3D Fluid Flow Through a Chamber

Separated by a Porous Membrane

a

Finite Element Analysis (FEA) Numerical Model

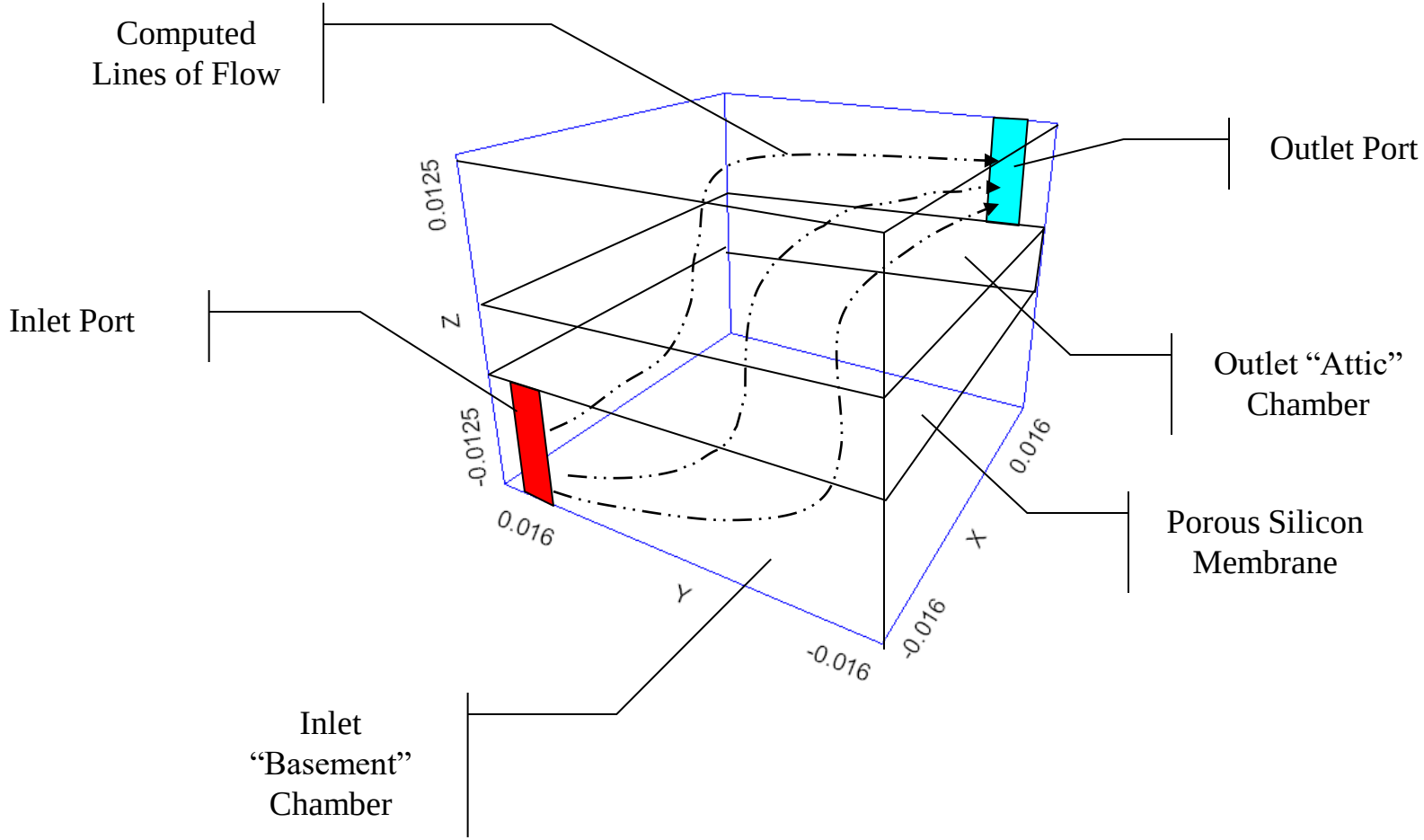
Craig E. Nelson - Consultant Engineer

Nelson Research, Inc. 2142 – N. 88th St. Seattle, WA. 98103 USA 206-498-9447 Craigmail @ aol.com

The Model Assumptions

1. Inlet fluid flows into an inlet chamber through a small inlet port “slot” in a lower “basement” chamber
2. Outlet fluid flows out of an upper “attic” chamber through a small outlet port “slot”
3. All fluid flows through the porous silicon membrane in an “out of the plane” Z axis direction
4. Fluid pressures and flow rates are “nominal”
5. The Z Axis Scaling is Expanded by a Factor of 10 for Clarity of Presentation

Nelson Research, Inc. 2142 – N. 88th St. Seattle, WA. 98103 USA 206-498-9447 Craigmail @ aol.com



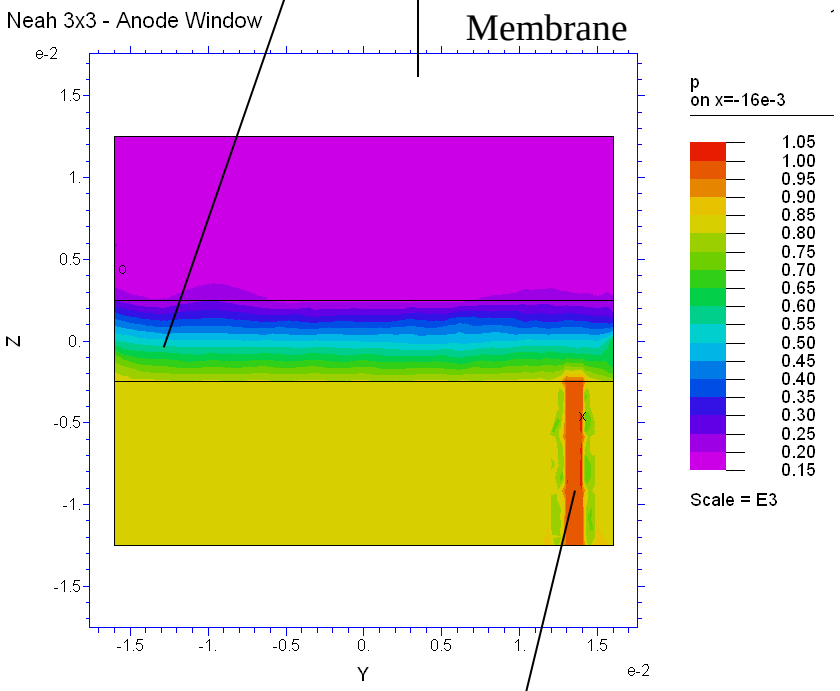
Geometry for the Numerical Flow Model

(Vertical Z Axis is Amplified by a Factor of 10
From the True Geometry)

Nelson Research, Inc. 2142 – N. 88th St. Seattle, WA. 98103 USA 206-498-9447 Craigmail @ aol.com

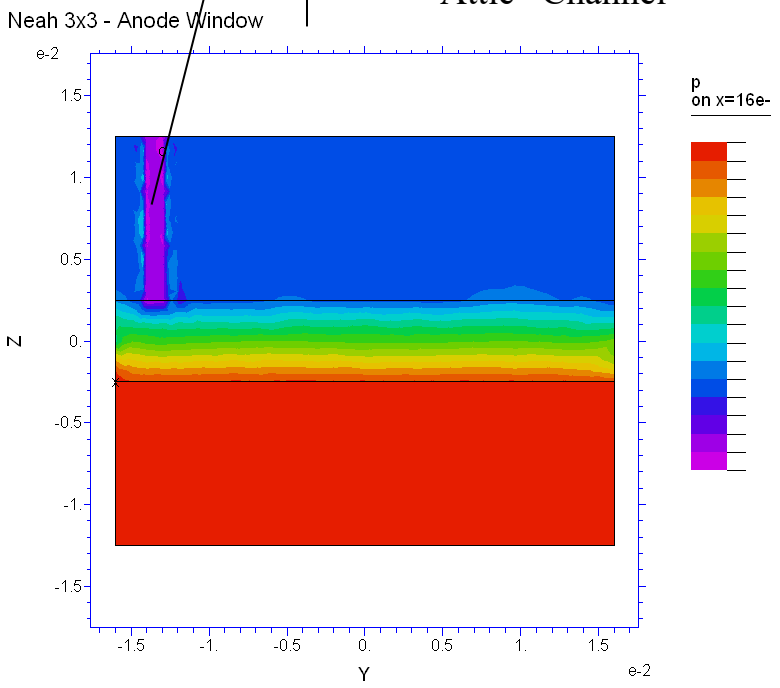
Left Cell Window Border

Porous Membrane



3d_Anode- 040407C: Grid#2 p2 Nodes=12662 Cells=8283 RMS Err= 3.3e-4
Integral= 0.404181

Outlet Port on Lower Right Side of Upper "Attic" Channel



3d_Anode- 040407C: Grid#2 p2 Nodes=12662 Cells=8283 RMS Err= 3.3e-4
Integral= 0.398563

Inlet Port on Upper Left Hand Corner of the Lower "Basement" Channel

Right Cell Window Border

Pressure Distribution on Left and Right Cell Window Borders

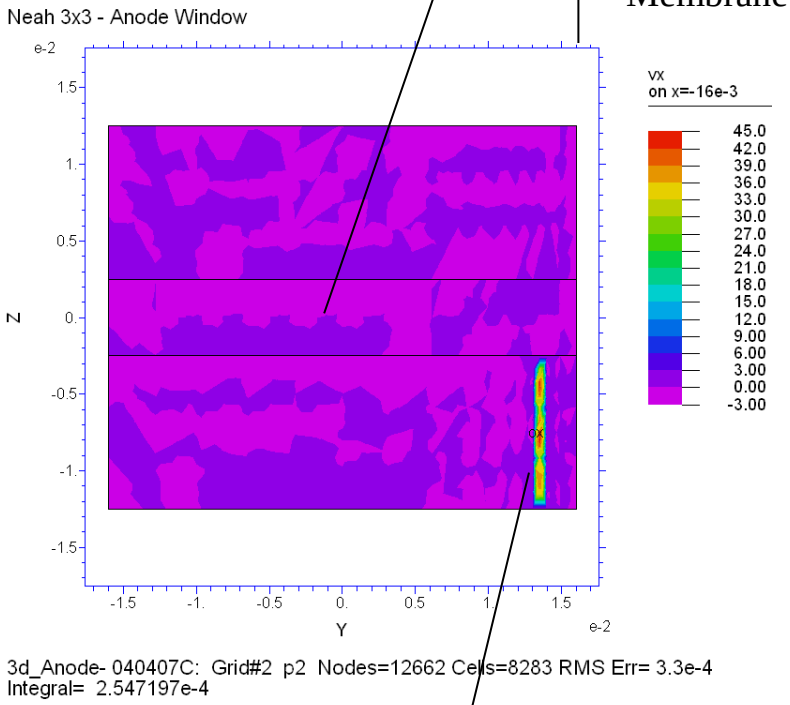
(1000 Pa at Inlet – 0 Pa at Outlet)

Nelson Research, Inc. 2142 – N. 88th St. Seattle, WA. 98103 USA 206-498-9447 Craigmail @ aol.com

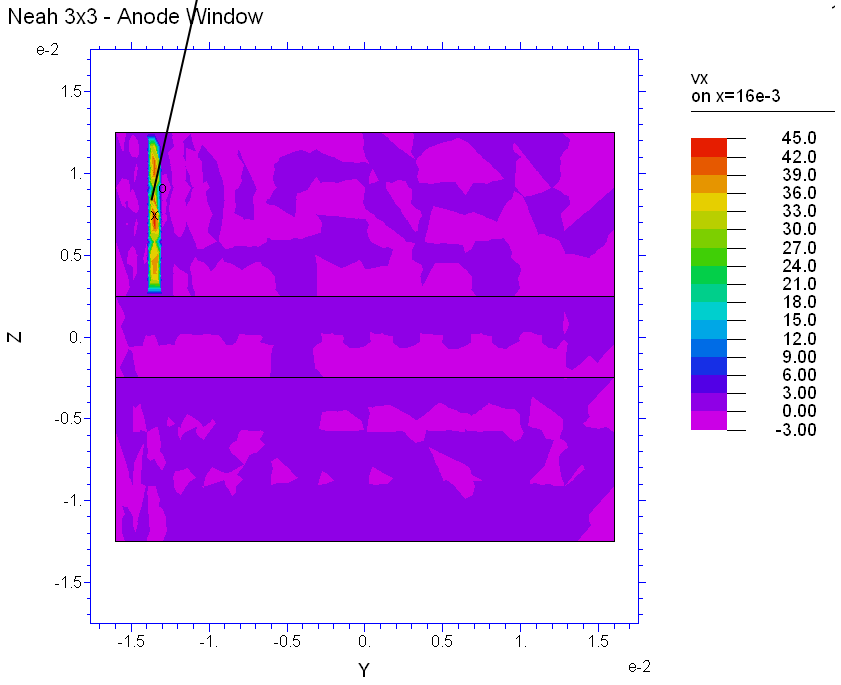
Left Cell Window Border

Porous Membrane

Outlet Port on Lower Right Side of Upper "Attic" Channel



3d_Anode- 040407C: Grid#2 p2 Nodes=12662 Cells=8283 RMS Err= 3.3e-4
Integral= 2.547197e-4



3d_Anode- 040407C: Grid#2 p2 Nodes=12662 Cells=8283 RMS Err= 3.3e-4
Integral= 2.560627e-4

Right Cell Window Border

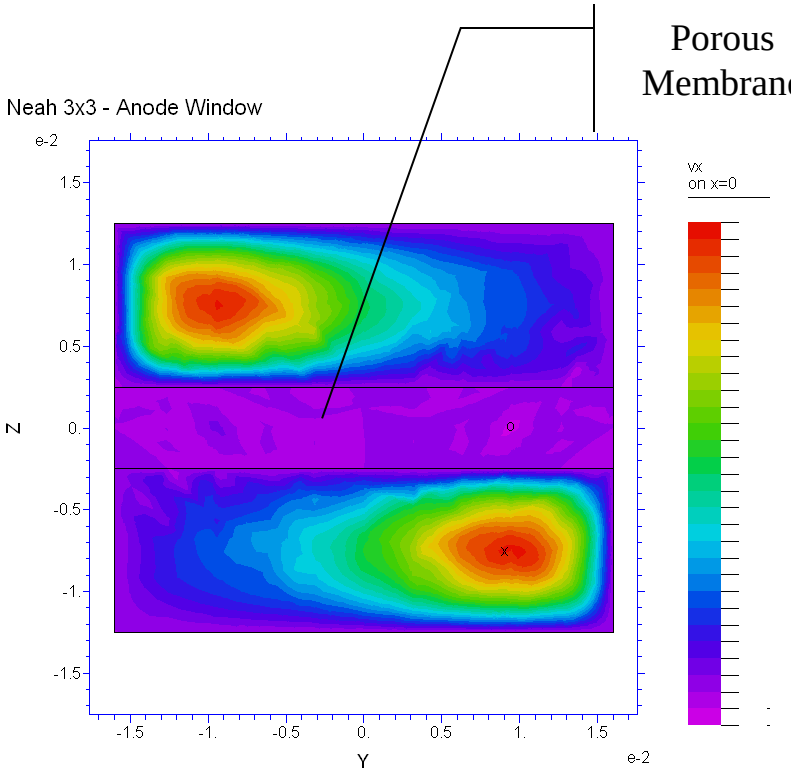
Inlet Port on Upper Left Hand Corner of the Lower "Basement" Channel

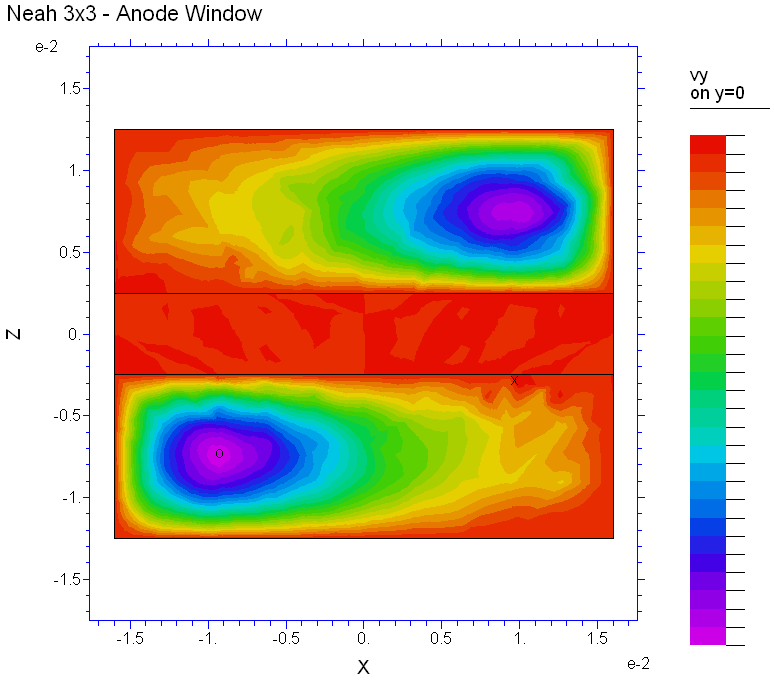
X Direction Velocity Distribution on Left and Right Cell Window Borders

Nelson Research, Inc. 2142 – N. 88th St. Seattle, WA. 98103 USA 206-498-9447 Craigmail @ aol.com

X = 0 Center Plane

Y = 0 Center Plane





X direction Velocity

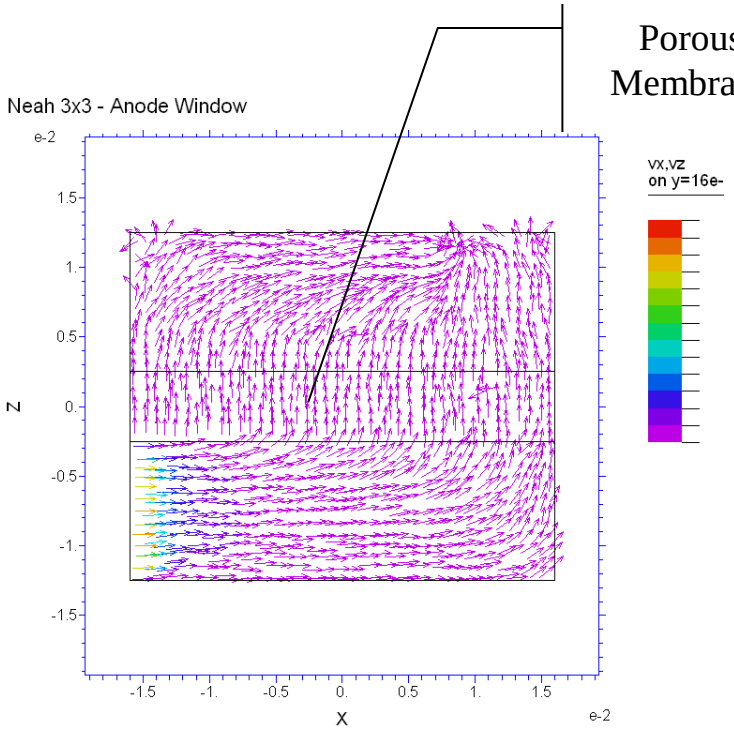
Y direction Velocity

Velocity Distributions on X=0 and Y=0
Cell Window Center Planes

Nelson Research, Inc. 2142 – N. 88th St. Seattle, WA. 98103 USA 206-498-9447 Craigmail @ aol.com

Y = Inlet Port Center Plane

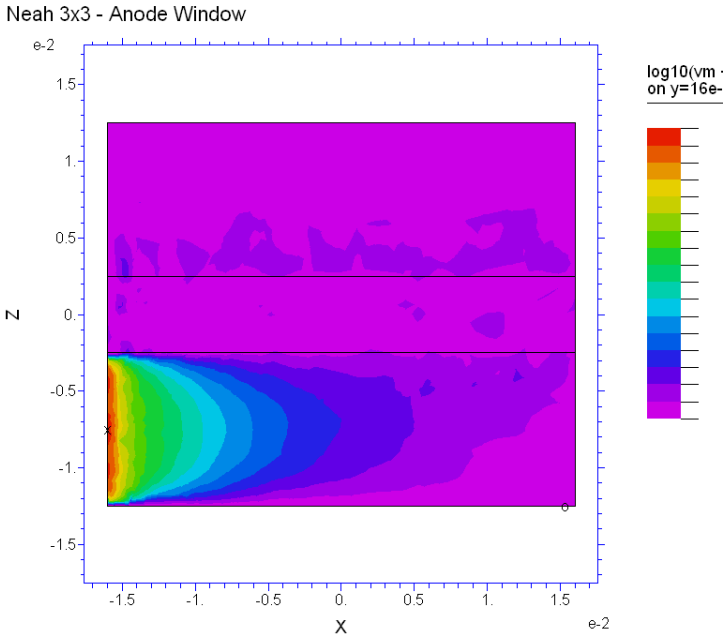
Porous Membrane



3d_Anode- 040407C: Grid#2 p2 Nodes=12662 Cells=8283 RMS Err= 3.3e-4

X – Z Vector Velocity

Y = Inlet Port Center Plane



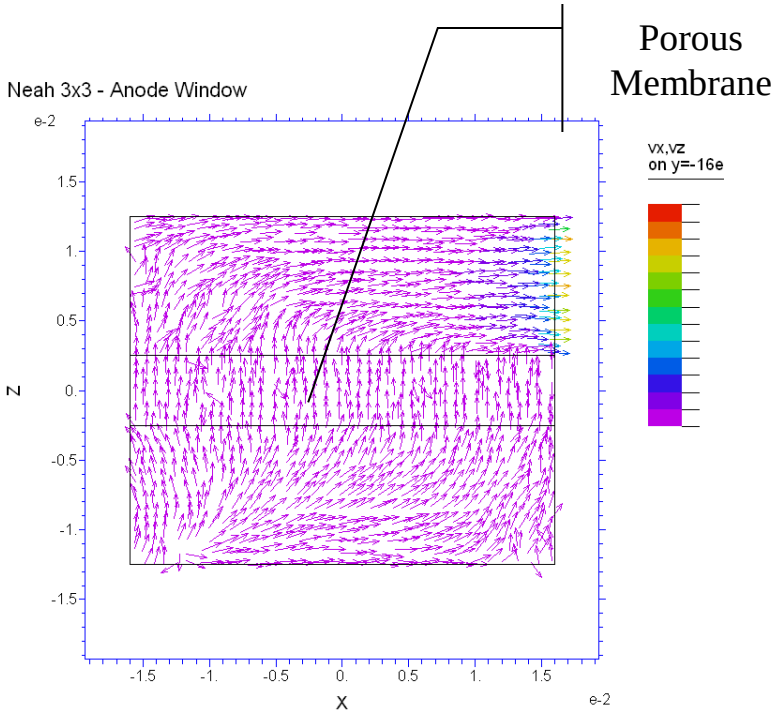
3d_Anode- 040407C: Grid#2 p2 Nodes=12662 Cells=8283 RMS Err= 3.3e-4
Integral= 1.427279e-4

X – Y – Z Velocity Magnitude

Velocity Distributions on Inlet and Outlet Port Center Planes

Nelson Research, Inc. 2142 – N. 88th St. Seattle, WA. 98103 USA 206-498-9447 Craigmail @ aol.com

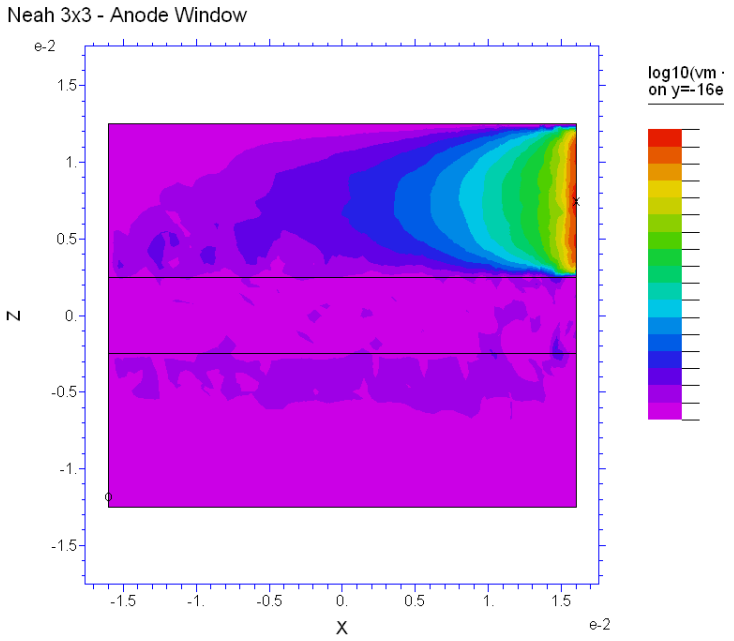
Y = Outlet Port Center Plane



3d_Anode- 040407C: Grid#2 p2 Nodes=12662 Cells=8283 RMS Err= 3.3e-4

X – Z Vector Velocity

Y = Outlet Port Center Plane



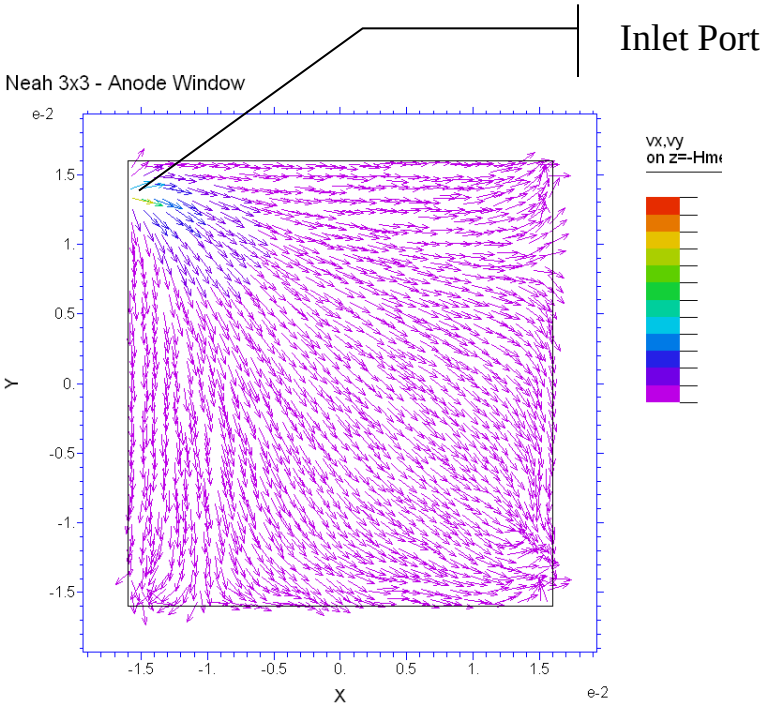
3d_Anode- 040407C: Grid#2 p2 Nodes=12662 Cells=8283 RMS Err= 3.3e-4
Integral= 1.454157e-4

X – Y – Z Velocity Magnitude

Velocity Distributions on
Outlet Port Center Plane

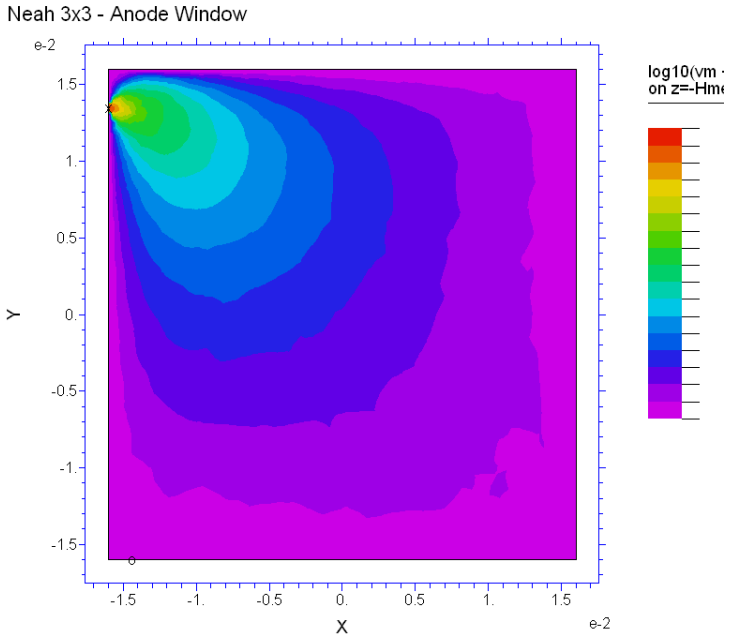
Nelson Research, Inc. 2142 – N. 88th St. Seattle, WA. 98103 USA 206-498-9447 Craigmail @ aol.com

Z = “Basement” Inlet Port Center Plane



X – Y Vector Velocity

Z = “Basement” Inlet Port Center Plane

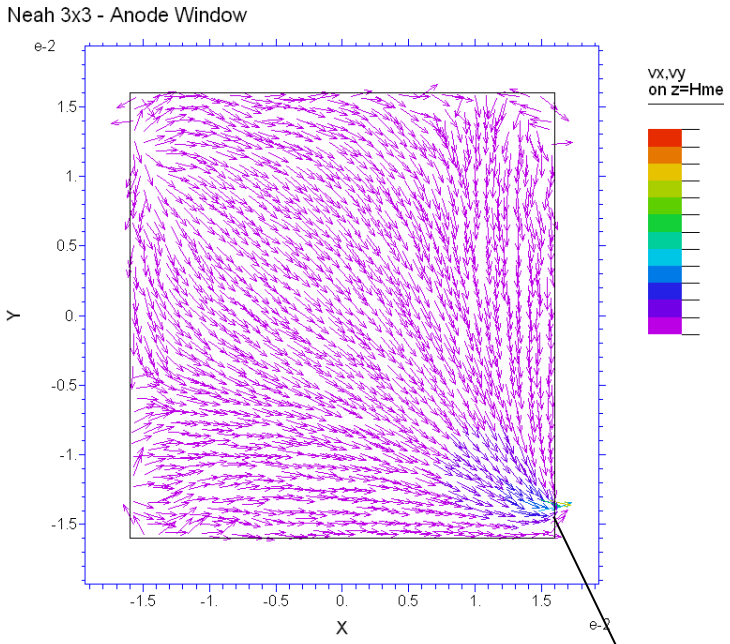


X – Y – Z Log10 Velocity Magnitude

Velocity Distribution on Z Axes
“Basement” Inlet Port Center Plane

Nelson Research, Inc. 2142 – N. 88th St. Seattle, WA. 98103 USA 206-498-9447 Craigmail @ aol.com

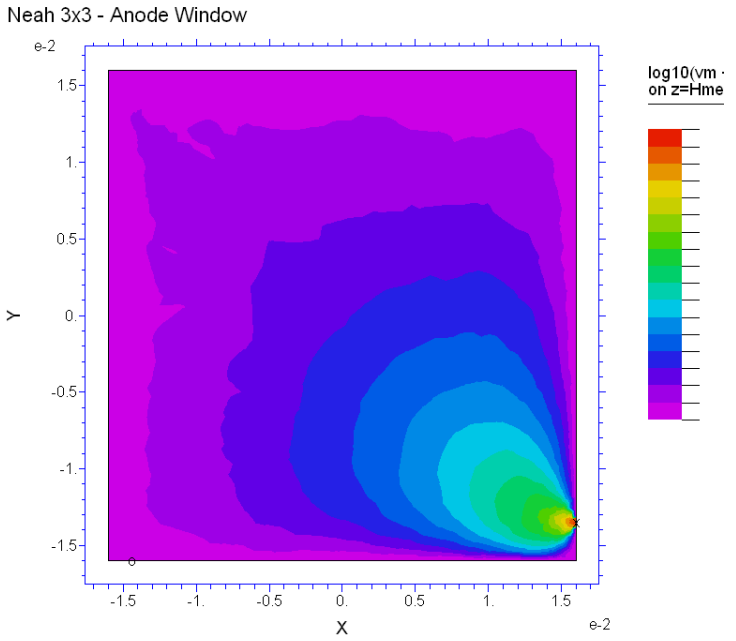
Z = “Attic” Outlet Port Center Plane



3d_Anode- 040407C: Grid#2 p2 Nodes=12662 Cells=8283 RMS Err= 3.3e-4

X – Y Vector Velocity

Z = “Attic” Outlet Port Center Plane



3d_Anode- 040407C: Grid#2 p2 Nodes=12662 Cells=8283 RMS Err= 3.3e-4
Integral= 2.417668e-4

Outlet Port

X – Y – Z Log10 Velocity Magnitude

Velocity Distribution on Z Axes
“Attic” Outlet Port Center Plane

Nelson Research, Inc. 2142 – N. 88th St. Seattle, WA. 98103 USA 206-498-9447 Craigmail @ aol.com

Summary

1. The inlet chamber pressure is almost constant across the membrane surface

2. In plane velocity falls rapidly to nearly zero a short distance away from the fluid inlet ports

3. Velocity in the inlet and outlet ports will be several orders of magnitude larger than in most parts of the fluid “Attic” and “Basement” Chambers

4. High inlet fluid velocity may provide a measurable pressure drop in the inlet port feed “pipe”.

5. High outlet fluid velocity and a small outlet orifice and related take-away “pipe” will probably interfere with bubble removal from the the “Attic” outlet chamber.

Nelson Research, Inc. 2142 – N. 88th St. Seattle, WA. 98103 USA 206-498-9447 Craigmail @ aol.com