Capillary Sampling Tubes for LAPD

Version 2

Hans Jostlein May 27, 2010

Introduction

We propose to install capillary sampling tubes into the LAPD tank to measure purity at several locations, in the liquid and gas spaces.

We propose two sets of sampling tubes:

--a "Purge Monitoring" set of 12 tubes with 1/16" capillaries, flowing 1.3 l / hour each, employing inexpensive oxygen sensors to monitor initial gas purging; and

--a "High Purity Monitoring" set of 6 tubes with 1/8" capillaries, flowing 21 l / hour to the "Menorah" gas switchyard and to the high sensitivity instrumentation

The Purge Monitoring Set

It is desirable to monitor closely the initial gas purge, down to 1 % oxygen or better. This includes the "Argon piston" phase and the subsequent purge/ vent cycles.

We want to know not only the average gas purity, but also gain enough information for comparison to FEA flow models to validate or improve those models. The models will be important for future large detectors such as the LAr20 proposal for LBNE. We will want temporal and spatial information. This will inform about the degree of diffusion and mixing during purges. Sampling close to the walls, top, and bottom will help detect any dead areas, if they exist.

Description of the Purge Monitoring Set

We wish to strike a balance between performance and cost/ effort with this system.

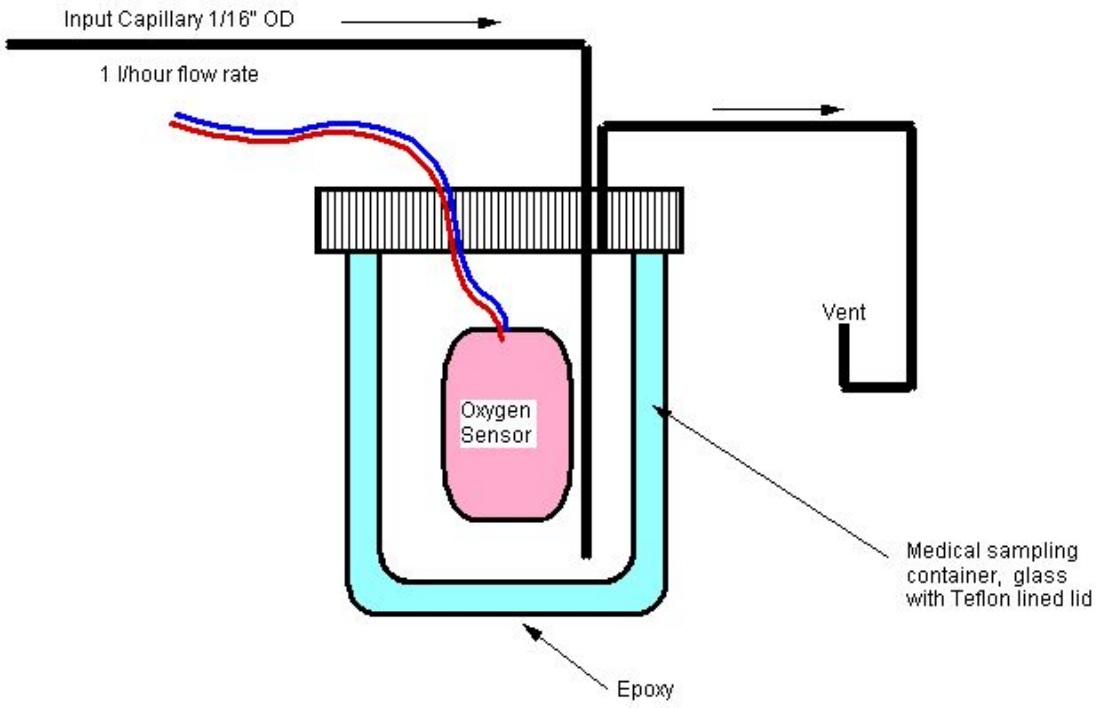
We propose to deploy 12 each industrial type oxygen sensors, similar to those used in the original "Argon Piston" test. The will be located in two strings of 6 each, one string near a wall, and the other near the tank center. Their vertical spacing will be about 2 ft, similar to the spacing in the original test.

The sensors will be inside glass “sample jars” with Teflon coated lids. The jars are inexpensive and come in many sizes.

The sample tubes will be 1/16” OD capillaries, which run continuously from the intake point through a CF flange to the jars. The jars can be mounted on the platform or near the ground, if convenient.

For the original test we received PC sensor-adapter boards form the AD. We need to check availability, and may have to make more copies of the boards if necessary.

Here is a picture of an oxygen sampling capsule:



Oxygen Monitor Capsule

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5/27/2010

Capillary Performance

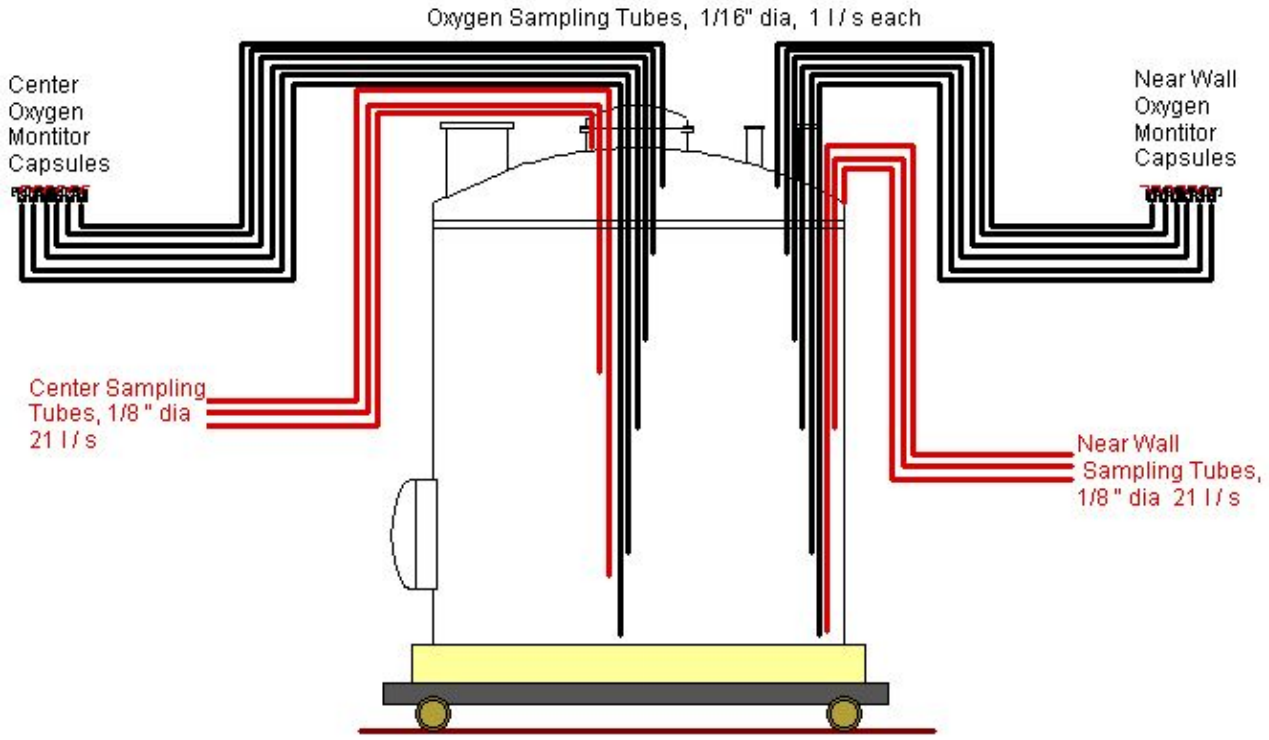
We will use capillaries of 1/16” diameter and 1/32” ID.

We want to use continuous lengths from the sample inlet point all the way to the valves in front of the analytical instruments. The purpose is to avoid leaks, preserve sample integrity, and to keep it simple. The capillaries would penetrate a CF flange where they will be welded into drilled holes. This implies the use of coiled capillary.

We have calculated the flow rate and average velocity of RT Argon gas under a pressure differential of 1 psi, see the excel sheet below. We find the average velocity to be 0.71 m/s, which guarantees fresh samples and quick response, even for the assumed length of 30 m. If open to the atmosphere, each capillary will purge out 1.3 l of G-Ar per hour. If the capsules have a volume of 4 ounces (0.12 l) it will take 6 minutes to change one volume. This is short on the expected time scale of changes (about one hour per 2 ft of height)

Sampling Capillary Layout

The following picture shows both sampling sets: the Purge sampling in black and the High Purity sampling in red:



Straight Capillary Sampling Tubes in the LAPD Tank For Oxygen Monitoring during Initial Purge

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5/27/2010

There are two sets of capillary bundles, one near the tankl center, and one near the tank wall.

Each bundle penetrates a single 2 .75” OD CF flange. The flange contains both the 1/16” OD and the 1/8” OD capillaries.

All sampling tubes go straight down inside the tank and end at the selected elevations.

Outside the tank the tubes may terminate on the platform (e.g. the 1/16” capillaries) or continue, in single runs, all the way to the Menorah. This will eliminate tube leaks minimize connections, and help preserve the gas purity.

Cost of the Purge Monitoring Set

We will need 12 each of these items:

--sensor cell $ 50.- each

--PC board—hope to get from AD

--Jars $ 2.- each

--capillary $ 3.- to 5.- per ft $ 100.- each

--Labor: I will do the capsules and capillary preparation, flange drilling, and installation into the flanges (2 each 2.75" OD CF). Installation effort is mostly electrical connection and integration into the process control system.

Total material cost less than $ 150.-per sample point, $ 1800.- total, plus integration labor.

The High Purity Monitoring Set

This set is separate and slightly different from the Purge Monitoring set to meet different instrumentation requirements:

--the high sensitivity instruments require about 1 scfh of gas flow. This calls for 1/8" OD capillaries, and shut-off valves.

--We wish to use the "Menorah" gas switch yard to connect the costly high sensitivity instruments (Oxygen and Water) to various sampling points as needed. Only a limited number of spigots is available for this on the Menorah. We assume (for now) that 6 spigots are available. If the number is smaller, we suggest to install all six capillaries, but to cap the unused ones to make them available later if their location needs to be studied.

The proposed capillaries are shown in red on the above drawing.

Conclusions

We find that a distributed sampling system in the LAPD tank is possible and easy and inexpensive.

We propose two systems, one for detailed studies of the gas purge, and one for high purity monitoring after the initial purge.

The costs are reasonable, and the effort is available in the required short time frame.

1 in=	0.0254	m		
1 Pa=	0.000145	psi		
1 psi=	6894.757	Pa		
1 psi=				
Argon gas density at RT	1.67	kg/m^3		
Ar gas visosity	2.10E-05	Pa s		
Tube diameter	0.0315	in	0.0008	m
Tube open area	0.000779	in^2	5.03E-07	m^2
tube length	30	ft	9.144	m
Pressure	1	psi	6894.757	Pa
dp/32	215.4612	Pa		
d^2/mu L=	3.33E-03	m / (Pa s)		
Flow rate Q=	3.61E-07	m^3/s	1.30E+00	l/hr
Linear velocity, average	7.18E-01	m/s		