



An Introduction to Low Flow-Rate Porous Air Bearing Technology

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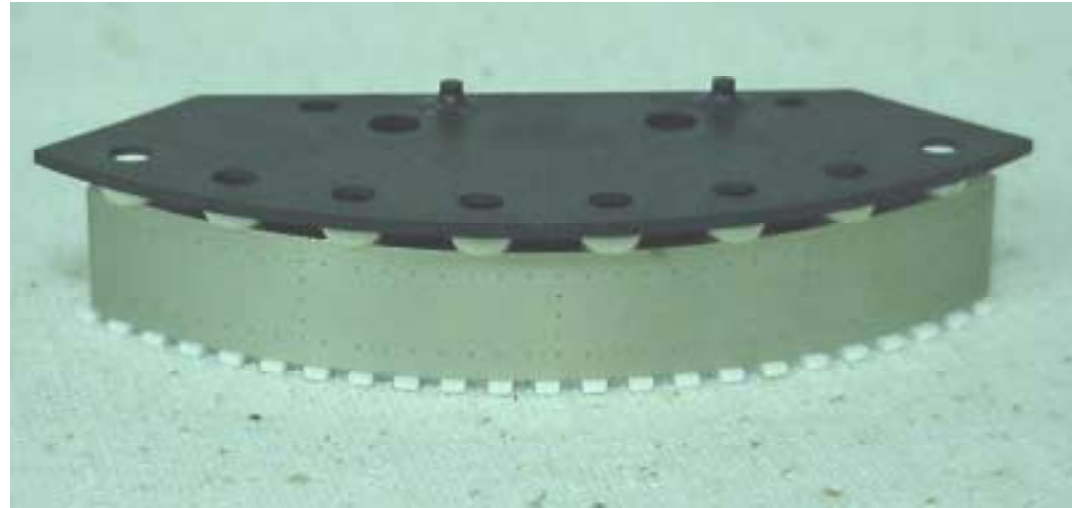
ARC* ATS performance characteristics

Static and dynamic flying height

Lateral stability - tape edge motion

*Advanced Research Corporation: www.gotoarc.com

Typical drilled air bearing assembly with compliant guides and toothed datum



- Used in high performance/high reliability applications
- Complex and costly assembly
- High airflow requires large pump and filter system
- Sharp ceramic edges can induce tape edge damage

Typical roller guide assembly

(Example shown from Quantum DLT tape drive)



Used in mid-range applications

Tape surface start/stop stress & wear due to roller inertia

Roller alignment critical; Complex assembly

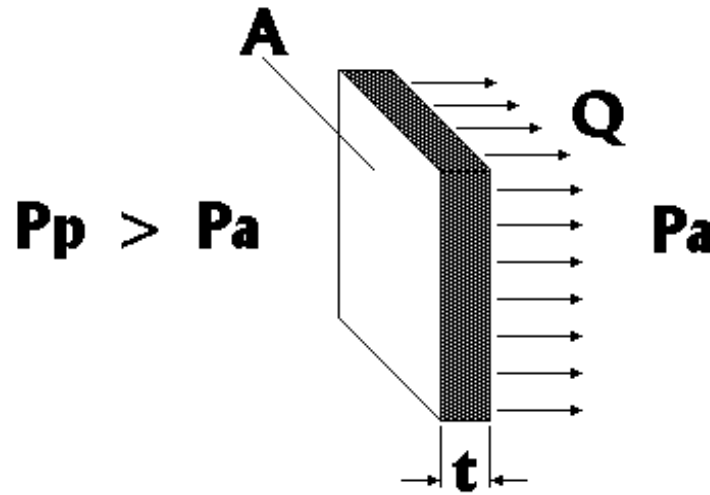
Segway ATS porous air bearing guide assembly

(US Patent 5,777,823 and others pending)



Air bearing benefits but with reduced complexity:
Lower airflow, smaller pump; compliant guides
and toothed datum eliminated; simple assembly;
Greatly improved lateral tracking stability with
thin tape at high speed.

Flow rate through a porous material



$$Q = \mu_b (dP) A / t, \text{ where}$$

$\mu_b =$ material permeability,

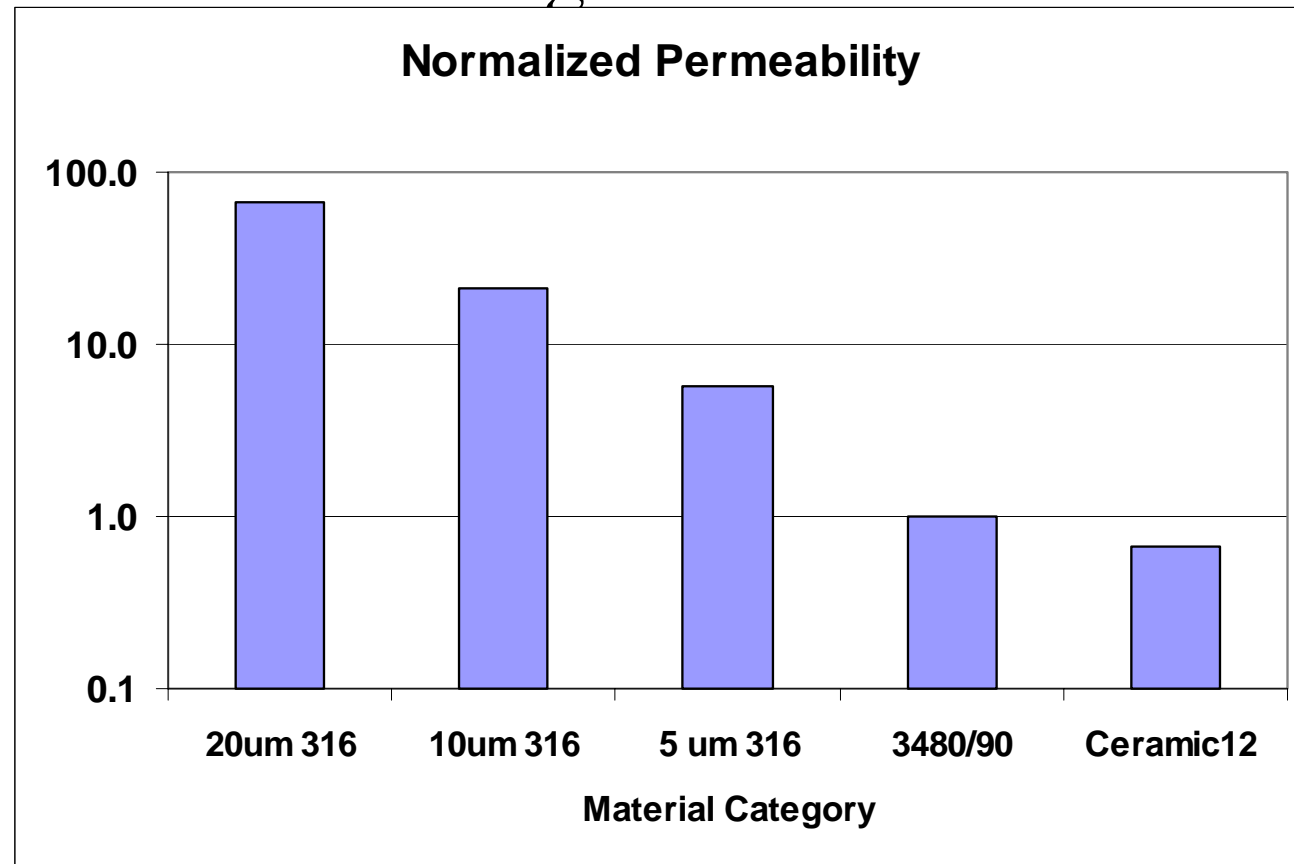
$dP =$ $P_p - P_a$,

$A =$ surface area, and

$t =$ material thickness

$$\mu_b = \{Q/A\} / \{dP/t\}$$

Permeability comparison - air bearing materials



20um, 10um, 5um SS 316 Porous Material Reference:

Baumann, G.W., Analysis of a Porous Gas Foil Bearing, Journal of Lubrication Technology, Trans, ASME, October 1971

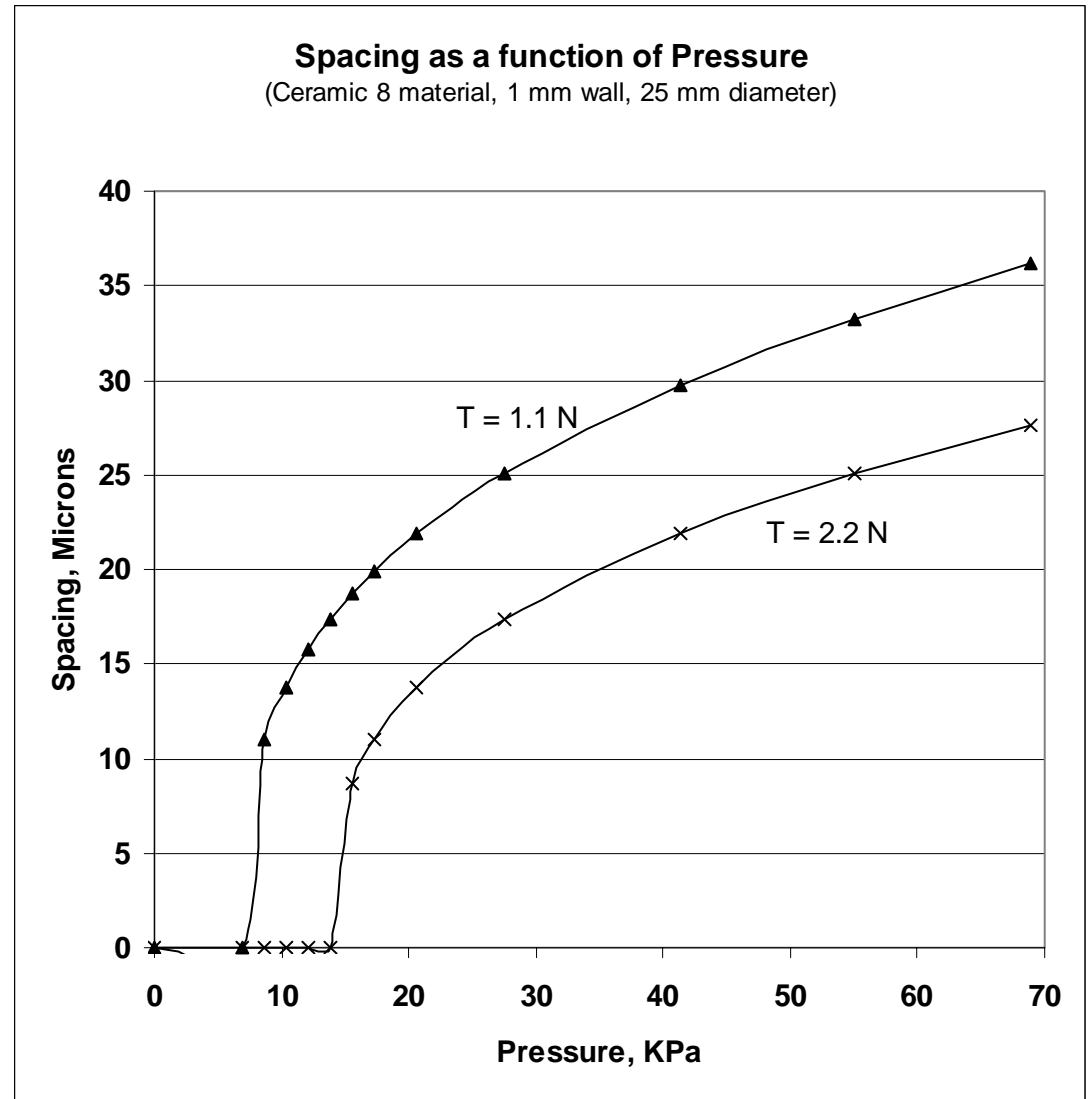
Flying Height of a Tape over a Porous Guide

$$H^3 = \{\mu_a \mu_b w^3 [P_p - (T / r_o w)]\} / [T \ln (r_o / r_i)], \text{ where}$$

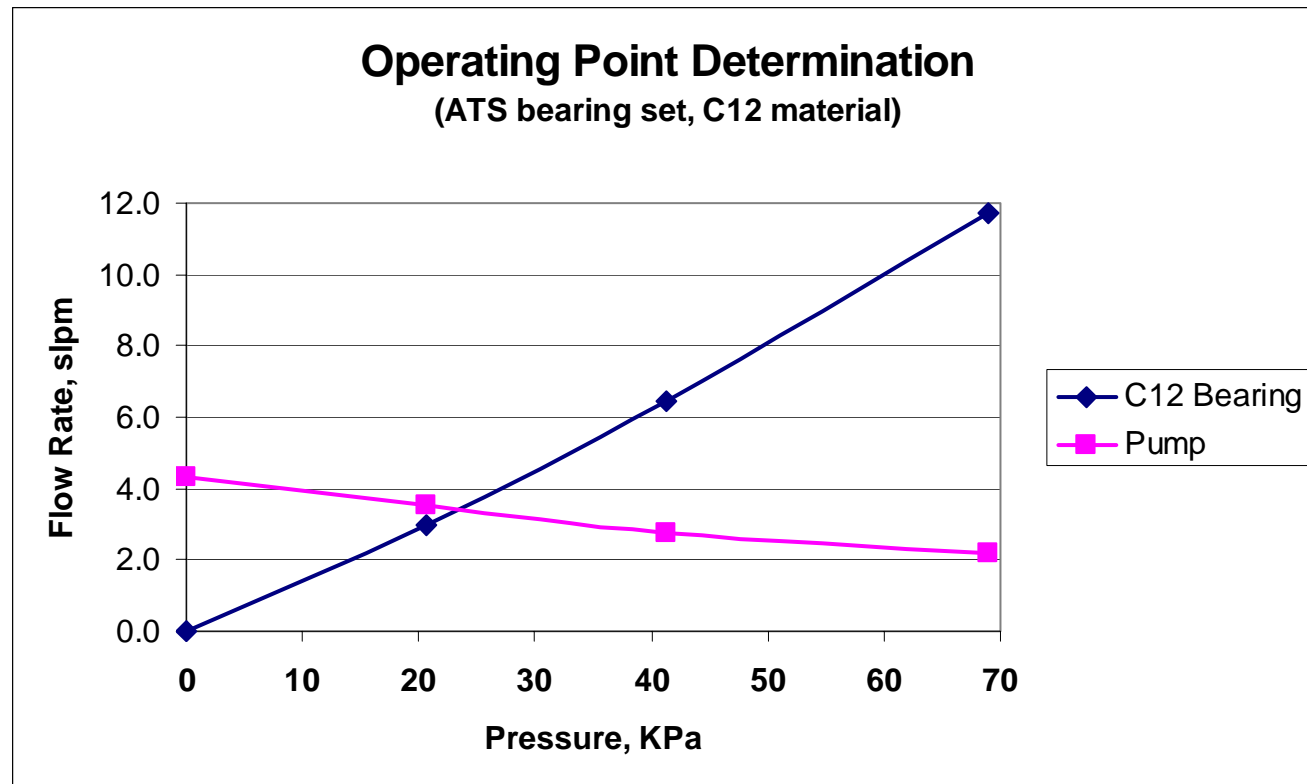
- H = flying height of the tape,
 μ_a = air viscosity,
 μ_b = bearing permeability,
 P_p = plenum pressure,
T = tape tension,
 r_o = bearing outer radius,
 r_i = bearing inner radius,
and w = tape width.

Theoretical porous air bearing flying height

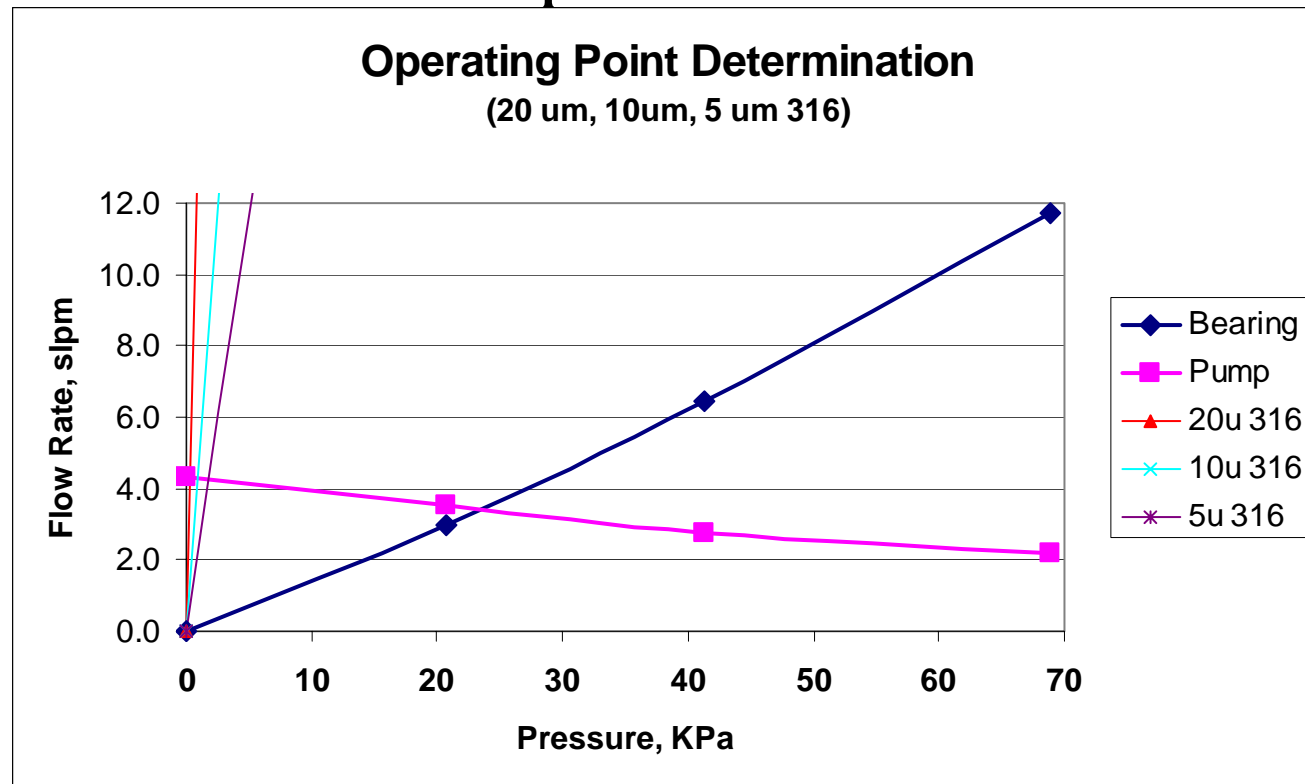
Critical Pressure:
 $T / rw =$
6.8 K Pa @ 1.1N



Flow characteristics of ATS bearing and supply pump



Flow characteristics and operating point determination with porous 316 materials



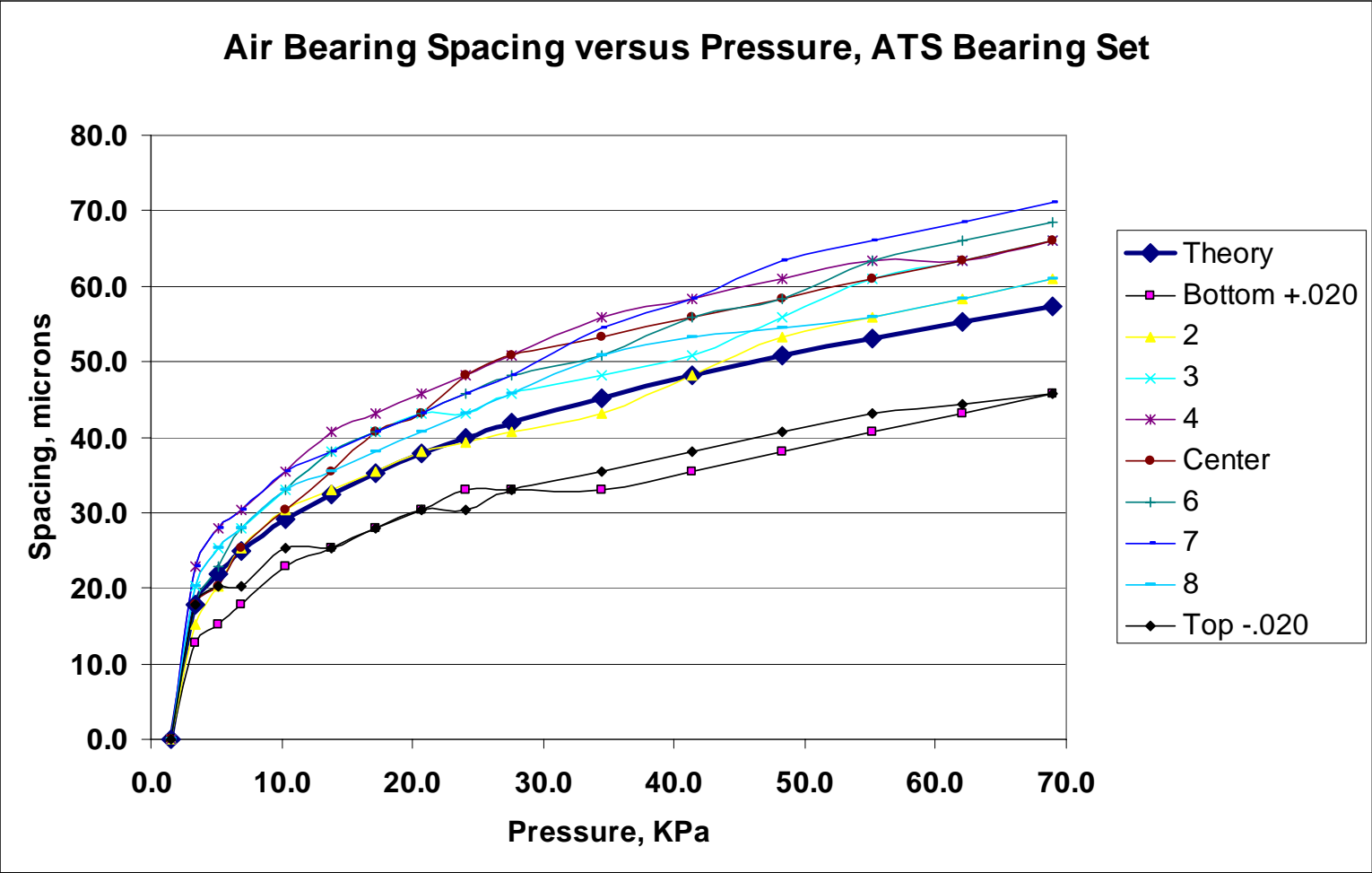
Note: 316 family operating point is less than T / rw ,
so the tape will not fly on 316 with this pump choice.

ARC ATS tape transport configuration



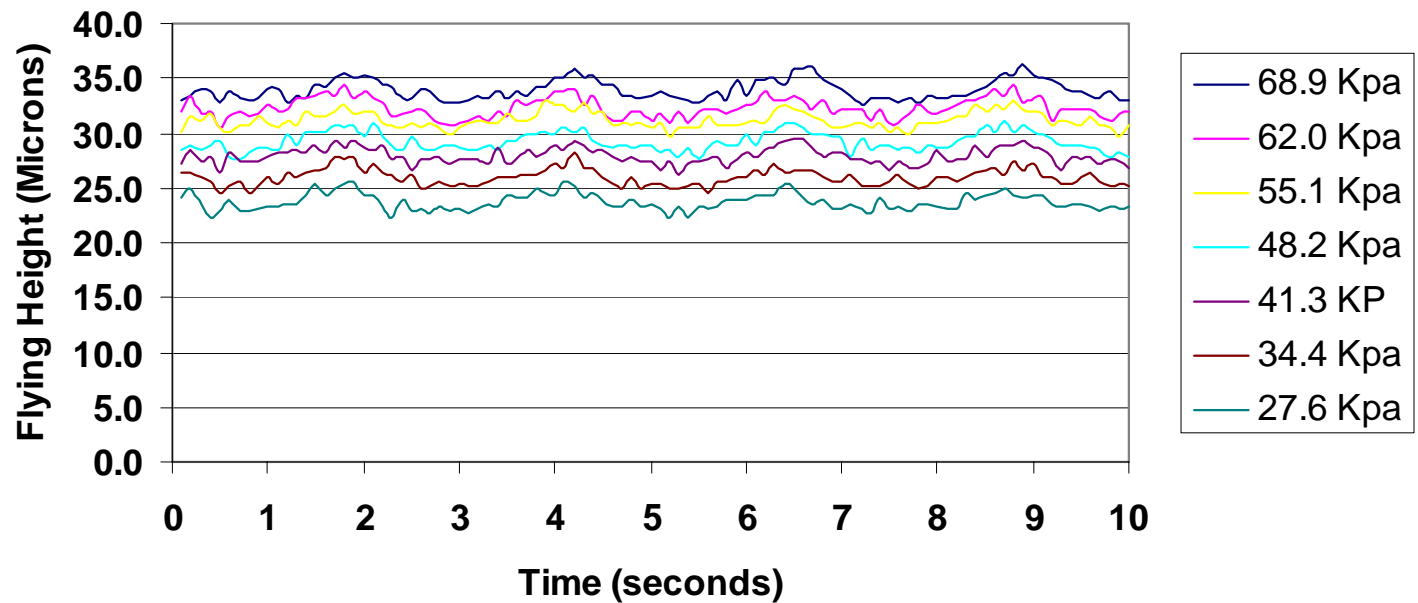
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Flying characteristics of ATS bearings

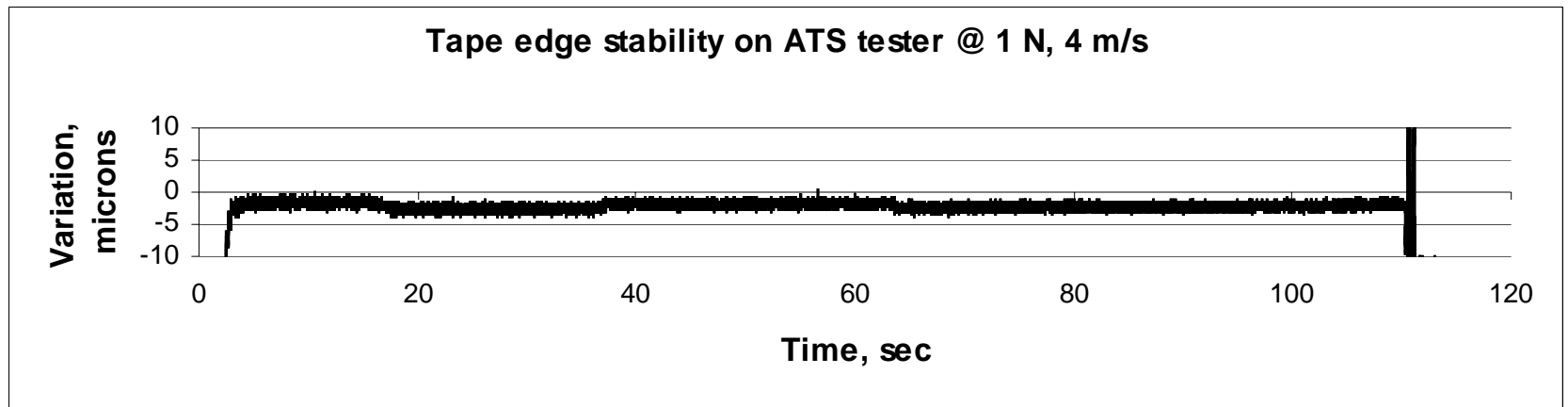


Dynamic flying height variation measured on ATS bearings

Dynamic flying height variation during shoeshine
(± 4 m/sec max velocity; 2.25 second shoeshine period)



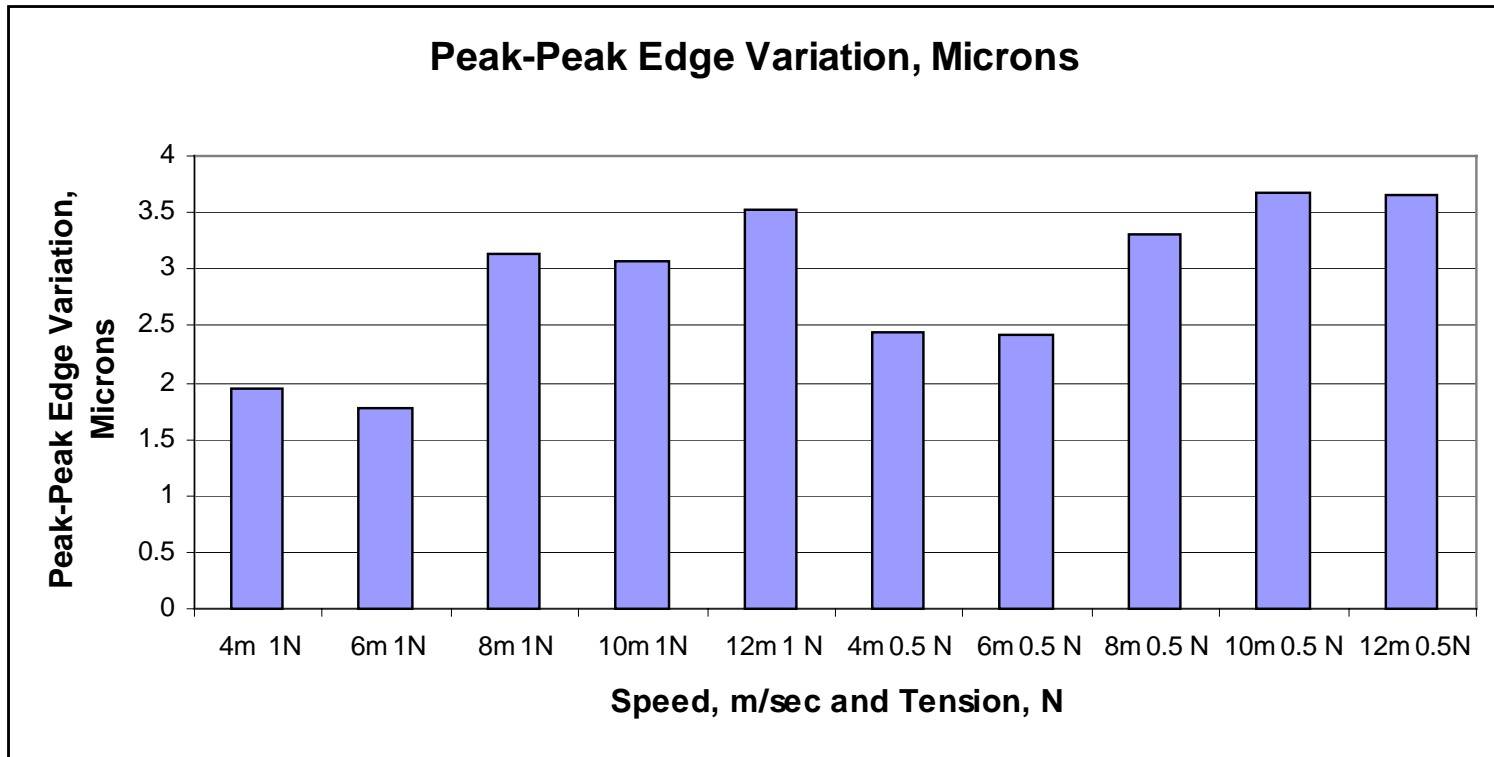
Tape edge stability as measured on ATS tester



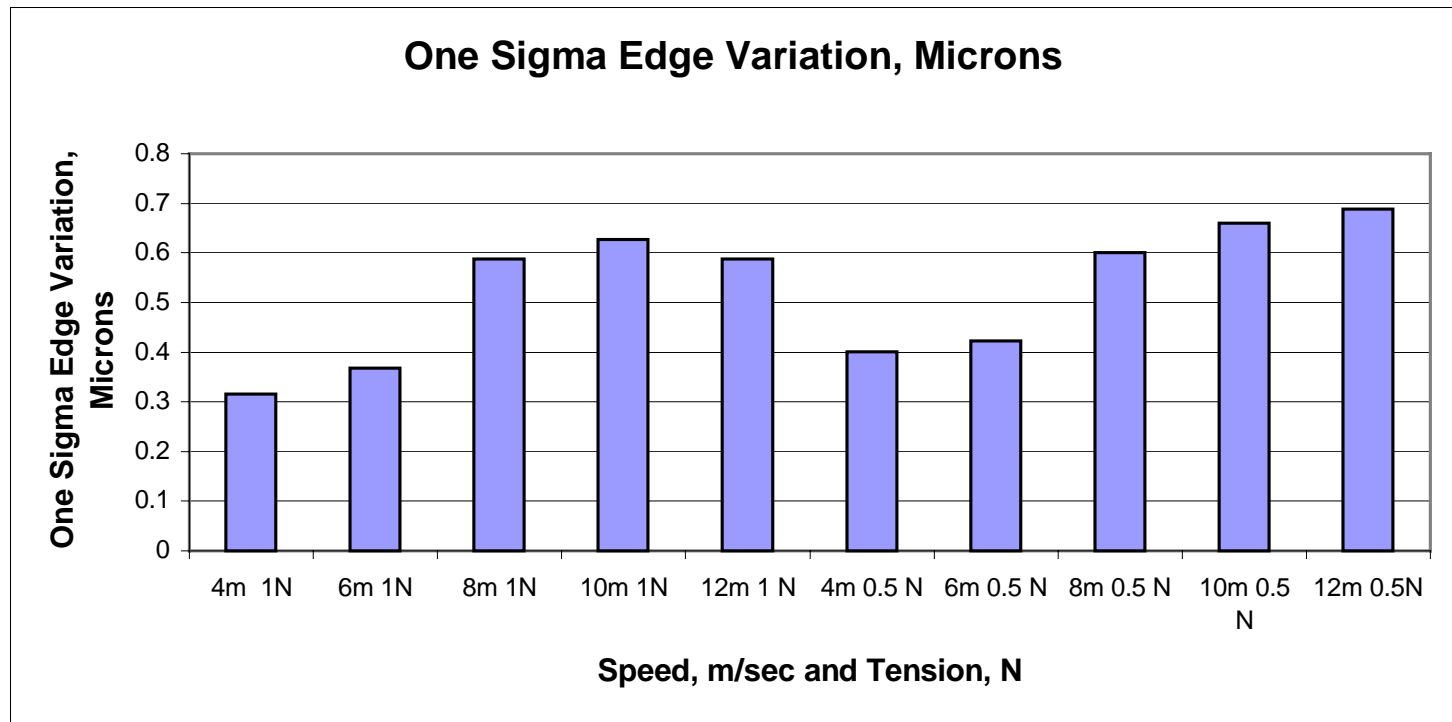
Notes:

- 1) ~2.0 - 3.5 microns peak-to-peak variation typical
- 2) 330 microns stagger at supply reels attenuated to 1 - 2 microns at the head location

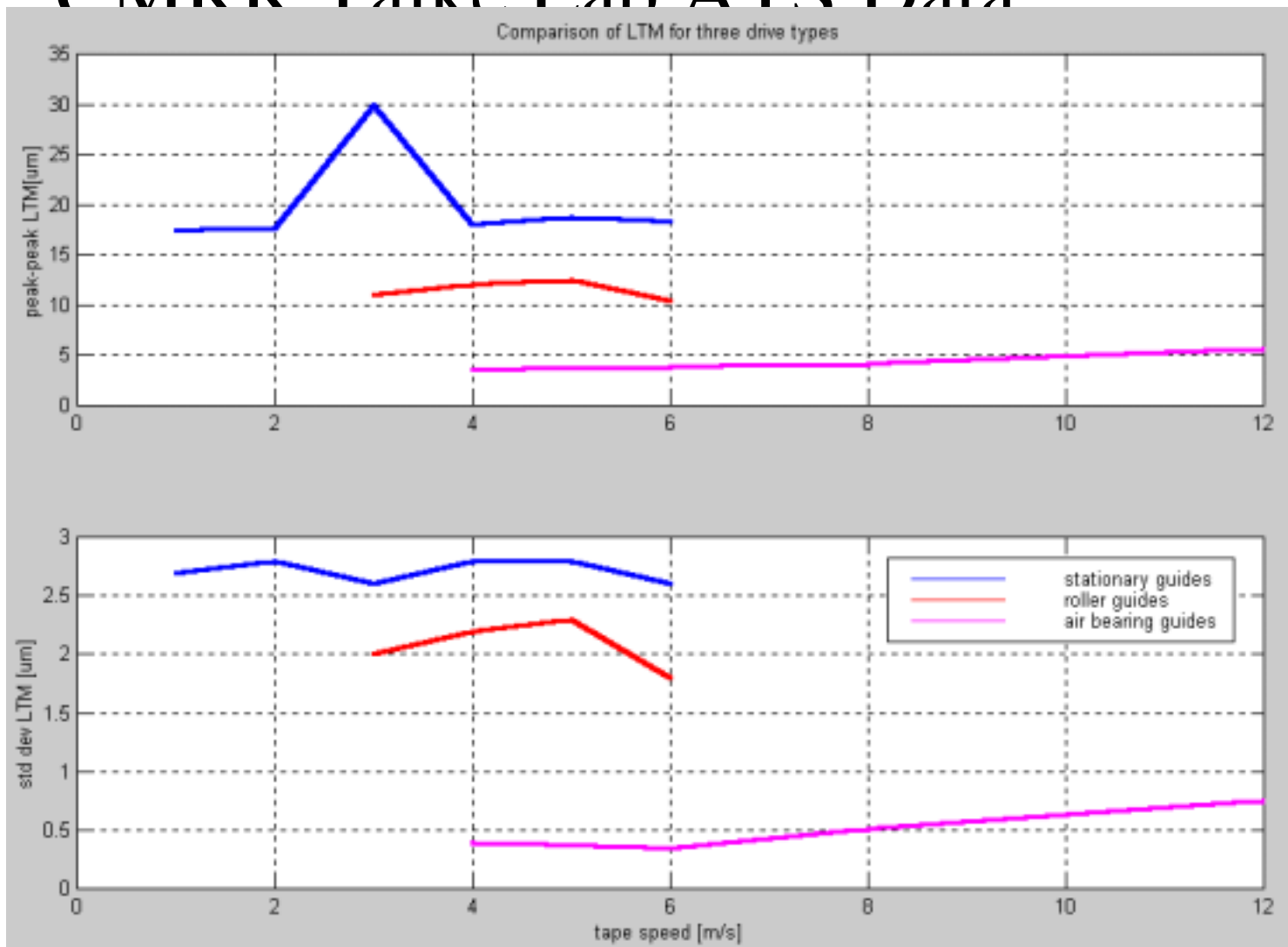
Typical peak-to-peak edge variation as measured on ATS tester



Typical one-sigma edge variation as measured on ATS tester



CMRR Talke Lab ATS Data



Conclusions:

Properly designed porous air bearing systems eliminate many fundamental issues associated with tape guiding based on rollers and hydrodynamic guides, resulting in gentler and more precise tape guiding, enabling the use of thinner and more fragile tapes. Optimized through complete system modeling, porous bearing materials can be chosen to vastly simplify the supporting air supply requirements. The resulting porous bearing systems retain and enhance the benefits inherent with high performance tape drives but without the associated high cost, complexity, power and space requirements.

In the ARC Advanced Test System configuration, the porous air bearing system has been shown to provide highly effective tape guiding with lateral stability of less than 0.7 micron (one sigma) at speeds of up to 12 meters per second. Further increases in operating velocity are possible as enhanced velocity control systems are added to these testers.

How can you feature this technology?

Existing products:

Cost savings

Smaller pump, lower power, less heat,
less debris, smaller filters

Performance enhancement

Higher track density, higher speeds and data rates

Customer Satisfaction

Improved tape and drive reliability
Simpler maintenance

How can you feature this technology?

New products: Jump to a new product roadmap

Time to Market

Rapid enablers necessary to compete with disk
Rate of improvement must accelerate
All new drives running late to plan

Maximize performance and capacity

Smaller form factor
Higher track density
Higher speeds and data rates

How can you feature this technology?

MOST IMPORTANTLY: Improve Customer Satisfaction

Improve tape reliability and data integrity

Improve drive reliability

Simplify maintenance

Reduce overall storage costs

Will roller-based or sliding guide drives penetrate the accounts of your most demanding customers, given their history of poor reliability with similar products and the increased need for massive data storage?

OR WILL THEY PUT THEIR DATA ELSEWHERE?

Why Segway?

Time to Market

Customer Satisfaction

Competitive Advantage