# KOTEL 161: RELIABILITY OF POLYMER MATERIALS (PORE)

## 1. INTRODUCTION

### Project background and present state

Products for consumer and industrial applications consist typically of many polymer materials. Polymers long term reliability and behavior in different environments and applications is critical to quality, but often not fully understood or managed. There is a wide coverage of theoretical studies concerning polymer physics and chemistry, but application quidelines for electronics and mechanical design engineering is often rather limited.

Polymer materials behaviour is diverse and thus requires a lot of knowledge of polymer materials theory. Even a small change in the polymer structure can have a huge change in the material properties, and that can of course effect the performance of the device dramatically. However, electronics or mechanical design engineers have limited knowledge in polymer materials theory and that is why some guidelines are needed. To ease the work of design engineer, it is important to improve the knowledge by collecting the key factors which influence the material properties of polymers into easily readable form.

## 2. PROJECT DEFINITION

### Project Goal(s)

The project focuses in creating common guidelines for non-material specialists to ease the selection of polymer material for their design. These guidelines list important things to consider prior to selection and describe shortly what the influences could be. Furthermore, this project has an experimental part where environmental testing to selected polymer materials and structures are conducted.

As an output from this project a handbook is created which is easily readable and usable and provides the information gathered during the project.

### Project milestones

- MS1: Literature review on the subject
    - Testing methods
    - Impact of manufacturing methods, use environment, additives, effects of polymer materials compatibility, recycled materials, etc.
    -
- MS2: Each participating company selects and provides one polymer material or structure which to study (the sample needs to be such that can be shared within the project)
    - Examples: Polymer materials used in mechanical structures and polymer sheet materials (insulators)
        - Polycarbonate (sheets and injection molded structures)
        - Polyuretane
        - Silicone

    - Different additives and composite materials
    - Casted materials
- MS3: Definition of the reference environments/mission profiles for the study (reference applications and environments/lifecycle phases)
    - humidity, temperature (temperature cycling), mechanical stresses, electrical stresses, chemical stresses, manufacturing & assembly stresses, UV stresses
- MS4: Testing methods definition, material testing and failure analyses based on mission profiling
    - Project participants to decide on test environment where the studies are carried out
    - Example: Humidity and temperature cycling testing with/without mechanical stress
- MS5: Test samples collection from the companies, testing of the samples and failure analysis after the test
    - Each participating company provides own samples to be tested against the mission profile agreed
- MS6: Issues to be taken into consideration when the properties, degradation and life time of the polymers are discussed (guidelines for material selection), examples:
    - manufacturing methods (including material adding methods)
    - use environment
    - additives
    - effects of polymer materials compatibility
    - recycled materials
- MS7: Handbook of polymer material selection guidelines and selected materials behaviors in selected environments including test methods and failure analyses

**Project focus**

- Project focus is priority order
    - Knowledge and results concerning selected materials behaviour and reliability in reference environments based on testing
    - Definition of relevant and practical test and analysis methods to proof and validate polymer reliability during product development
    - Engineering guidelines for material selection for various applications/environments

**Project restriction**

- Due to schedule and budget constraints number of selected polymer materials need to be limited (depends and decided by project participants)
- Testing time restrictions due to schedule decided for the project

**Work load in the project**

- External resources for material testing, analysis and expertise to be used, but project members resources and facilities may be also utilized if feasible/available
- Each project member commits to provide and prepare input to workshops (benchmarks, reference cases, literature references, presentations, etc.)
- Each participating company to provide one material and structure for the test. It should be noted that the test results are available for all project participants and in the handbook the results are presented (without the company information)
- Externally sourced literature studies and benchmarkings as agreed
- Brainstorming and discussions during workshops (using generic case as a platform for the project if agreed)
- Each member has own responsibility to secure the level of available information publicity. Workshop material should be available for all project participants if not otherwise noted or agreed.

**Participants**

- Minimum 3 companies. Cost per participants á 10 000eur (+VAT)

**Project length**

- 1 year, 3 months

## 3. PROJECT PHASES AND WORKING STYLE

**Project work package structure**

Project is roughly divided into six (6) work packages (workshops):

- WP1: Project construction (decision of materials to be studied, planning)
    - Planning of the whole project, schedule
    - Decision on literature study done for the project (MS1)
    - Decision on the structures to be studied, how many, which size etc. companies can provide for testing
    - Start of the guideline work
    - *1 workshopday*
- WP2: Definition of reference applications and environments/mission profiles (MS2, MS3)
    - Structures to be tested, introduction from companies
    - Building of the mission profiles
    - Selection of the mission profile against which the testing is performed
    - *1 workshopday*
- WP3: Test planning, execution, analyses (MS4, MS5)
    - Detailed test planning

        - Test profiles
        - Test place
        - Failure analyses
    - Review of the test results
    - *2 workshopdays + testing time*
- WP4: Polymer material properties and behavior in different environments (MS6)
    - Literature review and guidelines collection
    - Common guidelines and rules of thumb that are equal for all polymer materials
    - *2 short workshopdays (½ days)*
- WP5: Consolidation of results and Recommended actions (All MSs)
    - First review of the handbook
    - *1 workshopday*
- WP6: Handbook final review and meeting (MS7)
    - *1 short workshopday (½ day)*
- Project (internal) seminar

**Project schedule**

| | Calendar months (Month 1 equals the starting month of the project) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Work package | Month 1 | Month 2 | Month 3 | Month 4 | Month 5 | Month 6 | Month 7 | Month 8 | Month 9 | Month 10 | Month 11 | Month 12 | Month 13 | Month 14 | Month 15 |
| WP1: Project construction | | | | | | | | | | | | | | | |
| WP2: Definition of reference applications and environments/mission profiles | | | | | | | | | | | | | | | |
| WP3: Test planning, execution, analyses | | | | | Planning 1mth, testing 6mths, analysis 1mth | | | | | | | | | | |
| WP4: Polymer material properties and behavior in different environments | | | | | | | | | | | | | | | |
| WP5: Consolidation of results and Recommended actions | | | | | | | | | | | | | | | |
| WP6: Handbook final review and meeting | | | | | | | | | | | | | | | |
| Project (internal) seminar | | | | | | | | | | | | | | | |

**Ways of working in the project**

- Main work methods for workshops:
    - brainstorming & discussions during work package meetings based to theory & practical experiences
    - each WP detailed scope and needed prepatory tasks agreed latest in previous WP meeting
- Why, what and how questions are answered in every work package
- Handbook is written during the whole project
- Preparatory material should be available for all workshop participants preferably minimum 1 week before the actual meeting

## 4. UTILIZATION OF THE RESULTS

**Utilization of milestone outputs in the project**

- Workshops
    - Gathering and forming best practices
    - Co-operative discussions to increase participant and company competence
    - Increase knowhow of what key information exists (theory, tools, best practices)
    - Helps to understand how theory and practice are applicable for design engineers

- Collecting information and data for the handbook

- Handbook: Easy readable and usable, fast to implement

**Benefit for company: project participation vs. purchasing ready handbook from KOTEL**

- Participating to the project
  - Learning by doing, discussions and brainstorming in each workshop
  - Participant will have one own structure tested and analysed within the project
  - Participant can affect to the output of the project and handbook
  - Knowledge of the "quiet information" that is not written in the handbook
  - Fast access to the final handbook and draft version for quick utilization
  - No 'time of competitive restriction' (direct access)

- No project participation (purchasing ready handbook from KOTEL)
  - No learning by doing, no company external discussions, higher probability that utilization of handbook subjects is not successful to the company (compared if participating to the project)
  - No testing performed to company specific materials
  - No possibility to affect on the project or handbook content & output
  - No fast access to draft documents
  - Possible delay due to 'time of competitive restriction' (e.g. 1-2 year delay after the project is ready)

## 5. RESOURCES AND ORGANISATION

KOTEL will offer this project to it's member companies. Each participating company will have a representative in the project management group. Project management group and a responsible leader are set for the project by it's participating companies. A dedicated project manager and resources for the material testing and verification and literature studies are to be budgeted and named for the project. The project management group is responsible and entitled to do all the decisions regarding the project.

## 6. TIMETABLE

Detailed schedule is to be defined by project. Roughly, project is implemented between Q4 2016 – Q1 2018. More precise timetable will be written after the first project meeting and updated project plan.

## 7. RISKS & RISK MITIGATION

- Risk: Project doesn't contain enough valid information => Mitigation: Participants requirements/proposals, active participants to gather required information, limitations in project plan, clear plans for each work package, budget

- Risk: Project budget, resources and management => Mitigation: Company participants, named project manager, follow-up and steering

- Risk: Project not ready when planned => Mitigation: deadlines for work packages, strong project management

## 8. COST ESTIMATE AND FUNDING

Preliminary cost estimate for the project is 30 000 - 50 000 €.

COST ESTIMATE is without value added tax (VAT)

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|---|---|
| External supplier (tbd) | |
| Project Management | 7 500 € |
| Handbook and theroretical studies | 7 500 € |
| Overall | 15 000 € |
| | |
| External supplier(s) | |
| Material testing and analyses *) | 12 500 – 32 500 € |
| Overall | 12 500 – 32 500 € |

**) Rough estimate. 12 500 € covers maximum 3 materials basic study (simultaneous testing, separate material analyses). 32 500 € covers maximum 5 materials basic study (simultaneous testing, separate material analyses) or 2-3 materials extended study and analyses.*

| | |
|---|---|
| KOTEL ry | |
| Management (overall) | *2 500* € |
| Overall | 2 500 € |
| | |
| Overall | **30 000 – 50 000 €** |

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|---|---|
| FUNDING | |
| KOTEL ry (100 %) | 30 000 – 50 000 € |
| | |
| Overall | **30 000 – 50 000 €** |

Company funding shares: 3-5 companies á 10 000€ + VAT

Focusing and reducing of the content will be discussed together with the participating companies to fit to the new project budget.