LAPD Filter Sizing

Reed Andrews estimated the capacity of the MTS single pass oxygen filter as 0.5 g oxygen per kg of filter material in lartpc docdb document 430. Terry Tope and Ewa Skup later repeated this test and found the capacity to be 0.65 g oxygen per kg of filter material (also part of document 430). During the repetition of the test it was thought that the accuracy could be improved by injecting oxygen into the supply dewars. The test procedure introduces error in two main ways. Typical supply dewars contain only a few tenths of a ppm of oxygen. (1) The Delta-F DF-150 used to measure the supply oxygen content has an accuracy of +/- 0.05 ppm. Thus when a supply dewar contains only a few tenths of a ppm oxygen, the measurement error may be significant. (2) Due to the small amount of oxygen content in each supply dewar, several dewars must be passed thru the oxygen filter to saturate it. Each supply dewar is weighed before and after its contents are passed thru the filter. Due to the logistics of these operations, some test dewars vent significant boiloff gas during the test such that the argon mass passed thru the filter is over predicted.

Hardware has been purchased to improve upon these tests. The hardware will allow injection of oxygen into a supply dewar to raise its oxygen concentration to several ppm. This will increase the accuracy of the oxygen measurement and reduce the number of dewars required to saturate the oxygen filter.

That said, the LAPD oxygen filter was sized based upon the 0.5 g oxygen per kg of filter material capacity estimate.

The liquid used to fill LAPD is assumed to have an oxygen content of 1 ppm. Based upon our experience so far, it seems likely that the vendor will deliver argon with substantially less oxygen content than a 1 ppm spec. The LAPD tank has a volume of 22.2 m^3. Thus the amount of oxygen that must be removed is:

$$22.2\ m^3 \times \frac{1395\ kg}{m^3} \times \frac{m^3}{1.66\ kg} = 18{,}656\ m^3\ stp\ Ar\ gas$$

$$1 \times 10^{-6} \times 18{,}656\ m^3 = 0.01866\ m^3\ stp\ O_2\ gas$$

$$0.01866\ m^3 \times \frac{1.31\ kg}{m^3} \times \frac{1000\ g}{1\ kg} = 24.4\ g\ O_2$$

$$24.4\ g\ O_2 \times \frac{kg\ filter\ material}{0.5\ g\ O_2} = 48.8\ kg\ filter\ material\ required.$$

The filter material packed density is 0.81 kg/liter according to the mfg. Thus the volume of oxygen filter material required remove 1 ppm of oxygen from the supply argon is:

$$48.8\ kg\ filter\ material \frac{liter}{0.81\ kg} = 60\ liters\ of\ filter\ material.$$

The LAPD filter vessels are made from 12 inch SCH 10 SS pipe with an ID of 12.39 inches and a length of 39 inches. Thus the filter volume is

$$\frac{\pi}{4} \times 12.39^2 \times 39 = 4{,}702\ in^3 = 77\ liters.$$

The MTS filter residence time is 32 seconds while the LAPD filter residence time is 100 seconds. The MTS filter mass flux is 26.9 kg s^{-1} m^{-2} while the LAPD mass flux is 14.1 kg s^{-1} m^{-2}.

The single pass filtration system at PAB has identically sized molecular sieve and oxygen filters. The LAPD molecular sieve is also identical in size to the LAPD oxygen filter. Based on experience an identically sized molecular sieve has adequate water capacity and the oxygen filter will saturate first. Currently we do not have the ability to test the molecular sieve capacity.

It is expected that the LAPD filters will be regenerated between the gas recirculation step and the liquid fill to give the best chance of a long initial lifetime. Once the LAPD tank is full of filtered liquid argon, filter regeneration will likely be very infrequent. The internal filter in the MTS has been regenerated when convenient with respect to operations, but it has never saturated while in use.

LAPD will have a third filter vessel. This vessel is for investigating additional filter materials such as active charcoal. Using the centrifugal pump and a mass flowmeter injecting a known amount of oxygen (or other contaminant) into the pumped liquid stream, the LAPD purification system will allow for detailed filter capacity measurements.