

Course ID  
**RCFA-ME**  
Course Duration  
**2-4 days**

Course Title  
**Root Cause Analysis of Component Failure: Understanding Human and Engineering Factors for Improved Product Performance**

**Related Courses**

- Root Cause Analysis of Systems Failure: A Comprehensive Workshop (RCFA, 4-5 days)

**Aimed At**

Design, test, and maintenance engineers; failure analysts; technical purchasing agents and supplier quality engineers; and engineering managers looking to integrate the lessons of failure analysis into a more comprehensive design operation, and procurement process.

**Group Size**

5-25 for the tutorial and 5-15 for the workshop. For the larger groups who need a workshop, a team-taught version is also available.

**Prerequisites**

The standard presentation of this course assumes background in mechanical or materials (metallurgical) engineering. However, with some tailoring, the course can be understood by an audience with a bachelor's in any engineering discipline.

**Course in a Nutshell**

If you are a design, quality, or manufacturing engineer or manager, this course will help you realize the benefits you can receive from well-executed fracture analysis. If you are a more experienced fracture analysis practitioner, it will help you improve your ability to interpret and communicate the data provided by the tests that are typically performed during failure analysis.

In this course, we will study concepts and techniques that are useful for a very broad range of materials used in machinery and structural components (not electronic assemblies) that are subject to deformation, fracture, corrosion and wear. Given the importance of human factors in failure analysis, we will also devote about 20% of the course time to the discussion of difficulties inherent in the failure analysis process, personality characteristics and people skills that are helpful in this field, and the common thinking errors. You will receive tips and perform practice exercises that will help you avoid the common pitfalls and think more clearly. The workshop version of this courses uses extended real-life case studies to help you further apply the techniques taught in your own job.

### **Customize It!**

We can customize this course to meet your specific needs and concerns. Here are some of the ways in which we can tailor the course to help you get more out of it:

- *Are you interested primarily in metallic components subject to deformation and fracture?* We offer a version of the course that deals with wear, corrosion and high temperature applications. We also offer a version focused on steel and aluminum subject to fracture in ambient conditions.
- *Are you involved in an effort to expand your supplier base?* We can focus on how to address product requirements that typically do not show up on engineering prints or purchase specifications.
- *Are you interested in taking advantage of new materials?* We can help you understand what you need to know about evaluating polymeric materials, composites, or specialty metals that might substitute for the old standards.
- *Do you need to involve non-degreed technicians in your failure analysis efforts?* We can shorten the human factors discussion to focus more on the how-to fracture analysis techniques, giving the participants more time to practice the new skills.
- *Do you run a maintenance or reliability department?* We can focus on machinery components and include a section on specifying replacement components.

This course is offered in two versions: a two-to-three day fast-paced tutorial with a limited number of exercises and case studies and a four day workshop that includes short case histories and exercises sprinkled throughout the presentation and several more complete case studies at the end.

### **Learn How To**

- List levels of causes of failures
- Approach and plan an investigation, write a fracture analysis protocol
- Articulate and clarify objectives for a root cause failure analysis
- Set up a failure investigation
- Describe the key principles of materials science and engineering
- Apply practical macro and micro fractography
- Use optical metallography, NDT methods, composition analysis, mechanical tests, and FEA to analyze fractures.
- Prevent failures
- Gauge self-consistency in the conclusions of the various tests
- Read and evaluate root cause failure analysis reports
- Improve your ability to judge the quality of a failure investigation
- Make use of failure analysis to improve durability and economy

**Course  
Outline**

- Understanding Levels of Causes of Failures
  - Physical, mental, latent
  - Time of origin of causes: Design phase, manufacturing, maintenance, use, complex interactions
- Getting Set up to Perform a Failure Investigation
  - Understanding human nature
  - Techniques to improve use of our knowledge
  - The failure analysis toolbox
  - Evidence preservation in the lab and in the field
  - Basic visual examination
  - Specimen selection
  - Use of "control" parts
- Principles of Materials Science and Engineering: A Crash Course
  - Atoms, crystals, grains
  - Anisotropy
  - The process, structure, properties triangle
- Practical Macro and Micro Fractography
  - Crack appearance in different loading geometries
    - Axial
    - Bending
    - Torsion
    - Direct shear
    - Contact loading
  - Classical Microscale Features
    - MVC (“ductile dimples”)
    - Cleavage
    - Intergranular
    - Striations
    - Dealing with the lack of published data on polymeric fractography
- Fracture Analysis Techniques:
  - Optical metallography
  - NDT methods
  - Composition analysis
  - Mechanical tests
  - FEA in fracture analysis
- Preventing Failures
  - Quantitative determination of an adequate hardening heat treating specification for steel components
  - How to specify steel for stampings
  - “Guess and Hope,” “Guess and Test,” and “Comprehensive Engineering” approaches to design
- Putting It All Together
  - Evaluating self-consistency in the conclusions of the various tests
  - Putting together the component pieces of the analysis into a cohesive and incisive whole

- How to read and evaluate root cause failure analysis reports
- (Workshop only): Extended Case Studies
- Wrap-up: Course recap, Q/A, and evaluations

**How You Will Learn**

- A seasoned consulting engineer-instructor will present this course in interactive lecture/workshop format.
- Along with lecture, we use exercises, puzzles, case studies, and interesting group activities to enrich the instruction and drive home the essential points.
- If you already know something about this subject, we will build on that. We'll compare and contrast what's familiar with what's new, making new ideas easier to learn as well as more relevant.
- If your background is less technical, we will use meaningful and ingenious examples and analogies to simplify the complex subject matter.
- You will receive a printed Participant Handbook which will help you remember and retain what you learned in class and apply it on your job.
- You will learn the key concepts of root cause failure analysis from a theoretical, practical, and organizational perspective.

*Revised*

*March 11, 2007*