Choke Flange for High Power RF Components Excited by TE01 Mode

A. Dian Yeremian, Valery Dolgashev,
SLAC National Accelerator Laboratory, Menlo Park, CA,
August 31, 2009

A multifaceted program to study high gradient structures and properties of RF breakdown is under way at SLAC. This program includes testing of simplified versions of traveling wave and standing wave structures at 11.4 GHz. [Dolgashev] RF power is fed into these structures using a TE01 mode-launcher. An RF flange is used to connect the mode-launcher to the test-structure. The rf currents flow through either the stainless steel lip on the flange or, in an alternate assembly, through a copper gasket pressed between the same stainless steel lips. In a recent experiment with a single cell traveling wave structure, a flange with stainless steel lips was irreversibly damaged at RF power about 90 MW and ~100 ns pulse length. We suggest an alternative flange that does not rely on metal-to-metal contact in the rf power transfer region. The idea is to use an asymmetric choke flange, where the choke grove is cut into a conflat flange on the mode-launcher. The structures themselves will have a simpler, flat conflate flange with rounded corners on the vacuum side. The Vacuum seal is achieved with a Cu gasket between these two flanges above the RF region.

We have designed a flange with a choke which is almost field free in the vacuum gasket region, whose technical specifications and RF properties are presented below. Design simulations were conducted using HFSS, a 3D finite element code that solves electromagnetic fields in complex structures.

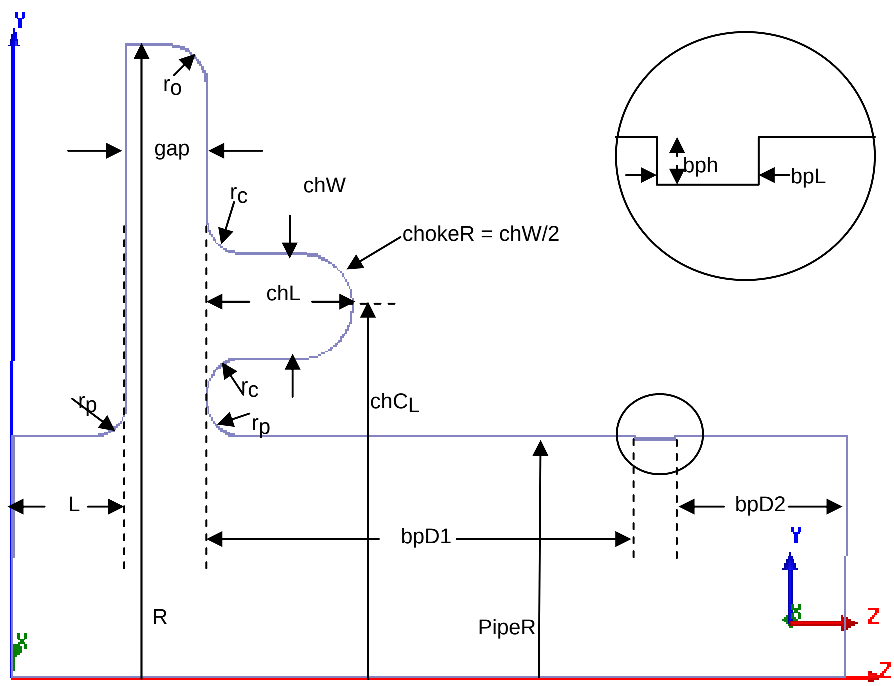

Fig. 1 Projected view of the choke flange.

Dimention	Size (mm)
gap	4
L	>3.6
bpD1	21.15
bpD2	>3.5
chL	7.18
chW	5
R	30
chCL	7.18
pipeR	11.43
ro	2
rc	1.6
rp	1.6
bph	0.10125
bpL	2

Work supported by US Department of Energy contract DE-AC02-76SF00515.

Figure 1 demonstrates the projected physical look of the choke flange, while the table next to it lists the critical parameters.

The maximum electric field for in this geometry is on axis at 33.6MV/m for 100 MW input. The electric flied near the gasket, meaning at the top of the choke gap is at 125kV/m or 1.25kV/cm. Figure 2 demonstrates the electric field strength profile in the geometry for 100 MW input power.

The maximum magnetic field for in this geometry is near the pipe at 59kA/m for 100 MW input. The magnetic field at the gasket at the top of the choke gap is at 225A/m or 2.25/cm. Figure 3 demonstrates the magnetic field strength profile in the geometry for 100MW input power.

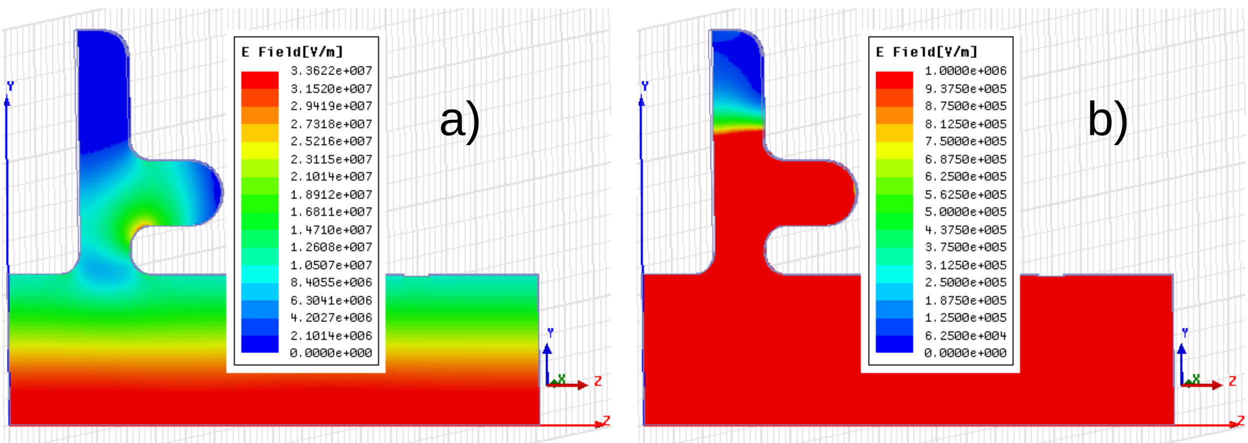

Figure 2. X band Choke Flange Electric Fields for 100MW input. a) auto-scaled to demonstrate max field on axis b) Manually scaled to demonstrate max field at top of choke gap. For 100 MW input power, on-axis E=33.6MV/m, at the top of the gap E= 125kV/m or 1.25kV/cm

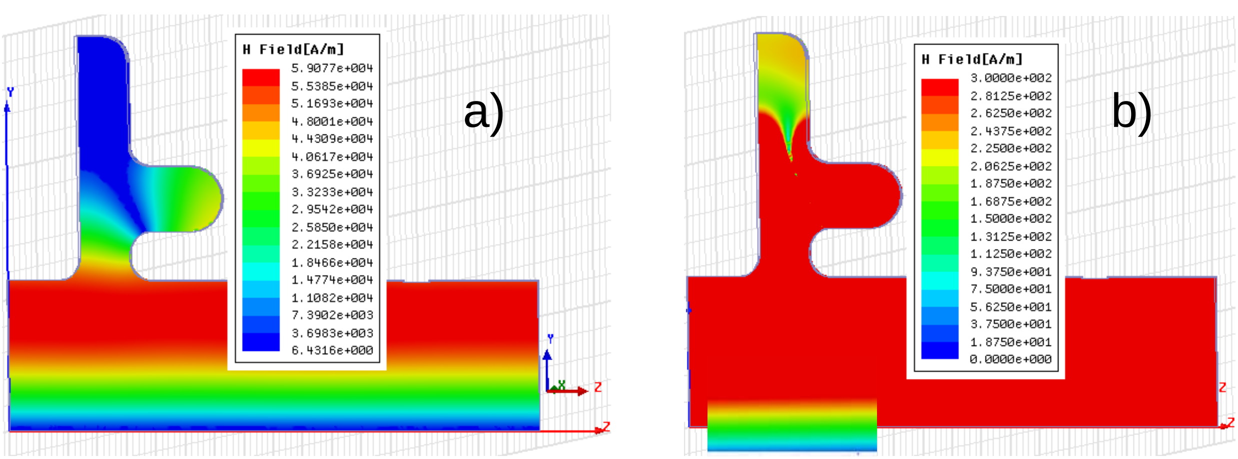

Figure 3. X band Choke Flange Magnetic Fields for 100MW input. a) auto-scaled to demonstrate max field on pipe b) Manually scaled to demonstrate max field at top of choke gap. For 100 MW input power, at top of gap H=225A/m, on pipe H=59kA/m

Using HFSS we also checked for possible trapped modes. All dipole, quadrupole and sextupole modes are well over 500MHz away from the fundamental frequency.

There is interest to use this flange on an RF load made from a material called Cesic. Cesic could be a favorable material for loads due to its high RF loss [Bowden]. Reducing the RF currents at the vacuum seal by moving it away from the RF fields expands our options for the types of vacuum seals. Tests at SLAC have shown that Cesic has a conductivity of 60mohs/cm. Thus we simulated this same geometry with two variations in surface conductivity of the walls. In one case we used Stainless Steel for all the surfaces and in another case we used the Cesic material on the leading pipe and the straight side of the gap and ideal conductivity everywhere else. The frequency sweep for all 3 cases is shown in Figure 4. At the operating frequency of 11.424 GHz, the reflection in the ideal conducting material case is less than 70 dB down, while in the Stainless Steel case it is 60 dB down with negligible shift in frequency. While for the case with Cesic material for the leading pipe and the straight wall of the gap, the resonant frequency has shifted to 11.392GHz and the reflection is greater at -47 dB down but still a very good match. At 11.424GHz for the case with Cesic material for the leading pipe and straight edge of the gap the reflection is -42dB down from the input power.

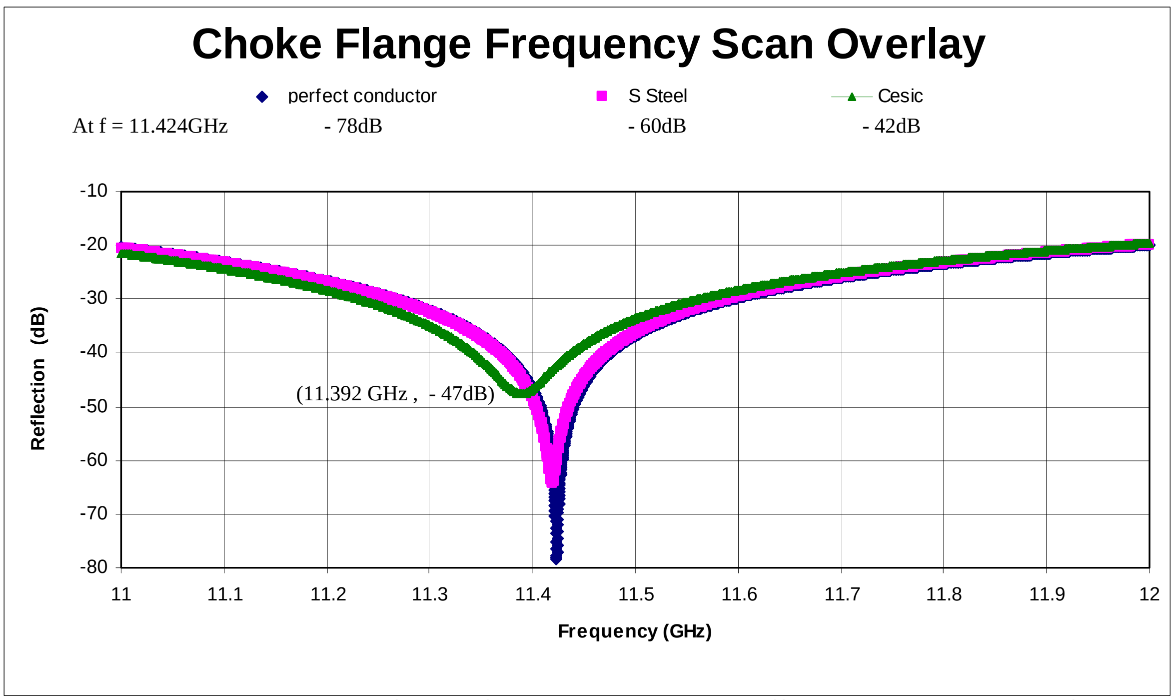

Figure 4. X band Choke Flange reflection frequency scans with 3 different wall materials: perfectly conducting, all Stainless Steel, and Cesic for the leading pipe and straight edge of gap and perfectly conducting everywhere else.

We also plotted the electric and magnetic fields for the case with the Cesic leading pipe and straight gap edge to assure that the fields near the gasket are low enough and at the axis sufficient enough for 100 MW input power. The maximum electric field on axis at 33.5MV/m and near the gasket meaning at the top of the choke gap it is at 125kV/m or 1.25kV/cm. Figure 5 demonstrates the electric field strength profile for this case. The maximum magnetic field on the pipe is at 59kA/m and at the gasket at the top of the choke gap it is at 225A/m or 2.25/cm. Figure 6 demonstrates the magnetic field strength profile for this case.

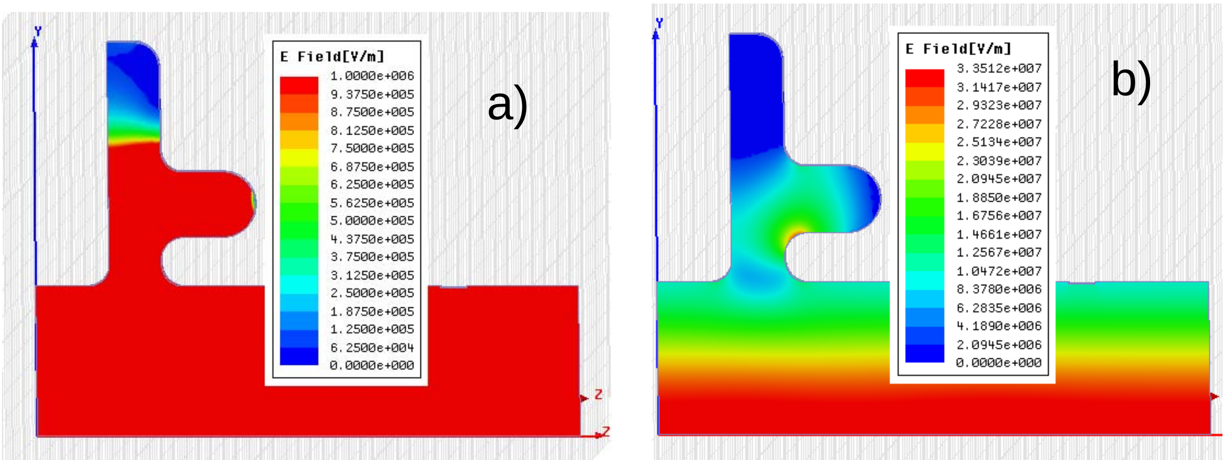

Figure 5. X band Choke Flange with Cesic material on the leading pipe and strait edge of the gap. Electric Fields for 100MW input. a) auto-scaled to demonstrate max field on axis b) Manually scaled to demonstrate max field at top of choke gap. For 100 MW input power, on-axis E=33.5MV/m, at the top of the gap E= 125kV/m or 1.25kV/cm

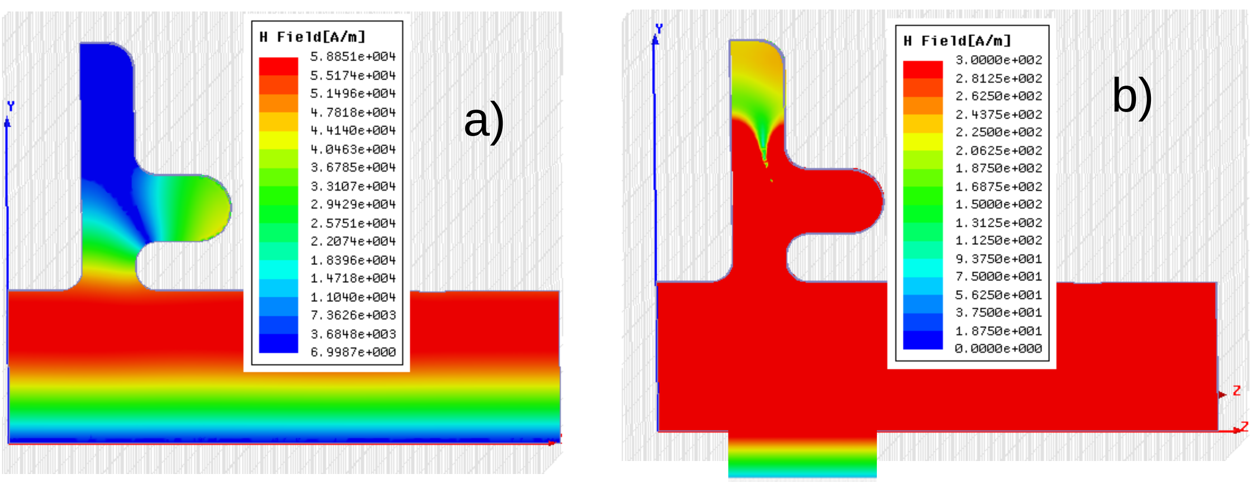

Figure 6. X band Choke Flange with Cesic material on the leading pipe and strait edge of the gap. Magnetic Fields for 100MW input. a) auto-scaled to demonstrate max field on pipe b) Manually scaled to demonstrate max field at top of choke gap. For 100 MW input power, at top of gap H=225A/m, on pipe H=59kA/m

In summary, we believe a choke flange with the characteristics shown above will be a robust way of connecting vacuum components in high power, high gradient applications.

References:

Gordon Bowden, “Cesic RF Attentuantion”, SLAC Memorandum, February 6, 2008

V. A. Dolgashev et al., "High Power Tests of Normal Conducting Single-Cell Structures," Proceedings of PAC07, Albuquerque, New Mexico, USA, 2007, pp.4230-4232.