TEST CASE DOCUMENTATION AND TESTING RESULTS

ANSYS-QA-LS-DYNA-AWG-ERIF-14-13

TEST CASE ID AWG-ERIF-14

*ELEMENT_BEARING

Tested with LS-DYNA® R13.0 Revision 365-gf8a97bda2a

Thursday 20th January, 2022

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Document Information	
Confidentiality	**external use**
Document Identifier	ANSYS-QA-LS-DYNA-AWG-ERIF-14-13
Author(s)	Prepared by LS-DYNA® Aerospace Working Group
Number of pages	12
Date created	Thursday 20th January, 2022
Distribution	LS-DYNA® Aerospace Working Group / internal ANSYS QA

Contents

1 Introduction

1.1 Purpose of this Document

The purpose of this test case is the demonstration of the *ELEMENT_BEARING feature in LS-DYNA® for a spinning beam element shaft. The reliability and consistency of LS-DYNA® as a finite element solver for this test case is evaluated by performing analyses on different cpu architecture platforms.

2 Test Case Information

Test Case Summary	
Confidentiality	external use
Test Case Name	*ELEMENT_BEARING
Test Case ID	AWG-ERIF-14
Test Case Status	active
Test Case Classification	Example
Test Case Source	ANSYS
Tested Keyword	*ELEMENT_BEARING
Member of Test Suite	AWG ERIF SUITE
Metadata	AWG ERIF

Table 1: Test Case Summary

3 Test Case Specification

3.1 Test Case Purpose

The purpose of Test Case ID AWG-ERIF-14 is the comparison of results from different cpu architectures for a test case containing *ELEMENT_BEARING keyword.
The reliability and consistency of LS-DYNA® as a finite element solver for these test cases is evaluated by performing analyses on different cpu architecture platforms.

3.2 Test Case Description

This Test Case consists of a spinning steel shaft made of beam elements with a center concentrated eccentric mass. The shaft has the translations fixed at one end of the beam and the other end of the shaft is supported by an *ELEMENT_BEARING that includes a preload.

Table 2 provides a short summary of the physical model setup.

Physical Model Information	
Steel Shaft	
Shaft Length	1.0 m
Shaft outer radius	0.05 m
Shaft inner radius	0.047 m
Center concentrated mass	10 kg
Concentrated mass eccentricity	4E-4 m
Steel Bearings	
Number of balls	14
Young's Modulus for balls (EBALL)	206.9E9 N/m
Poisson's Ratio for balls (PRBALL)	0.3
Young's Modulus for race (ERACE)	206.9E9 N/m
Poisson's Ratio for race (PRRACE)	0.3
Diameter of balls (D)	0.0127 m
Bore inner diameter (DI)	0.05 m
Bore outer diameter (DO)	0.09 m
Pitch Diameter (DM)	0.07 m (average of inner and outer bore diameter)
Unloaded, initial contact angle (A0)	15 $^{\circ}$
Inner race groove radius to ball diameter ratio (BI)	0.54
Outer race groove radius to ball diameter ratio (BO)	0.54
Unloaded bearing clearance (PD)	0.0
Force preload in local x-direction (XTRAN)	600 N
Force preload in local y-direction (YTRAN)	600 N
Force preload in local z-direction (ZTRAN)	500 N
Moment preload in local x-direction (XROT)	0.435 N-m
Moment preload in local y-direction (YROT)	0.435 N-m

Table 2: Physical Model Information

3.3 Model Description

The model consists of a spinning hollow shaft consisting of 10 beam elements. A 10 kg concentrated mass is located at the center of the shaft with a 4E-4 m eccentricity. The shaft rotational velocity is ramped up to 1000 rad/sec. The model specifications can be found in Table 3 and Table 4 provides the sub test case specification. The material definitions and their parameters can be found in the input deck.

FEA Model information	
Nodes	16
Beam Elements	10
Discrete Elements	1
Bearing Elements	1
Parts	2
Rotational Velocity	1000 rad/sec
Unit System	in (m), s (time), force (N), mass (kg), stress (N/m^2), energy (N-m)

Table 3: FEA Model Information

Specification of sub test cases	
Test Case ID	Input Deck Name
1	bearing14_shaft_rampup_high.k

Table 4: Specification of sub test cases

4 Test Specifications

4.1 Test Case Targets

Table 5 displays the test case targets. The test case targets specify values or a series of values taken from the finite element analysis solution of the test case and they are used in a comparison of analysis results on different cpu architectures. They are chosen in a way that they are representative of the numerical model.

Test Case Targets					
Target number	Sub Test Case ID	output	component type	component id	retrieved from
1	1	nodal	x-displacement	1	binout/nodout file
2	1	nodal	y-displacement	1	binout/nodout file

Table 5: Test Case targets for Test Case ID AWG-ERIF-14

Test case targets are used to evaluate the cross cpu architecture consistency (see section 4.2).

4.2 Pass/Fail Criteria

These are the Pass/Fail criteria used for the cross cpu architecture consistency test of the Test Case ID AWG-ERIF-14.

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® R9.0 Revision 108899 binaries by the following process:

- For a specific test case target, interpolate the data from different platform and executable (R9.0 Revision 108899) 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 (R9.0 Revision 108899) 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.

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 6 and the results are calculated with software versions defined in table 7.

Platform Name	Operating system	CPU type	MPI-Protocol	Number of cpu's [1]
cougar	openSUSE Leap 15.2	Intel® Xeon® E5- 2697 @ 2.30GHz	Platform MPI 09.01.04.03	4

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

Table 6: Used Platforms and CPU Type's

Product	Version	Release	Revision	Parallel type [1]	Precision [2]	executable
LS-DYNA®	971	R13.0	365-gf8a97bda2a	SMP	SP	ls971.365-gf8a97bda2a.R13.0
LS-DYNA®	971	R13.0	365-gf8a97bda2a	SMP	DP	ld971.365-gf8a97bda2a.R13.0
LS-DYNA®	971	R13.0	365-gf8a97bda2a	MPP	SP	mpp971.365-gf8a97bda2a.R13.0
LS-DYNA®	971	R13.0	365-gf8a97bda2a	MPP	DP	mpd971.365-gf8a97bda2a.R13.0

[1] MPP = Massively Parallel Processing, SMP = Symmetric Multiprocessing

[2] SP = single precision, DP = double precision

Table 7: Tested LS-DYNA® version

5.2 Results Summary

Table 8 contains the results of the Test Case ID AWG-ERIF-14 completed with all combinations of software and hardware defined in section 5.1 (1 * 3 * 4 total calculation runs).

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

The table 8 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	**FAIL**

Table 8: Results summary for Test Case ID AWG-ERIF-14

5.3 Result Details

The following subsections contain detailed results for the Test Case ID AWG-ERIF-14 for LS-DYNA® R13.0 Revision 365-gf8a97bda2a.

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.

Example for title:

Title:

'AWG_ERIF_TEST_CASE_14: bearing14_shaft_rampup_high.k' states the test case ID 14 and name of the input deck for sub test case 1.

5.3.1 Sub Test Case ID 1 - Test Target 1

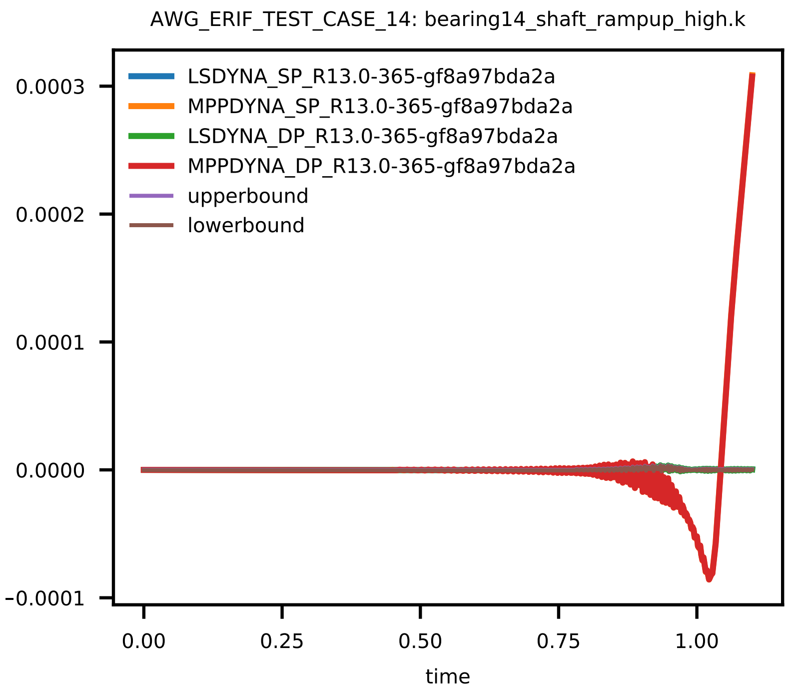

Figure 1: Cross platform results, node displacement in x-direction, node id 1, sub test case ID 1

5.3.2 Sub Test Case ID 2 - Test Target 2

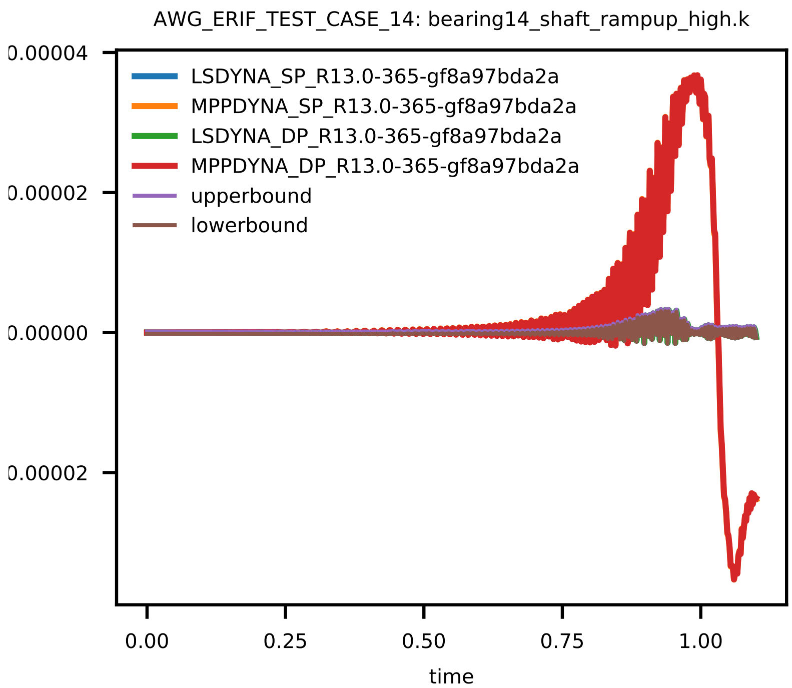

Figure 2: Cross platform results, node displacement in y-direction, node id 1, sub test case ID 1

References