TEST CASE DOCUMENTATION AND TESTING RESULTS

LSTC-QA-LS-DYNA-AWG-ERIF-17-7

TEST CASE ID AWG-ERIF-17

*MAT_224_Temperature Initialization

Tested with LS-DYNA® R12.0 Revision 148708

Friday 11th December, 2020

LSTC
Livermore Software Technology Corp.

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Contents

1 Introduction

1.1 Purpose of this Document

The purpose of this test case is the demonstration of the temperature initialization for *MAT_224 in LS-DYNA® . 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	*MAT_224_Temperature Initialization
Test Case ID	AWG-ERIF-17
Test Case Status	active
Test Case Classification	Example
Test Case Source	LSTC
Tested Keyword	*MAT_224, *INITIAL_STRESS_SOLID, *INITIAL_STRESS_SHELL
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-17 is to verify that *MAT_224 temperature can be initialized using history variable 10 for shells and history variable 14 for solids.

3.2 Test Case Description

Using *MAT_224, one shell element and one solid element are loaded in uniaxial compression and the temperature is initialized to 500 degrees F using history variable 10 for shells and history variable 14 for solids.

3.3 Model Description

Using *MAT_224 one solid element (element ID 4) and one shell element (element ID 14) are loaded in uniaxial compression (Figure 1). The temperature is initialized to 500 degrees F using history variable 10 for the shell element and history variable 14 for the solid element. Two subcases are defined with different values of beta, the fraction of plastic work converted to heat. In Subcase 1, beta is set to a very small number so that the temperature remains constant as the elements deform. In Subcase 2, beta is set to set to 1.0 so that all the plastic work is converted to heat and the material heats up as the elements deform.
The model specifications can be found in Table 2.The material definitions and their parameters can be found in the input deck. A summary of the sub test cases can be found in Table 3.

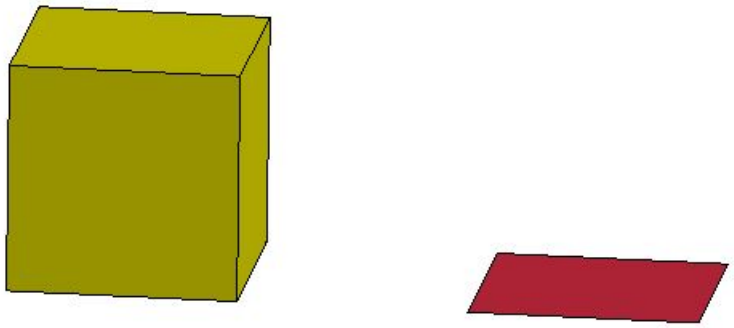

Figure 1: One solid element (ID 4) and one shell element (ID 14) using *MAT_224

FEA Model information	
Nodes	12
Solid Elements	1
Shell Elements	1
Materials	1
Parts	2
Units	in (length), s (time), lbf-s^2/in (mass), lbf (force), psi (stress), degrees F (temperature)

Table 2: FEA Model Information

Specification of sub test cases		
Test Case ID	Beta	Input Deck Name
1	1.0e-6	mat224_inittemp_newformat_rev.incl_shells_beta0.k
2	1	mat224_inittemp_newformat_rev.incl_shells_beta1.k

Table 3: Specification of sub test cases

4 Test Specifications

4.1 Test Case Targets

Table 4 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	components id	retrieved from
1	1,2	elout	Von Mises Stress	4	binout/elout file
2	1,2	elout	Effective Plastic Strain	4	binout/elout file
3	1,2	elout	History Variable 14 (temperature)	4	binout/elout file
4	1,2	elout	Von Mises Stress	14	binout/elout file
5	1,2	elout	Effective Plastic Strain	14	binout/elout file
6	1,2	elout	History Variable 10 (temperature)	14	binout/elout file

Table 4: Test Case targets for Test Case ID AWG-ERIF-17

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-17.

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® R10.1 Revision 123136 binaries by the following process:

- For a specific test case target, interpolate the data from different platform and executable (R10.1 Revision 123136) 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 (R10.1 Revision 123136) 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 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]
mars	CentOS 6.5	Intel® Xeon® E5- 2640 @ 2.50GHz	Platform MPI 8.2.0.0	4
dinar3b	SUSE LES 11	AMD® Opteron ® 6276 @ 2300MHz	Platform MPI 8.2.0.0	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	R12.0	148708	SMP	SP	ls971.148708.R12.0
LS-DYNA®	971	R12.0	148708	SMP	DP	ld971.148708.R12.0
LS-DYNA®	971	R12.0	148708	MPP	SP	mpp971.148708.R12.0
LS-DYNA®	971	R12.0	148708	MPP	DP	mpd971.148708.R12.0

[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-ERIF-17 completed with all combinations of software and hardware defined in section 5.1.

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**
2	**PASS**

Table 7: Results summary for Test Case ID AWG-ERIF-17

5.3 Result Details

The following subsections contain detailed results for the Test Case ID AWG-ERIF-17 for LS-DYNA® R12.0 Revision 148708.

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 result file name, output, platform, executable and number of cpu's separated by comma. A minus sign before the number of cpu's refers to the compatibility option for SMP calculations (see [1] for details on this option).

Example for title and legend:

Title:

'AWG_ERIF_TEST_CASE_17: mat224_inittemp_newformat_rev.incl_shells_beta0.k' states the test case ID 17 and name of the input deck for sub test case 1.

Legend:

'elout_effsg_4_4_1,mars,ls971.148708.R12.0,4' states that the graph shows the Von Mises Stress (effective stress) of element ID 4 derived from the 'elout' output file for an input deck which was calculated on the 'mars' platform with a LS-DYNA® R12.0 Revision 148708 binary (SMP, single precision) on four processors.

5.3.1 Sub Test Case ID 1, 2- Test Target 1

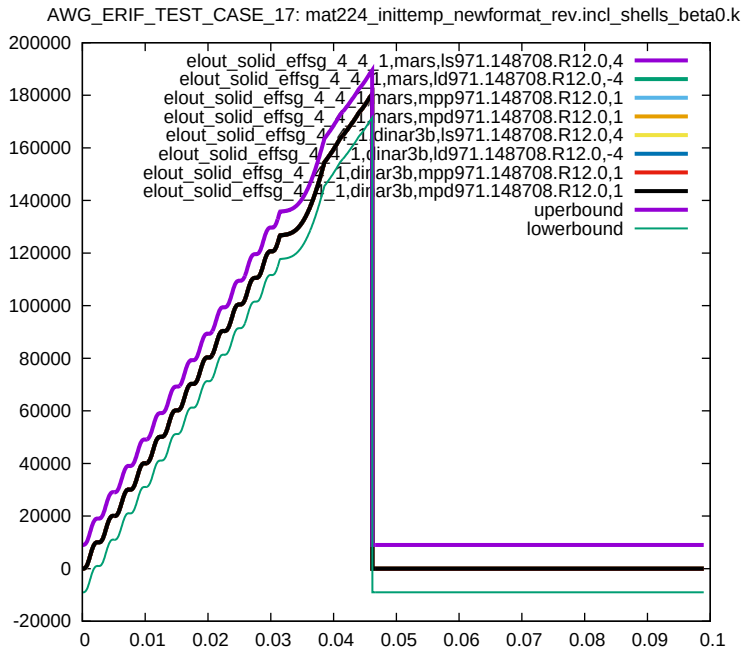

Figure 2: Cross platform results, Von Mises Stress, element ID 4, sub test case ID 1

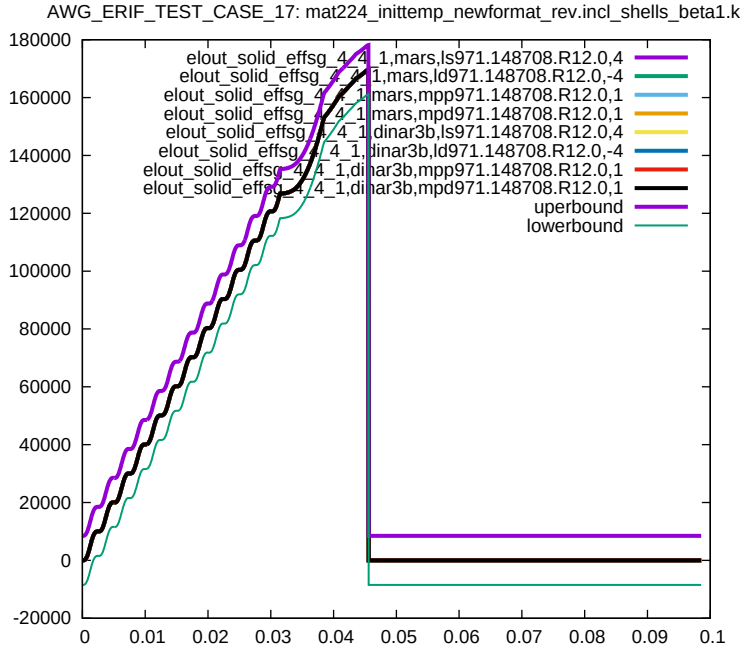

Figure 3: Cross platform results, Von Mises Stress, element ID 4, sub test case ID 2

5.3.2 Sub Test Case ID 1, 2- Test Target 2

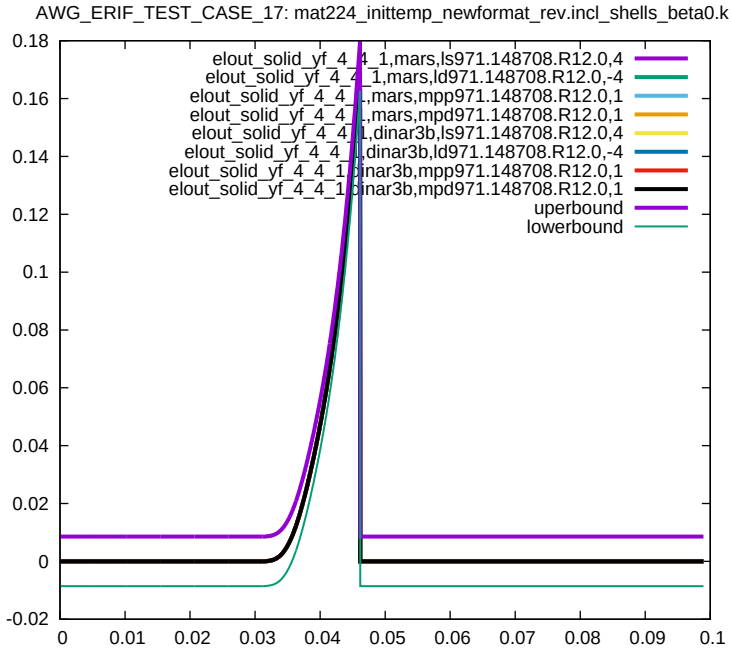

Figure 4: Cross platform results, Effective Plastic Strain, element ID 4, sub test case ID 1

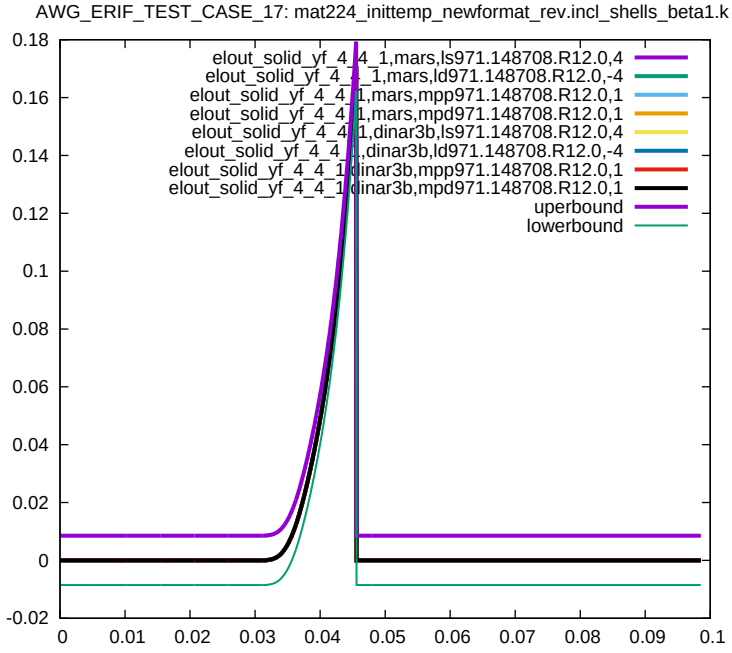

Figure 5: Cross platform results, Effective Plastic Strain, element ID 4, sub test case ID 2

5.3.3 Sub Test Case ID 1, 2- Test Target 3

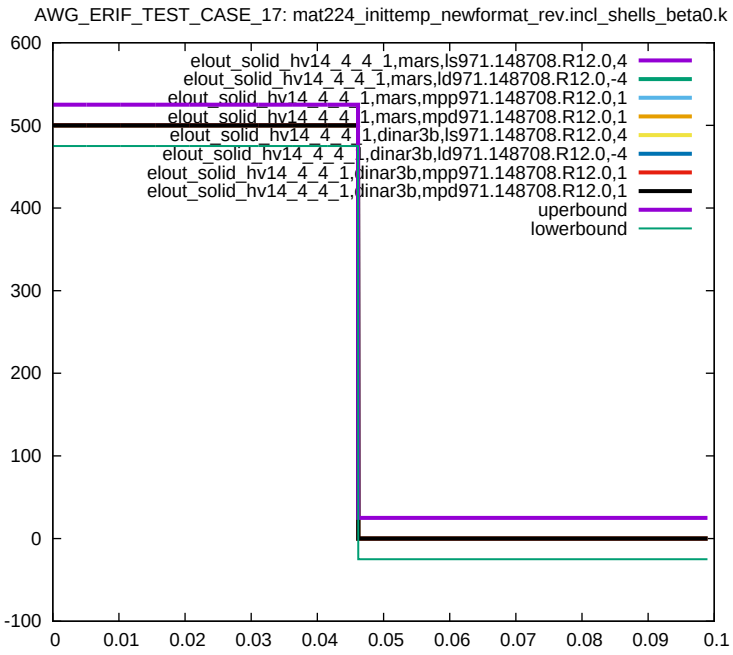

Figure 6: Cross platform results, History Variable 14 (temperature), element ID 4, sub test case ID 1

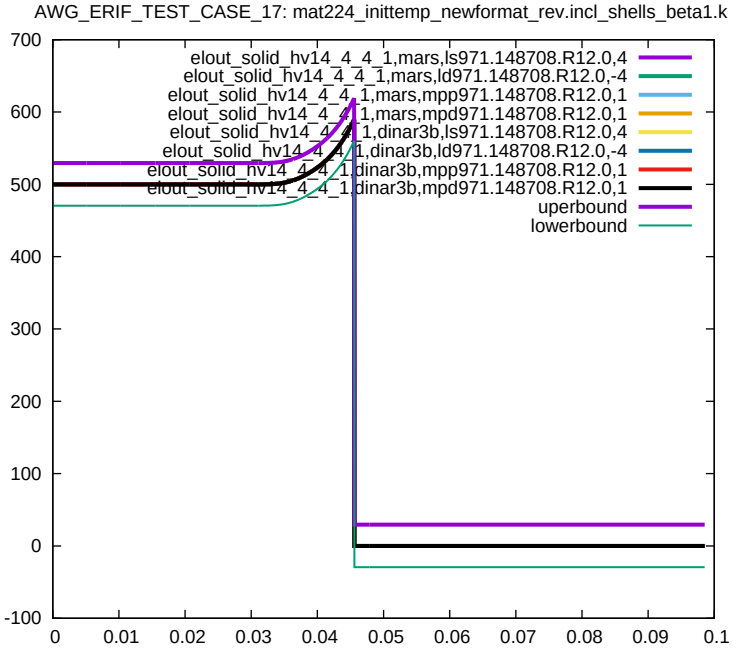

Figure 7: Cross platform results, History Variable 14 (temperature), element ID 4, sub test case ID 2

5.3.4 Sub Test Case ID 1, 2- Test Target 4

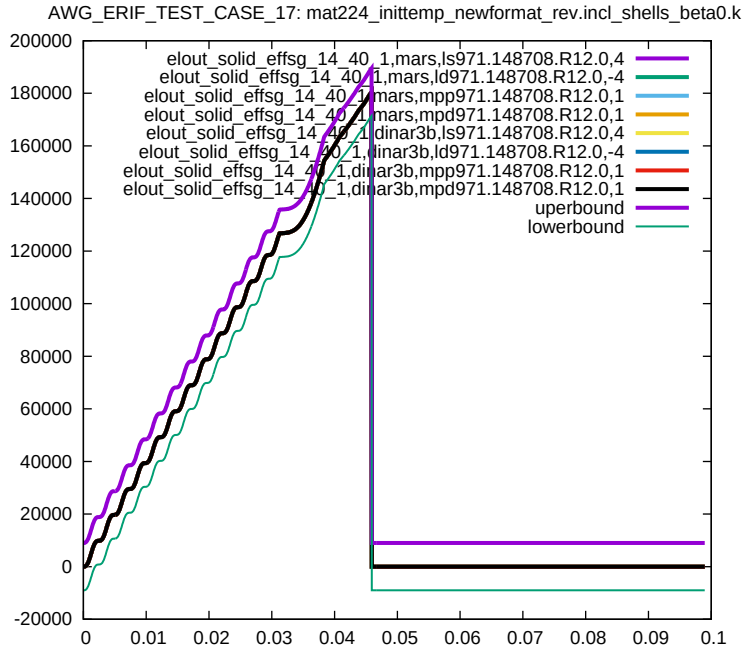

Figure 8: Cross platform results, Von Mises Stress, element ID 14, sub test case ID 1

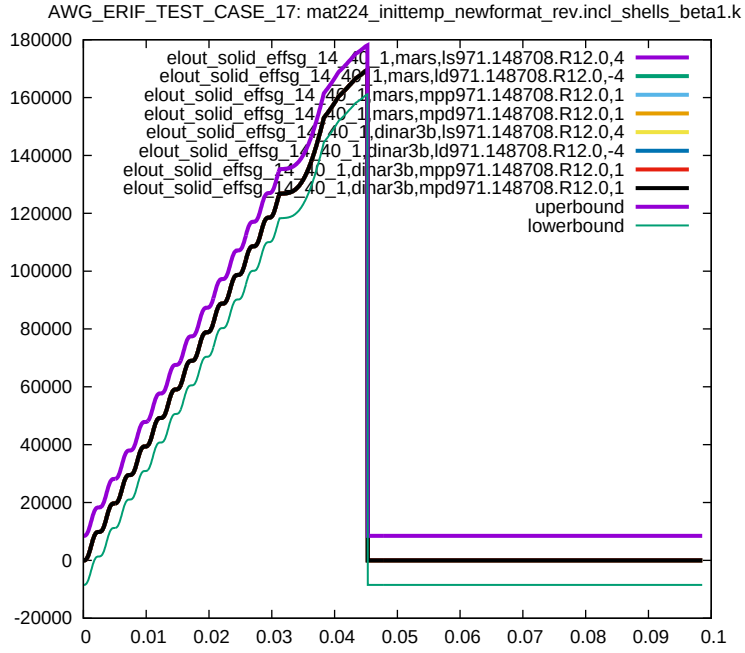

Figure 9: Cross platform results, Von Mises Stress, element ID 14, sub test case ID 2

5.3.5 Sub Test Case ID 1, 2- Test Target 5

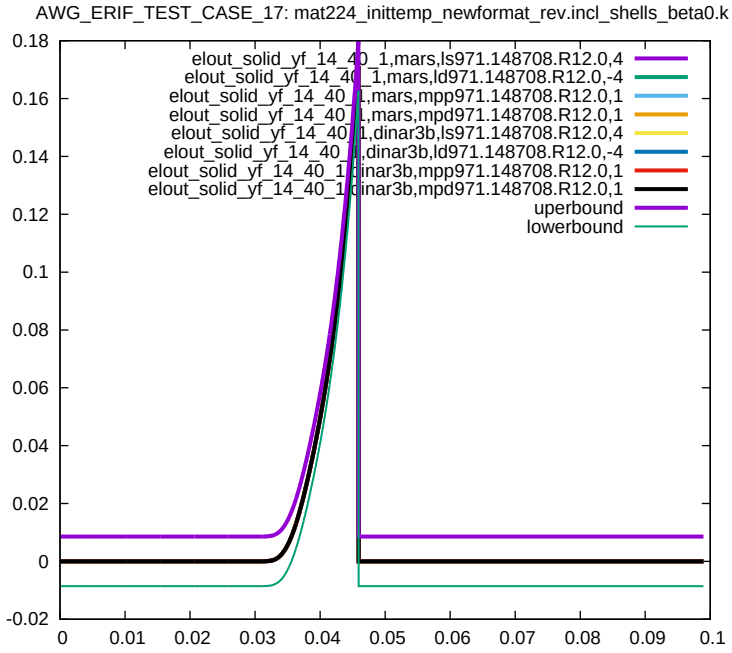

Figure 10: Cross platform results, Effective Plastic Strain, element ID 14, sub test case ID 1

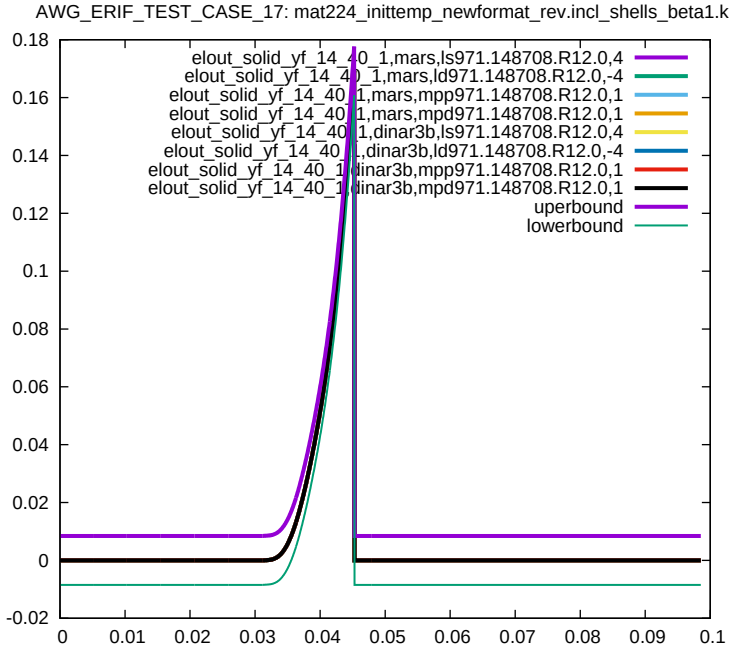

Figure 11: Cross platform results, Effective Plastic Strain, element ID 14, sub test case ID 2

5.3.6 Sub Test Case ID 1, 2- Test Target 6

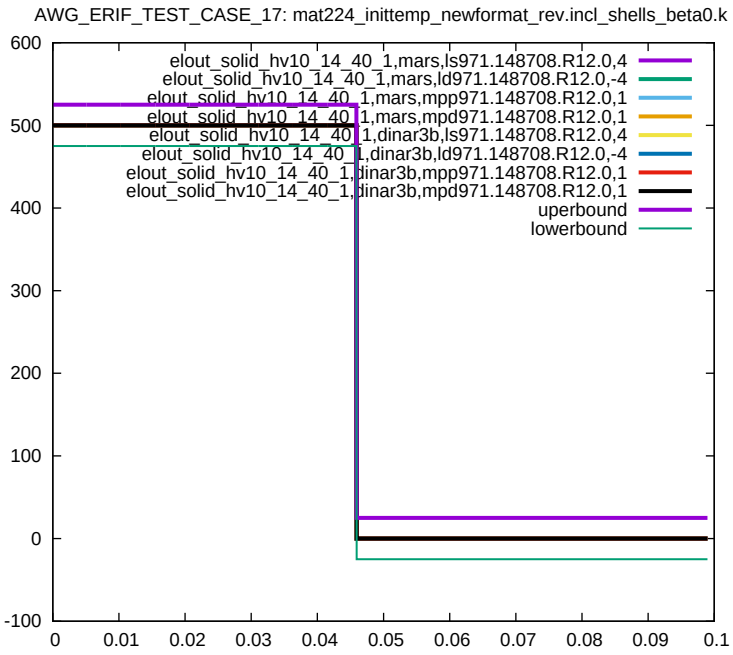

Figure 12: Cross platform results, History Variable 10 (temperature), element ID 14, sub test case ID 1

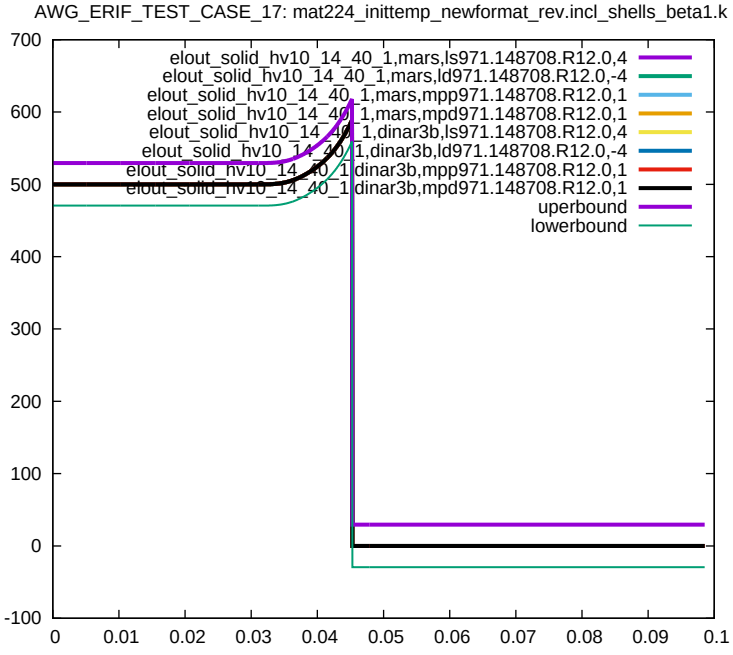

Figure 13: Cross platform results, History Variable 10 (temperature), element ID 14, sub test case ID 2

References

[1] LSTC, *LS-DYNA KEYWORD USER MANUAL*, 7374 Las Positas Road, Livermore, CA, 94551, USA, version 971 ed., May 2007.