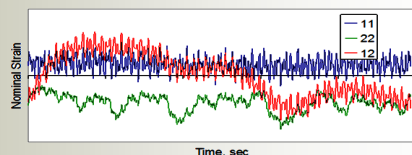
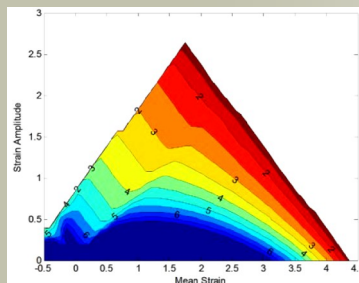


## Achieving a durable elastomeric component

Elastomers are outstanding in their ability to repeatedly endure large deformations, and they are often applied where fatigue performance is critical. Their macromolecular structure gives rise to unique behaviors, and so appropriately specialized experimental methods are needed to characterize, analyze, and design for durability. Some factors to be included in fatigue life analysis are:

- Finite Strains
- Nonlinear Elasticity
- Self-Heating
- Strain Crystallization
- Time Dependence
- Temperature Dependence
- Ozone Attack
- Mullins Effect

This fatigue week organized by Leartiker and Endurica will give you powerful approaches to anticipate, diagnose and solve fatigue-related issues in elastomeric materials.



Left, Haigh diagram and mean load effects.  
Right, multiaxial loading on real component.



## About the instructor Dr. Will Mars

Dr. Will Mars is an internationally acclaimed authority on the topic of damage mechanics in elastomers, and an award-winning speaker. He brings to his lectures two decades of experience developing product testing and simulation methods in the rubber industry, as well as experience teaching graduate courses as an adjunct professor at the University of Toledo.

Dr. Mars has received several awards for his scientific contributions and innovations, including the 2007 Sparks-Thomas Award of ACS Rubber Division, and the 1999 Henry Fuchs Award of the SAE Fatigue Design & Evaluation committee. Dr. Mars is also the current editor of the journal Rubber Chemistry & Technology, and is a past editor of Tire Science & Technology

## Course format

The course includes lectures, live lab demos, and hands-on exercises focused on processing and interpreting experimental measurements of fatigue behavior. Lunch, snacks, and dinner on Day 1 included.

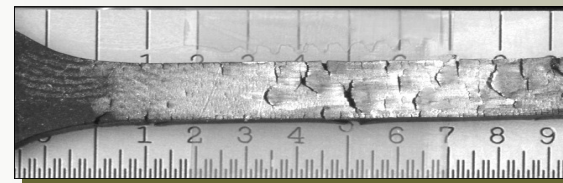
# Characterizing Elastomer Fatigue Behavior for Analysis and Engineering

Fatigue Week, 21-25 May 2018,  
in Leartiker, Markina-Xemein, Spain



leartiker

Endurica  
Get Durability Right



## Course 1: CHARACTERIZING ELASTOMER FATIGUE BEHAVIOR

Duration: 3 days.

When: 21, 22 and 23 May 2018

## Course2: THEORY AND APPLICATION OF RUBBER FATIGUE ANALYSIS WITH ENDURICA CL

Duration: 2 days.

When: 24 and 25 May 2018

## Course Fees:

Course 1 Fee: 2025€  
Course 2 Fee : 1375€  
Both courses Fee (10% Disc.): 3000€  
Second attendee of the company 20% Disc.

Courses in English -

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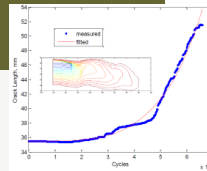
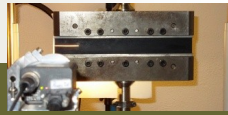
## Registration:

Course fees are considered for 14 days prior to course start. Registration after this date would incur a late registration fee of 250 €.

## Cancellation policy:

Leartiker reserves the right to reject registrations and to cancel a training class based on class size. A full refund will be made if a class is cancelled. If a participant cancels a registration more than 5 days before the class then a 80% refund will be given. There is no refund for cancellations during the last 5 days before the class.

## Course 1: CHARACTERIZING ELASTOMER FATIGUE BEHAVIOR FOR ANALYSIS AND ENGINEERING



### Course Objectives

- Know the physics and factors that govern rubber's fatigue behavior
- Use accurate models and efficient procedures to characterize rubber's fatigue behavior
- Take advantage of test strategies that minimize risk and maximize productivity
- Use crack nucleation and fracture mechanics approaches effectively
- Use characterization to inform accurate fatigue calculations
- Use characterization to diagnose and solve development issues

### Day 1- 21<sup>st</sup> of May 9:00 - 17:00 + (Course Dinner)

1. Introduction
2. Elastomers as engineered materials
3. Design, Analysis and Characterization for Durability with Rubber
  - Stiffness, mode of control, compound optimization
  - Overview of the fatigue property map
4. Stress-strain - molecular origins and hyperelasticity
5. Stress-strain - cyclic phenomena and advanced models
6. Self-heating in rubber
7. Tearing energy  
(20:30 Course Dinner)

### Day 2- 22<sup>nd</sup> of May 8:30 - 17:30

1. Characterizing strength of rubber
2. The fatigue threshold
3. Strategic considerations in fatigue testing
4. Characterizing Fatigue behavior of individual cracks - fully relaxing cycles
5. Characterizing Fatigue behavior - nonrelaxing cycles and strain crystallization
6. Crack nucleation, S-N curves, Continuum Damage

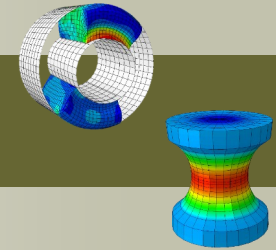
### Day 3- 23<sup>rd</sup> of May 8:30 - 17:30

1. Characterizing crack precursor size
2. Rubber's Fatigue Design Envelope
3. Aging
4. Multiaxial loading and Critical Plane Analysis
5. Fatigue in tension, shear, and compression
6. Variable amplitude loading, Rainflow counting, and damage Accumulation
7. Component testing



Theoretical training will be combined with live demos at Leartiker testing laboratories.

## Course 2: THEORY AND APPLICATION OF RUBBER FATIGUE ANALYSIS WITH ENDURICA CL



### Course Objectives

- Know what is at stake in fatigue analysis
- Understand principles and practices needed for accurate fatigue analysis
- Select and validate material models in Endurica Command Line
- Know how to set up your FE model to ensure accurate fatigue analysis
- Use Endurica CL to solve durability issues involving multiaxial, variable amplitude loading

### Day 1- 24<sup>th</sup> of May 8:30 - 17:30

1. Rubber product failure - what is at stake?
2. Overview of Endurica CL capabilities and workflows
3. Setting up the stress-strain model
4. Using material models for fatigue - fully relaxing
5. Using material models for fatigue - nonrelaxing and strain crystallization
6. Industry Application : bushing under a 2-channel road load signal, exhaust mount, prosthetic joint

### Day 2- 25<sup>th</sup> of May 8:30 - 17:30

1. Calibrating crack precursor size
2. FEA for life prediction
3. Hands-on: sheet with a hole example
4. Dealing with Multiaxial loading in fatigue analysis
5. Hands-on: Diabolo specimen
6. Dealing with Variable amplitude loading in fatigue analysis