Inert Gas, Dissolved Oxygen and CO_2

Gas	Nitrogen	Argon	Carbon Dioxide	Air
Molecular Formula	N_2	Ar	CO_2	78% N_2 and 20.9% O_2
Molecular Weight	28.01	39.95	44.01	28.53
Density (kg/m^3)	1.189	1.691	1.875	1.20
Solubility at 15°C (volume/volume)	0.017	0.038	1.01	0.02

How to displace all the air in a 15.5 gallon keg with argon

1) Use a diffuser at the end of the argon gas line, use a flowmeter after the gas regulator.
2) Protect the opening of the keg from air turbulence while still allowing the keg to vent. To do this, I use a "Ferm-rite" fermentation bung (the kind that has 5 holes punched in the silicon) and thread the argon gas line through center hole of the ferm bung. The diffuser is placed at the bottom of the keg.

3) With the regulator pressure set to 10 psi, and the **AIR flowmeter** reading 20 liters/minute (which corresponds to 15 L/min of argon), it took 5 minutes for the % oxygen at the top of the keg headspace to fall below 0.5% O_2.

   The 15.5 gallon keg is 58.67 liters. At 15 L/min, it should take about 4 minutes to exactly displace that many liters of air. Another 1 minute of gassing is required to ensure total air displacement. Without a diffuser there was too much turbulence and mixing to reach 0.5% O_2 in a reasonable amount of time. Without the ferm-rite bung shielding the keg opening, there was too much air movement and turbulence near the top of the keg.

How to displace all the air in a 550 gallon Custom Metalcraft tank with argon

1) Use a diffuser, and use a flowmeter after the regulator.
2) Make sure the tank is vented but protect the top opening from turbulence as follows: I thread the tygon tubing through the ferm-rite bung, attach the diffuser to the end of the tygon and then feed the diffuser, tubing and ferm bung through the top 2inch port in the lid of the tank until the diffuser is near the tank floor.
3) With the regulator pressure set to 20 psi, and the **AIR flowmeter** reading 100 liters/minute (which corresponds to 75 L/min of argon), it took 30 minutes to fall to 0.5 % oxygen at the top of the tank.
4) A 550 gallon tank is 2081 liters. At 75 L/min of argon, it should take 27 minutes to exactly displace the air in the tank. 30 minutes ensures total displacement.

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> **THE MYTH**: Argon is expensive.
>
> **THE FACTS**: Argon costs three times more than nitrogen by volume. But it is so much more effective that it actually does a better job for less money. In most cases, an argon blanket that stays put is better than several complete headspace volumes of nitrogen. Thus, argon is the cheapest and most effective means for excluding oxygen.

Why do you need a flowmeter? You can't use the psi reading on a gas regulator to dispense a certain volume of gas. Temperature, hose length, hose diameter, regulator size, and a host of other factors contribute to the relationship between pressure at the regulator and gas volume delivered. Flow meters measure gas flow. The flowmeter I recommend is sold by AirGas and costs $65. This flowmeter is calibrated for air flow. There are conversion charts that convert the flowmeter reading to the flowrate of different gases. Since argon is more dense than air, it flows more slowly than air through the flowmeter. (C. Smith, http://www.vinovation.com/ArticleArgon.htm, Gary Des Rosiers, AirGas)

How often should you displace the headspace of a partial tank? Sealed closed-top tanks vary in how airtight they are. "Airtight" tanks breathe. The headspace in an outside tank (vacillating between 15°C and 35°C) will pump 7% of its headspace in and out every day. An inside tank at constant temperature will pump 3% of its volume when the barometer swings from 30 to 29 inches Hg (such as when a storm passes). To generalize, you should gas a partial tank stored inside with argon weekly using a diffuser at the end of the gas line and if a big storm passes through, gas more frequently. (B. Kreisher of Grapecraft)

Volume Conversion Table

Cubic foot =	Cubic meter =	Liter =	U.S. gallon =
1.00	0.03	28.32	7.48
35.31	1.00	1000.00	264.17
0.04	0.001	1.000	0.26
0.13	0.004	3.785	1.00
40	1.13	1133	**299**
80	2.27	2265	**598**
200	5.66	5663	**1496**
300	8.50	8495	**2244**

Pressure Conversion Table

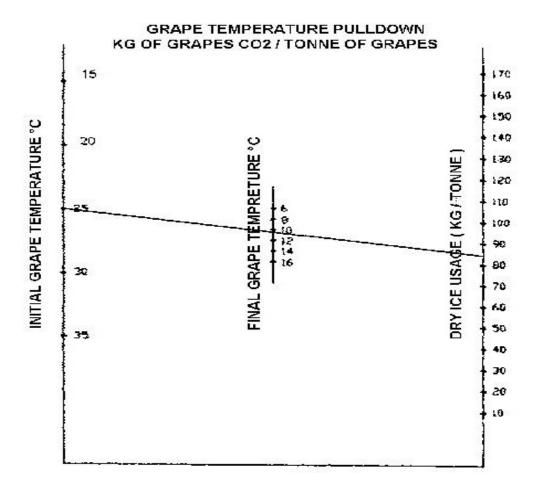| psi =	Atmosphere =	Bar =	kPa =
1.0	0.1	0.1	6.9
14.7	1.0	1.0	100.0
0.1	< 0.01	< 0.01	1.0

Inert Gas, Dissolved Oxygen and CO_2

Carbon dioxide (CO_2) is heavier than air but it is very soluble in wine. The solubility depends on the wine temperature and the partial pressure of the CO_2 in the headspace of the tank.

What are normal dissolved CO_2 levels in wine at bottling?
- Typical dissolved CO_2 levels in barrel fermented chardonnay at bottling are 1.0 g/L
- Legal limit for CO_2 in still wine is 3.92 g/L (at concentrations above 3.92 g/L the wine is considered sparkling)
- Perception threshold for spritziness varies for red or white wine and depends on temperature. In 1976, the threshold was published as 0.5-0.6 g/L (Lonvaud-Funel and Ribereau-Gayon)

Why use dry ice at the crusher?
Dry ice has the advantage of both cooling and protecting against oxidation. The technique is widely applied in Australia and New Zealand. From the graph below, the amount of dry ice required to cool grapes from an initial to a final temperature can be calculated. If the ambient temperature is 25 °C and the temperature desired is 10 °C then 85 kg of dry ice is required per metric tonne (1.10 U.S. tons) of grapes. (Allen, 1994) Note the units. (Conversion: 1 metric tonne equals 1000 kg which is the same as 2205 lbs or 1.10 U.S. tons.) Thus 85 kg/tonne of dry ice is the same as 170 pounds/U.S. ton.

GRAPE TEMPERATURE PULLDOWN
KG OF GRAPES CO2 / TONNE OF GRAPES