

TEST CASE DOCUMENTATION AND TESTING RESULTS

ANSYS-QA-LS-DYNA-AWG-CI-9-10

TEST CASE ID AWG-CI-8

Lug Joint

Tested with LS-DYNA® R14.1.1 Revision 4-gaf1eb871e8

Thursday 4th July, 2024



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1 Introduction

1.1 Purpose of this Document

This document specifies the test case AWG-CI-8. It provides general test case information like name and ID as well as information to the confidentiality, status, and classification of the test case.

A detailed description of the test case is given, the purpose of the test case is defined, and the tested features are named. The test case specifications also state the target measures for testing and the expected results, as well as their pass and fail criteria.

Testing results are provided in section 5 for the therein mentioned LS-DYNA® version and platforms.

2 Test Case Information

Test Case Summary	
Confidentiality	external use
Test Case Name	Lug Joint
Test Case ID	AWG-CI-8
Test Case Status	active
Test Case Classification	Application Benchmark
Test Case Source	Boeing
Tested Keyword	*ELEMENT_SOLID *MAT_ELASTC *MAT_PIECEWISE_LINEAR_ELASTICITY *BOUNDARY_PRESCRIBED_MOTION
Member of Test Suite	AWG CI SUITE
Metadata	AWG CI

Table 1: Test Case Summary

3 Test Case Specification

3.1 Test Case Purpose

The purpose of Test Case ID AWG-CI-8 is to evaluate the forces exerted in lug joints. This type of joint is a representation of a link or connection between multiple seat parts such as a seatback and seat pan or seat legs and seat track attachments.

3.2 Test Case Description

Figure 1 shows the double shear lug joint model consisting of the two stationary female lugs, the male lug that has a tensile load applied, and the bolt connecting the male and female parts.

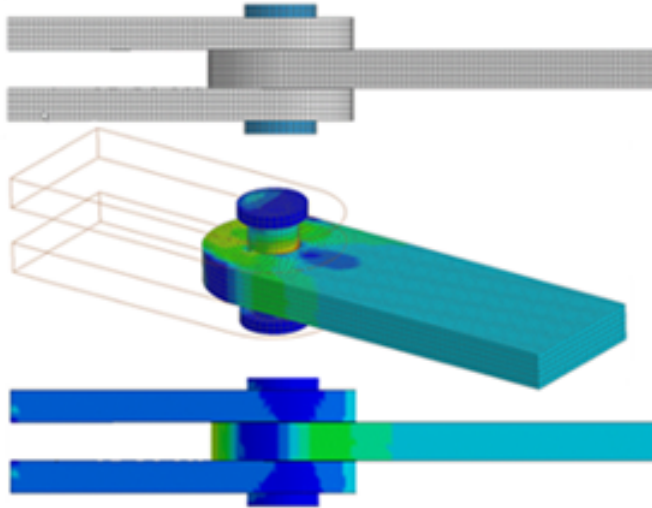


Figure 1: Lug Joint.

3.3 Model Description

The lug joint modeled is shown in Figure 2 and it consists of three parts. Part 1, the female lug, and Part 2, the male lug, are both made of Aluminum 7050-T7451. The female lug dimensions are length = 3.33 in, width = 1.417 in, thickness = 0.3125 in. The male lug dimensions are length = 4.42 in, width = 1.471 in, thickness = 0.375 in. The bolt is made of steel and has a 0.5 in diameter. A displacement controlled tensile force is applied on the male lug for 10 ms using *BOUNDARY_PRESCRIBED_MOTION with a rate of 1 in/10 ms.

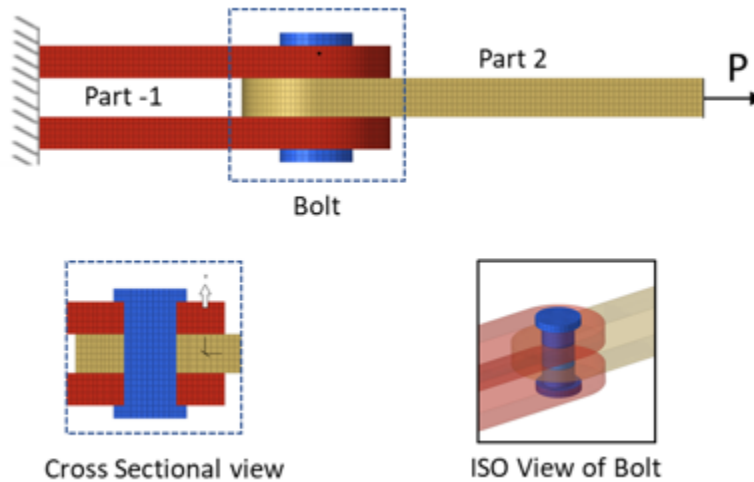


Figure 2: Rod Finite Element Model

Model information	
Nodes	41115
Solid elements	32776
Materials	2
Parts	3
Units	in (length), s (time), lbf-s ² /in (mass), lbf (force) psi (stress)

Table 2: FEA Model Information

Model information	
Test Case ID	Input Deck Name
1	lug_joint.key

Table 3: Specification of sub test cases

4 Test Specifications

4.1 Test Case Targets

Test Case Targets				
Target number	output	component type	component id	retrieved from
1	Resultant X-Force			binout/spcforc file
2	Internal Energy			binout/glstat file
3	CPU Time			d3hsp file

Table 4: Test Case targets for Test Case ID AWG-CI-8

4.2 Pass/Fail Criteria

These are the Pass/Fail criteria used for the Validation of the Test Case ID AWG-CI-8.

The sub test case passes if the test case target data falls within the corridor bounds. Otherwise the test fails.

The test case corridors are upper and lower bounds for the test case targets. They were defined based on the test target data obtained with LS-DYNA® R14.0 Revision 114 binaries by the following process:

- For a specific test case target, interpolate the data from different platform and executable (R14.0 Revision 114) combinations, so that the time domain is the same.
- Calculate the upper and lower bounds by:

$$bound_{up}(i) = max(i) + 0.2 \times [max(i) - min(i)] + 0.05 \times peak$$

$$bound_{low}(i) = min(i) - 0.2 \times [max(i) - min(i)] - 0.05 \times peak$$

where $max(i)$, $min(i)$ are the maximum and minimum values at the i_{th} time step across all platforms and executable (R14.0 Revision 114) combinations the test case was calculated with, $peak$ is the maximum absolute y value across the whole time domain, $bound_{up}(i)$ and $bound_{low}(i)$ are the upper and lower bounds for the i_{th} time step.

For CPU Time target, it holds:

$$bound_{up}^{CPU\ Time} = 2 \times Max + 1$$

$$bound_{low}^{CPU\ Time} = 0$$

where Max is the maximum CPU Time (in seconds) across all platforms and executable (R14.0 Revision 114) combinations the test case was calculated with and $bound_{up}^{CPU\ Time}$ and $bound_{low}^{CPU\ Time}$ are the upper and lower bounds.

5 Test Case Results

5.1 Software and Hardware Specifications

In order to ensure cross-platform consistency, the herein mentioned sub test cases are run on platforms specified in table 5 and the results are calculated with software versions defined in table 6.

Platform Name	Operating system	CPU type	MPI-Protocol	Number of cpu's ¹
cdcvdce7mbu01	CentOS 7.9	Intel® Xeon® Gold 6238R @ 2.20GHz	Platform MPI 08.3.0.2	4

¹ Number of cpu's used for calculation of the test case

Table 5: Used Platforms and CPU Type's

Product	Version	Release	Revision	Parallel type ¹	Precision ²	executable
LS-DYNA®	971	R14.1.1	4-gaf1eb871e8	SMP	SP	ls971.4-gaf1eb871e8.R14.1.1
LS-DYNA®	971	R14.1.1	4-gaf1eb871e8	SMP	DP	ld971.4-gaf1eb871e8.R14.1.1
LS-DYNA®	971	R14.1.1	4-gaf1eb871e8	MPP	SP	mpp971.4-gaf1eb871e8.R14.1.1
LS-DYNA®	971	R14.1.1	4-gaf1eb871e8	MPP	DP	mpd971.4-gaf1eb871e8.R14.1.1

¹ MPP = Massively Parallel Processing, SMP = Symmetric Multiprocessing

² SP = single precision, DP = double precision

Table 6: Tested LS-DYNA® version

5.2 Results Summary

Table 7 contains the results of the Test Case ID AWG-CI-8 completed with all combinations of software and hardware defined in section 5.1 (1 * 1 * 4 total calculation runs).

Details on the test results can be found in the section 5.3.

The table 7 cross cpu architecture consistency summary is:

- **PASS** - Pass criteria in section 4.2 is attained.
- **FAILED** - Pass criteria in section 4.2 is not attained.
- **ERROR** - sub test case terminates due to error.
- **N/A** - sub test case was not calculated.

Sub Test Case ID	PASS/FAILED
1	PASS

Table 7: Results summary for Test Case ID AWG-CI-8

5.3 Result Details

The following subsections contain detailed results for the Test Case ID AWG-CI-8 for LS-DYNA® R14.1.1 Revision 4-gaf1eb871e8.

For each sub test case defined in section 3.3 there is a graph displaying the time history of the result target defined in section 4.1 for the platform and software version combinations defined in section 5.1.

The title of the graph states the test case ID and the name of input deck. The legend contains the type, branch and the revision of the executable.

5.3.1 Test Target 1: Resultant X-Force

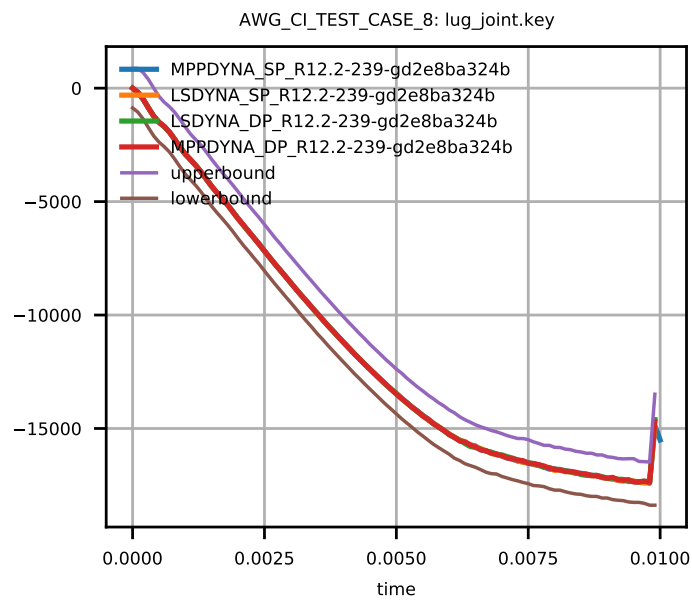


Figure 3: Resultant Reaction X-Force .

5.3.2 Test Target 2: Internal Energy

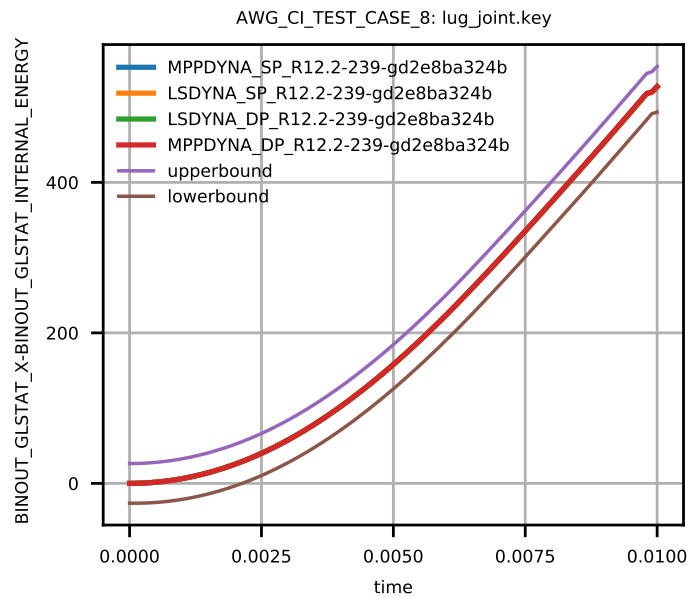


Figure 4: Internal Energy.

5.3.3 Test Target 3: CPU time

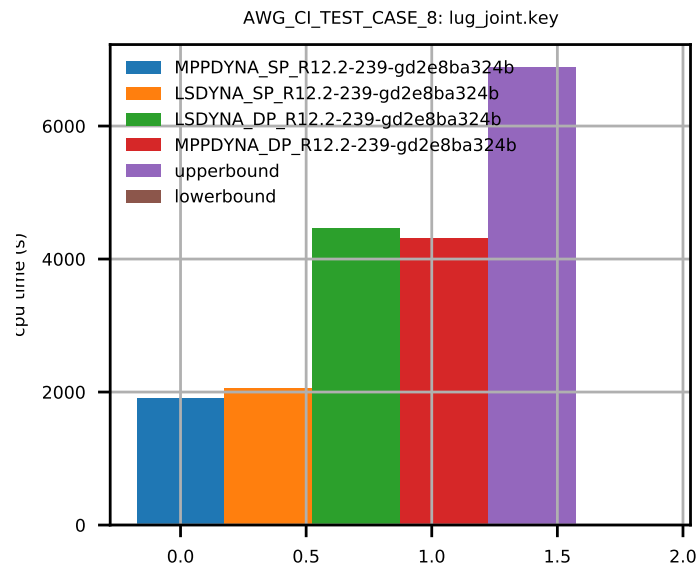


Figure 5: CPU Time Comparison.

References