JSC/EC5 U.S. Spacesuit Knowledge Capture (KC) Series Synopsis

All KC events will be approved for public using NASA Form 1676.

This synopsis provides information about the Knowledge Capture event below.

Topic: Joint Mobility

Date: October 28, 2010 **Time:** unknown **Location:** JSC/B5S/R3204

DAA 1676 Form #: 33218

A PDF of the presentation is also attached to the DAA 1676 and this is a link to all lecture material and video: \\js-ea-fs-01\pd01\EC\Knowledge-Capture\FY11 Knowledge Capture\20101028 J.Matty-Mobility\For 1676 Review & Public Release. Except for these charts, file name ICES_10_JEM_Torque_Final-w.timings.pptx, all other files within the link above have been approved by the DAA, per DAA 29675.

*A copy of the video will be provided to NASA Technical Library and STI Program's YouTube via the Agency's Large File Transfer (LFT), or by DVD using the USPS when the DAA 1676 review is complete.

Assessment of Export Control Applicability:

This Knowledge Capture event has been reviewed by the EC5 Spacesuit Knowledge Capture Manager in collaboration with the author and is assessed to not contain any technical content that is export controlled. It is requested to be publicly released to the JSC Engineering Academy, as well as to CASI for distribution through NTRS or NA&SD (public or non-public) and with video through DVD request or YouTube viewing with download of any presentation material.

* This file is also attached to this 1676 and will be used for distribution.

For 1676 review use_Synopsis_Matty_Joint Mobility_10-28-2010_Additional Charts.docx

Presenter: Jennifer Matty

Synopsis: This joint mobility KC lecture included information from two papers, "A Method for and Issues Associated with the Determination of Space Suit Joint Requirements" and "Results and Analysis from Space Suit Joint Torque Testing," as presented for the International Conference on Environmental Systems in 2009 and 2010, respectively. The first paper discusses historical joint torque testing methodologies and approaches that were tested in 2008 and 2009. The second paper discusses the testing that was completed in 2009 and 2010.

Biography: Jennifer Matty was graduated from the University of Oklahoma in 2005 with a bachelor of science in industrial engineering. Upon graduation, she joined Jacobs Technology and the ESCG as a project engineer. She has worked with EC5 at JSC, focusing on spacesuit mobility as a Constellation spacesuit engineer.

EC5 Spacesuit Knowledge Capture POCs:
Cinda Chullen, Manager
cinda.chullen-1@nasa.gov
(281) 483-8384

Vladenka Oliva, Technical Editor (ESCG)
vladenka.r.oliva@nasa.gov
(281) 461-5681

International Conference on Environmental Systems

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Results and Analysis from Space Suit Joint Torque Testing

Jennifer Matty

Jacobs Engineering and Science Contract Group (ESCG)

NASA – Johnson Space Center (JSC)

40th ICES, 11–15 July 2010, Barcelona, Spain

NASA

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Introduction

- Recently, testing was completed to characterize existing space suit joint torque.
- The purpose of the test was to provide insight on existing torques for requirements development of the Constellation Space Suit Element.
- This presentation summarizes the test and discusses general data traits found while testing.

Test Summary

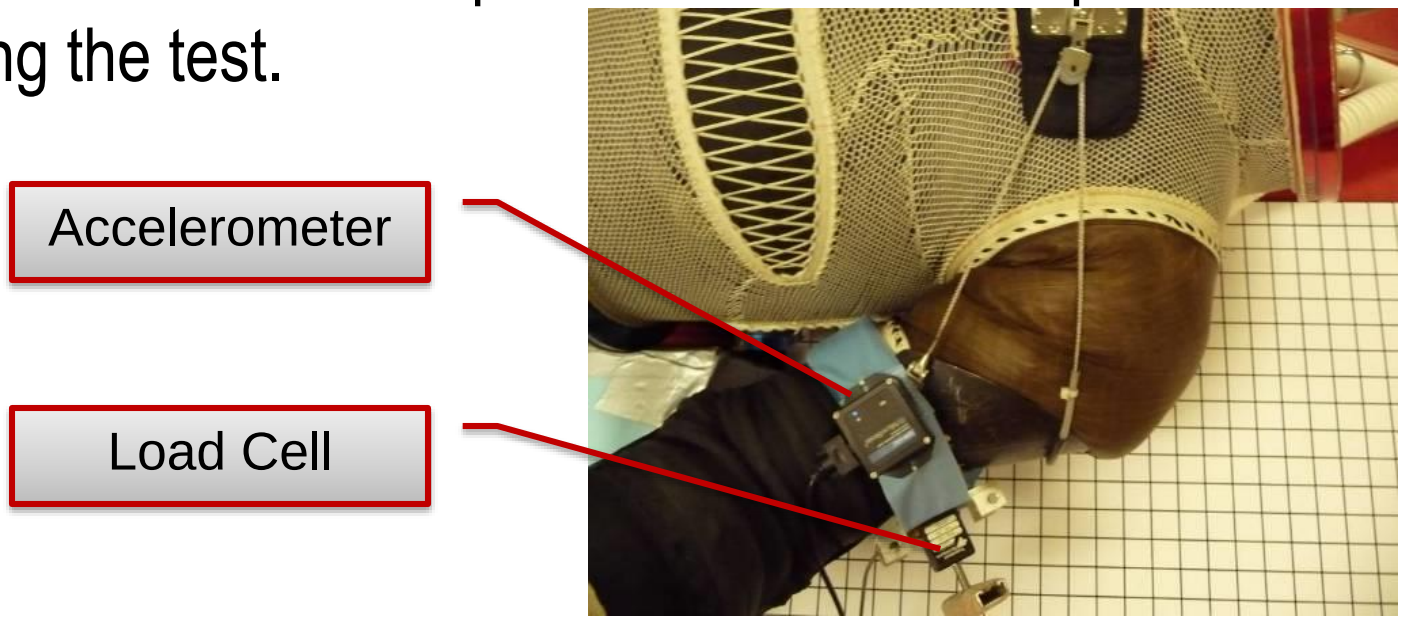
- Several joints need be tested on a variety of space suits.
- Space suits to be tested:
  - Extravehicular Mobility Unit (EMU)
  - I-Suit
  - Mark III
  - Advanced Crew Escape Suit (ACES)
  - Enhanced Mobility (EM)-ACES
  - D-Suit

Test Summary

- Joints to be tested:
  - Shoulder flexion/extension
  - Shoulder adduction/abduction
  - Shoulder medial/lateral
  - Shoulder external/internal rotation
  - Elbow flexion/extension
  - Torso rotation
  - Torso flexion/extension
  - Hip flexion/extension
  - Hip adduction/abduction
  - Hip external/internal rotation
  - Knee flexion/extension
  - Ankle flexion/extension
  - Ankle external/internal rotation
  - Wrist flexion/extension
  - Wrist adduction/abduction
  - Wrist pronation/supination

Test Summary

- The primary non-suit pieces of equipment included a miniature load cell and a three-axis accelerometer. The load cell and accelerometer transmitted force and position data to a computer during the test.

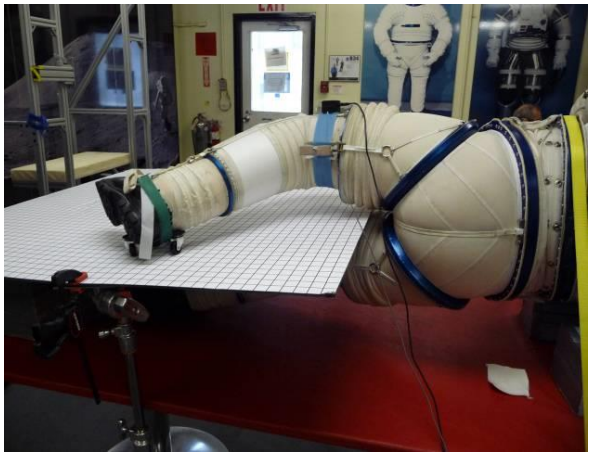


Test Summary

- The secondary pieces of equipment included:
  - Video camera/still camera
  - Ratchet straps
  - Foam blocks
  - Casters/rollers
  - Suit donning stand
  - Grid board/c-stands

Test Summary

- Key test notes:
  - All joint movements were parallel with the ground to eliminate the effects of gravity.
  - Portions of the suit, which were not involved in joint movement were secured to prevent errors in the data.

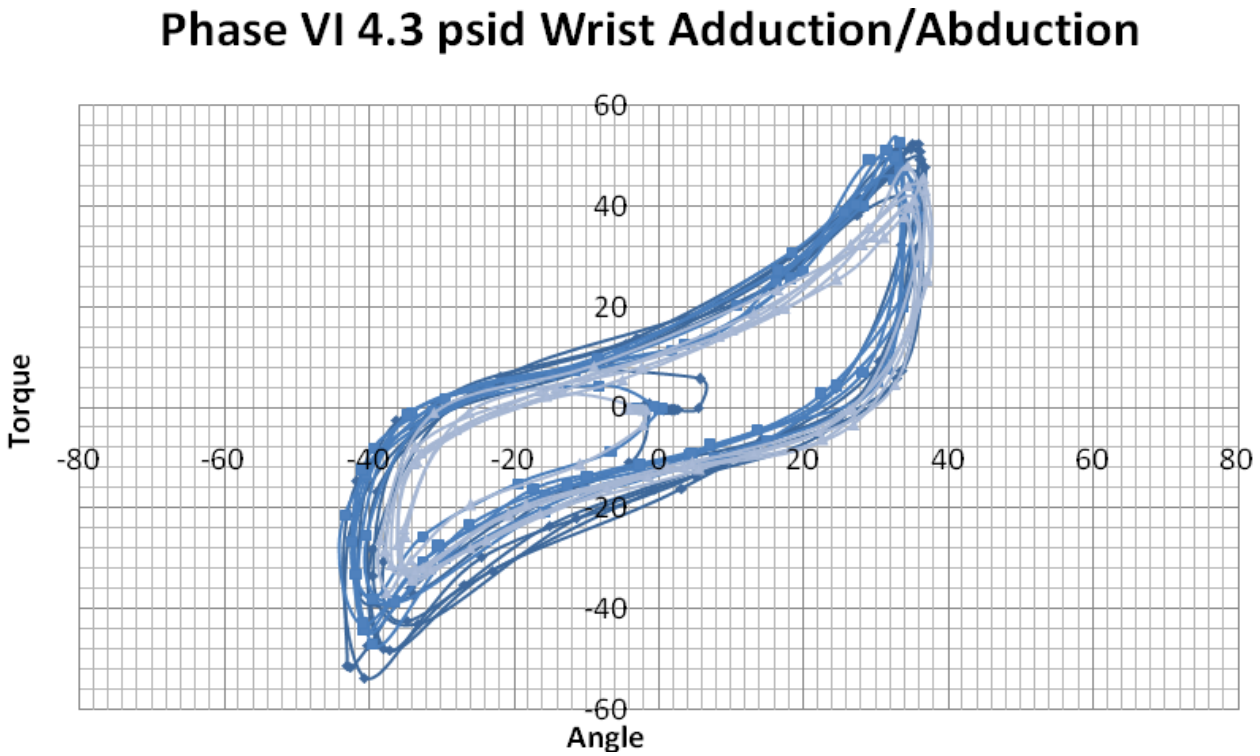


Trend Analysis

- This joint torque test the most comprehensive testing: six (6) space suits at sixteen (16) different joints at a minimum of two (2) different pressures.
- A complete report has been compiled, including all data results.
- The trend analysis provided in this paper introduces seven (7) joint traits found while reviewing the data.

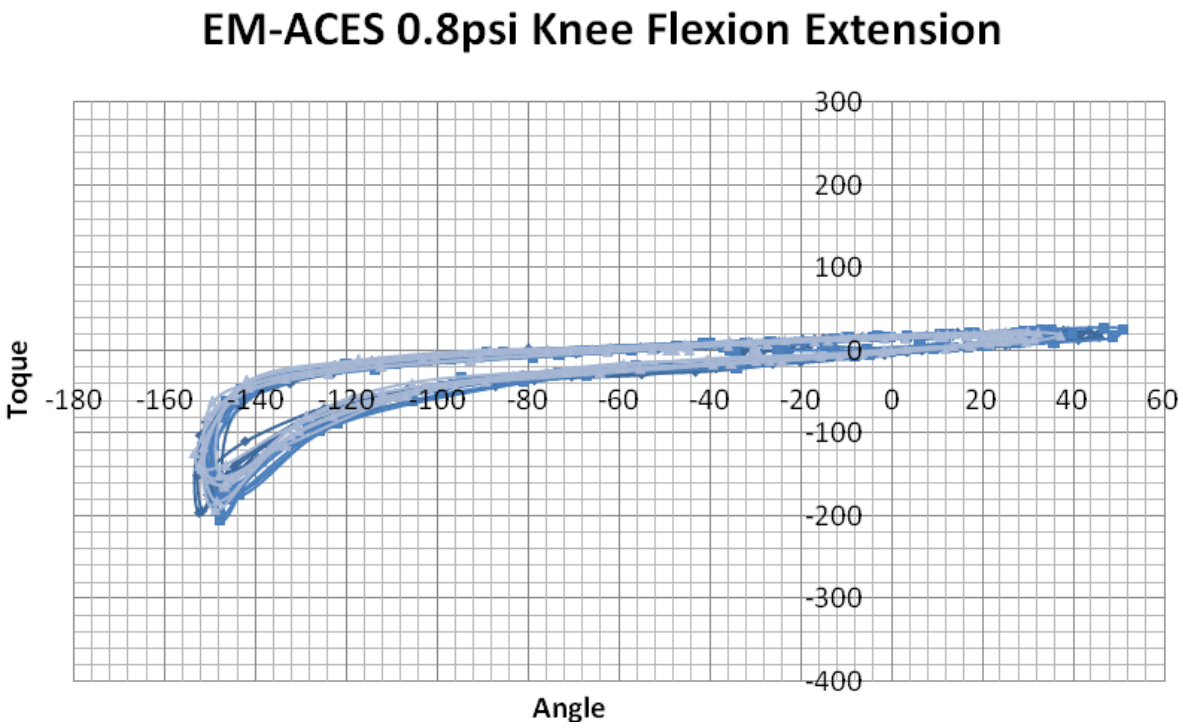
- Joint Traits
  - Basic single axis
  - Bearings
  - Strong neutral
  - Two-phase
  - Winged bearing flip
  - Butterfly
  - Multi-phase sweep

Trend Analysis – Basic Single Axis



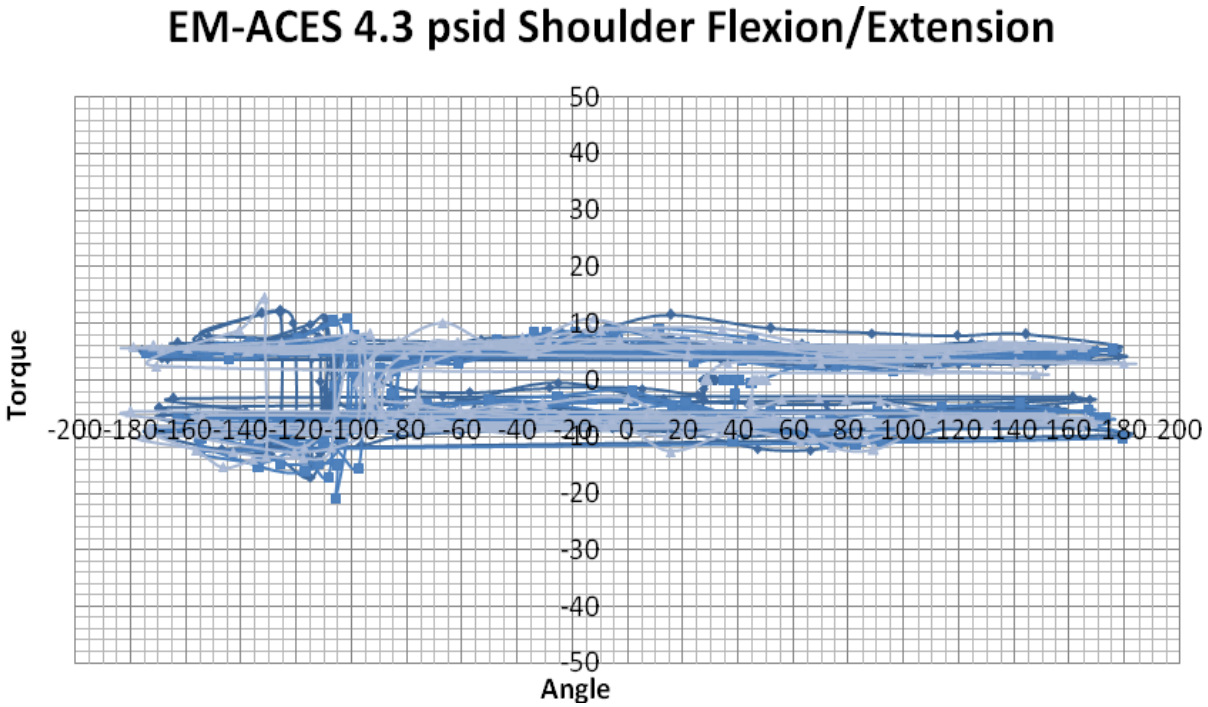
Torque profile for bidirectional single axis joint.

Trend Analysis – Basic Single Axis



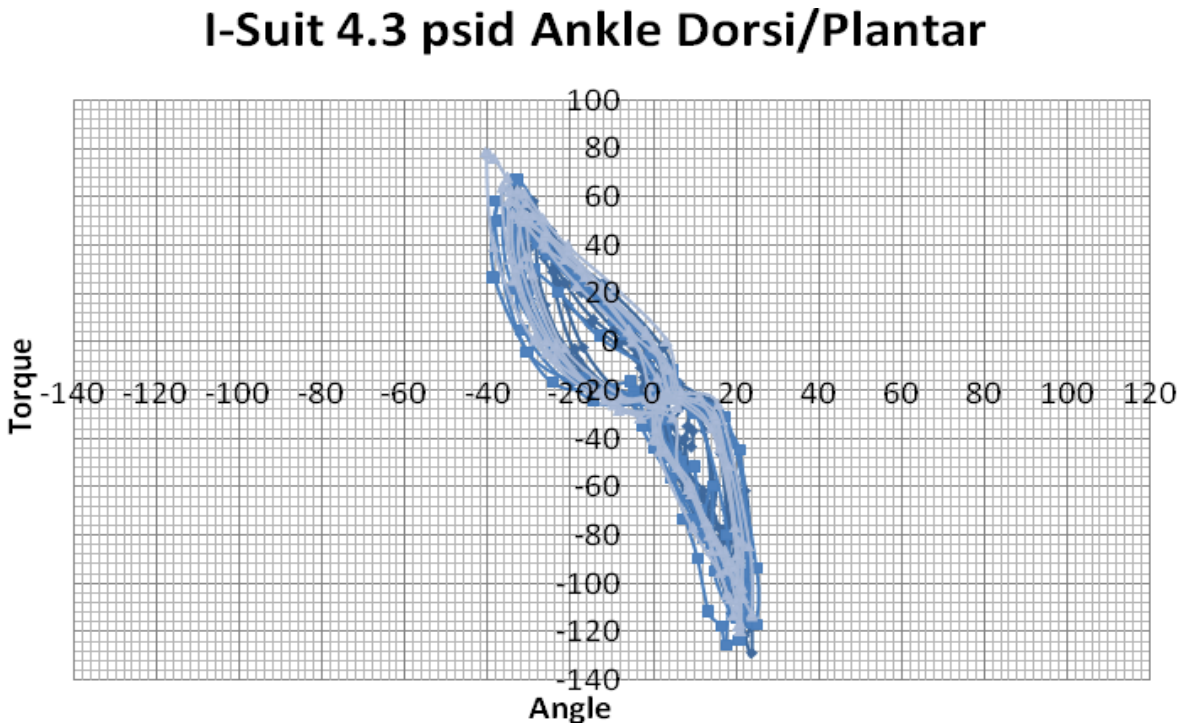
Torque profile for a unidirectional single axis joint.

Trend Analysis – Bearings



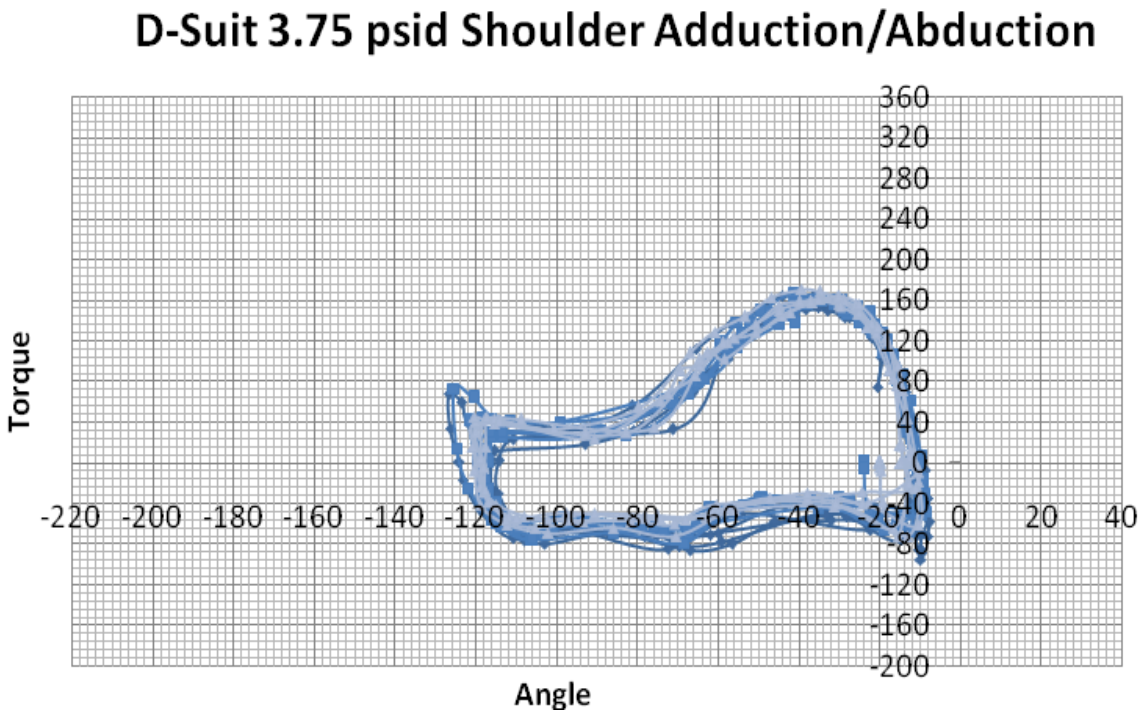
Torque profile for bearing joint.

Trend Analysis – Strong Neutral



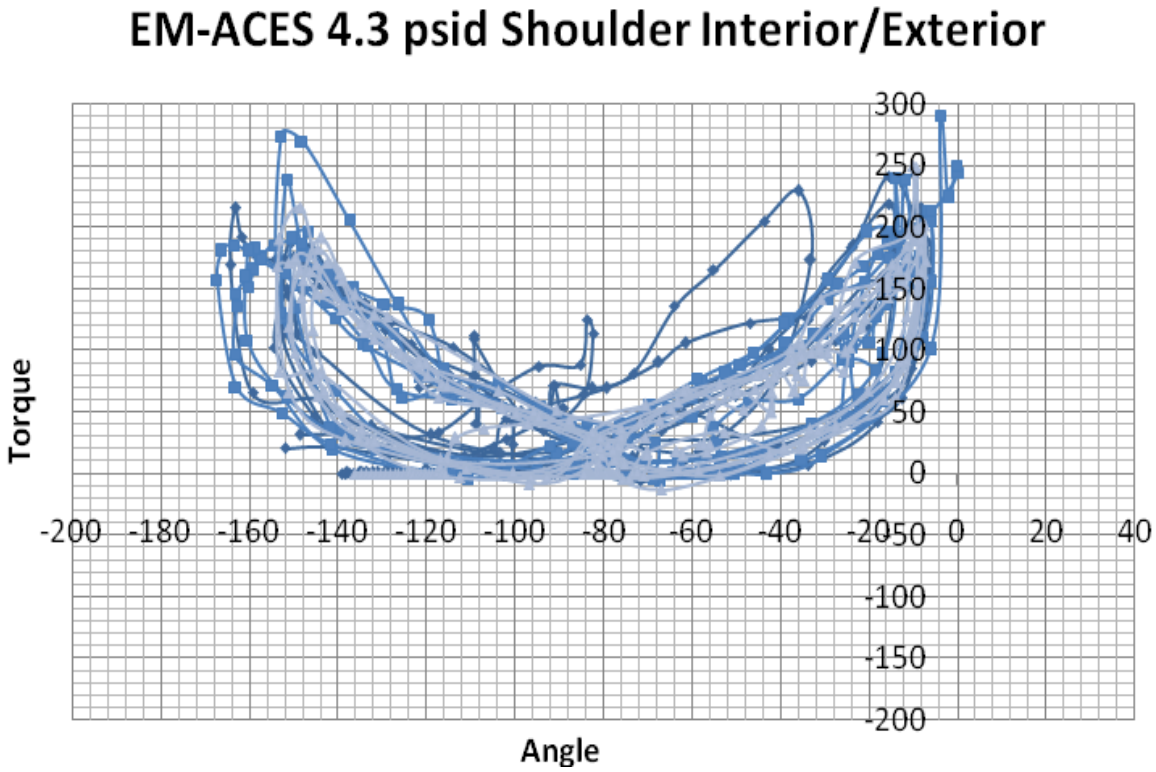
Torque profile for a strong neutral joint.

Trend Analysis – Two-Phase



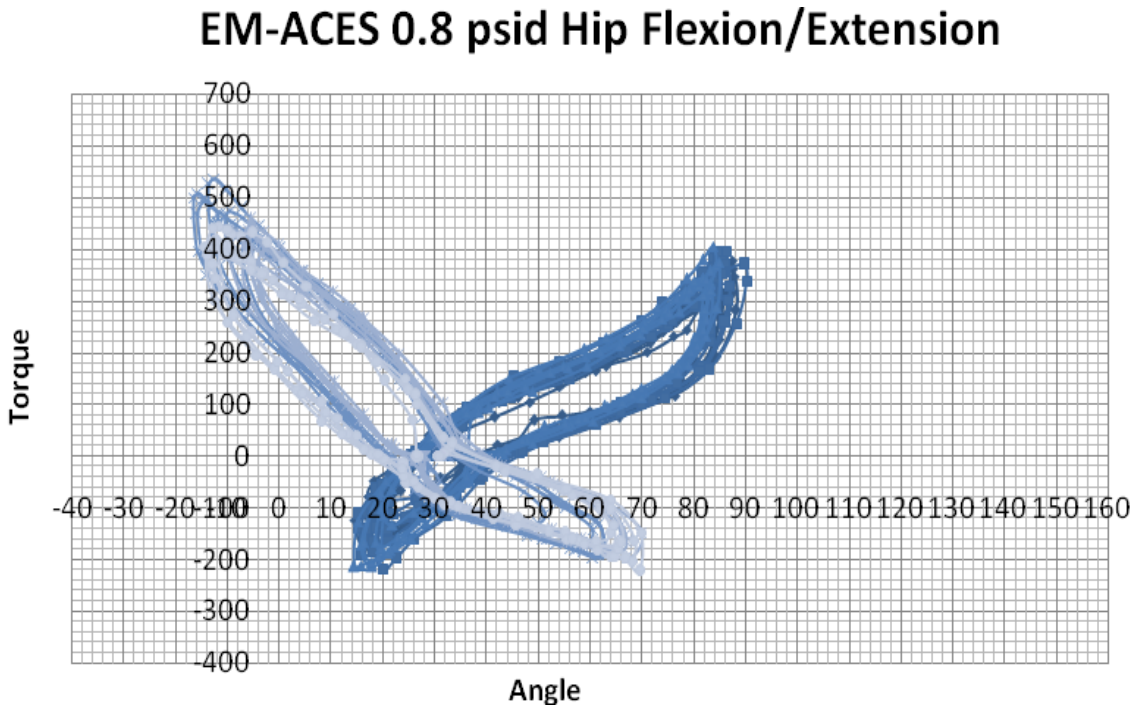
Torque profile for a two-phase joint.

Trend Analysis – Winged Bearing Flip



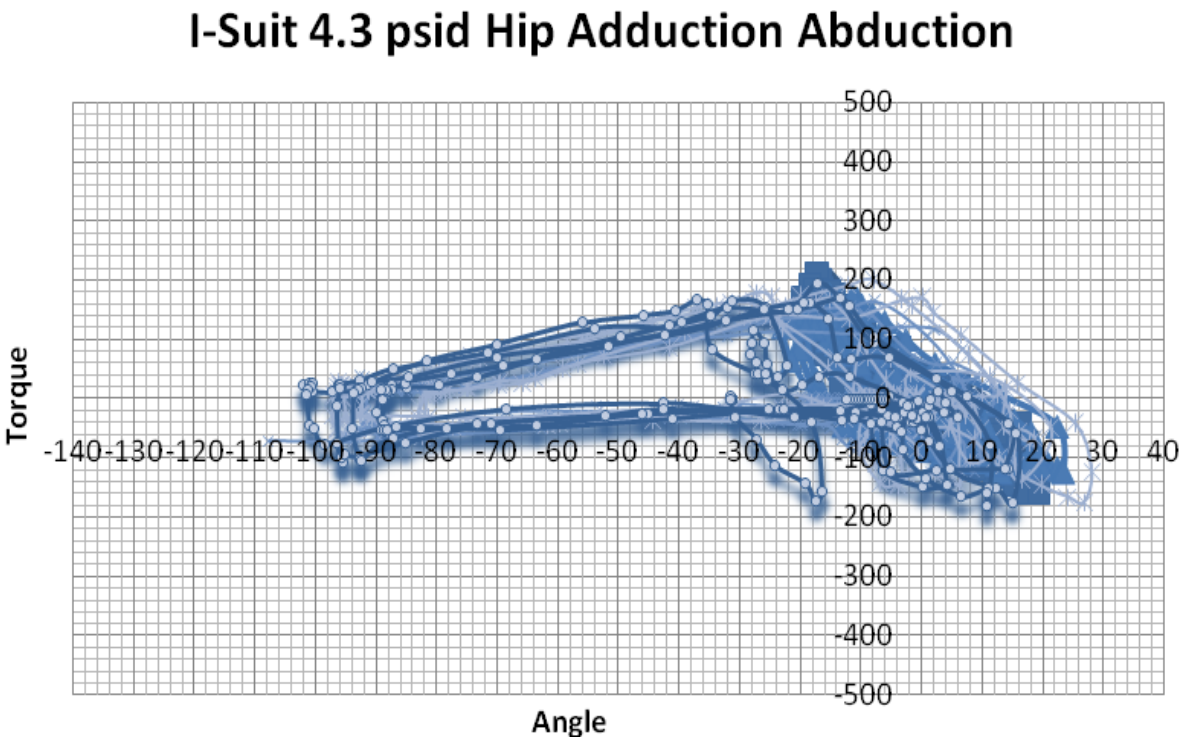
Torque profile for a winged bearing flip joint.

Trend Analysis – Butterfly



Torque profile for a butterfly joint.

Trend Analysis – Multi-phase Sweep



Torque profile for a multi-phase sweep joint.

Conclusion

- Some generalizations depicted in the seven types of traits discussed here will be identifiable using other test methods such bearings or single axis joints.
- Other traits such as butterfly joints or winged bearing flip joints, however, depend on protocol or test execution.
- Future work includes adding new prototypes to the torque catalog and investigating Thermal Micrometeoroid Garment (TMG) effects.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