



A4A NDT Forum 2019 Long Beach

Magnetic Particle Inspection of Low Pressure Turbine Shafts

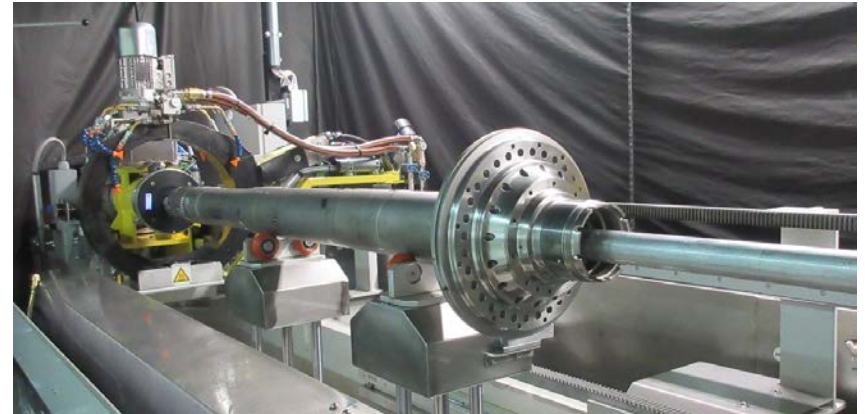
Christian Kalbfell | Lufthansa Technik AG | Engine Services | Sept. 2019



Lufthansa Technik

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Lufthansa Technik Group – Facts & figures

850+ 
customers
worldwide



23,219
employees
worldwide*

 5,131
aircraft under
exclusive contracts

 5.918
billion €
in revenue*

 36**
subsidiaries and
affiliates worldwide

*Lufthansa Technik AG Germany and 21 consolidated companies of Lufthansa Technik Group in 2018; employees as of 31.12.2018; **XEOS is in preparation

Lufthansa Technik Product Division Engines – Our locations



Lufthansa Technik Turbine Shannon

Components for HPT & LPT,
turbine vanes
and shrouds



Lufthansa Technik HAM, FRA, BER

CFM56-all, CF6-80C2,
PW4000, V2500,
GENx-2B (QT), GTF (ETR)



XEOS Wroclaw

GENx-2B
Planned: GE9x



Ameco Beijing

PW4000, RB211, V2500



Lufthansa Technik Shenzhen

Mobile Engine Services, Lessor
Services/ Engine Storage,
Common Nozzle,
Tail Cone, Engine Mount



BIZJET®

Mobile Engine Services,
Spey/Tay, Teardown



Lufthansa Technik AERO Alzey

CF34-3, -8, -10,
PW100, PW150



N3 Engine Overhaul Services

Trent 500, 700, 900, XWB



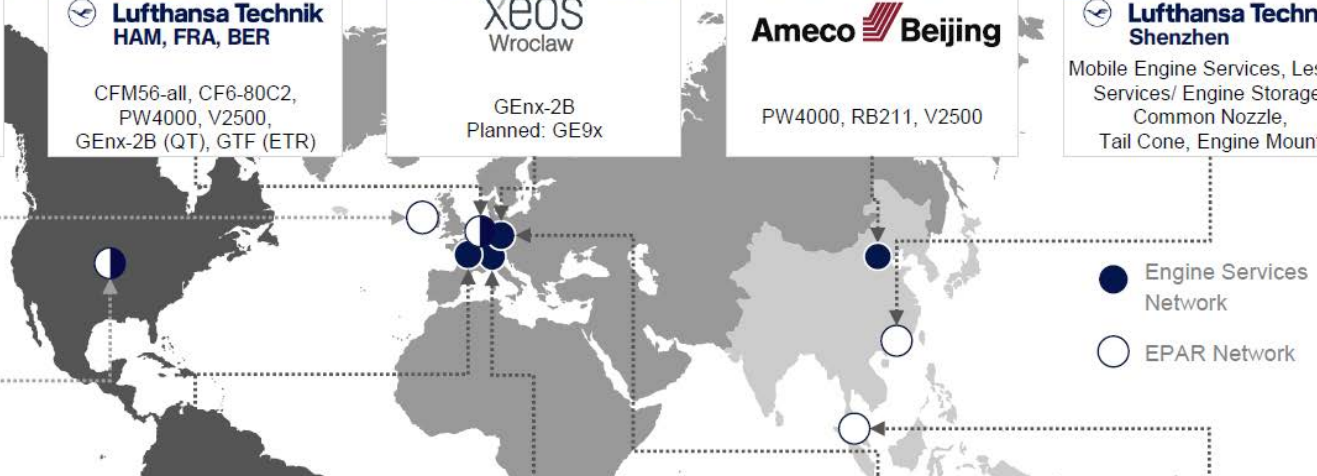
EMEAERO Rzeszow

In preparation: GTF



AIRFOIL services

HPC blades, vanes
and LPT blades



Lufthansa Technik

Product Division Engines

Turnover of
Engine Services:
2,900 million



33.000 Engine and APUs
overhauls in over 60 years
More than 1.000 overhauls in 2018



Material stock in 2018:

~ 500 m € and



~100 spare
engines



Number of
employees:
4,600*

11 Engine Services facilities and
7 test cells around the world
for ~40 engine
and APU types



Parts manufacturing approval
and design agency

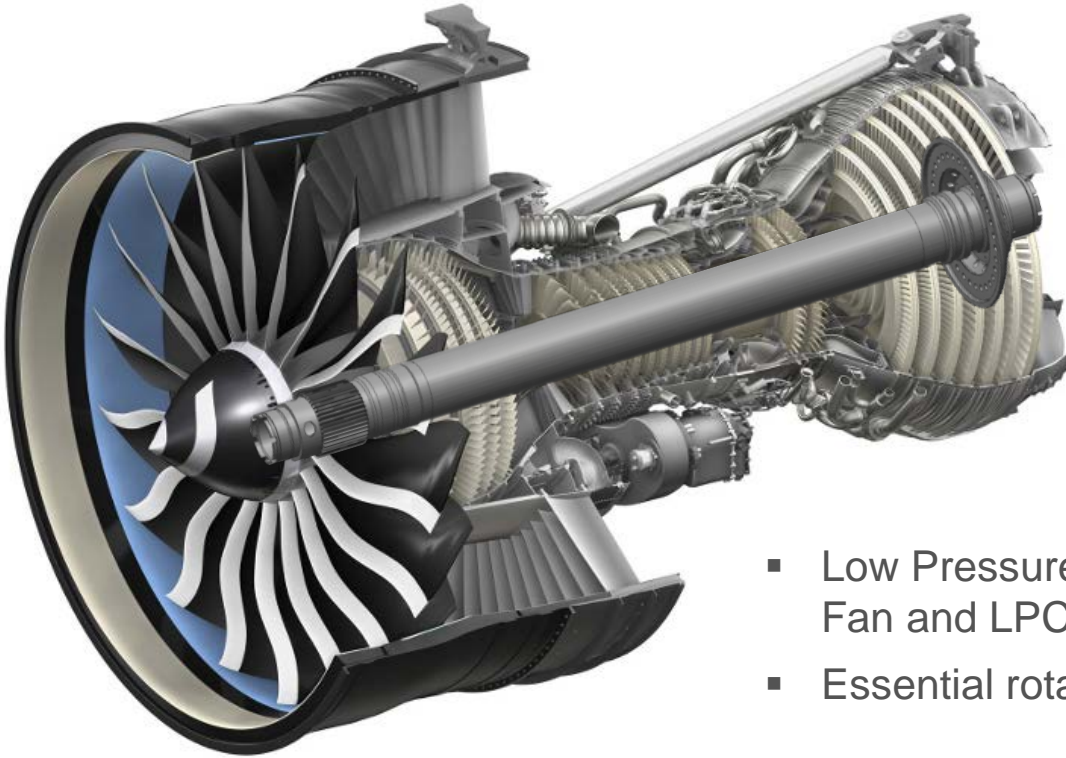
Repair station certificates
from 35 countries

Certified by FAA
and EASA

* as of 31.01.2019

Low Pressure Turbine Shaft - Introduction

Where to find the LPT Shaft in the engine?



- Low Pressure Turbine Shaft connects Fan and LPC with LPT
- Essential rotating part in jet engine

Setting up MPI for LPT shafts

All instructions we have:
Do a magnetic particle
inspection of the LPT Shaft

i.a.w. Engine Manual,
Standard Practice Manual,
ASTM Standards,
etc.



- ➔ Possibility to inspect the LPT Shaft from inside
Using UV-light endoscope for inspection of inner part surfaces
- ➔ Need of a known defect LPT Shaft
Manufacturing of representative cracks into a LPT shaft
for substantiation and parameter development

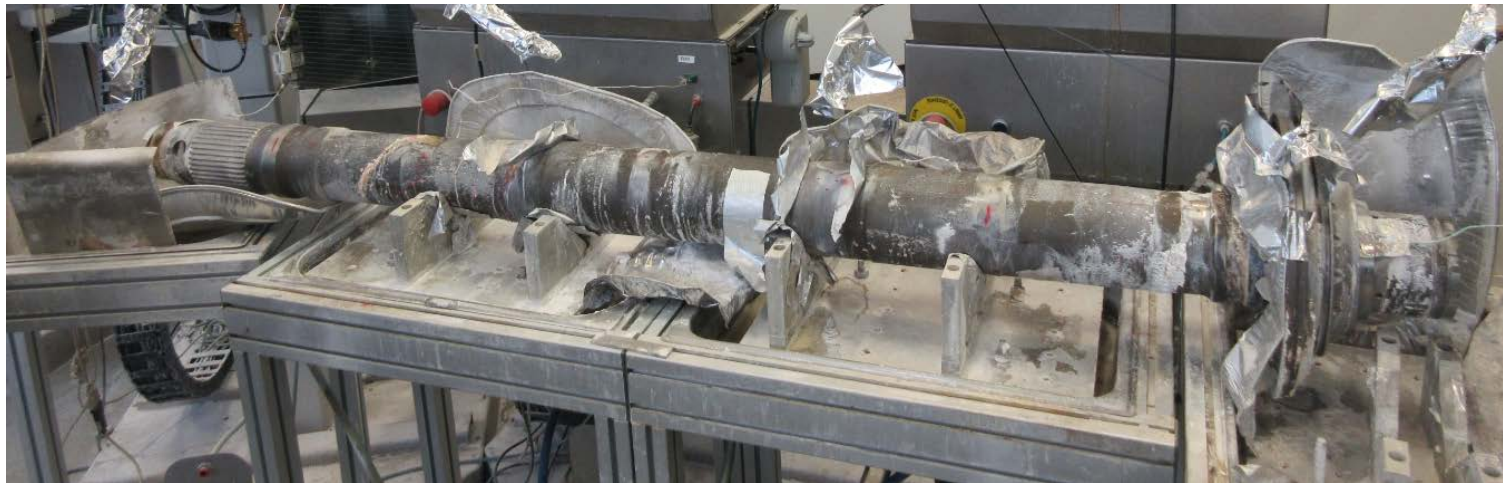
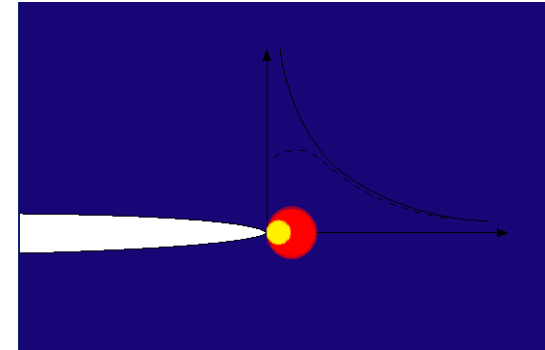


Setting up MPI for LPT shafts

Cracks with in-situ thermal fatigue

Real fatigue cracks manufactured caused by thermal fatigue

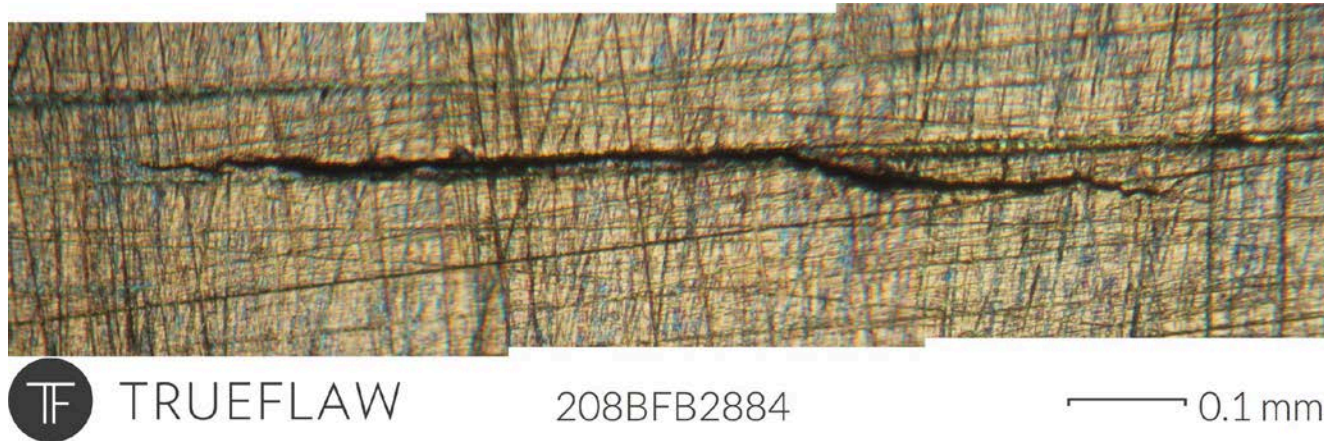
- Repeated heating and cooling
- Thermal stresses
- Fatigue
- Cracks



Process of real fatigue cracks manufactured into the shaft

Setting up MPI for LPT shafts

Real cracks are necessary

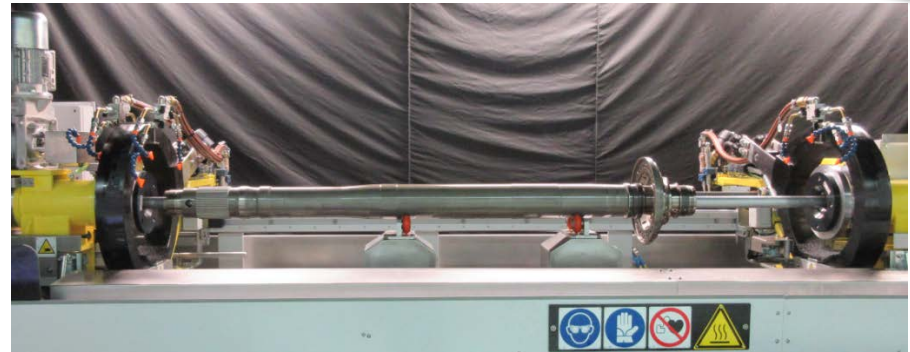
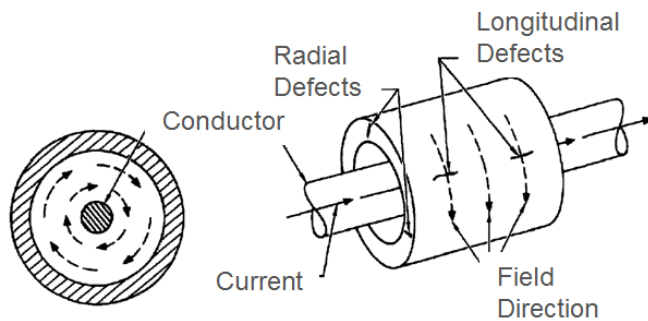


- In developing new methods and application solutions
 - ➔ to see what the method can really do
- In training and maintaining proficiency
 - ➔ to let inspectors know what to look for
- In reliability analysis and performance demonstration
 - ➔ to get reliable and realistic estimates

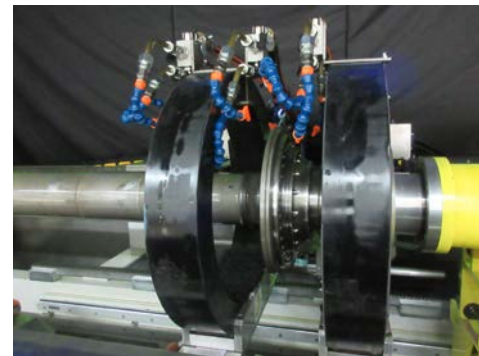
Setting up MPI for LPT shafts

- Step 1 - Circular magnetization by concentric central conductor of inner part
- Step 2 - Circular magnetization by concentric central conductor of outer part

Using full-wave
rectified
alternating
current-FWAC
monophase



- Step 3 - Circular magnetization of flange area

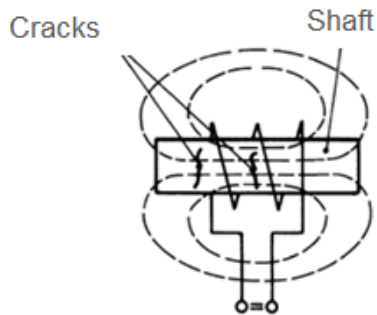


- Step 4 - Demagnetization of the part

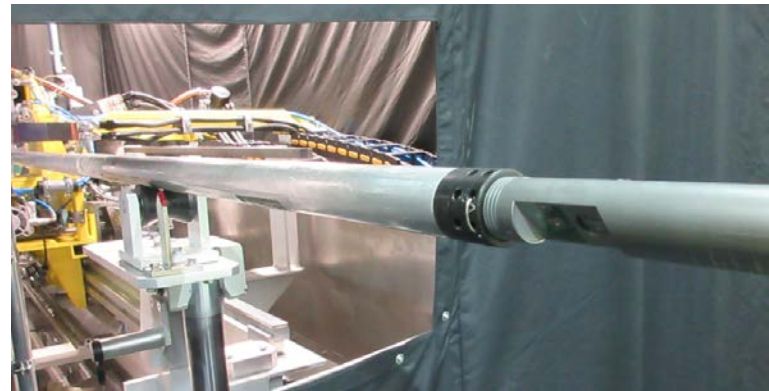
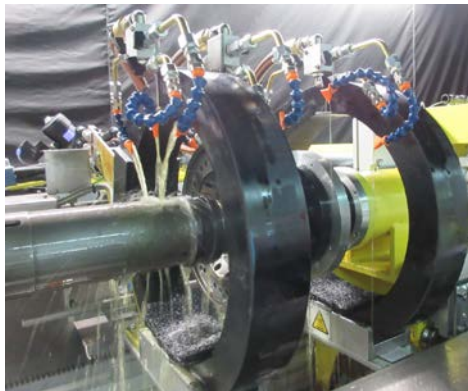
Setting up MPI for LPT shafts

- Step 5 - Longitudinal magnetization by coil of outer part

Using full-wave
rectified
alternating
current-FWAC
monophase



- Step 6 - Longitudinal magnetization by coil of Inner part



- Step 7 - Longitudinal magnetization by coil of flange area
- Step 8 – Demagnetization of the part

Setting up MPI for LPT shafts

- Sample cracks and other defects on the LPT shaft

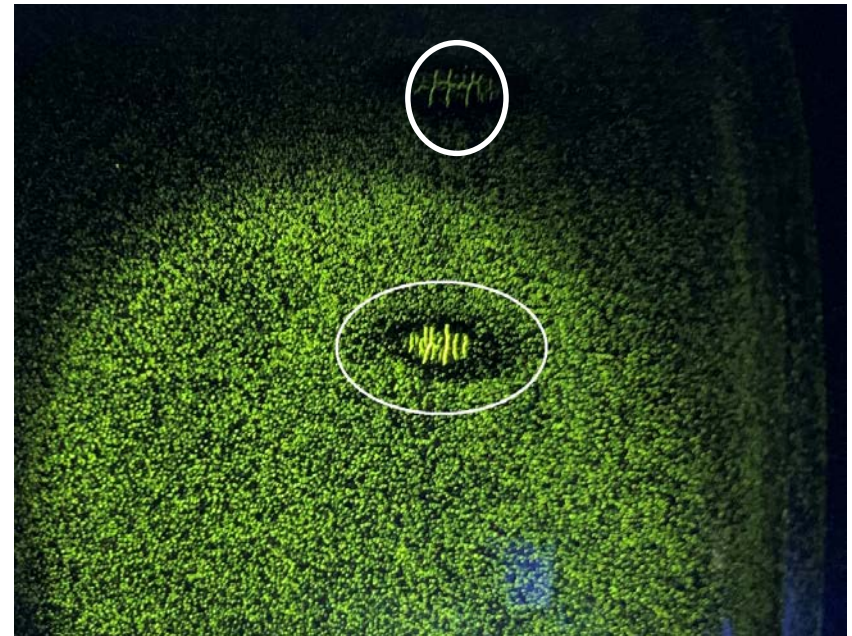
Longitudinal crack orientation after circular magnetization



Setting up MPI for LPT shafts

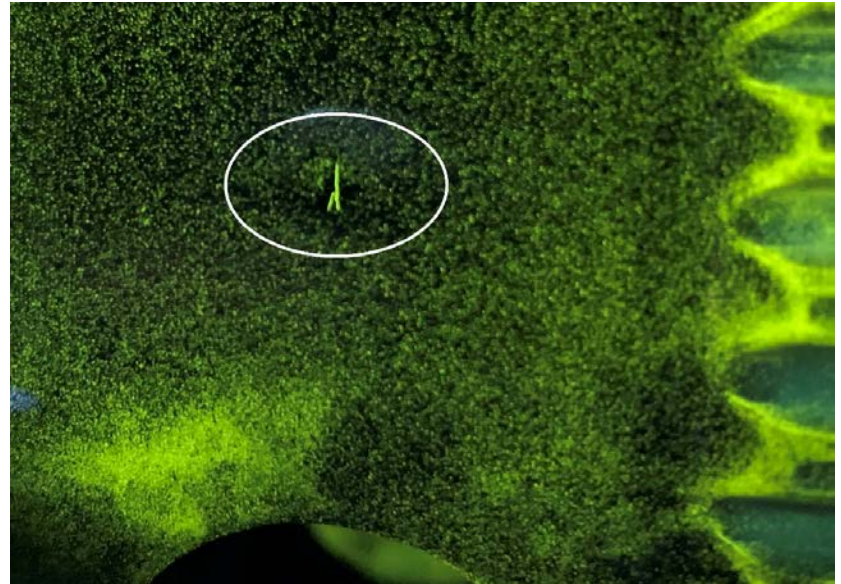
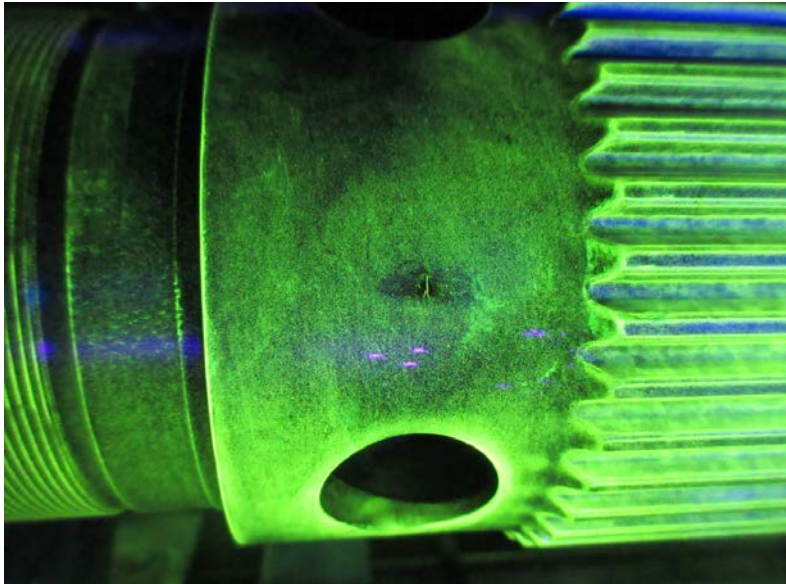
- Sample cracks and other defects on the LPT shaft

Longitudinal and circumferential crack orientation after magnetization



Setting up MPI for LPT shafts

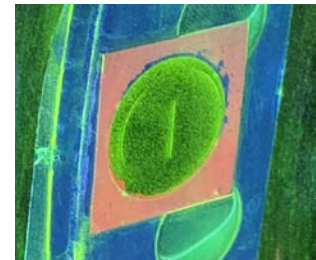
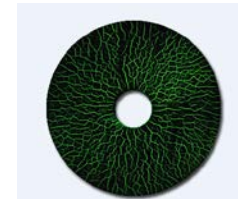
- Sample cracks and other defects on the LPT shaft
circumferential crack orientation after longitudinal magnetization



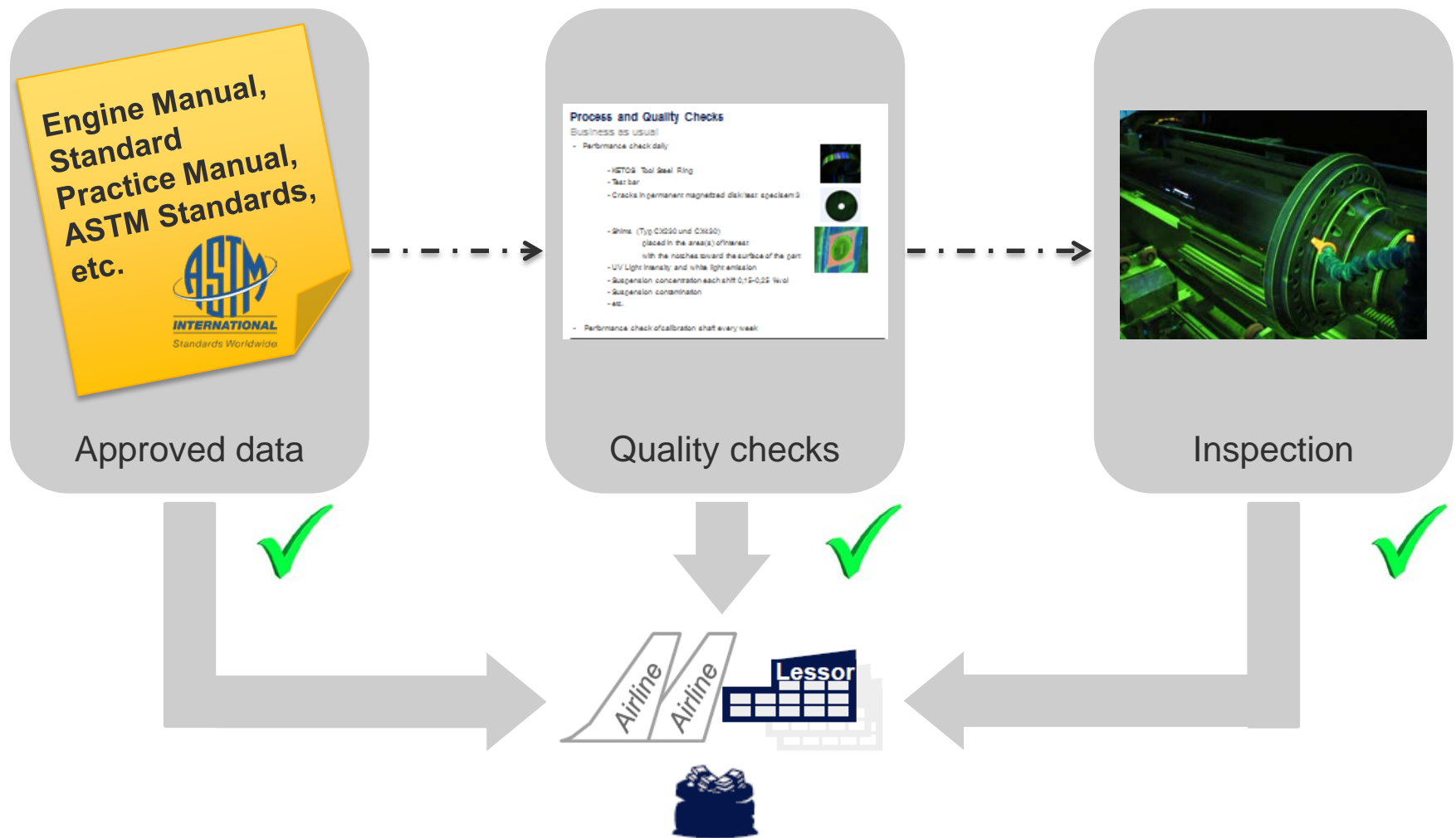
Process and Quality Checks

Business as usual - ASTM E 1444, ASTM E709

- Performance check daily
 - KETOS Tool Steel Ring
 - Test bar
 - Cracks in permanent magnetized disk/ test specimen 3
 - Shims (Typ CX230 und CX430)
 - placed in the area(s) of interest
 - with the notches toward the surface of the part
 - UV Light intensity and white light emission
 - Suspension concentration each shift 0,15-0,25 %vol
 - Suspension contamination
 - etc.
- Performance check of calibration shaft every week



Magnetic Particle Inspection of LPT Shafts



- Need of real cracks is essential – for setting up this MPI, calibration shaft is a big advantage

Thank you for your attention.

Any questions?

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