AMERICAN ENGINEERING GROUP

"Elastomeric Seal Life Prediction"
A Manufacturing Perspective

- O-ring, Gaskets, and Oil seal

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ISO 9001:2000

Elastomeric Seal Life Prediction
A Manufacturing Perspective

- **Topics to be Discussed**
  - **Introduction - Definitions**
  - **The AEG Approach**
  - **Three Examples**
    - Telecommunications
    - Aerospace
    - Semiconductor
  - **Future Work**

Customer Expectations of Seal Manufacturers Today

- Expanded Temperature Ranges
- Enhanced Chemical Resistance
- Performance Vs. Material Specifications
- Statistically Capable Properties
- “Tailored” Formulas for Specific Applications
- “Zero” Defects
- “Zero” Leakage
- ***Predictable seal life !!!***

The Engineering Challenge !

- **How long can I expect your seals to last in my application?**

Some Definition Challenges

- **Useful Seal Life?**
- **Leakage?**
- **Failure?**
- **Application Details?**

Three Categories of Seal Failures

- **Environmental**
  - Time/Temperature dependant
  - Physical/Chemical degradation
- **Application Details**
  - Extrusion, ED, Spiraling, etc
- **Human Error**
  - Installation damage, storage conditions,handling, etc
  - Manufacturing problems with seals

Analysis Tools for Failure Types

- **Environmental**
  - Various Predictive Models
    - Arrhenius
- **Application Details**
  - Non-linear Finite Element Modeling
- **Human Error**
  - Statistics/Probability Distributions

AEG Approach to Seal Life Prediction

- *Precise* Definition of the Application
- Material Performance Data
- Field Failure Data
- Determination of the *Primary* Aging Phenomena
- Service History Data Gathering
- Monitoring of the Seal in Application

AEG Approach to Seal Life Prediction

- Discuss timeframe of the analysis
- Discuss the predictive modeling options
- Determine “Seal Life” criteria
- Perform experiments as needed
- Adjust the model if time permits
- Compare with used seals if possible

AEG Approach to Seal Life Prediction

- **Arrhenius Model Limitations**
  - Tests can be rather long duration
  - Data is recipe specific
  - physical and chemical effects are often confused
  - extrapolation must be minimized
  - Temperatures must be realistic
  - Human and Application effects cannot be handled

Telecommunications Example

- **Application: Cellular Phone**
- **Seal Material: Conductive Elastomer**
- **Timeframe Allowed: 6 months**
- **Properties to be modeled**
  - Volume Resistivity
  - “Modified” Compression Set
- **“Failure” Criteria**
  - 0.010 ohm-cm
  - 50% Compression Set

Telecommunications Example

- **Arrhenius Model Life Predictions**
  - Volume Resistivity: 4.5 years
  - “Modified” Compression Set: 25.5 years
- **Actual Results**
  - Volume Resistivity: 2.5 years
  - “Theoretical” Compression Set: 19 years
- **Real World “Leakage” Problem**
  - Water permeation problems after 1.5 years!

Aerospace Example

- ***Application*: Turbine Engine Fuel line**
- ***Seal Material*: FKM Copolymer**
- **Timeframe for analysis: 30 days!**
- **Properties to be modeled**
  - "Modified" Compression Set
- **"Failure" Criteria**
  - 45% Compression Set

Aerospace Example

- **Arrhenius Life Prediction**
  - Compression Set - 4.1 years
- **Actual Results**
  - “Theoretical”Compression Set: 3.5 years
- **Real World Problem**
  - Extrusion, nibbling, cracking after 9 months!

Semiconductor Example

- ***Application*: Process Chamber Cover Plate**
- ***Seal Material*: Perfluorinated Elastomer**
- ***Timeframe*: 1 year**
- **Properties to be modeled**
  - Retained Sealing force(CSR)
  - Vacuum PumpDown Time
- **Failure Criteria**
  - 50% Retained Sealing Force
  - 12hr pumpdown maximum

Semiconductor Example

- **Arrhenius Life Prediction**
  - Retained Sealing Force: 3.4 years
  - Pumpdown Time: TBD
- ***Actual Results* : TBD**
- **Real World Problems so far**
  - Possible installation damage
  - Temperature spikes outside the analysis range

Future Work

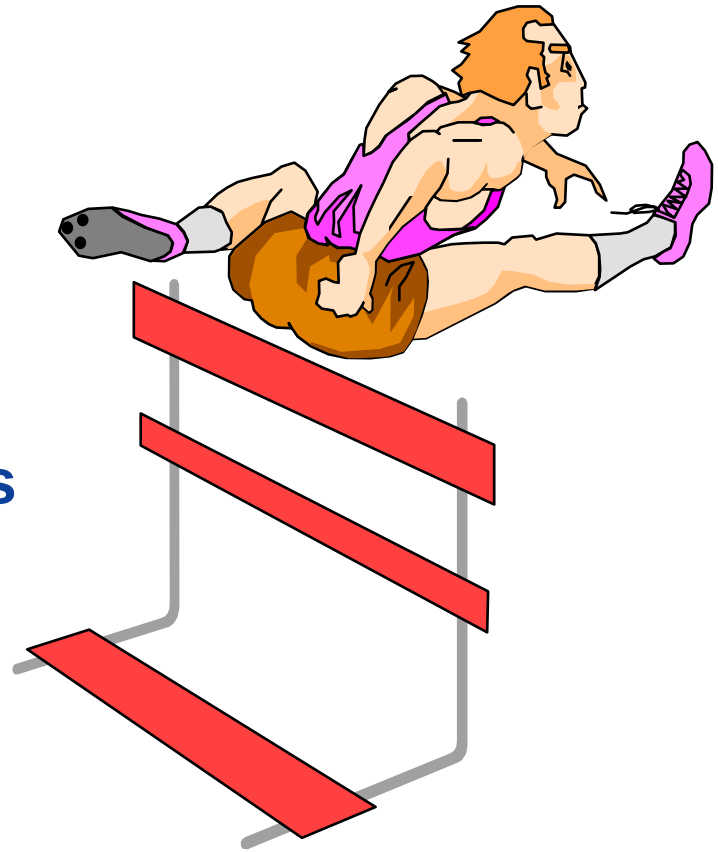
- **Couple Finite Element Modeling with Environment Prediction Models**
- **Investigate other predictive models for inclusion into our existing materials database**
- **Continue material characterization data for engineering database (both for FEA as well as life prediction models)**
- ***LONG TERM*: Consider the Human failure modes from a statistical point of view and incorporate into our models if possible**

Comments/Conclusions

- Arrhenius Modeling of material properties has proven rather effective for us
- Analytical tools and novel modeling approaches continue to improve
- More intense effort is needed to merge FEM with life prediction models
- OEM’s are becoming much more knowledgeable than ever before
- Volume of requests for life prediction projects is growing

Thank you

- Product Development
- Product Manufacturing
- FEA
- Product Design Analysis
- Project partnership
- Confidentiality
- ISO 9001



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