VLBA ACQUISITION MEMO #326

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Subject: Edge guiding force variation with vacuum door clearance

Earlier vacuum loop analysis (see Memos #124 & 281) has not adequately treated the variation with vacuum door clearance. Previously it was assumed that the edge contact forces were constant with values obtained by components of vacuum force perpendicular to the precision plate calculated for unperturbed circular loop geometry. While it was recognized that too little vacuum door clearance would squash the tape (developing very large edge forces) and too much door clearance would reduce the edge guiding forces, no quantitative analysis was performed.

I have now calculated the edge force variation with door clearance using an energy conservation method as follows:

1] Perturb the loop geometry from circular to elliptical and calculate the door height and volume of air enclosed by the high pressure side of the loop. [This geometry is calculated on the assumption that the tape is perfectly rigid in the plane of the film and perfectly flexible perpendicular to the film.]

2] Perturb the loop a little more and recalculate the door position and volume enclosed.

From the conservation of energy

$$F\Delta h = P\Delta v$$

where F = force on the front door
Δh = change in door height (distance between front door and precision plate)
P = vacuum pressure
Δv = change in air volume which results from the loop geometry change with door position change

Since the average vacuum force perpendicular to the plate is zero (or very close to zero because the loop components balance - some areas towards the precision plate and others towards the front door) the force on the precision plate balances the front door force or

$$2R = F$$

where R = force on each precision plate edge contact region

The results of the computation (done in double precision to avoid errors in the small differences) are shown in Figure 1. Also shown in the figure is the nominal location of the front door based upon the sloping geometry of Memo #290. A check of the method is provided by a calculation of the edge force from the circular loop geometry (with variable radius of curvature to match the wall tilt) using the perpendicular components of vacuum force, the differential tape tension in the center of the loop and then taking moments about the center of the loop. While it is very difficult to measure the edge force to verify these calculations I have observed that tracking degrades rapidly when the door is held open with a 10 mil or greater shim (giving a clearance of 16.5 mils). With 16" vacuum it takes a force of about 11 grams to push the loop until it barely touches the alumina plate. This force is about 4% of the tension. From this one infers a 2% force for each rear edge contact. [The force was measured using a gauge pushed against shim on the inside of a plastic door.]

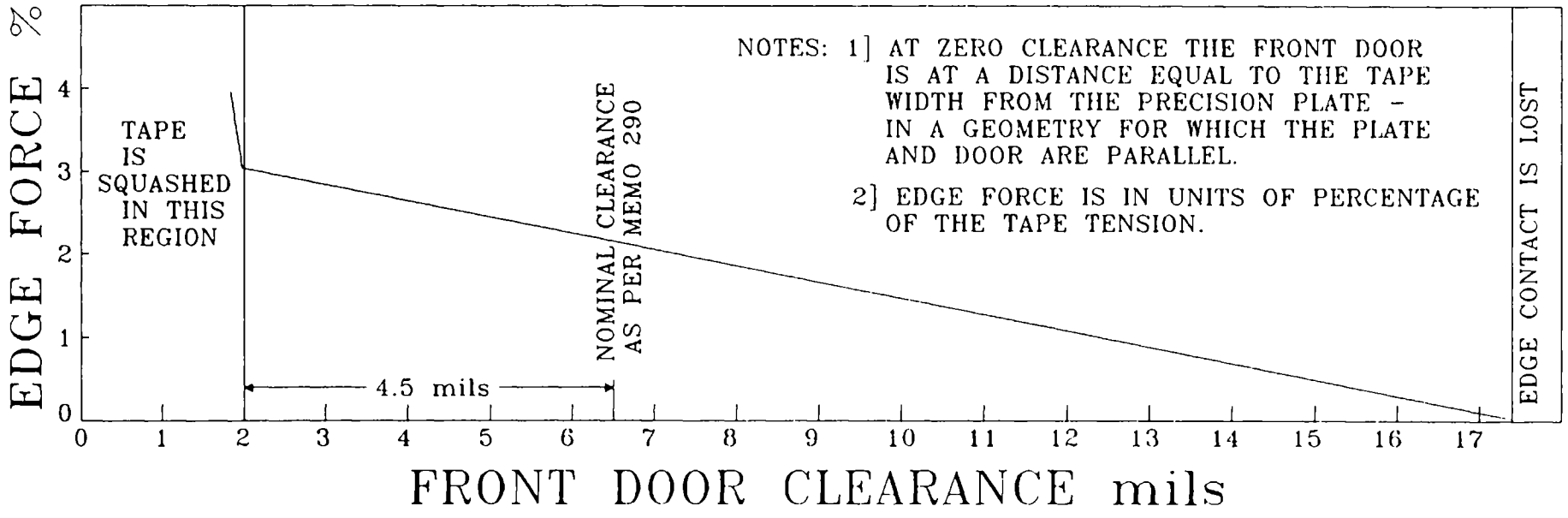

FIGURE 1. EDGE GUIDING FORCE VS FRONT DOOR POSITION