



# Magnetic Particle - NDT

Flat-Spiral Coil

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## Flat Coil / Split Coil Magnetic Particle Inspection of Turbine Components “Process Controls”

# Overview

- Introduction
- Review of Conventional MT
- Terminology
- Applications
- Process Controls and Systems Verification \*\*\*

# About StandardAero



Founded in 1911, StandardAero has become one of the world aerospace industry's largest independent maintenance, repair and overhaul (MRO) providers. Our company's success is the outgrowth of the synergistic merger of businesses with complementary specialties that have exponentially increased our capabilities and generated unprecedented customer commitment and value.

StandardAero offers extensive MRO services and custom solutions for business aviation, commercial aviation, military and industrial power customers. About 6,000 professional, administrative and technical employees work in 38 major facilities around the world, with additional strategically located regional service and support centers all across the globe.

Services include MRO for aircraft and rotorcraft engines, auxiliary power units and components; airframe services including major alterations; FAA authorized avionics capabilities; comprehensive engineering services; and custom exterior and interior design, completion and paint. We provide these capabilities through our network of specialized facilities and mobile service teams.

- Full MRO capabilities
- 577,000 sq. ft. MRO facility capable of full overhaul & test of multiple engines models
- Four test cells capable of supporting RB211-535: three 50,000 lb cells, and one 90,000 lb cell
- 38,000 sq. ft. engine test prep space
- 20,000 sq. ft. warehouse space
- Dedicated on-site Engineering Technical Support
- In-house component repair
- 24-hour customer response team
- Dedicated program management

With the requirements for inspection of large diameter ferromagnetic turbine components, some conventional magnetic particle equipment is incapable of adequate inspection. This is the case with many large turbine engine components. In order to adequately magnetize the parts, various issues such as material, diameter, and geometry must be considered. Using both flat coils (Pancake coils) and split coils are viable alternatives to conventional stationary magnetic particle equipment and provide excellent inspection of such parts.

In order to comply with most standards that exist today, it is a requirement to produce magnetic fields at various directions so as to improve the probability of detections (POD) of critical discontinuities in disk or ring shaped parts. Conventional test units would usually provide a means of inducing a magnetic field using a “toroidal technique” requiring a laminated ferrite core placed in a coil. Similar parts can be inspected using the flat coil which provides a means of detecting circumferential discontinuities just as the toroid does. The difference is the ease and efficiency with which the inspection can be performed.

In combination with the flat coil, a split coil can be used to establish a magnetic field essential perpendicular to the flat coil to comply with the requirements for fields to be essential perpendicular. A split coil will detect the radial discontinuities within the part.

Both the flat coil (pancake) and the split coil are excellent options for magnetic particle inspection of ring-shaped or circular components, as direct contact current is not required, and hence reduces the possibility of damaging parts.

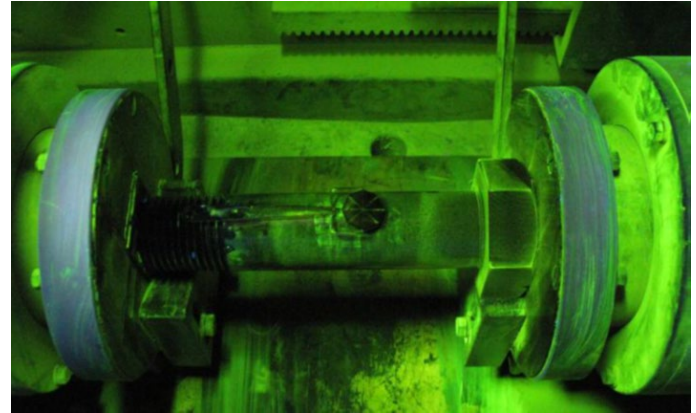
# Terminology ASTM E 1316

- Circular Magnetization – circumferential field established in the part. (head shot, CBC, TB)
- Longitudinal Magnetization – field which extends along the axis of the part. (coil, cable wrap, yoke, magnetic flow)
- Multi-Direction Magnetization – sequential fields imposed to create a vector field (helical)
- Direct Magnetization – electric current induced into the part, creating a magnetic field.
- Indirect Magnetization – the part placed in a magnetic field. (coil, CBC)
- Toroidal Magnetization – induced magnetization.
- Flat / Spiral Coil (Pancake) – spiral wound coil
- Split Coil -
- *Magnetic Flow*
- *Current Flow*
- *Threader Bar*

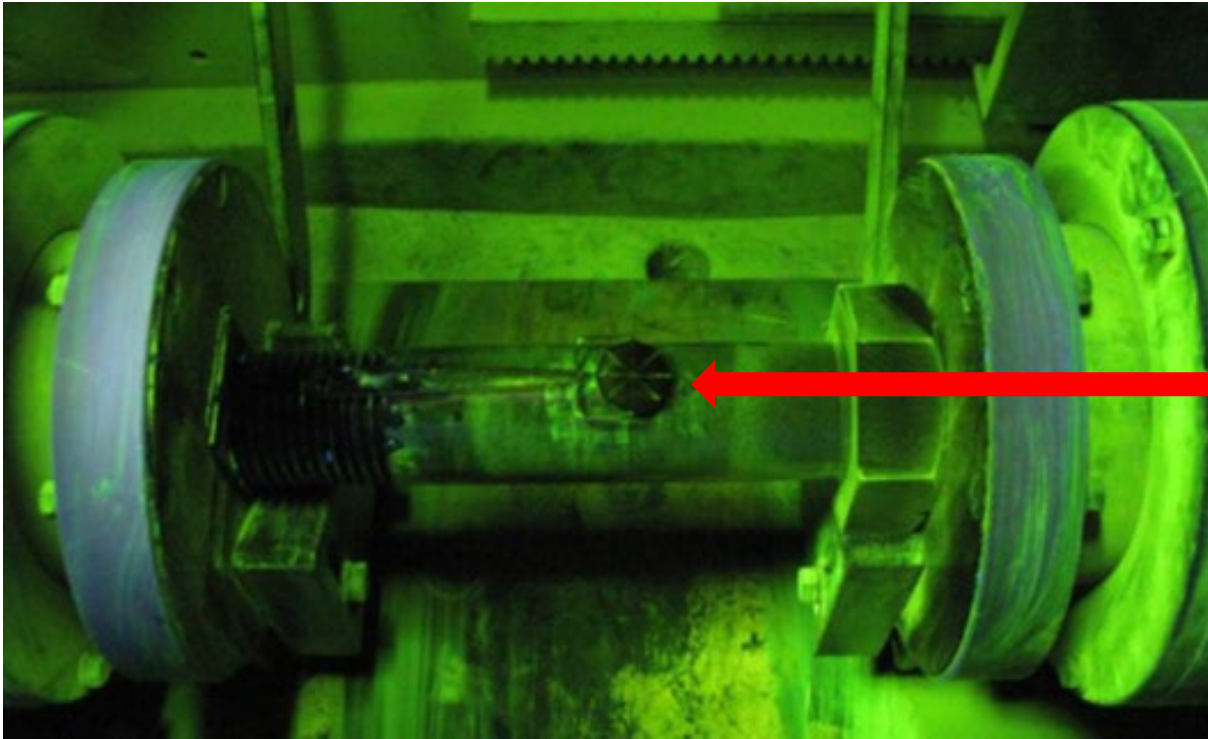
# Magnetic Particle Techniques

## Conventional:

- Head shot – circular field:  $\text{amps} / \text{cross section}$
- Coil shot – longitudinal field:  $L/D \text{ ratio}^*$
- Multi-direction shot – vector field
- *Yokes*
- *Prods*

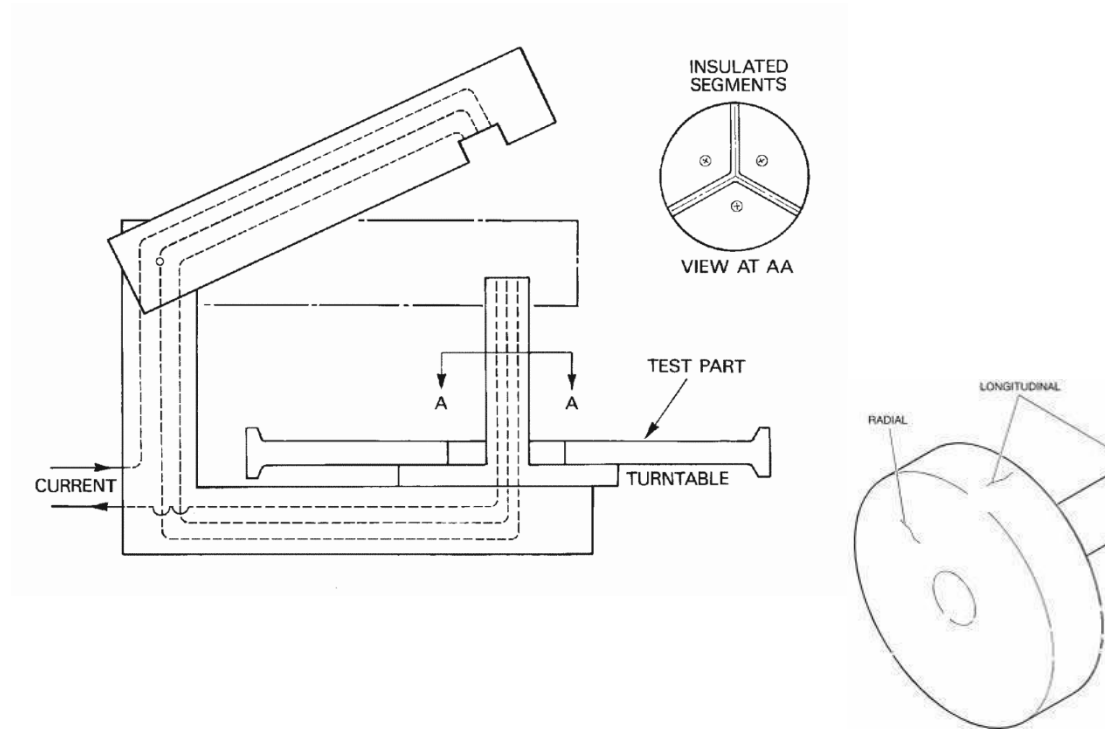






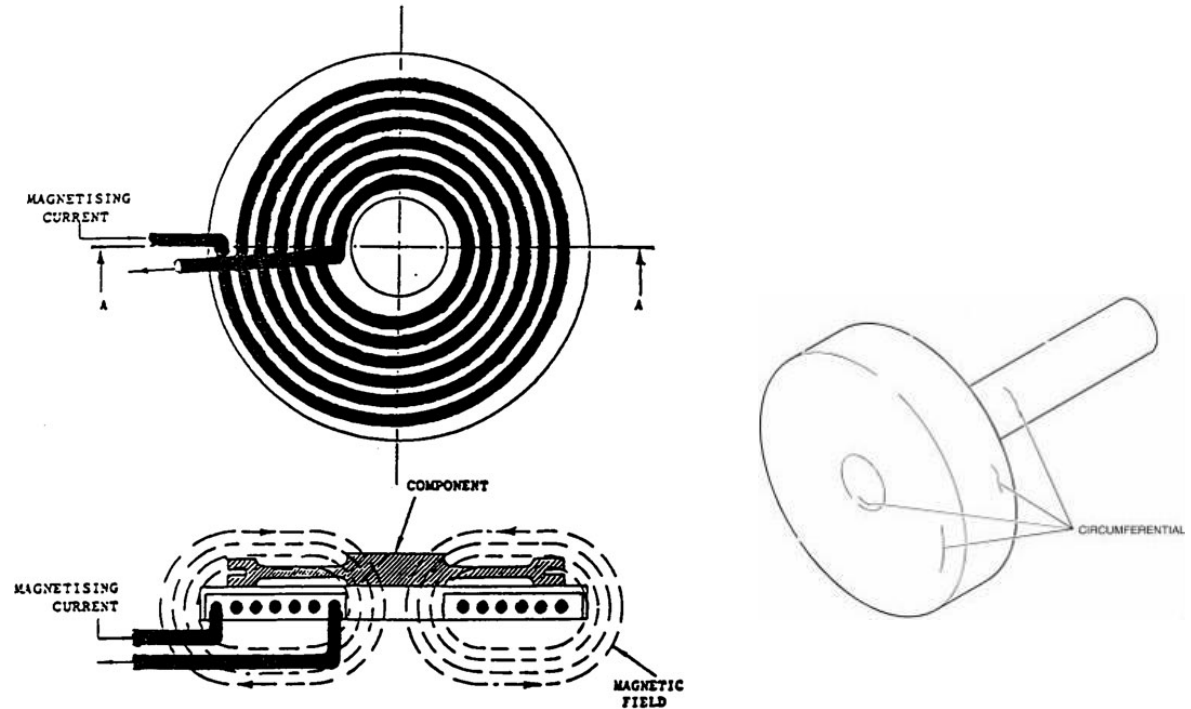
ASTM 1444  
pie gauges  
only for field  
direction

# Split Coil



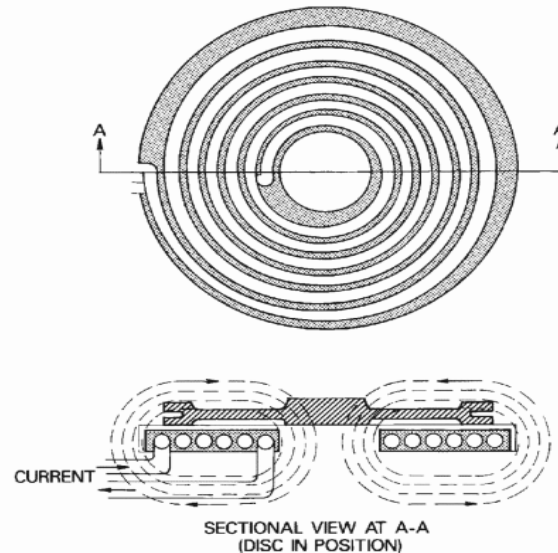
# Flat Coil

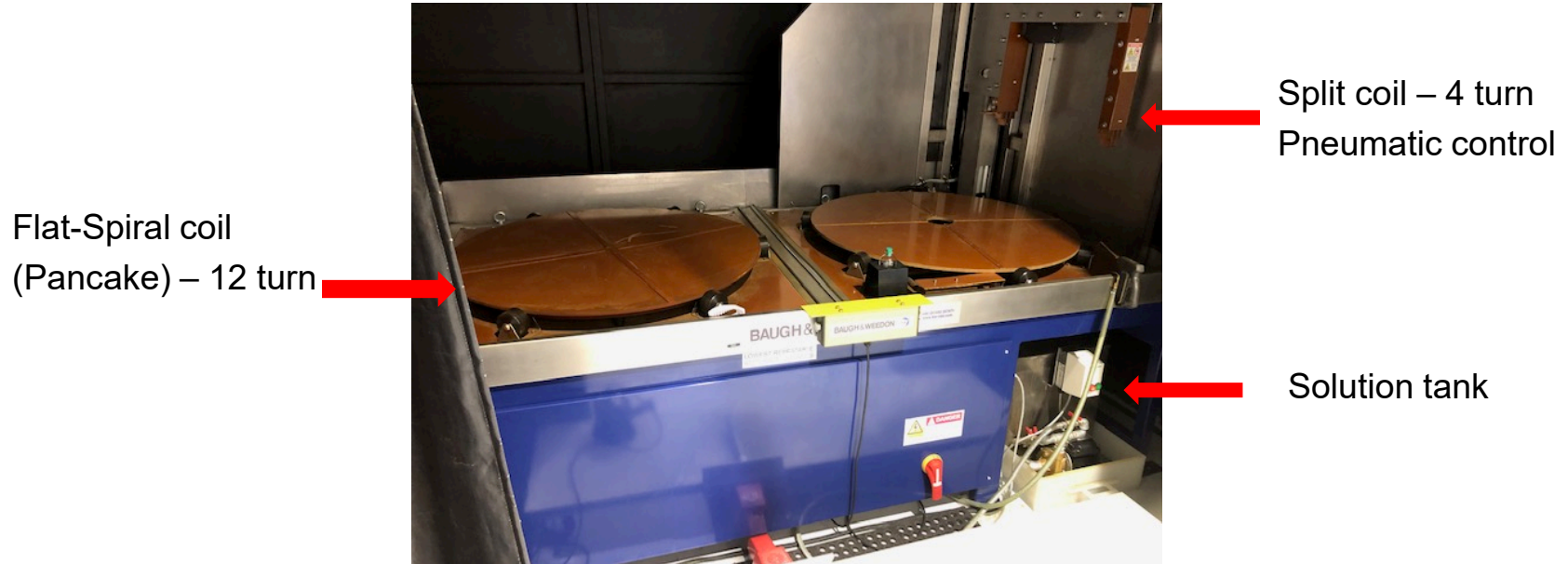
PANCAKE COIL (FLAT SPIRAL COIL)



# Pancake coil (Flat Spiral Coil)

- This technique creates radial magnetic flux capable of detecting circumferential discontinuities in discs, gears or similar geometries on faces parallel to the plane of the coil. The OD of the coil needs to be approximately 4" (100mm) greater than the OD of the part.





Control Panel not shown

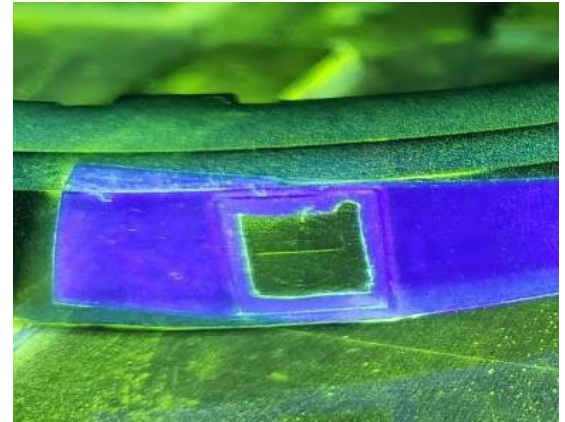
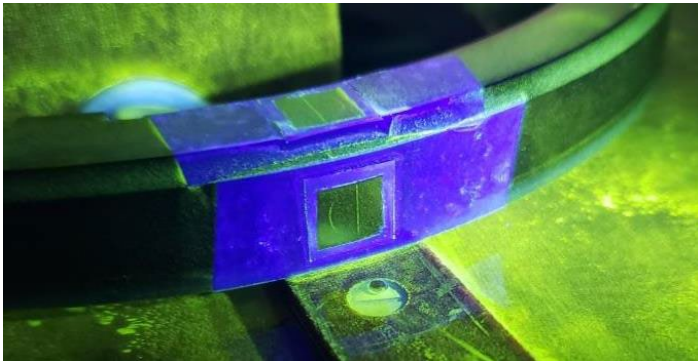
# Inspection Sequence



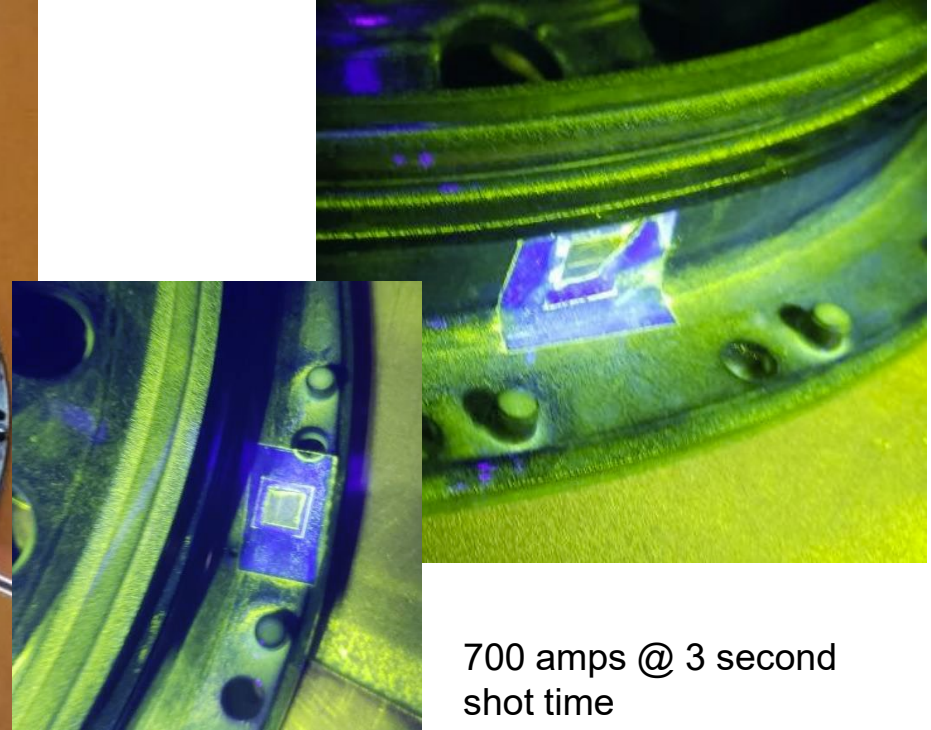
1. Split coil



2. Flat coil

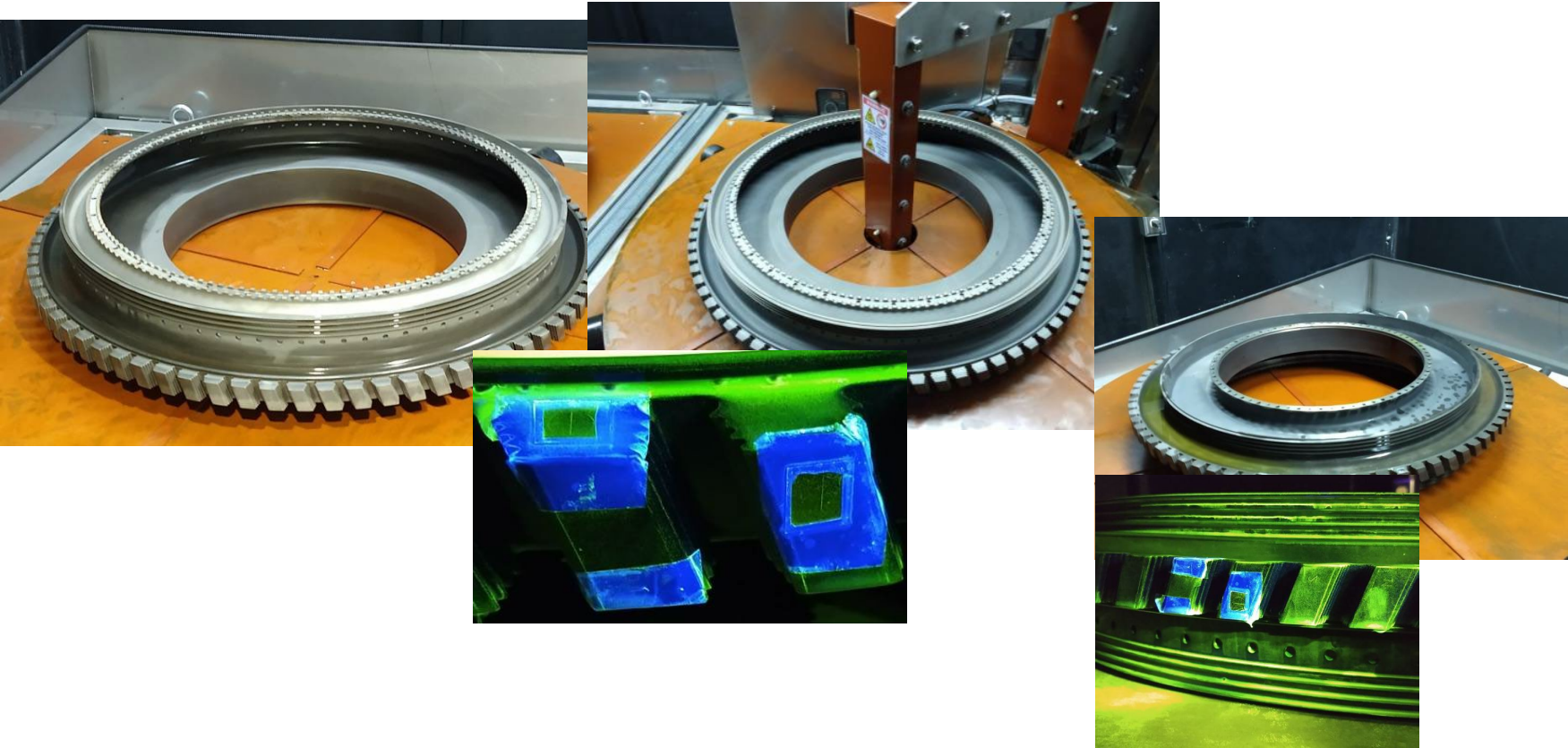


# RB211 Turbine Bearing Inner Race



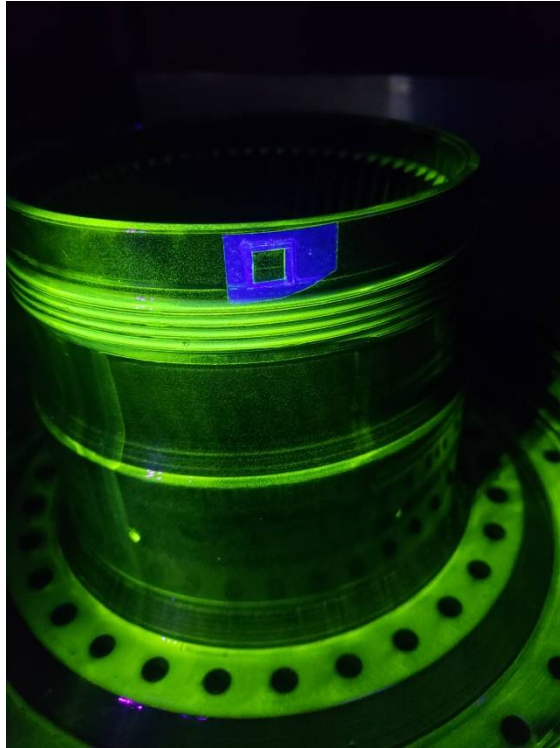
700 amps @ 3 second  
shot time

# LP Turbine Disc





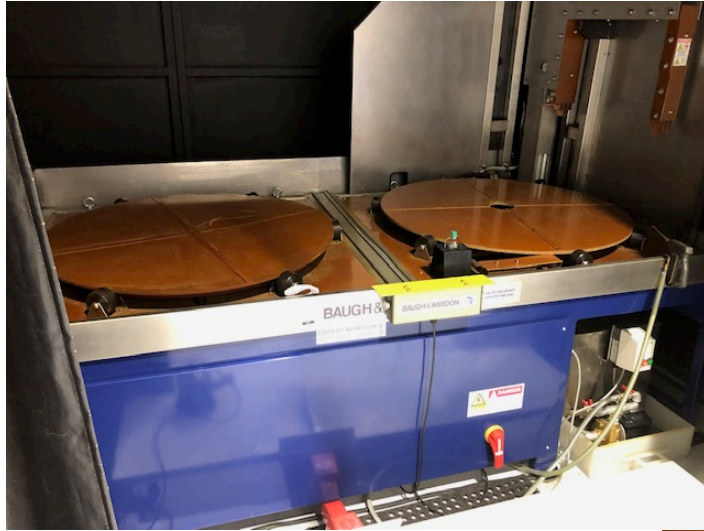
- While inspecting gears, discs and flanges the effective vertical height of the field will generally be a limited distance of a few inches. When performing the inspection it is necessary to flip the part in order to inspect each side (top/bottom). Generally there are no formulas to be used, and QQI's are required to determine adequate field strength and orientation.



Field extends  
approximately 6.5”  
vertically from the  
base of the spiral coil  
on this particular part.

- ASTM E 1444 and E 3024 require scheduled (daily) systems performance checks for magnetic particle equipment. These checks are generally referred to as “Process Controls”.
- Next editions of ASTM Standards are slated for later this year (Nov?) with several changes – (no formulas?)
- If you like to use the empirical formulas you can still find them in ASTM E 709
- No current references for flat-spiral (pancake) coils.

# The Equipment:



# Process Controls for Flat Spiral Coils

- Not referenced in ASTM, other than what is common for any Magnetic Particle test process.
  - Settling test
  - Contamination
  - UV light intensity
  - White light intensity
- Calibration is similar to other conventional coils; ammeter, timer, etc.

