NATIONAL RADIO ASTRONOMY OBSERVATORY
Socorro, New Mexico

VLBA Antenna Memo Series No.30

VLBA Azimuth Axle Failure – Follow UP

J. E. Thunborg
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The VLBA Azimuth wheel axle shown below failed after 11 years of service. Jim Ruff documented the replacement of this axle in VLBA Antenna Memo Series #28. It is important to understand the reason for this failure, so that we can reasonably predict if other axles in the field are about to fail. The ability to predict axle failures is of critical importance for elevation axles where a failure could be catastrophic. This memo attempts to document the results of the follow up investigations.

Fatigue is one suspected mode of failure for the axle. The axle broke at a high stress location near the wheel. The wheel is connected to the axle by a tapered coupling that presses the wheel and the axle together. This tight fit is a discontinuity in the cross section, which can concentrate the stress in a localized area. Due to the unknown variables associated with the press fit, it would be very difficult to simulate the failure using finite element analysis. Since we would have little confidence in an FEA model, we acquired additional information by testing axles that were subjected to similar conditions.

Two axles that were in service on VLBA drives for many years before they were removed because of bearing failures were transported to Atomic Testing Labs in Albuquerque, NM, for inspection. Atomic Testing performed both magnetic particle and ultrasonic tests on the axles. No cracks were detected. This does not guarantee that all of the axles in the field are free from cracks, but it does give us some confidence that cracks are not slowly progressing on all the axles. We do not know if the axle failed by the progression of a small crack over several years or if once the crack started it progressed rather rapidly. A rapid failure will be harder to detect with periodic inspections.

Another theory for the failure, presented by Jim Ruff, suggests that the bearing that failed 2 months earlier may have seized causing extremely high torsional stresses in the shaft. This cracked the shaft and it took 2 months for the crack to progress to the point where the axle failed. If this is the case, then it may be wise to inspect axles when bearings are changed.

In both cases, inspection could have detected a crack in the axle before it failed. Magnetic particle or die penetrant inspection are not feasible as they require that the axle assembly be disassembled before inspecting. Ultrasonic inspection however, can be accomplished with the axle still in place by introducing a sound wave to the exposed end of the axle and then recording the time required for an echo to return. Echoes are returned by any discontinuities in the shaft. If the shaft is without flaws, the ultrasonic flaw detector will return an accurate length for the axle. I received a quote of $6500 for a suitable ultrasonic flaw detector that could be used to check azimuth axles, elevation axles, bolts, welds and corrosion levels. Another possibility would be to contract with outside testing labs to inspect the axles.

Recommendation

If funds become available, we should purchase an ultrasonic flaw detector. We should inspect all new axles before they are installed on antennas to expose defects in the raw material. We should inspect both the VLBA azimuth and elevation axles during maintenance team visits. We should also inspect all of the VLA elevation axles. Elevation axles are not likely to fail, but an elevation axle failure could result in a catastrophic collapse of an antenna. The ultrasonic flaw detector should also be used in other high stress areas on the antennas, such as the VLA azimuth gearboxes.