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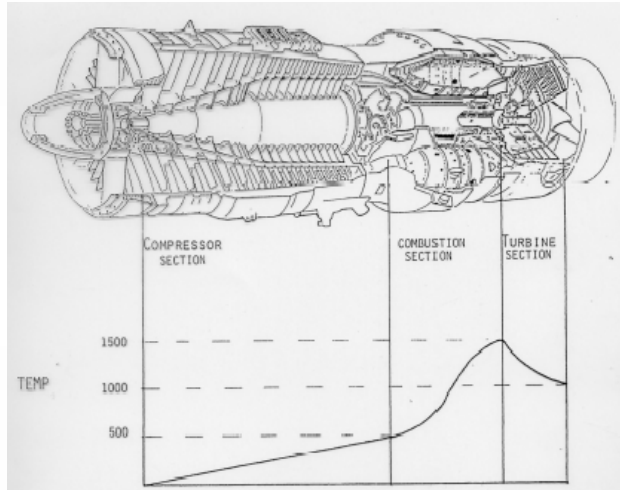
Presentation is based on:

“Six steps to successful repair of GT components”
 Hans van Esch

- Step 1 How to assess the condition of GT parts onsite
- Step 2 Preparing meaningful component repair specs
- Step 3 Selecting the appropriate repair vendor
- Step 4 Vendor Verification: Incoming inspection
- Step 5 Vendor Verification: Work In Progress
- Step 6 Vendor Verification: Final Inspection

Reference: Combined Cycle Journal 2Q/2005, 3Q/2005, 4Q/2005 and 1Q/2006

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- Receiving**
- Cleaning / Stripping**
- Inspection**

- Heat treatment**
- Welding**
- Brazing**
- Blending / Machining**

- Coating**
- Final inspection**

Defined repair specs – Step 2

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Receiving
 Cleaning / Stripping
 Evaluation of condition
 Defining workscope
 Heat treatment
 Welding
 Brazing
 Blending / Machining
 Inspection
 Coating
 Final inspection

Verification / Step 4 - 6

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Bidding process

WIP

Release for repair

WIP

WIP

WIP

WIP

WIP

Release for coating

WIP

Release for shipment

Receiving
 Cleaning / Stripping
 Evaluation of condition
 Defining workscope
 Heat treatment
 Welding
 Brazing
 Blending / Machining
 Inspection
 Coating
 Final inspection

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CONCLUSIONS

Different repair facilities
New, sold, closed or relocated

Technology and experience

Changing human resources
Internal
External

Competitive pricing

Fast growing company

Learning curve and history

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STAGE 1

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CONCLUSIONS

AUDITS:
Technical Audits
Knowledge
Capability
Expertise
Quality Audits
Environmental Audits



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CONCLUSIONS



VENDOR VERIFICATION:

- Compressor blades diaphragms
- Liners and transition pieces
- Nozzle and Vane Segments
- Buckets and Turbine Blades
- Compressor and Turbine Rotors



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STAGE 2

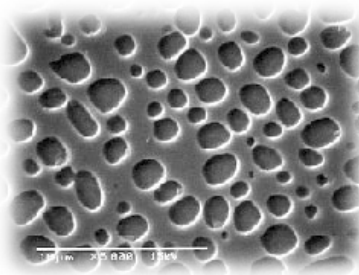
STAGE 3

CONCLUSIONS



METALLURGICAL EVALUATIONS:

- Incoming Inspection
- Life Assessment
- Coating qualifications
- Failure Analysis
- Mechanical testing
- Corrosion testing



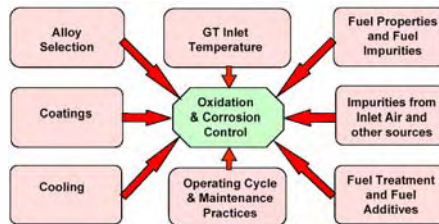
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Participants should be able to:

Recognize degeneration of IGT gas turbine components.

Select the proper repair and coating technology to reverse this effect.

Create an action plan to refurbish (repair and coat) these components, with proper heat treatments and in the right sequence.



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First Day

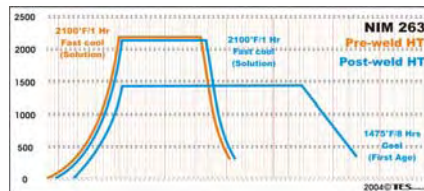
General metallurgy, Superalloys and heat treatments

Second Day

Degeneration, coating, and cleaning and stripping

Third Day

Welding, brazing and Non Destructive Testing



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OTHER:

- Component assessment
- Component management
- Repair specification development
- Quote development
- Literature investigation
- Research and development



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CONCLUSIONS



Sulzer Elbar:

- Metallurgical evaluations
- Coating development: Diffusion, Air and Thermal Spray
- Heat treatment development (HIP)
- Weld procedure development (IN 939)
- Clean and Stripping development (FCC)
- Brazing development

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CONCLUSIONS 



Hickham – Elbar / Sulzer Hickham:

Engineering and metallurgy

Inspection

ISO 9001

Production

Sales, Marketing and Business development

HICoat

Development: Brazing, coating

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Chromalloy Holland:

Production

Coating (Diffusion and thermal spray)

Brazing (Honeycomb)

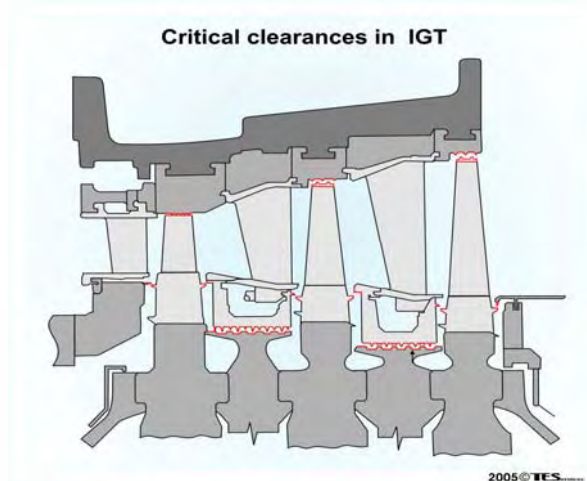
Welding (EB – welder)

Machining (Laser)

Heat treatment (training course)

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Checking Dimensions



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Checking Dimensions



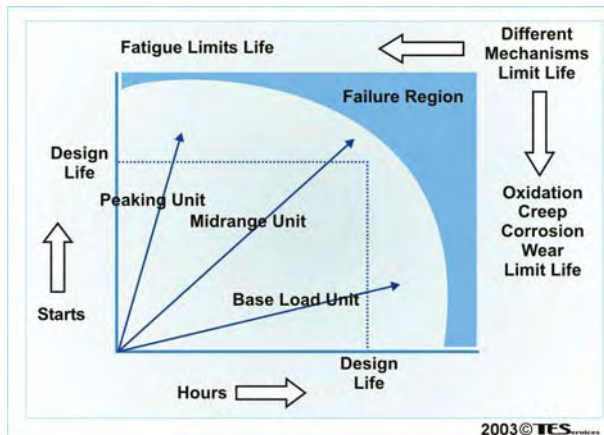
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Visual Inspection



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Operating History



2003 © TES services



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Operating History

Base load operation **Cyclic operation**

Stress rupture **Thermal Mechanical fatigue**

Creep deflection **High cycle fatigue**

High cycle fatigue **Rubs / wear**

Corrosion **Impact damage**

Oxidation

Erosion

Rubs / wear

Impact damage



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Component History

End-user:
Part traceability

Part history:
Operation
Refurbishment



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CONCLUSIONS



Checklist **per component per engine type:**

- Dimensions to be checked
- Inspection of surface (coated and un-coated)
- Wear**
- History operating
- History components

Frame 6 users group

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CONCLUSIONS



Repair / bid specifications based on:

- Dimensional and visual inspection
- History of operation - components

Repair specifications based on

- Previous
- Others end-users
- End-users organizations

Frame 6 users group

Independent consultancy

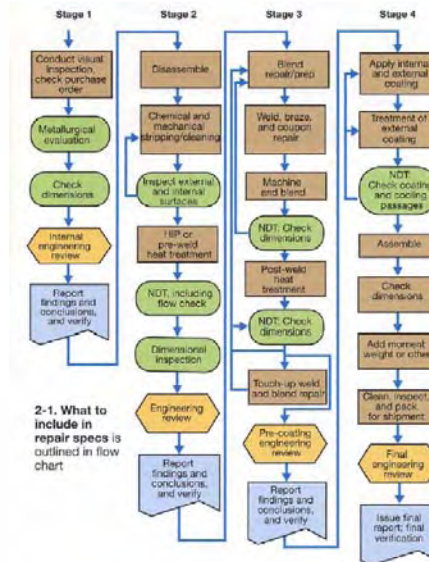
No repair or coating vendors

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Repair / bid specifications including:

- Cleaning and stripping
- Inspection (NDT and dimensional)
- Metallurgical evaluation
- Heat treatment
- Engineering review and reporting
- Verification
- Weld, braze and coupon repair
- Coating
- Options

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Reference: Combined Cycle Journal 2Q/2005

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Commercial impact

Technical impact

Quality impact

Delivery time impact



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CONCLUSIONS

What is included and what not
Options

Which methods are allowed
Which are not

Which standards to be used

Feed back
Verification stops
Access



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Criteria:

Stage 1

Experience and reputation

Stage 2

Technology and sub-contracting

Stage 3

Human resources and management system



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Engine model:

6A / 6B / 6C / 6FA

Component:

Compressor / Combustion / Turbine

Rotating / Non-rotating

Spare part

Base material / Coating / Cooling

Operation:

Baseload – Peeking

Availability



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Engine general:
 Field service
 Overhaul rotor

Component:
 Inspection
 Metallurgical evaluation
 Failure analysis
 First article repair and coating
 Reference list

Note: Comparable models, design, material coating and/or cooling systems

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Component:

- Reference list**
- Work scopes**
- Procedures**
- Specifications**
- Inspection forms**
- Fixtures - Qualification**

Note: Comparable models, design, material coating and/or cooling systems



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Check (former) customers:

- Communication**
- Quality**
- Adders**
- Resolving quality issues**
- Delivery time**
- Documentation**

Note: Try to find customers who experienced (quality) issues



Stage 1: Experience and reputation

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General assessment: Experience and Reputation (For specific engine and components)

	Points		
	1	3	5
Field service experience	Similar unit	< 3	> 3
Overhaul performed	Similar unit	< 3	> 3
Performed incoming inspection part	< 2	< 5	> 5
Performed repair on part	1	< 5	> 5
Fixtures available for your specific components (inspection, repair and coating)	In development	Available	Qualified
Performed coating on part	1	< 5	
Technician / supervisor with company (the person who will direct your repairs)	> 2 year	> 4 years	> 8 years
Quality as seen by customers	Not meeting specifications	Not meeting expectations	Meeting both Specs and Exp.
Resolving quality issues	Not willing, To be forced	Willing but slow	Pro-active, highest priority
Delivery time	Within 2 weeks as promised	Always on time	
Documentation of the repair and coating	Critical inspection steps	Summarized and complete	Summarized-complete-digital

Reference: Combined Cycle Journal 3Q/2005

Stage 2: Technology

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NDT:

VT	Visual
PT (LPT)	Red dye - Zyglo
MT	Magnetic particle
RT	X-ray
UT	Ultrasonic
RT	Eddy current

Note: Qualification and experience

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Metallurgical:

- Visual Microscope
- Scanning electron microscope
- Mechanical testing

Dimensional:

- Conventional measure equipment
- CMM and other
- Calibration

Note: Experience engineers
Organization / authority

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Welding:

Technology:

- GTAW / PAW / Laser / EB welding
- Qualification process
- Qualification / training welders
- Quality control

Brazing:

- Qualification process
- Process
- Training technicians
- Quality control

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Machining:

Conventional equipment
Other: CMM / EDM / Laser
Training machinist
Quality control

Blending / gritting:

Equipment
Training blenders
Quality control (heat tint)



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Chemical stripping:

Qualification process
Process
Training technicians
Quality control

Coating:

Qualification process
Process
Training technicians
Quality control



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Heat treatment:

Vacuum furnace
 Training technicians
 Quality control

Qualification and calibration:

Furnace survey and thermocouples
 Criteria and process based on:
 MIL, NadCap, AMS, ARP

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Stripping and cleaning
 Heat treatment
 NDT and flow testing
 Machining
 Welding
 Brazing
 Coating (thermal spray and diffusion)

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Audit
Process defined
First article review
P.O. covers what needs to be performed
Certification and other quality records
Incoming inspection
Access

Dispute: who is responsible and will take responsibility

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General assessment: Technology and sub-contracting			
	Points		
	1	3	5
NDT: VT, LPT, UT, MT, RT, UT, ET	Technologies < 3	Technologies < 5	Technologies > 5
Metallurgical laboratory (experience engineer)	Qualified vendor > 10 years exp.	Internal > 3 years exp.	Internal > 10 years exp.
Stripping (similar coating – base material – design)	Qualified vendor > 10	Internal > 5	Internal > 10
Heat treatment Vacuum	Qualified vendor (NedCap – ISO)	Internal	Internal (NedCap – ISO)
Heat treatment Controlled atmosphere and other	Internal	Internal (NedCap – ISO)	
Weld repair, TIG - Plasma	> 1 year	> 3 years	> 5 years
Weld repair, Plasma or EB welding	Qualified vendor > 5	Internal > 3	
Weld method / application qualification	Performed	Performed per ASME Section 9	Up-to-date per ASME Section 9
Braze repair	> 2 year	> 4 years	> 8 years
Braze method / application qualification	Performed	External qualified	Published
Machining Conventional, CNC, EDM or laser	Conventional	And CNC	And EDM or laser
Coating: Thermal spray	Qualified vendor > 5 years exp.	Internal APS – HVOF > 3 years	Internal Robotic appl. > 5 years
Coating: Diffusion:	Qualified vendor > 5 years exp.	Pack segm. > 3 years exp.	True CVD > 3 years exp.

Reference: Combined Cycle Journal 3Q/2005

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Inspectors according ASNT:
Level I / II / III

Welders according ASME Section 9:
Adapted for repair
Per material type

Blenders training program:
Ability and years of training

Coating operators:
Formal and on the job training

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Metallurgical
Years of experience required

Mechanical
Reverse engineering
Repair versus new parts

Process:
Welding
Brazing
Coating

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Direct material:

Core-plugs / coupons

Weld wire

Coating powder

Quality:

Specification

P.O.

Verification before use

Traceability

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Who created the workscope

Who can change the workscope

Is the workscope reviewed during WIP

How defined is workscope

Is the workscope signed off (per batch)

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Who created the procedure
Who can change the procedure
Who approved the procedure
Is the procedure a controlled document
Who has access to procedure
Is the procedure known on the floor



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Change of organization:
 Ownership, location and manager
Organization Chart:
 Present, up to date and used
Job description:
 Present, up to date and used
Quality manual:
 Present, up to date and used
Quality system (ISO / NadCap)
 Internal / external auditors
 > 5 years



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General assessment: Human resources and management system

	Points		
	1	3	5
Last time organization changed (relocated, ownership, management)	> 2 year	> 4 years	> 8 years
Organization chart	Present	Present Up to date	
Job description	Present	Present Up to date	
Quality manual	Present	Present - Up to date	
Quality system audited (ISO – NadCap – Etc.)	Internal auditors	External auditors	External auditors > 5 years
Procedures (weld-coat-inspect)	Present	Present Up to date	Being used
Work scopes	Present	Present Up to date	Being used and signed off
Direct material (replacement parts – filler/coating material)	Order requires certification	Verification	Traceability
Sub-contractors (heat treatments – coating – shot peening)	Vendor audited	First article verification	Verification work performed
Engineering department (mechanical – metallurgical – process)	1 > 10 year exp.	3 > 10 years avg.	5 > 10 years avg.
Inspection department VT, LPT, UT, MT, RT, UT, ET	1 - Level II > 3 years/discpl.	3 - Level II > 5 years/discpl.	> 3 Level II/III > 5 years/discpl.
Welding	>2 welders >3 avg exp.	>5 welders >5 avg exp.	5 welders >5 y. Qualified
TIG experience and qualification per material			
Blenders	2 blenders >3 years	>2 blenders > 5 years	
Coating Operators	2 operators >3 years	>2 operators > 5 years	Robotic 2 operators >5 y

Reference: Combined Cycle Journal 3Q/2005

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In 6 steps:

**Onsite access – Specifications – Selection
Verification: Incoming – WIP – Final**

Repair and coating:

**Focused on degeneration past and future
Defined requirements and expectations
By a facility that can meet the requirements
and expectations against an attractive
compensation.**

**Ensure that requirements and expectations
are met.**

INTRODUCTION

Checklist **per component per engine model.**

TEServices

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Specifications and criteria **per component per engine model.**

STEP 2

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Make use of other end-users, end-users organizations and consultancies.

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CONCLUSIONS



INTRODUCTION

Create a checklist **per component per engine model.**

TEServices

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Create a repair and coat specification **per component per engine model.**

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Select and audit repair facility **per component per engine model.**

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Frame 6 users group



Step 1, 2 and 3 together

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CONCLUSIONS



Review degeneration onsite **per** end-user for each component.

Create a checklist **per** component **per** engine model.

Generate repair and coating specifications **per** component.

Select and audit repair facility **per** group of components.

TEServices can provide above services for \$17,500 **per** end-user **per** engine model, based on a minimum of 3 end-users.

Advantages being pro-active

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CONCLUSIONS



O.E.M. will become more responsive:

Cost saving

Faster delivery time

OEM has to justify their decisions

Creating more FS 6 component repair vendors:

Cost saving

Better service

Better repairs and coating

Improving repairs and component:

Better understanding degeneration

More options for repair and coating

Components will last longer or require less expensive repairs and/or coatings