



Aviation Material Failure Analysis

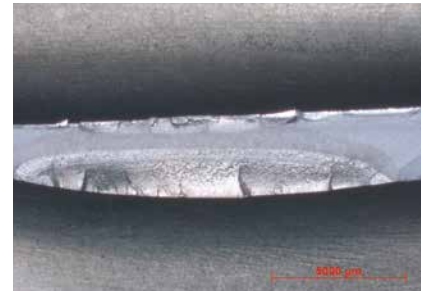
Lufthansa Technik operates a one-stop shop for MRO Laboratory Services covering analytical investigations across all aviation materials. To identify the causes of failures, a comprehensive range of analytical investigations is available advising on the failure mechanism and on future damage prevention.

Aviation materials are exposed to unique stress and aging profiles during flight operation, for instance during takeoff or at high altitude. These conditions can cause damage and failures. Lufthansa Technik offers a broad range of investigations into defective or damaged aircraft parts for the purpose of identifying the cause of failures and damage. On the basis of the results the material expert team is able to give advice on the failure mechanism, the prevention of future damage and process optimization.

The Lufthansa Technik Central Laboratories Service Team possesses extensive know how and over five decades of experience in material failure analysis dating back to 1960. With its state of the art metallographic/technological equipment the team of experts is able to conduct examinations to a high standard both on- and off-site.

The typical structure and modules of the Failure Analysis process in four steps, incorporating best practice recommendations from Association of German Engineers (VDI) guideline 3822 (Failure Analysis), are outlined on page 2.

If you have any special analysis requirements or would like us to perform a failure root cause analysis, please contact our Lufthansa Technik laboratory team. Together we will find a solution for an appropriate investigation approach. Please send your request and clearly labelled samples to the address below. Be sure to cover and protect the fractured surface carefully to avoid sample damage during transportation.



Fatigue mode fracture of a compressor blade



Fracture of a Safety Seat Belt by SEM



Cross section of crack formation in composite



Fine granular microstructure in metallurgical cross section

Contact

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Failure analysis procedure and modules

Module 1: Documentation of failure and record of failure history

The first step in a failure analysis is to document the failure symptoms. This entails:

- Preliminary documentation of the failure (e.g. starting point of fracture or crack)
- Collection of all material data
- Recording of the failure history. This provides background information that can help with identifying the failure mechanism

Lufthansa Technik's team of experts collects the relevant material and failure history data, for example,

- Material data description
- Component or system condition, e.g. time since overhaul (TCO) or time since inspection (TCI)
- Age of parts
- Surface features
- Workshop and manufacturing data
- Reference data

Module 2: Component investigation

The second step in a failure analysis entails the application of various destructive and nondestructive test and examination methods for the purpose of evaluating:

- Failure symptoms and characteristics
- Material composition
- Material macro- and micro-structure
- Chemical, physical and technological properties of the material and components
- Application parameters
- Structure examination
- Material standard determination/identification

Lufthansa Technik provides the specialist equipment necessary to perform these tests and examinations.

Examples of these tests are listed below:

- Energy Dispersive Analysis by X-ray (EDX)
- Optical Emission Spectroscopy (OES, ICP-OES etc.)
- Scanning Electron Microscopy (SEM) investigation
- Hardness tests (e.g. Micro, Nano/Fischerscope)
- Referential tests such as tension/torsion tests
- Fourier transform infrared spectroscopy (FTIR)
- Differential Scanning Calorimetry (DSC)
- Thermo gravimetric methods (TGA)
- Metallographic evaluations

Module 3: Result interpretation and conclusion

The next step is to evaluate the investigation results in context so as to determine their relevance in terms of failure causation

The evaluations are applied to:

- Actual/setpoint comparisons
- Hypothesis regarding the possible failure root causes and influences
- Failure correction and prevention measures
- Report documentation

Module 4: Failure report and documentation

In the final step Lufthansa Technik provides a detailed failure report

The report correlates findings and provides conclusive results, and if applicable, recommendation for improvement.

| How-to guide | Shipping address: | Substance labelling: |
|---|--|---|
| <p>If you are interested in trying our service, we suggest that you proceed as follows:</p> <ol style="list-style-type: none"> 1. Contact our Laboratory Service team for any question regarding your component and tribological system failure. 2. We will send you an estimate of the cost of performing your individual failure analysis. 3. We recommend that your samples are firmly sealed and clearly labelled. | <p>Lufthansa Technik AG Laboratory Services Material Failure Analysis Department HAM TQ/M-M Building 250, Room 241/Bhf. 36 Weg beim Jäger 193 22335 Hamburg, Germany</p> | <ul style="list-style-type: none"> • Component description • Customer/operator/part number • Material data • Component history (TT, TCO etc.) • Manufacturer <hr/> <p>Supplementary:</p> <ul style="list-style-type: none"> • Purchase Order • Contact information incl. e-mail address |