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### Gas Turbine Failure Analysis – Consultancy Support

The engineers at [Oswald Consultancy](http://www.oswald.co.uk) have many years of expertise in the UK gas turbine industry, primarily working for Rolls-Royce, GEC, and more recently as independent consultants. From our team of experts, we build specialist teams capable of solving the most challenging gas turbine failures. Our expertise includes in-service operation, repair and overhaul, design, development of turbines operating in the all three sectors: electrical generation, oil & gas and marine. We find most failure investigators concentrate their work on metallurgical inspection of failed components, which is certainly very important, we also consider any failure that may have occurred across the whole gas turbine system; for example there can be interactions between control, flow, fuel etc. We like to work and resolve the most difficult failure challenges.

It is not possible to give full details of the investigations we have completed as these are carried out under confidentiality agreements. However, the following table gives a simple summary. We have worked in many countries around the world.

In service failure investigations:

Year	Description		System understanding	Stress Analysis	Design	Fluid Flow	Metallurgy	Manufacture	Controls	Combustion	Noise test
1993	Turbine blade high cycle fatigue	Mid East	✓	✓	✓	✓	✓	✓	✓	✓	✓
1996	Exhaust vibration fatigue, Cogen	Canada	□	□	□	□	□	□	□	□	□
2002	Noise - CCGT	China	✓	✓	□		✓				✓
2004	Gearbox failure	Portugal	□	✓	✓		□				✓
2005	Excessive noise - GT package	UK	□	✓	✓		□				✓
2006	Combustion hot section, fatigue cracking, repeated failures.	UK, USA	✓	✓	□	✓	✓	✓			
2010	GT, fuel escape, explosion	UK	✓	✓	✓	✓	✓	✓	✓	✓	✓
2012	GT vibration leading to trips	UK	✓	□	✓	□	□	□			
	Who:		Jim, Mark, Nick	Jim, Mark	Jim	Nick, Jim	Sub-con	Peter	Adrian, Jim, Mike	Bryn	Bryn

All of the above prevented gas turbine operation, and are hence classed as failure cases.

## The approach

With any large failure investigation there is always too much information and this needs to be filtered into a manageable form and sifted for important evidence. Failures can lead to many outcomes including loss of performance, poor engine control, excessive noise and vibration, excessive exhaust emissions or structural failure leading to loss of availability. Cracking and metallurgical failure is perhaps the most common failure type we are asked to investigate. Typically for an investigation into structural failure we would follow the following steps:

1. Obtain metallurgical evidence of the fracture surface and identify if the cracking is caused by creep, fatigue, vibration, etc.
2. Complete a Finite Element Analysis (FEA) of the failed component and identify loads that could lead to the cracking observed.
3. Carry out detailed review of the engine history including operational and maintenance records and strip reports detailing past failures.
4. Once these assessments are complete it is necessary to consider and assess different failure hypotheses. This involves looking for a failure pattern
5. Once this is completed (and it can be a hard road) one or two hypotheses come to the fore and these stimulate new ideas and force the investigating team to return to the historical records and look for supporting evidence.
6. Even when the team is convinced the failure cause has been proven it is not the end of the journey, as the last stage is to take the case to the client's management team and explain and justify the case. This can be a crucial time as evidence will be challenged and questioned before the argued case is accepted.

To sum up, it takes a calm, creative and highly experienced engineering team to find the solution to the most challenging gas turbine failures. These investigations can be very taxing and undertaken at time of significant stress on the customer and on us.

## The team

The core team used on gas turbine failure investigations is:

		Years Experience
<b>Jim Oswald</b>	Expert in stress, design and development. Background in design, innovation, stress analysis and project management, covering over 30 years	35
<b>Bryn</b>	Expert on gas turbine combustion. Bryn has a background in aero and industrial combustion research covering over 30 years.	40
<b>Mark</b>	Expert on acoustics and stress analysis. Background in industrial gas turbine stress and acoustic analysis covering over 20 years.	30
<b>Pete</b>	Expert in manufacturing methods and management in the gas turbine industry, covering over 30 years.	40
<b>Dr Hezlin Ashraf-Ball</b>	Senior Research Engineer at Oswald Consultancy with PhD in Chemical Engineering and expertise in heat transfer.	6
<b>Nick Vanter</b>	Engineering Consultant. Expert in fluid flow, system understanding and modelling. Excellent team leader.	15
<b>Adrian</b>	Expert in controls. Programme management leader.	20

On particularly large tasks we may call on additional external expert support including: specialist metallurgical support, additional Finite Element support, any customer's preferred advisors.

If you have a gas turbine failure problem and would like some professional support then please contact us at <mailto:info@oswald.co.uk>

## Failure Investigation Course

If you wish to carry out your own investigations, but develop your engineering you team, you could consider our 4 day training course.

Delegates learn:

- How to think through gas turbine failure sequences
- What information to request and what to investigate further
- How to avoid misleading information
- Formal methods including Fishbone and Sequence of Events diagrams
- Relevance and understanding of creep life, fatigue life and compressor surge
- How to use metallurgy reports

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