Bladder with dissolved substances for NC

R.B. Schubank, UBC

The format of this presentation will be to address questions posed by H. Robertson regarding NC detection schemes.

**Question A: What is it?**

It is proposed to insert a transparent, flexible, thin, impermeable bladder into the main acrylic vessel to physically sub-divide it into two regions:

- an inner one containing an \((n,r)\) dissolved salt (NaCl, or Gd, or Cd)
- an outer one containing an \((n,a)\) dissolved salt (H\(_3\)BO\(_3\))

Nominal size and shape of the bladder is 5m radius sphere, with a cylindrical neck 8m long by 24" diameter, although other sizes & shapes (hemi-sphere) are also feasible. The bladder can be inserted or removed at anytime.

Desired material (so far) is 1-5mil TEFilon film (see spec sheet), chosen for its mechanical, physical, chemical and optical properties (refractive index matches water!)

Other materials (TEDLAR, ACLAR, SARAN, etc.) are superior in some aspects, such as ion-permeability or weldability; a compromise may still need to be reached.

The outer region helps to eliminate NC background signals originating from the acrylic vessel, light-water, PMT & reflector assembly, liner and rock.

This configuration allows simultaneous monitoring of all 3 nu-induced signals. For 5m radius bladder we get:

\[
\begin{align*}
1667 & \ T \ H_2O \quad \text{yields ES} & (ES= e + nu \rightarrow e' + nu') \\
420 & \ T \ D_2O \ + \ ^{10}B \quad \text{yields ES+CC} & (CC= d + nu \rightarrow p + p + e) \\
580 & \ T \ D_2O \ + \ NaCl \quad \text{yields ES+CC+N} & (NC= d + nu \rightarrow n + p + nu')
\end{align*}
\]
TOP CONTROL LINES (4) ATTACHED TO PATCHES ON TRANSITION PATCH

SPHERICAL BLADDER 30.17 DIA (HCM)
FORMED BY WELDING TOGETHER 20 EQUAL SECTOR PANELS.

BUTTOM CONTROL LINES (4) ATTACHED TO PATCHES ON SOUTH POLE PATCH AND ALIGNED WITH TOP CONTROL LINES
BLADDER ROLLED INTO CYLINDER AND LOWERED DOWN HOLE IN BLAC FLANGE
HEAT UNROLLED AND CLAMPED IN PLACE USING TAPERED CLAMP FLANGE
CONNECT INNER FLEXIBLE TUBE TO DDC PIPING AND GENTLY PULL BLADDER AT THE SAME TIME AS UNROLLING BY MEANS OF CONTROL LINES
Blades located by pulling it up.

Blades need to be removed. Will require

Gripping blade at lower end of

Need a tool to feed blade
down. Need to cut blade damage

Will require that control line anchor

Blades be designed so that they

Will not bind blades as it is

Being withdrawn.

Blades to be checked before removal.

By pumping fluid into valve, and removing

Emulsion of fluid from top end

Of package. It may be necessary

To insert a temporary end plug. After

The package is closed to

Remove both of the fluid from it.
GLOVE BOX WALL

TUBULAR NUT

BLADDER MATT CLAMPED BETWEEN 'BUNG' FLANGES

NECK OF BLADDER

FLEXIBLE SEAL

1 31/32
<table>
<thead>
<tr>
<th></th>
<th>TEFLON</th>
<th>TEDLAR</th>
<th>ACLAR</th>
<th>CH2</th>
<th>C3H6</th>
<th>EVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>2.15</td>
<td>1.5(2)</td>
<td>2.1(5)</td>
<td>0.95</td>
<td>0.91</td>
<td>0.94</td>
</tr>
<tr>
<td>Bursting Strength</td>
<td>11</td>
<td>19-70</td>
<td>23-31</td>
<td>11</td>
<td>---</td>
<td>11</td>
</tr>
<tr>
<td>Tearing Strength</td>
<td>125</td>
<td>12-100</td>
<td>2-40</td>
<td>15-300</td>
<td>7-10</td>
<td>50-300</td>
</tr>
<tr>
<td>Folding Endurance D2167-63T</td>
<td>4K</td>
<td>5K-47K</td>
<td>Good</td>
<td>V.high</td>
<td>Excl.</td>
<td>V.high</td>
</tr>
<tr>
<td>Water Abs. %</td>
<td>&lt;0.01</td>
<td>&lt;0.5</td>
<td>nil</td>
<td>nil</td>
<td>&lt;0.005</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Water Vapour trans.</td>
<td>0.4</td>
<td>3</td>
<td>.040(15)</td>
<td>0.3</td>
<td>0.40(5)</td>
<td>14</td>
</tr>
<tr>
<td>Permeability CO2</td>
<td>1670</td>
<td>11</td>
<td>16-40</td>
<td>580</td>
<td>370</td>
<td>6000</td>
</tr>
<tr>
<td>Permeability H2</td>
<td>2200</td>
<td>58</td>
<td>220-330</td>
<td>400</td>
<td>850</td>
<td>---</td>
</tr>
<tr>
<td>Permeability N2</td>
<td>320</td>
<td>0.25</td>
<td>2.5</td>
<td>42</td>
<td>25,c&lt;1</td>
<td>400</td>
</tr>
<tr>
<td>Permeability O2</td>
<td>750</td>
<td>3</td>
<td>7-15</td>
<td>185</td>
<td>120,c&lt;1</td>
<td>840</td>
</tr>
<tr>
<td>Refractive Index</td>
<td>1.34(1)</td>
<td>---------1.4 to 1.5---------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TEFLON** = FEP fluoroplastic  
**TEDLAR** = Polyvinyl fluoride  
**ACLAR** = Polytrifluoro(chloro)ethylene copolymer  
**CH2** = Polyethylene (high density)  
**C3H6** = Polypropylene (c=saran coated)  
**EVA** = Ethylene vinyl acetate copolymer

(*) Data from "Guide to Plastics", by Editors of "Modern Plastics Encyclopedia", (McGraw-Hill, Inc.)
# T₂ FILMS OF "TEFLON" PFA FLUOROCARBON RESIN

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST METHOD</th>
<th>SI Units (A)</th>
<th>English Units (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mechanical</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tensile Strength at Break</td>
<td>D-882</td>
<td>69/24 MPa</td>
<td>10,000/3,500 psi</td>
</tr>
<tr>
<td>Elongation at Break</td>
<td>D-882</td>
<td>60/450%</td>
<td>60/450%</td>
</tr>
<tr>
<td>Elastic Modulus</td>
<td>D-882</td>
<td>760/1400 MPa</td>
<td>110,000/210,000 psi</td>
</tr>
<tr>
<td>Tensile Creep (1,500 psi /1000 hr)</td>
<td>-</td>
<td>4/15%</td>
<td>4/15%</td>
</tr>
<tr>
<td>Tear Strength - Propagating (b)</td>
<td>D-1922</td>
<td>1.8/0.9 N</td>
<td>0.4/0.2 lb</td>
</tr>
<tr>
<td>Impact Resistance</td>
<td>D-3420B</td>
<td>24 J/mm</td>
<td>5.3 in-lb/mil</td>
</tr>
<tr>
<td><strong>Thermal</strong></td>
<td>DTA</td>
<td>304°C</td>
<td>580°F</td>
</tr>
<tr>
<td>Melt Point</td>
<td>-</td>
<td>260°C</td>
<td>500°F</td>
</tr>
<tr>
<td>Service Temperature - Continuous</td>
<td>D-2863</td>
<td>95%</td>
<td>95%</td>
</tr>
<tr>
<td>Oxygen Index</td>
<td>Du Pont</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimensional Stability - Type M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200°C (392°F)</td>
<td></td>
<td>2.0/0.8%</td>
<td>2.0/0.8%</td>
</tr>
<tr>
<td>250°C (482°F)</td>
<td></td>
<td>4.0/1.2%</td>
<td>4.0/1.2%</td>
</tr>
<tr>
<td>Shrinkage 250°C (Heat Shrink Type)</td>
<td></td>
<td>40/5%</td>
<td>40/5%</td>
</tr>
<tr>
<td><strong>Electrical</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dielectric Strength (b)</td>
<td>D-149(A)</td>
<td>160 kV/mm</td>
<td>4000 V/mil</td>
</tr>
<tr>
<td>Dielectric Constant</td>
<td>D-150 (1 khz)</td>
<td>2.1</td>
<td>2.1</td>
</tr>
<tr>
<td>Dissipation Factor</td>
<td>D-150 (1 khz)</td>
<td>0.0002</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

(a) MD = Machine Direction
(b) TD = Transverse Direction

T² Films are uniaxially oriented by a patented DuPont process that improves mechanical properties, dimensional stability, and impermeability. Many improvements are made in both the machine direction and transverse direction.
OPTICAL PROPERTIES

"Teflon" FEP fluorocarbon film transmits more ultraviolet, visible light and infrared radiation than does ordinary window glass. Figures 1 and 2 show the light transmission and absorbence of 1 and 5 mil "Teflon" FEP vs. ordinary window glass. It will be noted that "Teflon" FEP is much more transparent to the infrared spectrum than is glass and also transmits more of the ultraviolet range. Since transmittance and absorbence are reciprocal functions, they are both plotted as ordinates in Figures 1 and 2.

Figure 1
ABSORPTION SPECTRUM FOR "TEFLON" FEP FILM

Figure 2
ABSORPTION SPECTRUM FOR "TEFLON" FEP FILM

REFRACTIVE INDEX

The refractive index of "Teflon" FEP film is between 1.341 and 1.347.

*Reg U.S. Pat. Of

**1 Micron = 10,000 Angstroms = 0.001 mm
Questions B & C: What is the signal for the SSM? (Assume 5000 NC interactions per KT-Y.)

First, look at models for n-capture r decays (averaged from NDS):

D$_2$O:

E$_1$ = 6.25

NaCl:

P = rnd
If (P < .046) E$_1$ = 8.6, goto end
If (P < .160) E$_1$ = 6.1, E$_2$ = 1.2, E$_3$ = 0.8, E$_4$ = 0.5, goto end
If (P < .278) E$_1$ = 5.6, E$_2$ = 3.0, goto end
If (P < .512) E$_1$ = 6.1, E$_2$ = 2.0, E$_3$ = 0.5, goto end
   E$_1$ = 7.4, E$_2$ = 1.2

end:

Gd(a):

E$_0$ = 8.0
E$_1$ = Rnd*E$_0$ or E$_1$ = 4 + Rnd*4
   E$_2$ = Rnd*(E$_0$ - E$_1$)
   E$_3$ = Rnd*(E$_0$ - E$_1$ - E$_2$)
   E$_4$ = Rnd*(E$_0$ - E$_1$ - E$_2$ - E$_3$)
   E$_5$ = (E$_0$ - E$_1$ - E$_2$ - E$_3$ - E$_4$)

Gd(b):

Bot:

E$_2$ = Rnd*(E$_0$ - E$_1$)
E$_3$ = Rnd*(E$_0$ - E$_1$ - E$_2$) or E$_3$ = E$_0$ - E$_1$ - E$_2$
E$_4$ = E$_0$ - E$_1$ - E$_2$ - E$_3$ or E$_4$ = 0
E$_5$ = 0 or E$_5$ = 0

Cd:

P = Rnd
E$_0$ = 9.043
If (P < .048) E$_1$ = 8.80, goto bot
If (P < .161) E$_1$ = 7.68, goto bot
If (P < .345) E$_1$ = 6.33, goto bot
If (P < .732) E$_1$ = 5.83, goto bot
   E$_1$ = 5.55, goto bot
Then compton scatter & look at compton electrons. Cerenkov light output based on plot in Annex 15, scaled to 55% coverage & 24% ave PMT efficiency:

\[ \text{# of photons created} = (E_0 \times 116.5 - 106) \]
\[ \text{# of photons detected} = \text{#created} \times 0.10 \]

| pmต eff | 0.24 (WB) |
| coverage | 0.55 (WB) |
| D\(\text{2O}\) trans | 0.87 (WB) |
| Acrylic trans | 0.90*(WB) |
| H\(\text{2O}\) trans | 0.98 (WB) |

\[ \text{net photon collection efficiency} = 0.10 \]

Fraction of hits above threshold (FT):

<table>
<thead>
<tr>
<th>4.5 MeV</th>
<th>5.0 MeV</th>
<th>x-section</th>
<th>amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(\text{2O})</td>
<td>0.48</td>
<td>0.26</td>
<td>0.5 mb</td>
</tr>
<tr>
<td>NaCl</td>
<td>0.70</td>
<td>0.52</td>
<td>34 b</td>
</tr>
<tr>
<td>Gd(a)</td>
<td>0.29</td>
<td>0.18</td>
<td>49 Kb ((^{nat})Gd)</td>
</tr>
<tr>
<td>Gd(b)</td>
<td>0.45</td>
<td>0.30</td>
<td>260 Kb ((^{157})Gd)</td>
</tr>
<tr>
<td>Cd(4g)</td>
<td>0.56</td>
<td>0.38</td>
<td>2 Kb ((^{nat})Cd)</td>
</tr>
<tr>
<td>Cd(3g)</td>
<td>0.62</td>
<td>0.43</td>
<td>20 Kb ((^{113})Cd)</td>
</tr>
</tbody>
</table>

Capture prob. per total vol. | # of NC events seen = \( \frac{5000 \times R^3 \times \text{CP} \times \text{FT}}{6^3} \)

<table>
<thead>
<tr>
<th>R</th>
<th>CP</th>
<th>D(\text{2O}) Salt</th>
<th>D(\text{2O}) NaCl</th>
<th>Gd(^b)</th>
<th>Cd(^3)</th>
<th>E&gt;(\text{4.5MeV})</th>
<th>E&gt;(\text{5.0MeV})</th>
</tr>
</thead>
<tbody>
<tr>
<td>3m</td>
<td>0.16</td>
<td>0.69</td>
<td>50</td>
<td>300</td>
<td>190</td>
<td>270</td>
<td>30</td>
</tr>
<tr>
<td>4m</td>
<td>0.18</td>
<td>0.72</td>
<td>130</td>
<td>750</td>
<td>480</td>
<td>660</td>
<td>70</td>
</tr>
<tr>
<td>4.5</td>
<td>0.19</td>
<td>0.73</td>
<td>170</td>
<td>1080</td>
<td>700</td>
<td>960</td>
<td>100</td>
</tr>
<tr>
<td>5m</td>
<td>0.19</td>
<td>0.74</td>
<td>270</td>
<td>1500</td>
<td>970</td>
<td>1330</td>
<td>140</td>
</tr>
<tr>
<td>6m</td>
<td>0.20</td>
<td>0.75</td>
<td>480</td>
<td>2640</td>
<td>1700</td>
<td>2340</td>
<td>260</td>
</tr>
</tbody>
</table>
salt(n,\gamma) signals

Gd(a): E\gamma_1 = \text{Rnd} \times 8.0 \text{ MeV}

Gd(b): E\gamma_1 = \text{Rnd} \times 4 + 4 \text{ MeV}

counts per 100000n

equivalent electron energy in MeV
D$_2$O + NaCl

PMT hits

Events per year reconstructed within D$_2$O/MeV

E(MeV)

Internal: β-γ
PMT: β-γ
ES
NC
NC background
External

DOE/INSEAC/NRC Report Oct/89
Cd & Gd ($n,\beta$) schemes complicated!  
implies suggest actually measure Čerenkov light: **MKII TEST CH**

- 1m radius
- 0.8m
- 2m height
- 1.6m

Diagram:
- $H_2O$
- 0.5mφ
- BAG
- O³
- SALT
- (NaCl, Gd Cl, Cd Cl)

Tube baffle with 2 mirror

2m cylinder:
- $\text{tof. vol} = 6.3 \, m^3 \equiv 6.3 \, T \, H_2O$
- inner vol = 3.2 $m^3$
- inner area = $3.8 \, \pi \, m^2$
- area/pmt $= 0.01 \, \pi \, m^2$ Flat
- 0.02 $\pi \, m^2$ hemi.

$\Rightarrow 50 \, 8'' \, \text{PMT} = 0.26 (52) + 0.24 (E) + 3.6 (\text{Ref})$

$\equiv 22\% \, \text{collection}$

($= 2 \times \text{SNO}$)
**Question C:** What are all the known sources of background? How will they be determined? If possible, make an estimate of the absolute precision of measurement of the NC flux per year, ignoring uncertainties in the number 5000. Include estimates for known sources of systematic uncertainty.

- **D₂O** @ 0.011 ppt U & Th
- **Acrylic** @ 2 ppt U & 1 ppt Th
- **1mil bladder** @ 10 ppt U & Th
- **H₂O**
- **PMT**
- **Al-reflectors**
- **Stainless Steel liner & rock**

<table>
<thead>
<tr>
<th>Source</th>
<th>Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>D₂O @ 0.011 ppt U &amp; Th</td>
<td>= 3.0 n/d = 1095 n/Yr</td>
</tr>
<tr>
<td>Acrylic @ 2 ppt U &amp; 1 ppt Th</td>
<td>= 4.0 n/d = 1460 n/Yr (near vessel)</td>
</tr>
<tr>
<td>1mil bladder @ 10 ppt U &amp; Th</td>
<td>= 0.04 n/d = 15 n/Yr</td>
</tr>
<tr>
<td>H₂O</td>
<td>= 0.2 n/d = 73 n/Yr (near vessel)</td>
</tr>
<tr>
<td>PMT</td>
<td>= 0.1 n/d = 37 n/Yr</td>
</tr>
<tr>
<td>Al-reflectors</td>
<td>= 0.01 n/d = 4 n/Yr</td>
</tr>
<tr>
<td>Stainless Steel liner &amp; rock</td>
<td>= &lt;0.25 n/d = &lt;91 n/Yr</td>
</tr>
</tbody>
</table>

D₂O background scales with volume \((1095*R^3/6^3)\) inside & remainder is attenuated by Boron n-absorbtion & D₂O r attenuation & raytracing external background is attenuated by additional r & neutron absorbion (using conservative factor of 10 attenuation per meter).

**BELOW 5M RADIUS THE NC BACKGROUND IS DOMINATED BY THE RADIOIMPURITIES IN THE HEAVY WATER ITSELF!**

Background from dissolved radioimpurities could be monitored during initial gradual removal by plotting rates vs. U & Th concentrations.

Additional sources of background:

The effect of \(F(\alpha,n) (Q=-2.0MeV)\) and \(F(\alpha,p+\gamma>2.2) (Q=+1.7MeV)\) needs to be investigated if using TEFILON bladder.

Mass for 5m radius TEFILON bladder is 17.2 Kg per mil thickness, 72% of which is fluorine, or 12.4 Kg per mil.

The backgrounds do not include the High Energy r flux, which is identical to that presented in the WB, annex, and 1989 DOE/NSERC/NRC presentation for the standard Mark-II vessel with and without NaCl or Gd additives.
Question D: List the necessary radiopurities of materials and describe the production and measurement programs needed to achieve them.

- Mass of TEFLOMN (or other plastic) is quite small. Initially, the thickness and radioimpurity levels were determined by assuming a contribution to NC background not to exceed that produced by a 1 ppt U & Th contamination in the acrylic vessel, attenuated by 1m of water.

- A 500g sample of 1mil TEFLOMN FEP film was radioassayed (Simpson et al.): no evidence of U or Th was found, with an upper limit placed at <12 ppt. Telfon is expected to be at least as pure than acrylic because teflon contains no added stabilizers or polymer-chain inhibitors.

- Even for a 10mil thick bladder at 10 ppt, the contribution to NC background will not exceed that of the acrylic (now deemed to be 2 ppt U & Th); Obviously, with a more realistic value of 1 mil film at 1 ppt, there is no impact to NC background.

- A similar argument holds true for the NYLON tether lines used to anchor the bladder, especially since the bulk of the tether lines remain at the acrylic vessel.

- α-induced reactions on Fluorine should be investigated to verify if they make only a small contribution.
**Question E:** Describe calibrations

The bladder is designed to accommodate the "standard" SNO e, r, and n sources. The largest source that must fit through the bladder's neck is the High Energy $^3$He+n r source, which poses a constraint on the minimum diameter of the bladder's neck.

Since the bladder maintains spherical symmetry (default shape is 5m radius sphere), post-insertion scanning of efficiency with position need only be done in the vertical direction.

**Question F:** How does the method affect CC signal recovery from the ?

- The CC signal is not at all adversely affected. In fact, it is enhanced: the region between the vessel and bladder is sensitive only to CC+ES, whereas the region within the bladder sees NC+CC+ES.

**Question G:** List the ways in which the method affects the design and construction of the acrylic vessel.

Anchors for the tether lines must be installed inside the acrylic vessel. Their design is similar to the ring + footplate as proposed by the $^3$He detector group (20Kg Force/plate * 220 plates = 4.4T Force total on vessel).

In the scenario that 1.45T NaCl (2.5T*0.58) will be used in the inner region, then 1.07 T of solute (containing boric acid) must be added to the region outside the bladder to achieve overall neutral buoyancy. Since a slight overpressure within the bladder may be desirable to maintain shape rigidity, the 1.07T could be reduced, limited by the loading on the bladder by the tethers. The static load that must be borne by the acrylic vessel is considerably less than that imposed by the $^3$He counters.

A dynamic load will be imposed on the tethers and their anchors during careful insertion of the bladder. Since this load is limited by the more fragile nature of the bladder, the impact of loading on the vessel should be negligible.

See section E for impact on calibration systems.
**Question H:** List the ways in which the method affects the design and construction of the water treatment systems.

Provision has been made for water-recirculation on either side of the bladder, thus allowing for continual scrubbing of undesired contaminants. This removes necessity of relying exclusively on cleanliness of both the bladder and the heavy water prior to insertion.

- provision made for two heavy water systems (one is awkward but possible)
- impact of additives $\text{H}_3\text{BO}_3$ and either $1.45$T NaCl, $2.7$Kg $^{157}$Gd, $0.5$Kg $^{157}$Gd, $38$Kg $^{157}$Cd, or $4.7$Kg $^{113}$Cd (+ complimentary ions)
- salts will have to be removed from $\text{D}_2\text{O}$ at completion of SNO
- may need to scrub out opposite salt & reintroduce it to the appropriate side

(No hard data available yet on ion permeability, but will measure; if assume ion transport is similar to water vapour transmission in TEFLON T2 film (4g/m$^2$/d/mil), then for 1mil film we get:

in-->out: $1.1$Kg/Y NaCl, $29$g/Y Cd, $4$g/Y $^{113}$Cd, $2$g/y Gd, or $0.4$g/Y $^{157}$Gd

out-->in: $9$g/Y $^{157}$B or $2$g/Y $^{10}$B.

In terms of cross-section weighings, amount of salt to boron outside is $0.1\%$/year, and amount of boron to salt inside is $0.08\%$/year, so salt-separation would not be necessary over the operational life of SNO.)

**Question I:** List the Monte Carlo calculations that will be needed before proof-of-principle

First order information already available from WB, Annex (1&7), DOE/NSERC/NRC, because using spherical symmetry & TEFLON is transparent & adds no re-scattering from RI mismatch, so proof-of-principle is already established.

The use of more conventional transparent plastics (RI = 1.45 to 1.5) will double the effect from the acrylic on RI surface scattering, or $2*15\%$, so second-order MC would still be desirable (+ traceback resolution, threshold shapes, etc.).
ELLIPSE DESIGNATES SEALS BETWEEN VARIOUS ATMOSPHERIC REGIONS

TOP SECTION OF GLOVE-BOX CAN BE REPLACED WITH OTHER CONFIGURATIONS WHEN BLADDER REMOVED

ACRYLIC COVER WITH 2 SETS SEALED GLOVES

EQUIPMENT INSERTION DOOR

REMOVABLE PANELS ON GLOVE-BOX DRUM FOR ACCESS TO HARDWARE

COLLAPSIBLE FEED TUBE
1. BE will need to enlarge access port to accommodate $(^3\text{He} + n)$ at MeV $\gamma$ source.
PIPE ROUTE THROUGH MONITOR DRIFT

(dims approx)

105 ft.

132 ft.
**Question J:** List the engineering calculations (stress, fracture, etc.) needed before proof-of-principle

Present design of the vessel structure calls for support system to bear loads and handling from 3He counter array; again, first order calculations of the bladder system indicate a much smaller impact on vessel structure.

Winzen Co. Ltd, Sulphur Springs, TX and American Durafilm Ltd., Holliston, MA, are two manufactures interested in building the (TEFLON) bladder. The former has the world's greatest expertise on dynamics of large, thin, flexible and loaded membranes, as they research and construct balloons up to 100,000 m³ or greater; they are capable and willing to do stress, fracture, seam, etc. analyses.

**Question K:** List the people who will be working on the system R&D and how much time they will spend.

Manpower for Spherical Bladder Design:

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.B. Schubank</td>
<td>UBC Research Associate</td>
<td>full-time (&lt;30/6/91; then ??)</td>
</tr>
<tr>
<td>C.E. Waltham</td>
<td>UBC Assistant Professor</td>
<td>part-time</td>
</tr>
<tr>
<td>L. McGarry</td>
<td>UBC MSc student</td>
<td>full-time</td>
</tr>
<tr>
<td>A. Morgan</td>
<td>Van. Eng. Consultant</td>
<td>part-time</td>
</tr>
</tbody>
</table>

+ consultations with:
E. Jernigan of American Durafilm, Holliston, MA
L. Sealy of Winzen Co., Sulphur Springs, TX

Possible collaboration with J. Simpson & Princeton Group to investigate Split-vessel / hemi-spherical bladder compromise.