



# NuMI Horn Water Line Ceramic Isolator Overview

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Ceramic Isolator  
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## Horn Water Spray Supply Line Electrical Isolators- Operational Experience With First NuMI Horns

*Kris Anderson*

*AD/Mechanical Support/NuMI Target Hall ME Group Leader*

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*Experienced two water line electrical isolation ceramic assembly failures since beamline commissioning (~March 2005)*

- *Horn 2 Suction Line*
- *Horn 1 Spray Nozzle Delivery Line - Operating Pressure of 30 psig*
- *System uses a total of 11 ceramic isolators for 2 horn system (Qty. 6 isolators on PH1-01 and Qty. 5 isolators on PH2)*



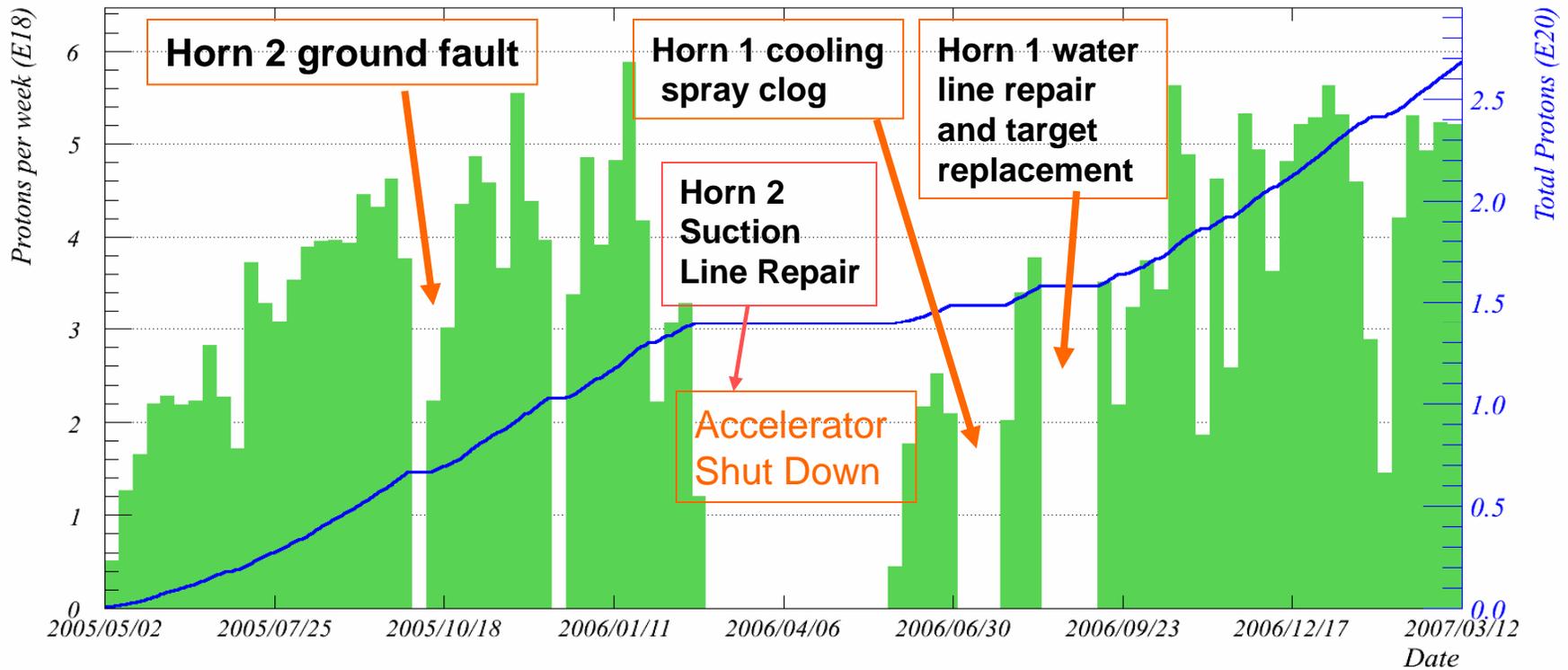
# Horn Repair History

## Total Protons on Target

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Total NuMI protons to 00:00 Monday 12 March 2007





# PH2-01 Failed Ceramic Isolator Location

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*Horn 2 Suction Line  
PH2-01 Prior to  
Beamline  
Installation*

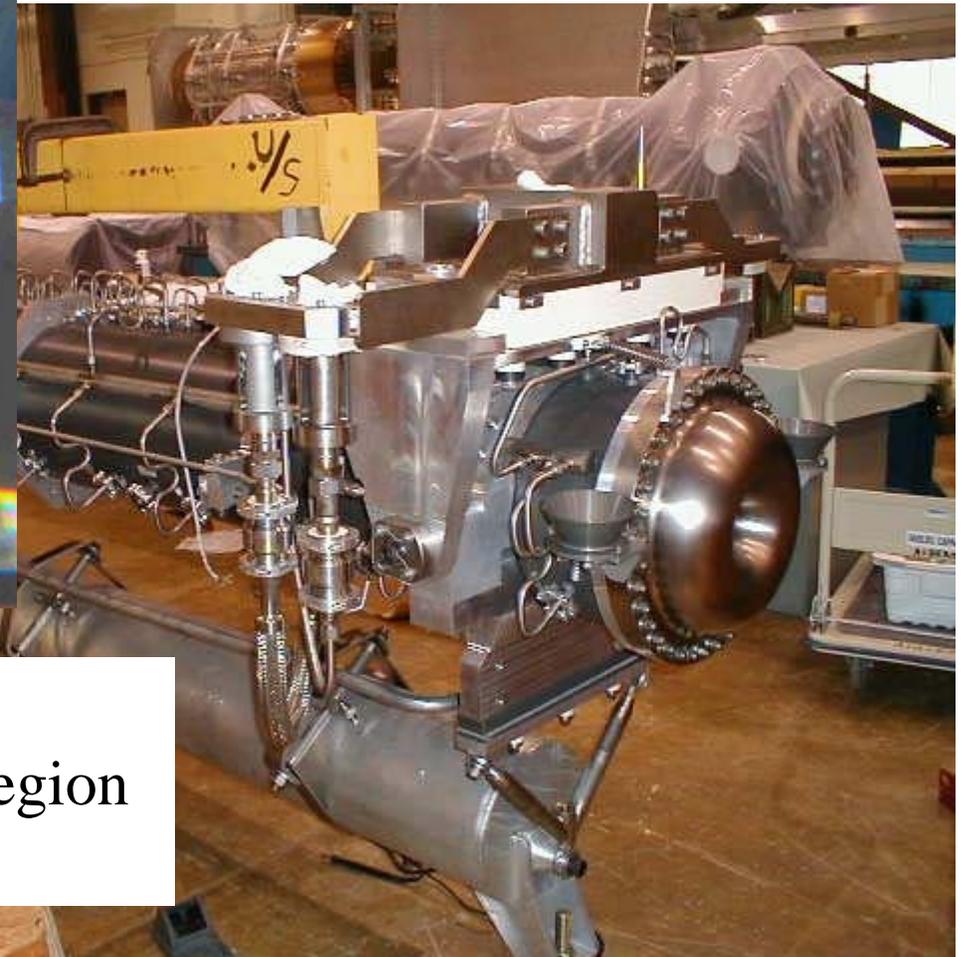
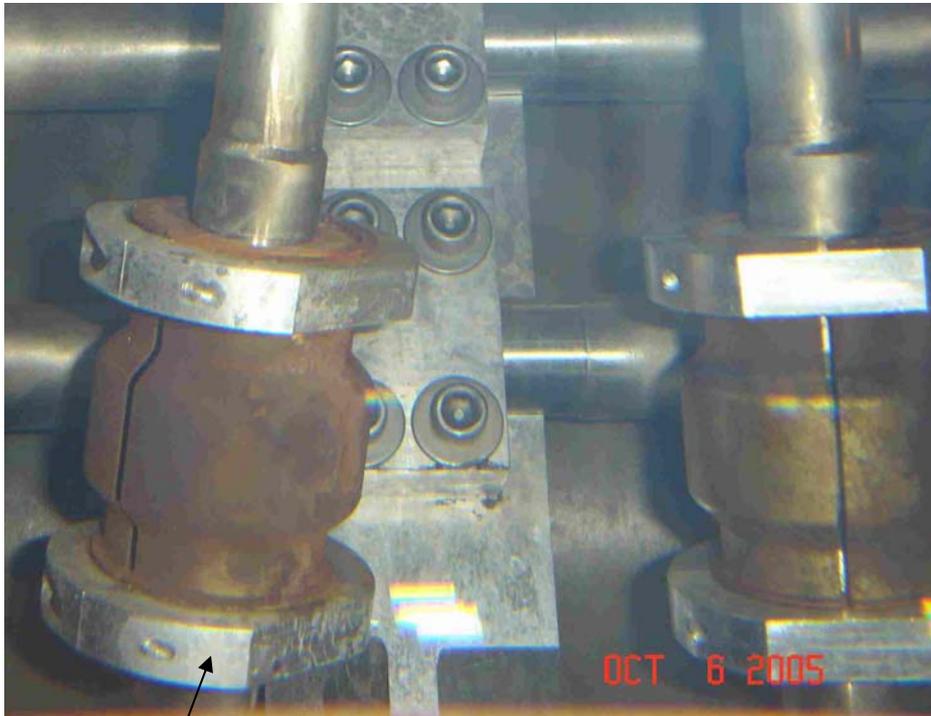
*Electrical Isolator  
Assembly Shown  
with Invar 36  
Structural Support  
Shell- DS Beam  
Right*



# PH1-01 Failed Ceramic Isolator Location

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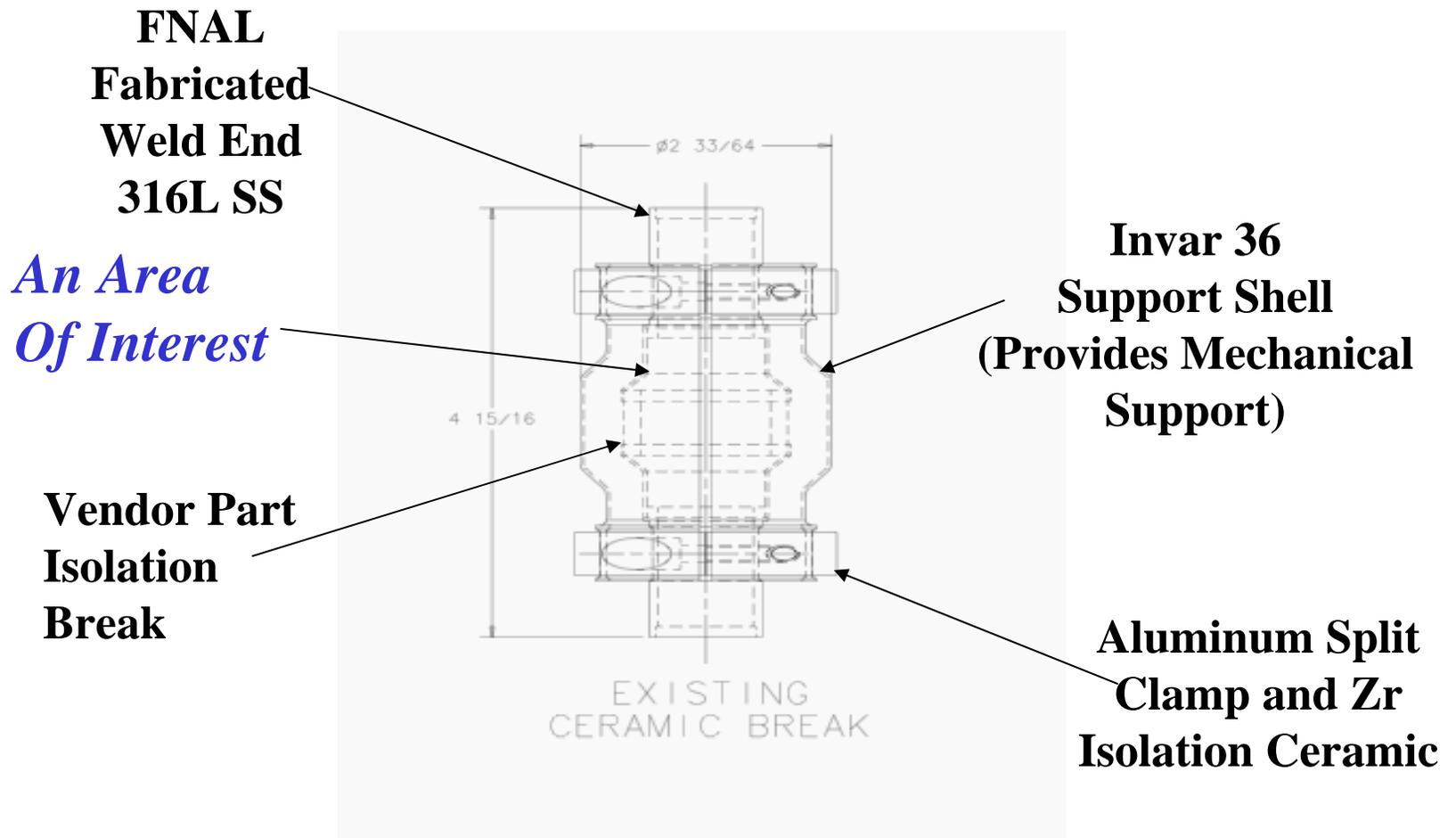
Leaking Isolator Assembly  
US Beam Left--Higher Radiation Region  
Compared to Horn 2



# Horn Water Line Ceramic Isolator Assembly

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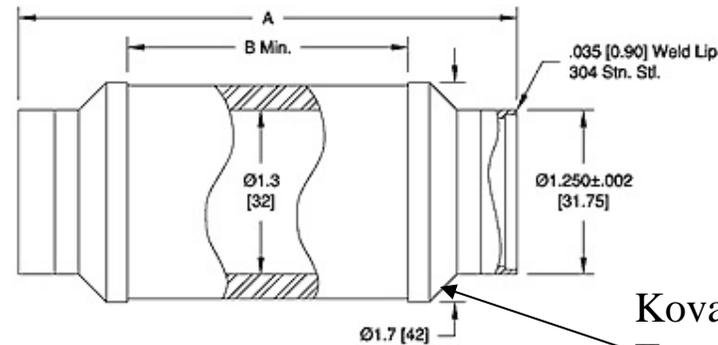




# Ceramic Isolator- Vendor Part Ceramaseal

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[CAD Drawing File](#)

**Insulator ID: 1.3 [32]**

Installation: Weld

Voltage DC	Length		Pressure @ 20 °C		Temperature °C		Magnetic Materials	Part Number	Price
	A	B	PSIG	Bar	Min	Max			
5 kV	1.9 [48]	0.16 [4.0]	250	17	-269	450	No	<a href="#">17199-01-W</a>	\$235.00

- **Kovar- 29%Ni, 17%Co, Trace Si&Mn, Balance Fe (Low Expansion Alloy)**
- **0.020” Nominal Thickness, Yield Strength=50ksi, UTS=75ksi, 30%Elongation**
- **Transition Piece Fabricated by Spinning, Brazed to Ceramic with Ag Braze Alloy**
- **Moderate Corrosion Resistance, Form Protective Oxide Layer**



# Cross-Section of Vendor Part New Ceramic Isolator

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Tapering  
Wall  
Thickness

The Area  
Of Interest

304 Braze  
End Piece





# Horn Water Line Ceramic Isolator-Horn 1 Leak

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## Horn 1 Leak- Hardware General Appearance After 1.6E20 POT

- *Alumina Ceramic Intact*
- *Stainless Steel Hardware Appearance OK*
- *Kovar Transition Dull Gray-Covered by Oxide Layer*
- *Invar 36 Shell Rust Layer Noted on External Surfaces*

*Not Terrible in Appearance  
Considering Its Operational  
Environment.....*





# Horn Water Line Ceramic Isolator-Horn 1 Leak

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## Horn 1 Leak

- *Corrosion pit in Kovar near transition bend region*
- *Small hole, estimate few mils diameter (not precision measurement), Size consistent with leak rate*
- *Location- downstream end of flow direction on Kovar transition angle*
- *Low flow velocity, ~3 ft/sec*
- *Braze Joints Intact*





# Horn 2 PH2-01 Ceramic Isolator

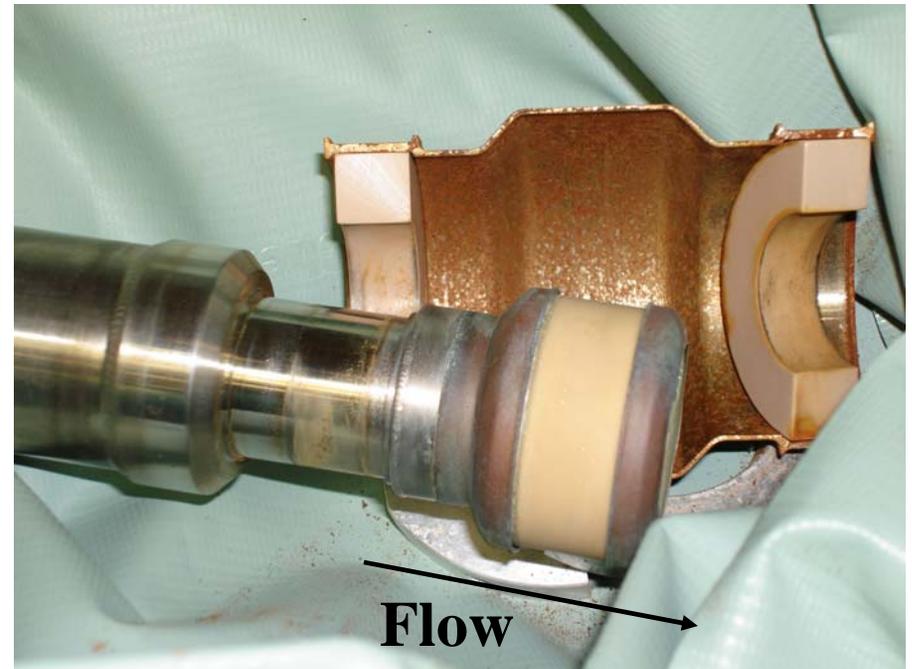
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Prior To Invar Shell  
And Clamp Removal

Now Have 2 Sections





# Horn Water Line Ceramic Isolator

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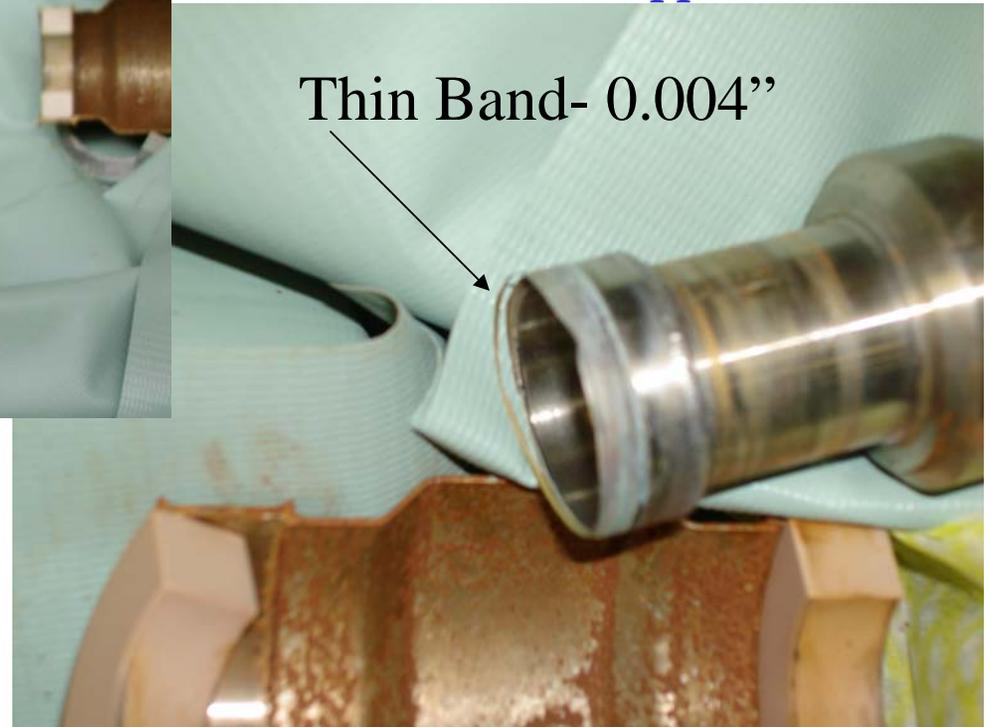
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## Fracture at Geometry Change

- Thin Wall*
- Stress Concentration Area*
- Located in DS Flow Path*
- Shear Failure Appearance*

Thin Band- 0.004"





# Potential Failure Scenario

## PH1-01 Supply Line:

- *Corrosion Pit, Perhaps Due to Thin Wall Section or Material Inclusion in Kovar Base Metal*
- *Unlikely That Fluid Erosion Accelerated Failure - Low Flow Velocity*

## PH2-02 Suction Line- Shear Failure Compounded by:

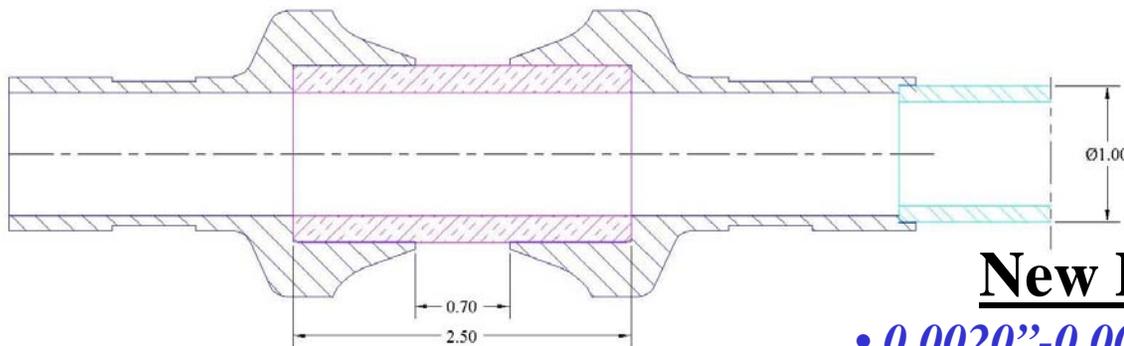
- *Thin Wall and Stress Concentration at Geometry Transition*
- *Possible Kovar Wall Variation and Lack of Consistency Due to Fabrication Technique (Spinning)*
- *Erosion from Flow, DS Side Turbulence (Note: Flow Velocity Only ~8 ft/sec, but Ejector Pump Check Valve Exhibits Cyclic Operation Causing Turbulence)*
- *Split Clamp Preload Loss on Invar Shell Would Result in Torque on Ceramic Isolator Due to Mechanical Vibration of Current Pulse Transmitted Through Suction Line Mass*



# Horn Water Line Retrofit Ceramic Isolator

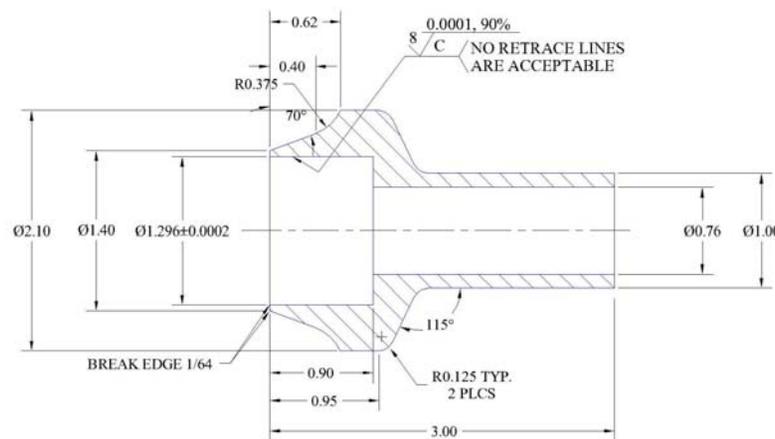
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## New Design Features

- *0.0020''-0.0025'' Shrink Fit, Assembled at 300°C- Eliminate Braze Alloy and Thin Kovar Material Requirement*
- *Thick Cross-Section Ends Featuring 316L SS Tapered Ends for Long-Term Corrosion Considerations*
- *99.8% Alumina Ceramic Isolator- Operational Experience Indicates This is Suitable Material*
- *Still use Invar Support Shell*





# Prototype Test Summary

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## Have Fabricated Qty. 2 Prototype Test Pieces

- *Hydrostatic Test at 150 psig, No Leak Both Assemblies*
- *Helium Leak Check, Assy #1 @ 1E-9 Torr-l/sec, Assy #2 @ 1E-6 Torr-l/sec*
- *Thermal Cycle Both Assemblies Between 20C and 80C for 30 Cycles, Hydrostatic Test 150 psig at 50C - No Leaks Noted*
- *Secured One Assembly To PH1-02 on Horn Test Stand to Simulate Real Vibration Environment With No Invar Support Shell, 100,000 pulses at 205 kA - No Leak Noted*



# Installation Schedule

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- *Have 12 Pieces 99.8% Alumina Ceramics (PH1-02 Retrofit and PH2-02 Assembly)*
- *316L SS End Pieces Machined by End July (VMS Fabrication)*
- *Shrink Fit, Leak Test, & Final Machine for Invar Shells August*
- *Complete Line Fabrication and Installation on Spare Horn PH2-02 Late September & Pulse Test*
- *Start Retrofit Spare Horn PH1-02 early October*
- *Identify Suitable CVD Coating for Invar 36 Corrosion Mitigation (Cr-Ni, Si-Ni, Must Work in  $\text{HN0}_3$  Environment)*