LORD Corporation

Magnelok™ – Rotary Brake Technology

NDIA Joint Armaments
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Presentation by Scott Miller

LORD
AskUsHow™

A Technology-Oriented Global Corporation

Core Competencies:
- Surface science
- Polymer science and engineering
- Material science
- Mechanical design
- Dynamic system design and analysis
- Electromechanical systems

- $610 million annual sales
- 2,400+ employees
- 17 manufacturing facilities and 8 R&D centers in 9 countries
- Over 90 sales and service centers worldwide
- Corporate headquarters in Cary, NC
- Privately held

Aerospace Customers

Honeywell

BAE SYSTEMS

AIRBUS

GENERAL DYNAMICS

LOCKHEED MARTIN

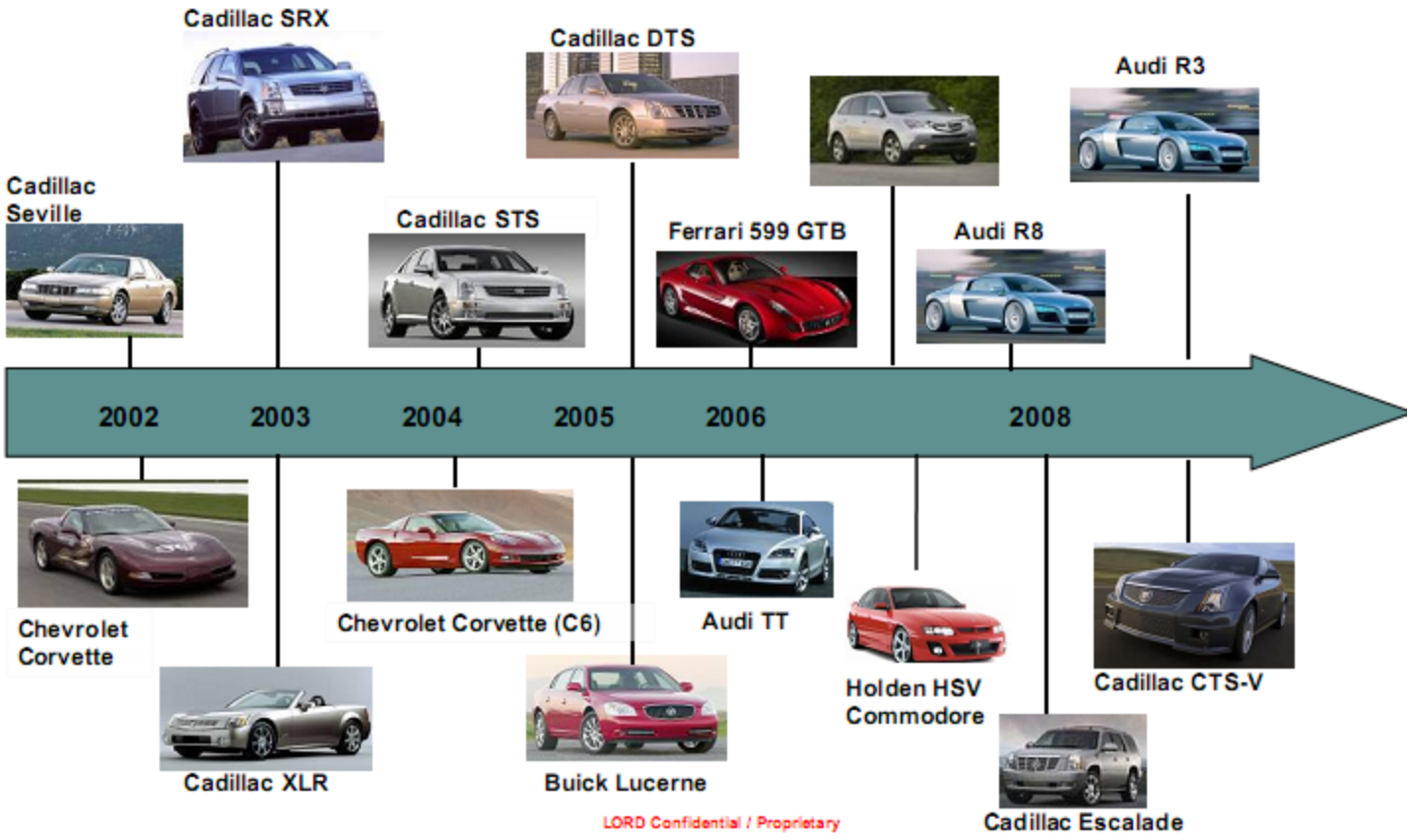
Raytheon

NORTHROP GRUMMAN

Rockwell Collins

Magneto-Rheological (MR) Fluid-Based Controllable Dampers

- LORD Corporation's MR technology has been proven through the licensing and broad intellectual property portfolio used in developing BWI Group's MagneRide™ suspension system. The system now appears with more than 500,000 MR devices in more than a dozen models from multiple automotive OEMs of LORD MR technology.



Magnelok ™ – A Technology Platform

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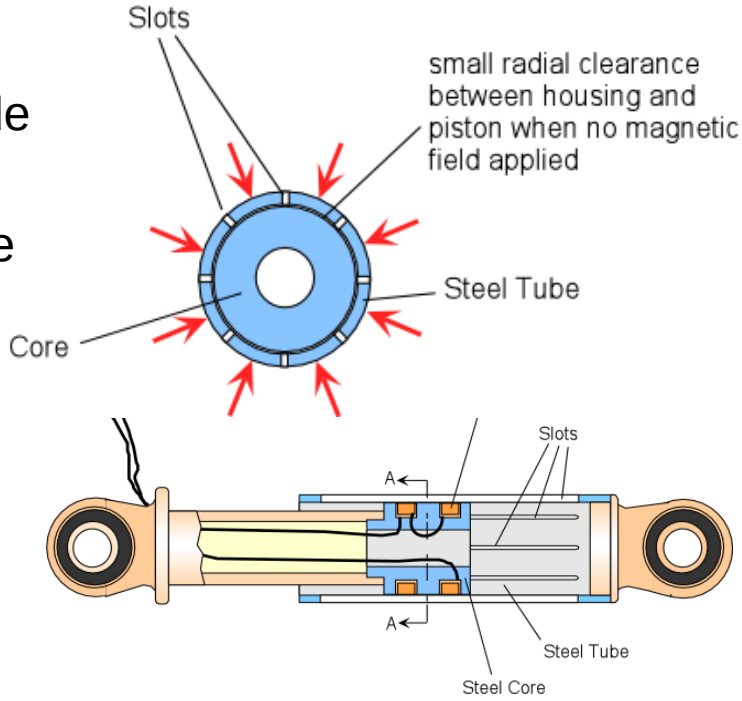
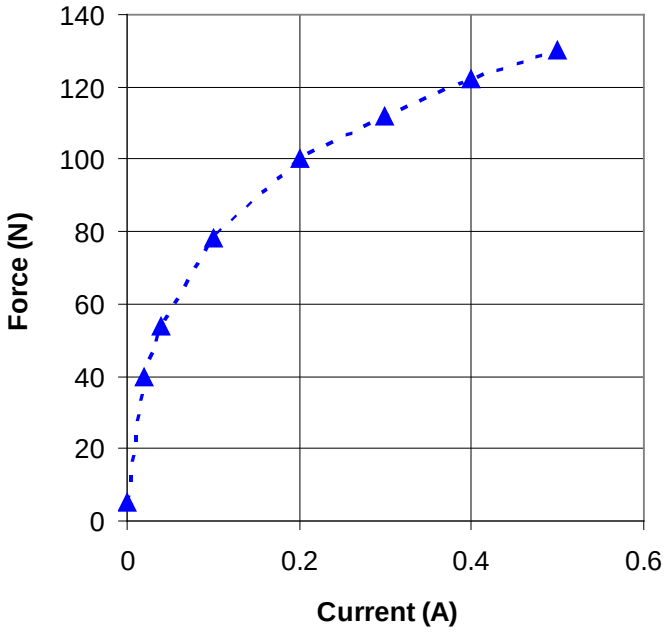
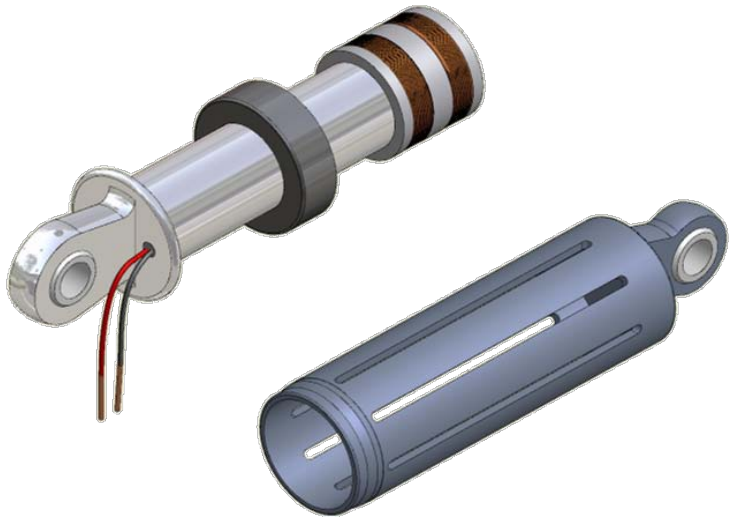
- Complimentary to MR fluid technology
- Magnelok™ devices contain no MR fluid and provide better locking capability and complete decoupling
- In linear versions, normal force is proportional to the magnitude of the magnetic field
- Application of magnetic field causes the housing to constrict radially and squeeze the piston
- Force is a function of the magnetically-controlled normal force and the coefficient of friction

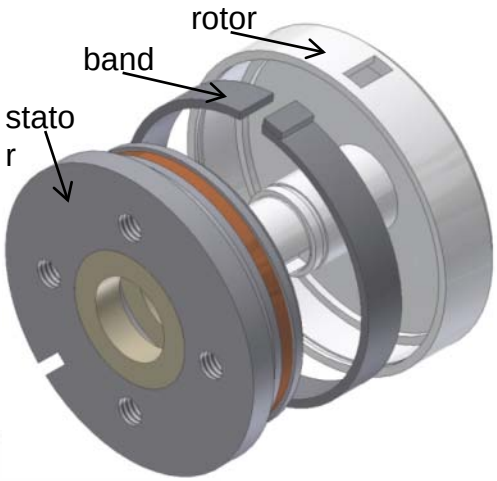


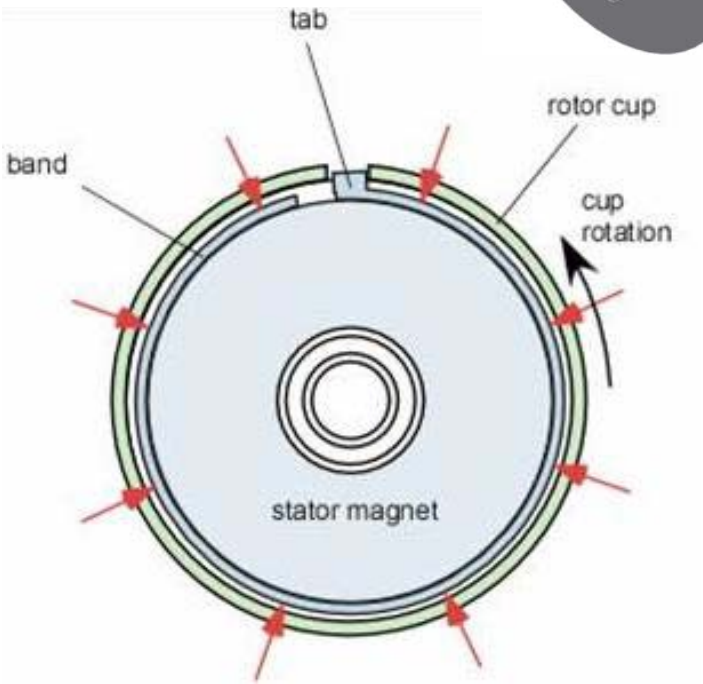




Rotary Magnelok™ Brakes Became Particularly Intriguing as They Evolved into Band Brakes

- The rotary Magnelok™ brake utilizes a flexible band
- The band is pulled azimuthally around the core by the rotor cup
- The rotary Magnelok™ brake leverages the property that the friction coefficient affects the torque output exponentially—leading to the potential of very high torques in small packages



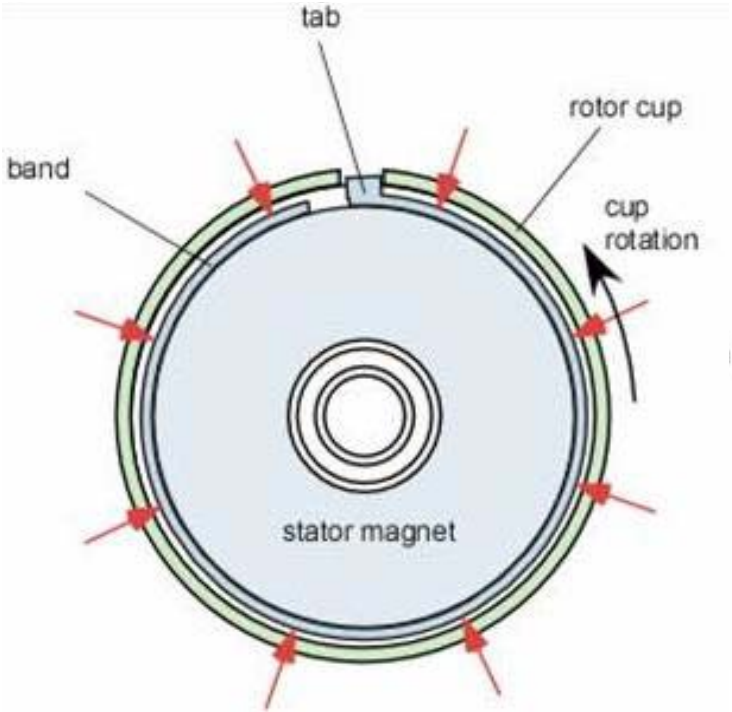


$$Torque = P_{mag} r^2 w\left(e^{\mu\phi} - 1\right)$$

Failsafe (Power-to-Unlock) Magnelok™ Brakes are a complementary development

Traditional Magnelok™ Band-Brake (power-to-engage)

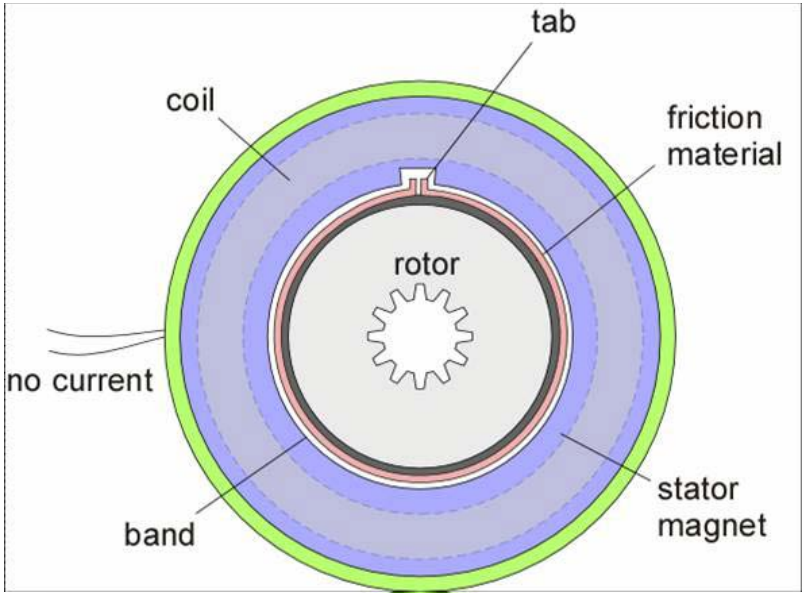
Magnetic field controls the normal force and hence the frictional force



T.R.L. ≈ 7

Failsafe Magnelok™ Band-Brake (power-to-unlock)

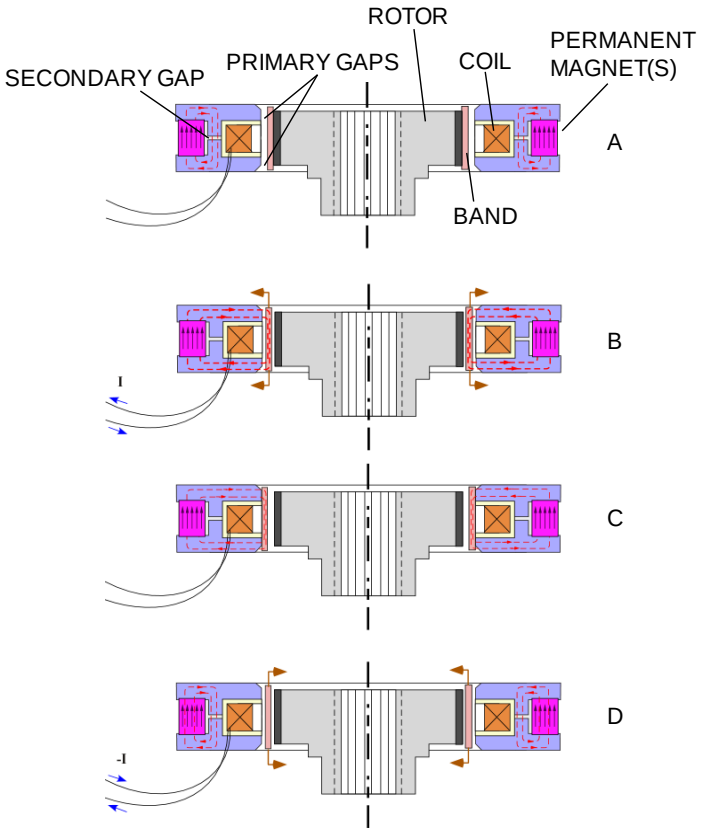
Band stiffness controls normal force and hence frictional force



T.R.L. ≈ 3

Pulse-On/Pulse-Off Embodiment

- A version of the technology that changes state in response to an electrical pulse has been demonstrated, and is near T.R.L. 2



Magnelok™ Competitive Advantage

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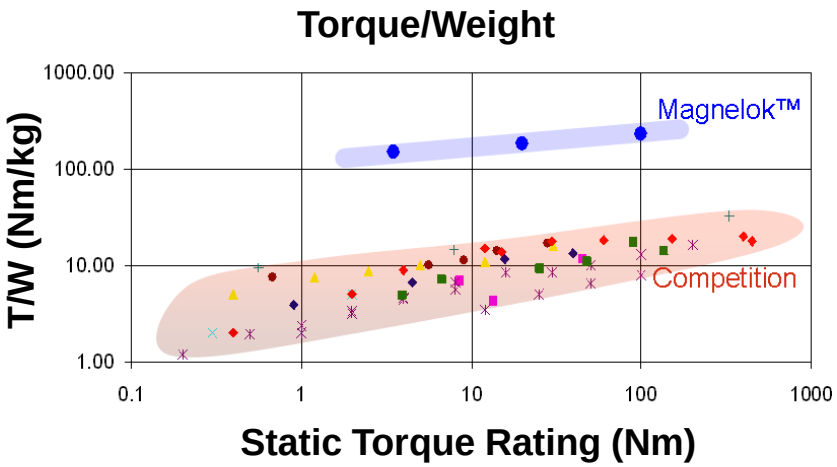
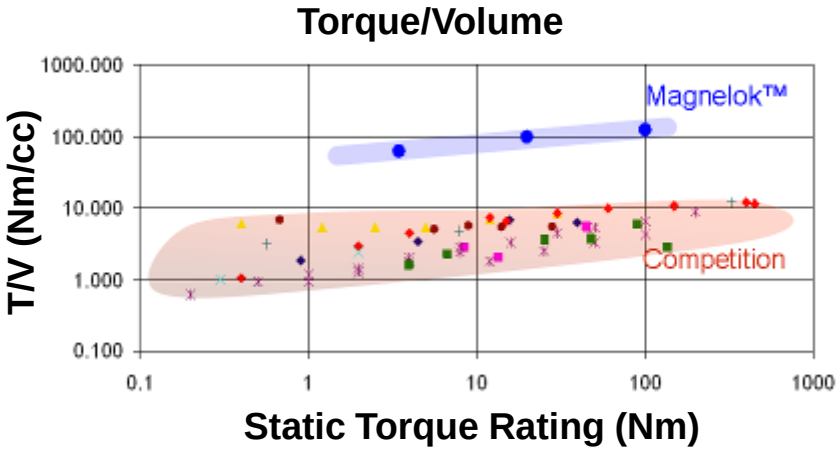
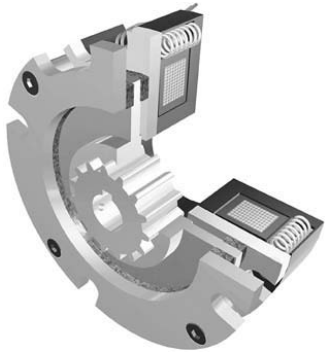
… is lower weight



… takes less space

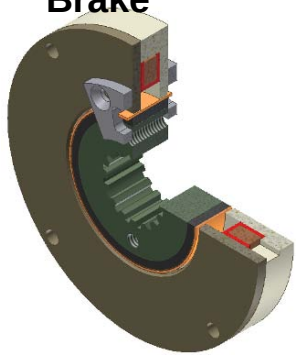


Incumbent



$$T = \frac{2}{3} P \pi \mu \left(r_o^3 - r_i^3 \right)$$

Magnelok™ Brake



$$T = Pwr^2 \left(e^{\mu\phi} - 1 \right)$$

Magnelok™ band-brake performance example

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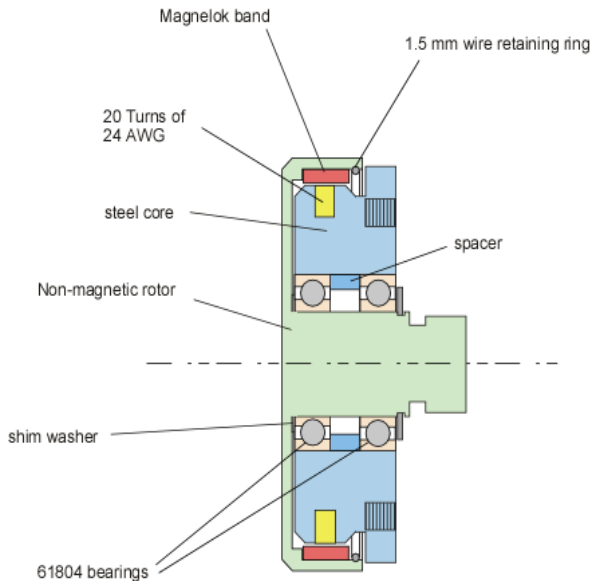
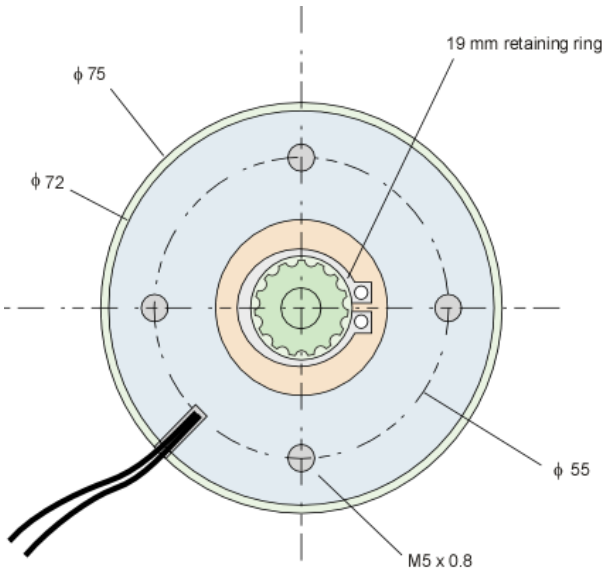
100 N-m Magnelok™ Band Brake

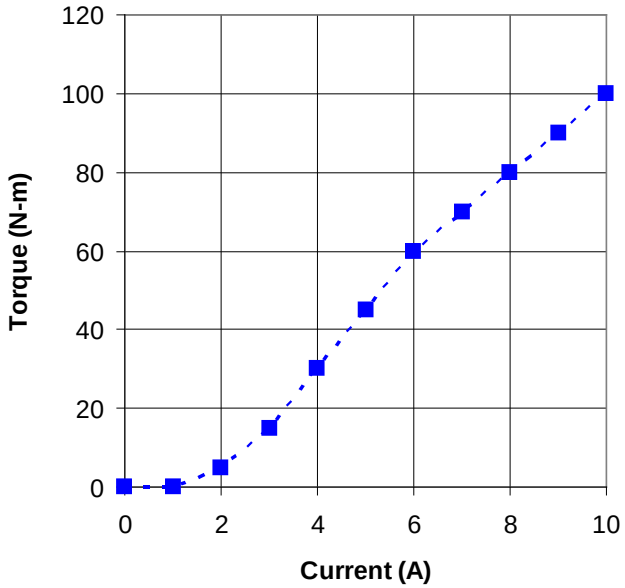
75 mm (3 in) diameter

25.4 mm (1 in) axial length

~ 0.5 kg (1 lb) weight







Magnelok™– Applications

Aerospace Applications

- Control surface motor drive locking devices
- Backdrive prevention devices
- Stopping brakes and electrical brake actuators
- Control stick, knob or other human interface locks
- Cockpit door locks
- Seat recline or other articulation mechanism locks
- Retractable door step hinge locks
- Exit door hinge locks
- Kitchen galley cart wheel locks
- Cargo container wheel locks
- Thrust reverser mechanism locks
- Bin door hinge locks
- Engine door locks
- Helicopter particle separator mechanism locks
- Helicopter winch mechanism locks
- Landing gear door locks

Industrial Applications

- General Industrial electric brake motors
  - Many applications from fractions of an oz-in to thousands of ft-lb have been demonstrated
- Belt tensioners
- Door hold-open locks
- Seat articulation locks

Questions?

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