# VLBA ACQUISITION MEMO # 313

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*8 June 1992*

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Subject: Some calculations of forces experienced by tapes when dropped

## Accelerations during drop

When a tape is dropped from a height, $H$, the deceleration experienced is a stopping distance, $D$, is approximately

$$(H/D)g$$

The compact shipping canister presently used for shipping individual tapes can only provide a very short stopping distance and hence the deceleration is extremely high - the saving grace could be the ability of this canister to evenly distribute the forces.

## Flat drop

When the tape canister is dropped on the flat side deceleration and distribution of force is controlled by a plastic shock absorber. If the reel were only supported by the hub, the deflections (see Figure 1a) of the reel flange are given by Timoshenko (Strength of Materials, Part II, page 113, Krieger, Malabar, Florida Reprint Edition, 1976)

$$W = K_1 P a^2 / (E h^3)$$

where

$P$ = load (~10 lbs for 1$g$) ($g$ = acceleration of gravity)
$a$ = outer radius of flange (7")
$E$ = Young's modulus of glass ($10^7$ psi)
$h$ = flange thickness (0.088")
$K_1$ = constant ~0.3 (for case *3* given by Timoshenko) and $a/b$ ~*3*
$b$ = inner radius of flange (2.25")
$W$ = maximum deflection of flanges

giving a value for the deflection of

$$10\ mils/g \quad (g = accel.\ of\ gravity)$$

under the following assumptions

1) Both flanges move together.
2) The flanges are clamped at the hub.
3) The tape is loosely wound and free to slide between turns (zero interlayer pressure).

If only one flange takes the load, the deflection is doubled. If the tape pack doesn't shift between layers, the strength is greatly increased and the deflection reduced by a factor of 30. In all cases, the deflections are large with large decelerations even with the assumption of a rigid tape pack. For average wind conditions the interlayer pressure is about 200 *psi* and the pack will shift with forces of 100-1000 lbs.

When the reel flange is supported by the canister the deceleration forces are distributed between the hub and the flange as illustrated in Figure 1b. In this case the deflections during deceleration are limited by uniformity and deformation of the shock absorbing plates. Deformation of the reel between the rings in the absorbing plate is given by

$$\left(\frac{P}{Eh^3}\right)\left(\frac{5d^4}{32\pi a^2}\right) \sim 6X10^{-3} mils/g$$

where $d$ = separation between rings (1.5")

The deformation of the shock absorbing rings is given by

$$(Pdz)/(\pi a^2 tE) \sim 1.5X10^{-3} mils/g$$

where

$t$ = thickness of ring (55 mils)
$z$ = height of ring (95 mils)
$E$ = Young's modulus of ring ($\sim 10^5$ psi)

Side drop

When the canister is dropped on the side, the deceleration force is transferred to the tape via the reel hub since the canister supports the reel at the hub and allows free rotation. In this case the stopping distance will be determined by the deformation of the outer plastic sides of the canister. The deformation is approximately

$$\frac{P}{2CE} \approx 4X10^{-2}\ mils/g$$

where

$C$ = canister wall thickness (0.125")
$E$ = Young's modulus of canister ($\sim 10^6$psi)

Multiple impacts

Normally when a canister is dropped or thrown in shipment it will not land exactly on its face or side, but will suffer several impacts as the first impact converts some linear to angular momentum about an axis in the plane of the tape pack. For example, first impact on the canister edge of an almost flat impact will convert about 20% of the falling momentum to angular momentum. In general, the deceleration impulses in multiple impacts are less than that of a single flat drop.

A four-foot flat drop - worst case deceleration

Equating the deflection of the shock absorbers to the stopping distance

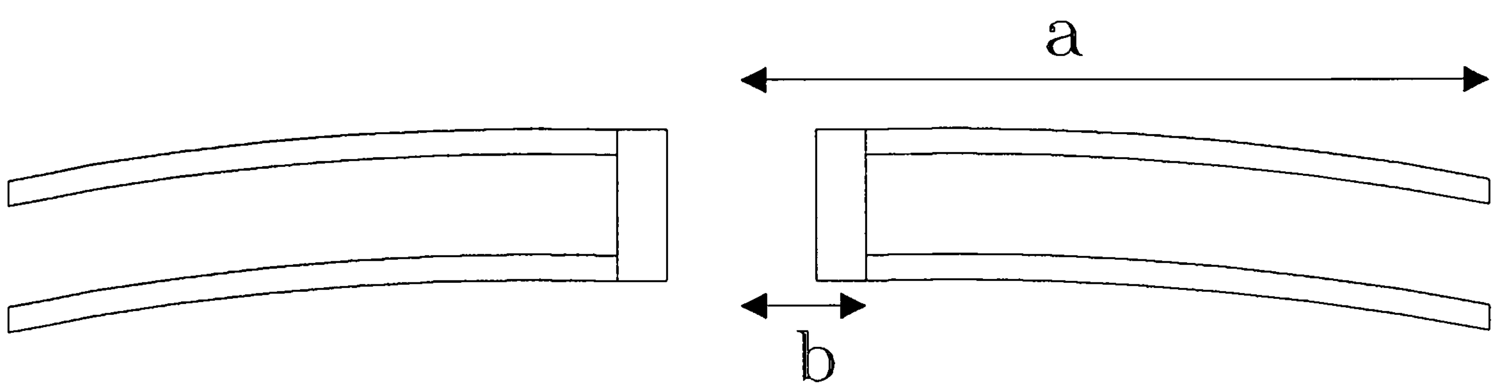
$$1.5x10^{-6}(H/D) = D$$

so that $D = 9\ mils\ for\ H = 48"$

and the deceleration is 5000g. This deceleration exerts a pressure of about 320 psi on the edges of the tape which is within the elastic limit (1% deformation ≈8000 psi) provided the deceleration force is uniformly supported. However, scattered blocks of turns could easily experience excessive force. Four feet is arbitrary - we have yet to determine actual drop heights experienced in shipment.

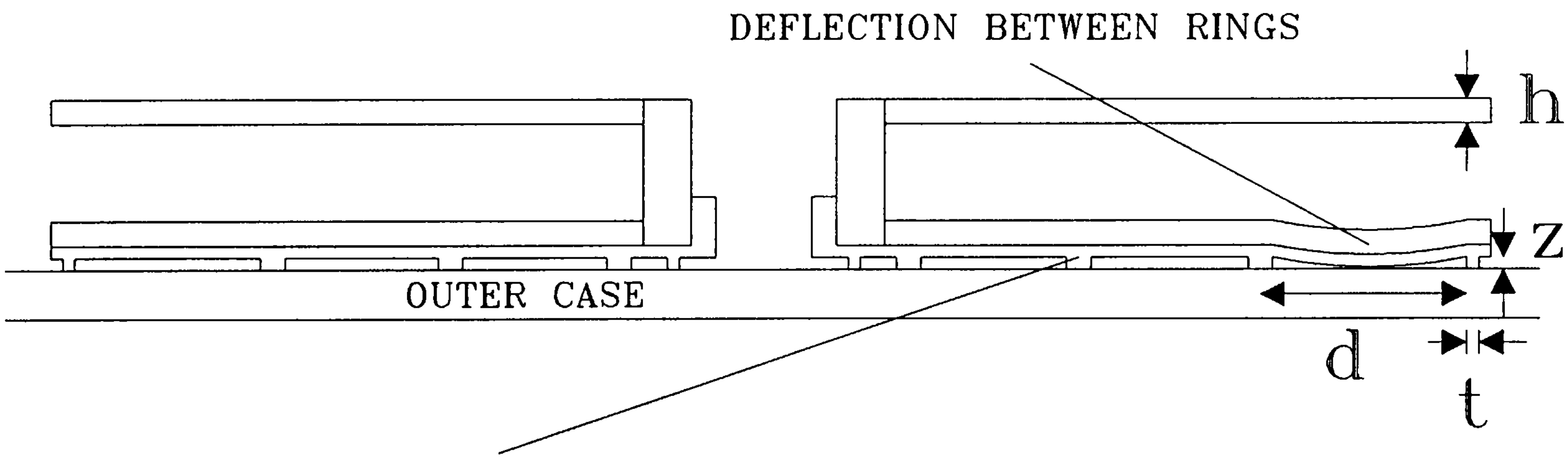
Limiting the deceleration to 100g

The deceleration could be limited to 100$g$ for a four-foot flat drop by ensuring a stopping distance greater than 0.5 inch. A soft covering (>0.5 inch thickness) could limit the deceleration if given the correct choice of elastic modulus for the covering. For a four-foot drop, the elastic modulus on the flat side should be about 6 psi and harder on the edges in inverse proportion to the contact area of the impact.




REEL BENT WITHOUT SUPPORT OF FLANGES

FIGURE 1a




REEL SUPPORTED BY SHOCK ABSORBING PLATE

FIGURE 1b