Presented by Jeff Andrasik

Testing Considerations for Optimal Hose Performance

Presented by Jeff Andrasik
Today’s Agenda

• Understanding hose failures
• Common conditions that cause hose failures
• Standard test methodology
  – Common industry standards
  – Step-by-step : beginning the testing process
  – Understanding different types of testing
• Key test setup considerations and optimizing your product’s performance
• Increasing efficiency when testing
  – Evaluating the value of external testing
  – Smithers Rapra Test Cost Comparison Calculator
Truths about Hose Failures

• Determining failure for hoses is time, temperature, and stress dependent.

• Prior to exposure to normal operating conditions, failure modes are unknown until you test.

• Service conditions often vary, coupled with fault situations.

• For complex applications, it’s impossible to fully replicate service conditions in accelerated tests.

• Failure mechanisms are not always progressive, a stepwise change in properties can occur.
Common Conditions Causing Hose Failure

• Construction/design flaws
  – Flexing hose is smaller than specified bend radius
  – Unsuitable crimping process

• Improper Assembly
  – Hoses and connectors not specified to be used together during operation
  – Fittings and clamps not being used
Common Conditions Causing Hose Failure

- Incompatible Environment
  - Pinching hose or rubbing against another surface
  - Changes in surrounding operating system causes incompatibility with existing design
How can I reduce the risk for hose failures? What are my options for testing?
Types of Testing

Material Testing vs Product Testing

Material Testing
• The effect of different environmental factors can be evaluated in isolation
• Data can be carried over to new applications
• Can aid in the initial selection of candidate materials

Product Testing
• More effectively replicates the service conditions
• Only relates to the specific product under test
Common Test Methods by Industry

Automotive
• FMVSS 106
• SAE J1610
• SAE J2260
• SAE J2044 / J2045
• GMW 16153
• GMW 14785

Industrial
• SAE J343
• SAE J517
Beginning the Testing Processes

• What property should be measured?
  – What is critical for the application?
  – What key attributes must be replicated to achieve true, comparable results?

• What is the end of life or threshold criterion?
  – A 50% loss in property is commonly used but an absolute value may be more appropriate.

• What is the thickness of the test sample?
  – Thickness influences the rate of diffusion of gas or liquid into the material.
  – Thinner parts are more susceptible to short-term degradation.
  – The bulk properties of very large components may remain almost unaffected.

• How long should I test?
  – Developing a test to evaluate a product after a specified period of time is easier than testing to failure.
Test Decisions

- Mounting?
- Working temperature?
- Fluid exposure?
- Other moving parts?
Types of Hose Testing Evaluations

- **PRESSURE**
  - Static
  - Impulse
  - Burst

- **TEMPERATURE AGING**
  - Tensile
  - Creep
  - Cycling

- **FLUID COMPATIBILITY**
  - Change in physical property
  - Response to Temperature

- **VIBRATION**
  - Flex Fatigue
  - Vibration
Pressure Testing

Each hose has a Maximum Allowable Working Pressure (MAWP). There are 3 common pressure tests used to verify the hose and hose assemblies pressure range:

- **Static** (aka Leak Checks or Proof Tests) – Requires you to apply pressure up to MWAP to verify the hose will not rupture and the assembly (i.e. crimp area) does not leak

- **Impulse** – Designed to produce a high pressure / low pressure effect on the assembly to simulate the pump being turned on and off

- **Burst** – Requires a constant increase in pressure inside a hose assembly until failure occurs. This determines the Safety Factor Ratio of the hose
Temperature: Accelerated Aging Evaluations

Temperature is used to accelerate tests. Greater energy for reactions to occur in a shorter timeframe.

Limitations

- Higher temperatures can cause varying reactions
- Need to ensure material has not undergone any transitions over accelerated temperature range
- Keep below the recommended upper operating temperature
Temperature Aging: Tensile

When testing tensile strength, failure always occurs in the center. Easy to measure the failure point in the product.

What can we learn from behavior in polymers:

- Understand how the tensile strength, hardness, elongation changes
- Sudden transitions, ductile to brittle behavior can be seen
Temperature Aging: Creep testing

• Creep is the measurement of the change in extension (creep strain) under a constant applied load.

• TTS used to extrapolate data to predict service life.

• Creep rupture is the terminal event of creep and is a measure of the time that a material under a constant applied tensile load takes to fail.

• The testing period for creep testing is typically weeks or months.
Temperature Cycling

- Used to evaluate the behavior of the product when exposed to varying temperature extremes.
- An environmental chamber, capable of cycling temperature, is used during this test.
Vibration Testing

Vibration is used to simulate how a hose is affected when it is being flexed or shaken. Two types of vibration testing include:

**Flex Fatigue** – this forces the hose to move in low frequency, high displacement motion. Typically one end is moving and the other is stationary.

**Vibration** – this forces the hose to move in high frequency, low displacement motion. Typically one end is moving and the other is stationary.
Fluid Compatibility Testing

Fluid compatibility testing is usually done on the finished material. Studies need to be performed to confirm that the material the hose is comprised of can withstand prolonged exposure with the fluid.

Typical Testing Protocol for fluid compatibility - ASTM D471
Fluid Compatibility Testing

How do we evaluate material compatibility with fluids?

• By the change in physical properties:
  – Tensile strength
  – Elongation
  – Hardness
  – Volume swell

• By its reaction to the elevated temperature of fluids, including:
  – Fuels
  – Oils
  – Coolants
  – Brake fluid
  – Cleaning agents
I understand my testing options and what methods would be most beneficial for my product but how do I optimize my product’s performance?
Optimizing Your Hose Performance

Often when testing, manufacturers do not consider **all** variables that their product could potentially be exposed to during the development phase.

In the case where there is an enhancement to an existing hose product, developers fail to evaluate the whole product or system. Small changes could have a bigger affect on the performance.
## Considerations for Test Setup

<table>
<thead>
<tr>
<th>Setup Variable</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation</td>
<td>Should the part be arranged the same way that it sits during operation?</td>
</tr>
<tr>
<td>Flow</td>
<td>What is the flow rate on the pump? Direction of flow can affect performance</td>
</tr>
<tr>
<td>Torque</td>
<td>What is the torque on the tightening of the fittings, clamps, etc.?</td>
</tr>
<tr>
<td>Abrasion</td>
<td>While in service, is abrasion a factor?</td>
</tr>
</tbody>
</table>
Considerations for Test Setup (continued…)

<table>
<thead>
<tr>
<th>Setup Variable</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaks</td>
<td>Are leaks occurring at certain temperatures or pressures?</td>
</tr>
<tr>
<td>Motion</td>
<td>Should the part be moving during operation? Are other elements around it moving? Should they be moving?</td>
</tr>
<tr>
<td>Fluid exposure</td>
<td>What are the specifications on the type of fluid(s) that are used during operation?</td>
</tr>
</tbody>
</table>
Other Considerations to Optimize Performance

- Consider what stage you are in the research and development process
  - May influence the type of testing required
  - May influence the type of exposure (temperature, fluid, etc.)
  - May influence the length of time for testing

- Consider the specific application / use

- Consider how much time you have before production
Efficiency in Testing

*External testing decreases the delays and gets products to market faster*
Exploring the Value in External Testing

- With internal testing, companies often face delays that can push product launches out several weeks even months resulting in lost revenues.

- When external testing is introduced, delays can be reduced. External testing can also:
  - Allow you to test different variables at one time
  - Conduct multiple iterations
  - Benchmark against competitive products
<table>
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<tr>
<th>Product Price</th>
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<tbody>
<tr>
<td>Monthly Volume</td>
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<tr>
<td>Monthly Revenue</td>
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<tr>
<td>Months Delayed (Internal Testing)</td>
<td>5</td>
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<tr>
<td>Months Delayed (External Testing)</td>
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</tr>
<tr>
<td>External Testing Cost</td>
<td>$5,500</td>
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</tbody>
</table>

Gains/Loses with Internal Testing vs. External Testing

Revenues Gained after 5 Months with Internal Testing
$489,500.00

Revenues Gained after 5 Months with External Testing
$92,400.00

Net Difference
$561,500.00

Available at [www.smithersrapra.com/calculator](http://www.smithersrapra.com/calculator)
Questions?
Jeff Andrasik
Product Testing Manager
Senior Test Engineer

Tel (330) 762-7441
Email jandrasik@smithers.com

Smithers Rapra
425 West Market Street
Akron, OH 44303
USA

www.smithersrapra.com