Standards and Approaches for Ball Joint Durability Testing

Tuesday, May 6, 2008  Stuttgart, Germany
Ball Joint Overview

Ball Joint Basics

» Common ball joint applications
» Types of ball joints

Ball Joint Components

Types of Ball Joints

Inner Ball Joint
Upper Ball Joint
Tie Rod End
Lower Ball Joint
In general, J193 tests are uni-axial . . .

. . . except for Assy Fatigue/Heat Treat.

<table>
<thead>
<tr>
<th>J193 Ball Joint Tests</th>
<th>MTS Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact Strength</td>
<td>✓</td>
</tr>
<tr>
<td>Yield</td>
<td>✓</td>
</tr>
<tr>
<td>Tensile Load</td>
<td>✓</td>
</tr>
<tr>
<td>Rotation &amp; Oscillation Torque</td>
<td>✓</td>
</tr>
<tr>
<td>Axial End Movement</td>
<td>✓</td>
</tr>
<tr>
<td>Cam-Out Strength</td>
<td>✓</td>
</tr>
<tr>
<td>Assy Fatigue and Heat Treat</td>
<td>✓</td>
</tr>
<tr>
<td>Pull-Out/Push-Out Strength</td>
<td>✓</td>
</tr>
</tbody>
</table>

A multi-axial test system is required.
J193 Endurance Load Requirements

5.2.4 Ball Stud and Socket Assembly Fatigue and Heat Test
5.2.4.1 Objective – To determine fatigue and wear characteristics of ball stud and socket assemblies.

5.2.4.2.2 Phase II Test – Endurance Load: "To correlate the cycle life of the assembly for the *average load* to which the assembly will be subjected in application and environment, with life *in actual use* . . .”

The Goals:
- Determine ball joint loads experienced during service life.
- Translate those loads into an easily-reproducible laboratory test.
Comments on Loading/Cycle Life from J193

» “The loading use in the test procedures should be as representative as possible in magnitude and direction with loads encountered in the design application.”

» “Using a vehicle . . . a program loading procedure can be utilized to obtain a more realistic loading assessment.”
Focus: Front Lower Control Arm
What is the Loading Environment?

Input
• Loads
• Moments

Attachment
• Loads
• Moments
What is the Loading Environment?

Strain Gauged Ball Joint
Test Planning – Peak Valley Slicing

Is this a Multi-axial Case?

Yes

Is there a linear relationship between any axis of loading?

No

Reduced DOFs

Yes

Is Reproduction of frequency content Important?

No

Sinusoidal or Block Cycle

Yes

Time History Simulation or PSD repro

Is Reproduction of Frequency content important

No

May be able To use PV Slicing Method

Yes

Time History Simulation
Peak Valley Slice Technique

Multi-axial case

Phasing between Vertical, Lateral & Long Inputs is critical; frequency reproduction is not important
Peak Valley Test Methodology

Peak Valley Slice Test Method

Identify Peak/Valley pairs in multi-channel data.
Peak Valley Slice Test Method

5 kph Braking events

Raw Time History = 40 sec

PV Time History = 10 sec

Benefit: Speed up “slow” events
Peak Valley Slice Test Method

Pothole Strike Reproduction

Raw Time History

PV Time History

Benefit: Slow down “fast” events
Peak Valley Slicing

Benefits of PV Slicing

» Applies accurate max/min displacements to specimens.
» Ensures phase relationships between peak loads are maintained.
» Can reduce test time.
» More representative damage accumulation than block cycle testing.

When PV Slicing is not applicable

» Elastomeric or components with frequency-dependent characteristics.
Test Planning – Time History

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Time History Simulation
What is Remote Parameter Control?

Remote Parameter Control (RPC) is an advanced simulation technique used to repeatedly replicate and analyze “in service” vibrations and motions of a specimen using a dynamic mechanical system in a controlled laboratory environment.

1. REMOTE

2. PARAMETER

- e.g. Accelerometer

3. CONTROL

Control of
- Amplitude Distributions
- Spectral Densities
- Multi-axial Phase Relationship
The RPC Process – Typical Correlation

Iterations – example response data

Simulation results are typically evaluated in the time, frequency, and statistics domains; often times fatigue is also used.
MTS Standard Ball Joint Test System Examples

Three Axis Test
(Inner Ball Joints)

Four Axis Test

Five Axis Test
Thank you for your attention