to decide on what is really needed and to formulate the specifications for environmental monitoring of a wine cellar in engineering terms. Here are our conclusions as to what is needed and how a wine cellar should be monitored:



Temperature

Over the long term wine should be stored within a proper range of temperature to avoid damage and to properly age. A frequently suggested range is 45 to 65 °F (8 to 18 °C) with a target storage temperature of 55 to 60 °F (13 to 16 °C). Significantly higher temperatures for a long time are definitely bad but shorter term exposures to high temperatures (for example, 100 to 120 °F for a few hours) is likely not harmful, but should be avoided. Temperatures significantly below 45 °F (but above freezing, about -5 °F) for moderate periods are not harmful but the wine will not age properly. Temperatures moderately above 65 °F are not immediately harmful but will accelerate aging.

Although storage at any point in the 20 °F range is acceptable, it is desirable to avoid temperature cycling since this promotes passage of air through the cork, causing oxidation of the wine. A maximum fluctuation of 5 °F (peak-to-peak) during storage is suggested.

It is probably true that high precision of the temperature sensors is not required because the acceptable range for storage is fairly broad. Most low-end sensors, which have an accuracy better than +/-4 °F, would be adequate. However precision thermistors (+/- 0.5 or 0.2 °F), which are readily available at moderate cost, are preferred because they provide a more comfortable margin of safety. Resolution to a 10th of a degree is necessary to properly measure the temperature fluctuation.

Bottle (internal liquid) temperature differs from air temperature because of the thermal capacity (inertia) of the liquid in the bottle. Measurements indicate the time constant of a 750 ml bottle to be about 30 min. Often a temperature probe (thermistor) is put into a bottle with water (through a cork) to measure the bottle temperature. We propose instead using a “simulated bottle temperature” by averaging the response of a faster thermistor on a metal block attached to the rack in a central position. Because the air and bottle temperature sensors are at different locations, there may be a small difference between them. We expect that the air temperature fluctuations would be kept to under 5 °F except for brief periods during cellar visits. This should result in bottle temperature fluctuations under 1 °F.



Humidity

Short term variations in air humidity have little or no effect on the liquid within the bottle but, over the longer term, humidity extremes should be avoided. Humidity approaching 100% may cause condensation and damage to the label. Long term low humidity can dry out the cork or cause loss of liquid inside (affect fill level). Most experts suggest a range of 50% to 80%

relative humidity (Rh) with a target of 60% or 70% (probably 30% to 90% would not be harmful). Precision of the humidity sensor need not be very high because of the wide acceptable range of humidity. Most commercial humidity sensors have an acceptable precision of +/- 3% to 5% Rh).



Light

Strong sunlight (100,000 lux) is reported to cause deterioration of wine in a fairly short time (hours or days). Standard room illumination (100 to 400 lux) over long periods should be avoided, especially with fluorescent lights which have an appreciable UV component. We have found no quantitative data on damage to wine vs accumulated exposure (dose) but we think that this parameter should be recorded.

Vibration

Experts sometimes state that vibration should be avoided during long-term storage. One scientific study suggests that vibration levels over 0.01 g (10 Gal) have an effect on wine chemistry. We are uncertain regarding the value of vibration monitoring.

Records

Time-stamped, continuous records of the temperature and other parameters is necessary for assurance that the wine has been stored under the proper conditions during the entire period of storage. We consider data storage on the Internet (cloud storage) as best.

Alerts

Messages should be sent to the cellar owner or steward by email, text message or phone if an abnormal condition (exceeding threshold) is detected. To avoid false alarms, time averaging or pattern recognition may be used.

Visitor/intrusion detection

While not strictly a part of environmental monitoring, the detection and recording of visitors or intruders is usually a part of the system because the sensors (motion, camera) utilize the same signal processing and communication system.