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High Voltage Sparking in a Decommissioned CESR Horizontal Separator

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A horizontal separator in CESR at 44W was removed and replaced with a new low impedance model in June 1994. The removed device had had the highest spark rate of the four installed separators. In August 1994 it was decommissioned, cut up and inspected. Some interesting observations were made and are reported in this paper.

This separator had seen about 5-10 years of service in CESR. During normal operations it ran at voltages between ± 50 and ± 100 kV with stored beam currents of up to 100 mA/beam. The electrodes are spaced by 12 cm. The typical spark rate during operation was about 4 sparks/day which was slightly more than the spark rate of the three other separators combined.

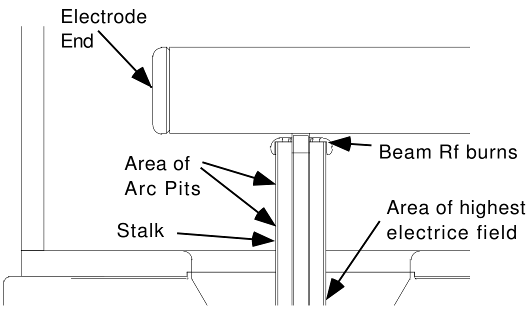

Figure 1: Major parts of the separator high voltage electrode supports where sparking was taking place.

Each of the two high voltage electrodes was held up by two 'stalks' which consist of diamond polished stainless steel tubes with similarly polished corona rings resting the top. See figure 1.

As expected a substantial number of arcing scars were found on the ends of the high voltage electrodes. This area was known to be a source of intense x-ray radiation during high voltage processing. Also, the ends of the electrodes were quite close to the (grounded) chamber wall and had rather sharp radii resulting in peak electric field levels that were many times higher than the electric field between the electrodes. See figure 1 and figure 2.

There was considerable evidence that some of the high spark rate was caused indirectly [1] by beam rf arcing at the loose joint between the corona ring and the stalk. It should not be surprising that beam rf arcing was happening. The average dissipated power density in the separator ($3\ kW/0.2\ m^3$) is of the same order as that in a conventional microwave oven ($0.6\ kW/0.02\ m^3$) where rf arcing is commonly observed.

We found that of the four stalks,

[1] For reasons that are given below, I believe that the beam rf arcing was between components at the same DC potential and therefore would not directly have caused the collapse of the DC voltage.

Figure 2: Arcing marks at one of the ends of one of the high voltage electrode shown in this photo. They are particularly prevalent on the sharply rounded corner where the electric field is the highest.

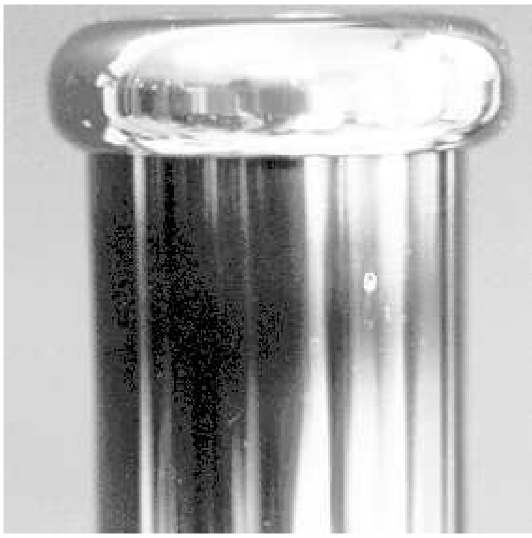

Figure 3: Discoloration typical of three out of four of the the high voltage stalks and corona rings taken from the 45W horizontal separator.

three had substantial discoloration, high voltage arc pitting, and melted stainless steel at rf contact points, while one showed neither discoloration nor arc pitting, and only a relatively small spot of melted stainless at a possible rf contact point. If the discoloration and melted stainless are indeed due to beam rf arcing, then the observed high voltage arcing pits would seem to be associated with it, though the association could be merely coincidental.

The discoloration of the three damaged stalks was a patina of blue to brown around the upper 1 to 1.5 inches (see figure 3). The same patina appeared on the corona rings which rest on top of the stalks. A darker patina appeared on the main part of the electrode near the top of the stalks as shown in figure 5. The numerous arc pits were about 2 inches from the top and distributed more or less uniformly azimuthally around the stalks. Melted stainless steel was seen on the underside of the corona ring, where it makes physical and rf contact with the stalk (where there could not have been any DC electric field), and seen on the corresponding spot on the end of the stalk. See figure 4. It is then difficult to imagine any mechanism that could melt the stainless steel other than beam rf arcing.

These observations support the hypothesis that beam rf arcing caused melting of the stalk and corona ring and led to a substantial amount of material being deposited onto nearby surfaces. Presumably the debris from the arcing either initiated a DC breakdown directly, or continually contaminated the surfaces and reduced the DC breakdown potential. This hypothesis is supported by the circumstantial fact that the arc pits on the stalk are not in the region of the stalk where electric field is the highest, which is about three inches below the pitted region.

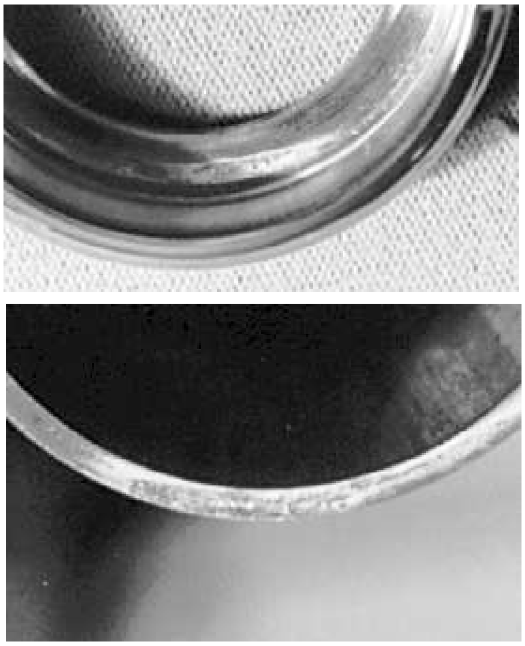

Figure 4: Beam rf arcing damage at the junction between the stalk (lower picture) and the underside of the corona ring (upper picture).

So, in addition to high voltage DC arcing at the electrode ends, this separator probably experienced frequent beam rf sparking which caused additional DC arcs. However, it is not at all clear why this separator had a consistently higher spark rate than the three other separators in the ring.

New low impedance separators are being installed to replace the older units. The corresponding joint between the corona ring and the stalk is a tightly threaded assembly of two stainless parts and can probably take substantially more beam rf power. Also, even though the stored beam current will be raised by a factor of three as part of the luminosity upgrade, the maximum level of beam rf currents should not be much different. The lower impedance of the new separators largely offsets the higher beam currents we expect to reach in the near future.

Figure 5: Discoloration on main part of the electrode near apparent arcing locations.