TEST CASE DOCUMENTATION AND TESTING RESULTS

TEST CASE ID AWG-MAT_213-162

*MAT_213 Test Case 162: Single Shell Element - Generalized Tabulated

Tested with LS-DYNA® R14.1 Revision 7-gea5f83301c

Friday 21st April, 2023

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Contents

1 Introduction

1.1 Purpose of this Document

This document specifies the test case AWG-MAT_213-162. 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	*MAT_213 Test Case 162: Single Shell Element - Generalized Tabulated
Test Case ID	AWG-MAT_213-162
Test Case Status	In Development
Test Case Classification	Verification
Test Case Source	Arizona State University
Tested Keyword	*MAT_213 *BOUNDARY_PRESCRIBED_MOTION_SET *BOUNDARY_SPC_NODE
Member of Test Suite	AWG MAT_213 SUITE
Metadata	AWG MAT_213

Table 1: Test Case Summary

3 Test Case Specification

3.1 Test Case Purpose

The purpose of Test Case ID AWG-MAT_213-162 is verification of the *MAT_213 T800/F3900 input for shell elements.

3.2 Test Case Description

This test case is a single shell element verification model for T800/F3900 with 1-2 shear load and using the Generalized Tabulated Failure Criterion. The test case details include:

- Displacement controlled
- Deformation and failure
- Visco-plastic assumption (VEVP=0)

3.3 Model Description

A single shell element test case using *MAT_213 with displacement control; deformation and failure; and visco-plastic assumption (VEVP=0).

Model information	
Nodes	4
Shell Elements	1
Parts	1
Materials	1
Unit System	inch (length), second (time), lbf-s^2/in (mass), pound (force), psi (stress), Celsius (temperature)

Table 2: FEA Model Information

Model information	
Test Case ID	Input Deck Name
1	162_Single_Shell_Element_Generalized_Tabulated_Failure_.k

Table 3: Specification of sub test cases

4 Test Specifications

4.1 Test Case Targets

Test Case Targets					
Target number	Output	Integration pt.	Component type	Component id	Retrieved from
1	Stress xx	1	Element	5	binout/elout
2	Stress yy	1	Element	5	binout/elout
3	Stress xy	1	Element	5	binout/elout
4	Stress xx	2	Element	5	binout/elout
5	Stress yy	2	Element	5	binout/elout
6	Stress xy	2	Element	5	binout/elout
7	Stress xx	3	Element	5	binout/elout
8	Stress yy	3	Element	5	binout/elout
9	Stress xy	3	Element	5	binout/elout
10	Stress xx	4	Element	5	binout/elout
11	Stress yy	4	Element	5	binout/elout
12	Stress xy	4	Element	5	binout/elout
13	lower_ipt_strain_x	1	Element	5	binout/elout
14	lower_ipt_strain_y	1	Element	5	binout/elout
15	lower_ipt_strain_xy	1	Element	5	binout/elout
16	Internal Energy				binout/glstat
17	Kinetic Energy				binout/glstat
18	Hourglass Energy				binout/glstat
19	CPU Time				d3hsp file

Table 4: Test Case Targets

4.2 Pass/Fail Criteria

These are the Pass/Fail criteria used for the Validation of the Test Case ID AWG-MAT_213-162.

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 331 binaries by the following process:

- For a specific test case target, interpolate the data from different platform and executable (R14.0 Revision 331) 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 331) 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 331) 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]
cdclstreg5	CentOS 7	Intel® Xeon® E5- 2697A v4 @ 2.60GHz	Platform MPI 08.02.00.00 [10060] Linux x86-64	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	7-gea5f83301c	SMP	SP	ls971.7-gea5f83301c.R14.1
LS-DYNA®	971	R14.1	7-gea5f83301c	SMP	DP	ld971.7-gea5f83301c.R14.1
LS-DYNA®	971	R14.1	7-gea5f83301c	MPP	SP	mpp971.7-gea5f83301c.R14.1
LS-DYNA®	971	R14.1	7-gea5f83301c	MPP	DP	mpd971.7-gea5f83301c.R14.1

[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-MAT_213-162 completed with all combinations of software and hardware defined in section 5.1 (1 * 2 * 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-MAT_213-162

5.3 Result Details

The following subsections contain detailed results for the Test Case ID AWG-MAT_213-162 for LS-DYNA® R14.1 Revision 7-gea5f83301c.

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: Shell Element Stress xx at through-thickness integration point 1

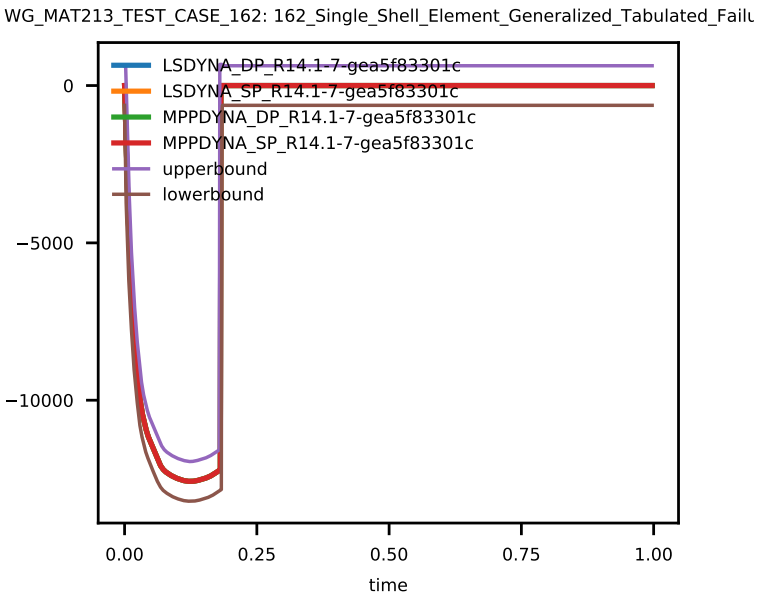

Figure 1: Shell Element Stress xx at through-thickness integration point 1.

5.3.2 Test Target 2: Shell Element Stress yy at through-thickness integration point 1

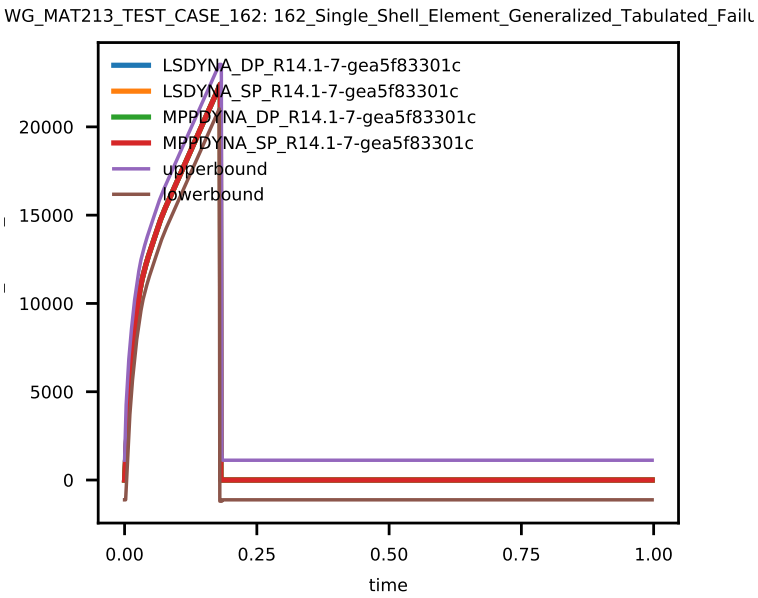

Figure 2: Shell Element Stress yy at integration point 1.

5.3.3 Test Target 3: Shell Element Stress xy at through-thickness integration point 1

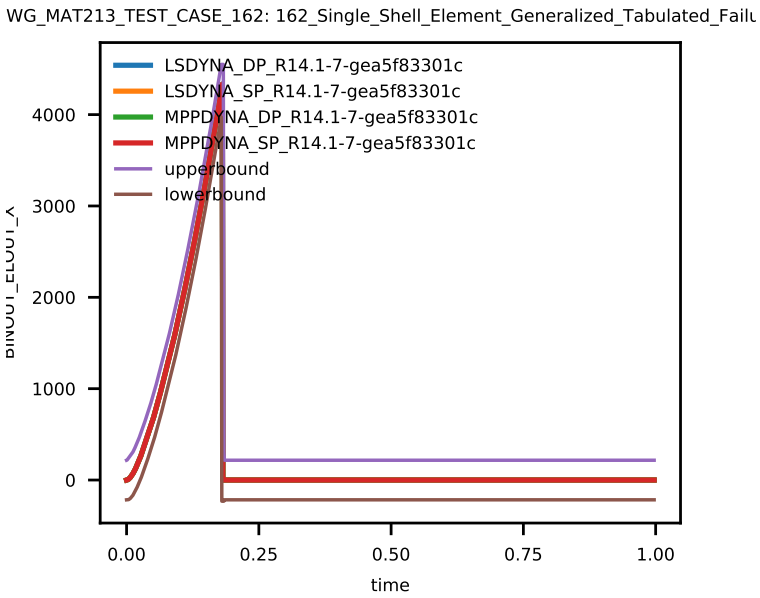

Figure 3: Shell Element Stress xy at integration point 1.

5.3.4 Test Target 4: Shell Element Stress xx at through-thickness integration point 2

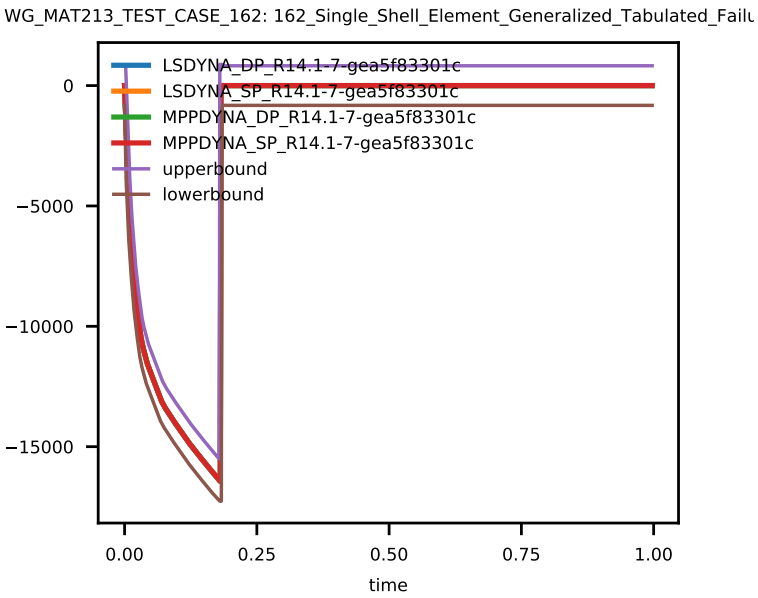

Figure 4: Shell Element Stress xx at integration point 2.

5.3.5 Test Target 5: Shell Element Stress yy at through-thickness integration point 2

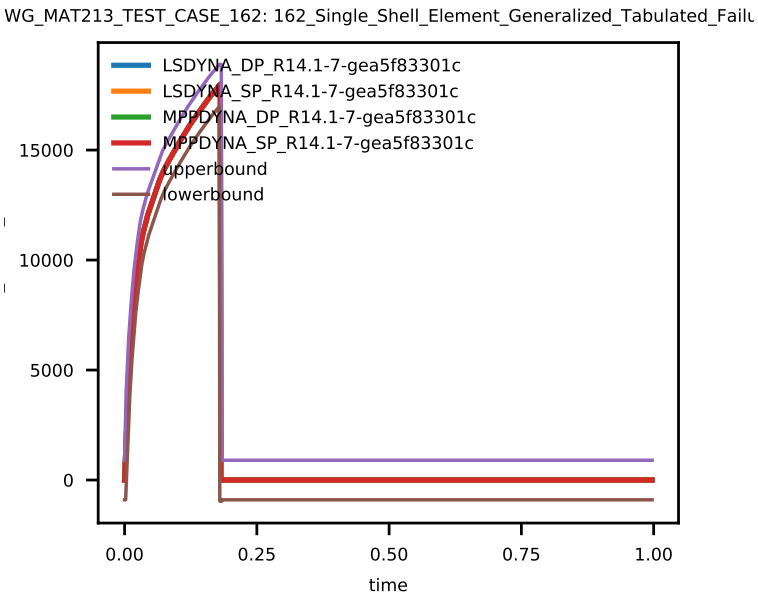

Figure 5: Shell Element Stress yy at integration point 2.

5.3.6 Test Target 6: Shell Element Stress xy at through-thickness integration point 2

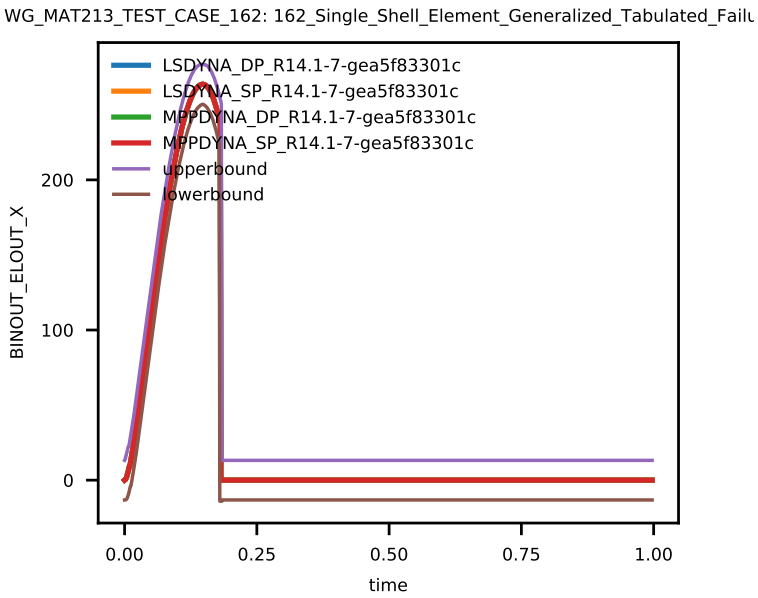

Figure 6: Shell Element Stress xy at integration point 2.

5.3.7 Test Target 7: Shell Element Stress xx at through-thickness integration point 3

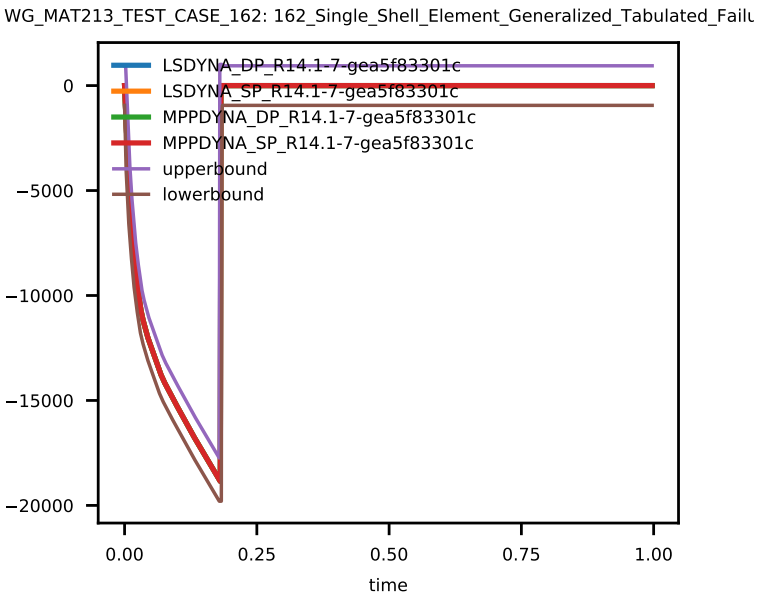

Figure 7: Shell Element Stress xx at integration point 3.

5.3.8 Test Target 8: Shell Element Stress yy at through-thickness integration point 3

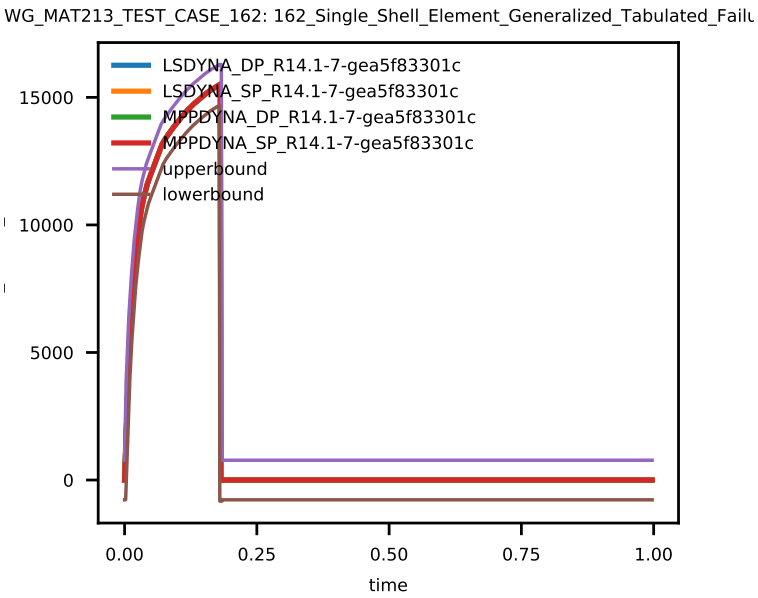

Figure 8: Shell Element Stress yy at integration point 3.

5.3.9 Test Target 9: Shell Element Stress xy at through-thickness integration point 3

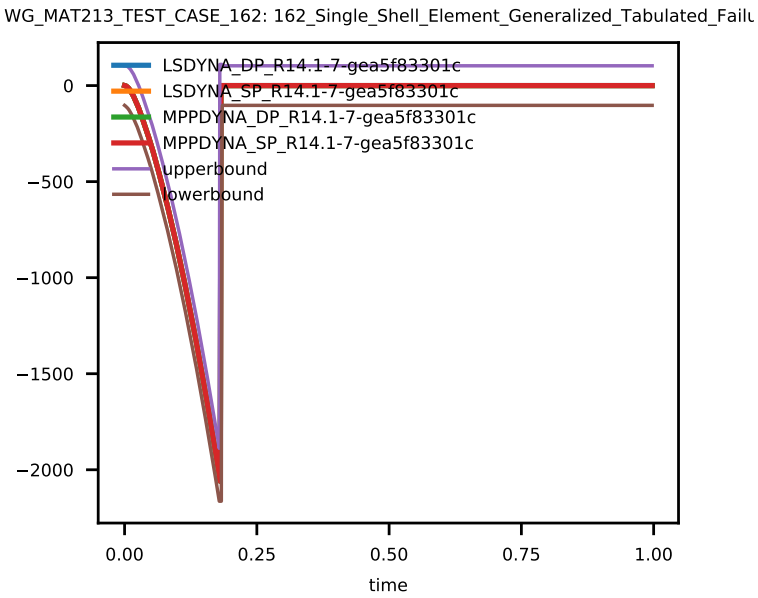

Figure 9: Shell Element Stress xy at integration point 3.

5.3.10 Test Target 10: Shell Element Stress xx at through-thickness integration point 4

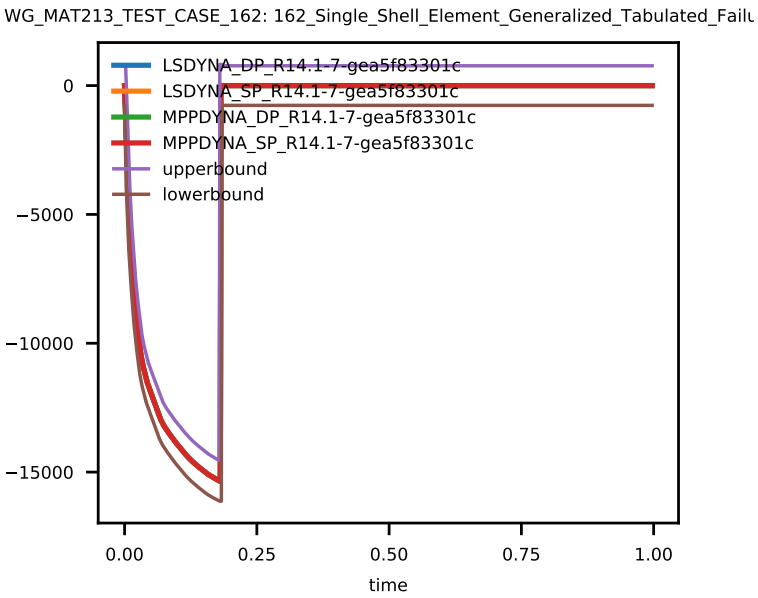

Figure 10: Shell Element Stress xx at integration point 4.

5.3.11 Test Target 11: Shell Element Stress yy at through-thickness integration point 4

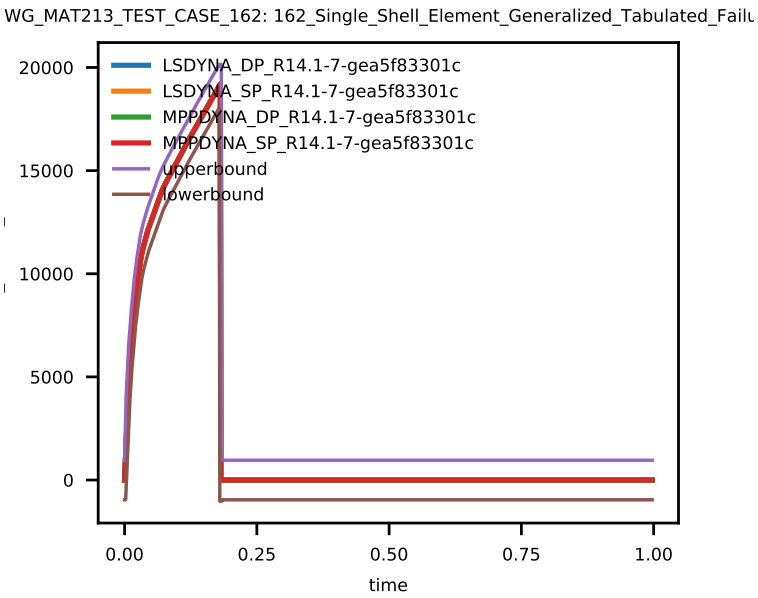

Figure 11: Shell Element Stress yy at integration point 4.

5.3.12 Test Target 12: Shell Element Stress xy at through-thickness integration point 4

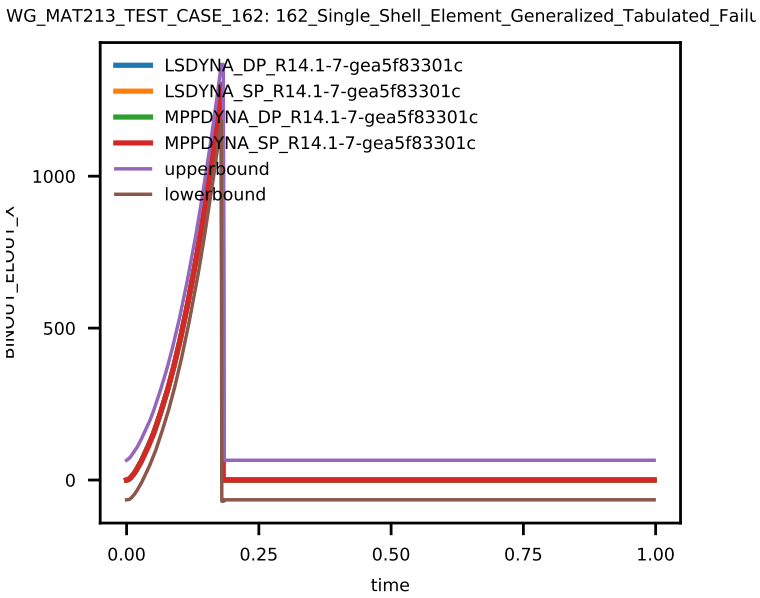

Figure 12: Shell Element Stress xy at integration point 4.

5.3.13 Test Target 13: Shell Element Strain xx at lower integration point

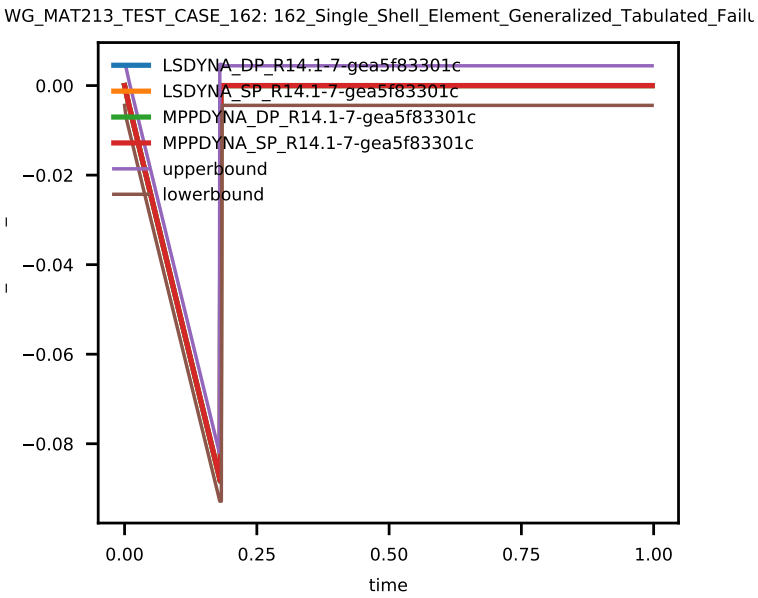

Figure 13: Shell Element Stress xy at lower integration point.

5.3.14 Test Target 14: Shell Element Strain yy at lower integration point

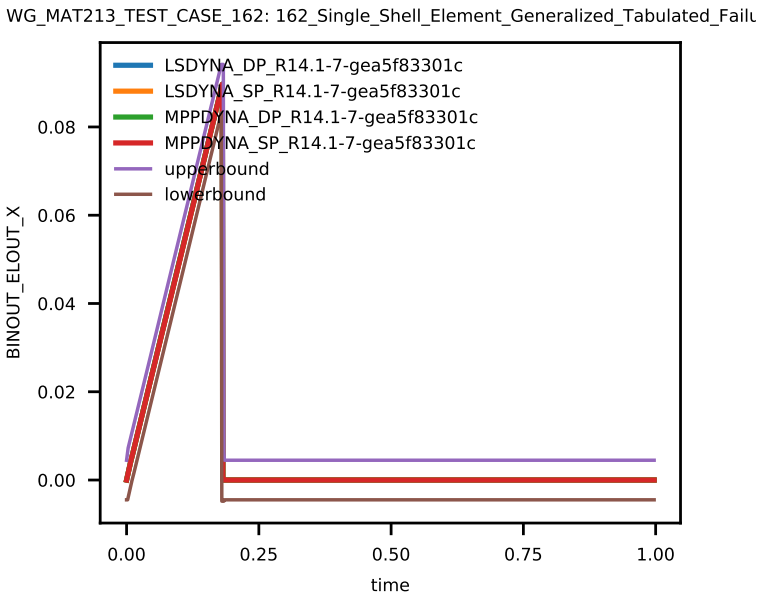

Figure 14: Shell Element Stress xy at lower integration point in thickness.

5.3.15 Test Target 15: Shell Element Strain xy at lower integration point

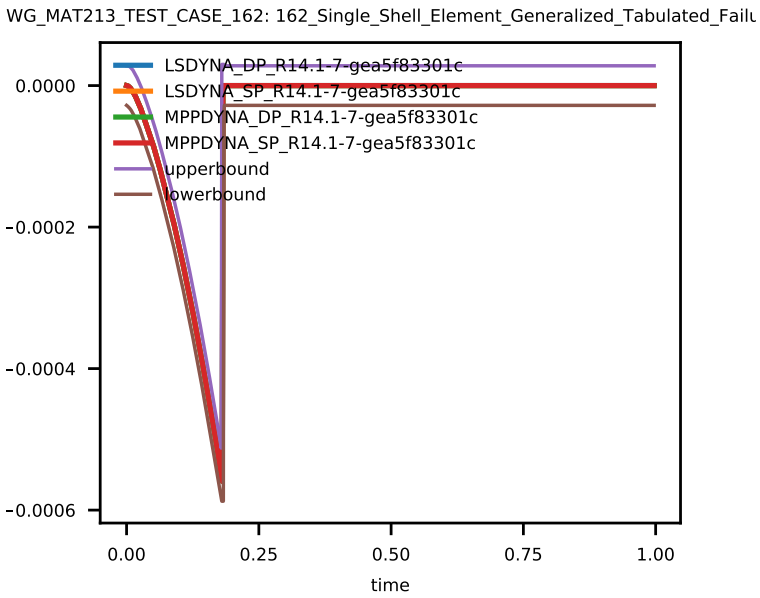

Figure 15: Shell Element Stress xy at lower integration point in thickness.

5.3.16 Test Target 16: Global Internal Energy

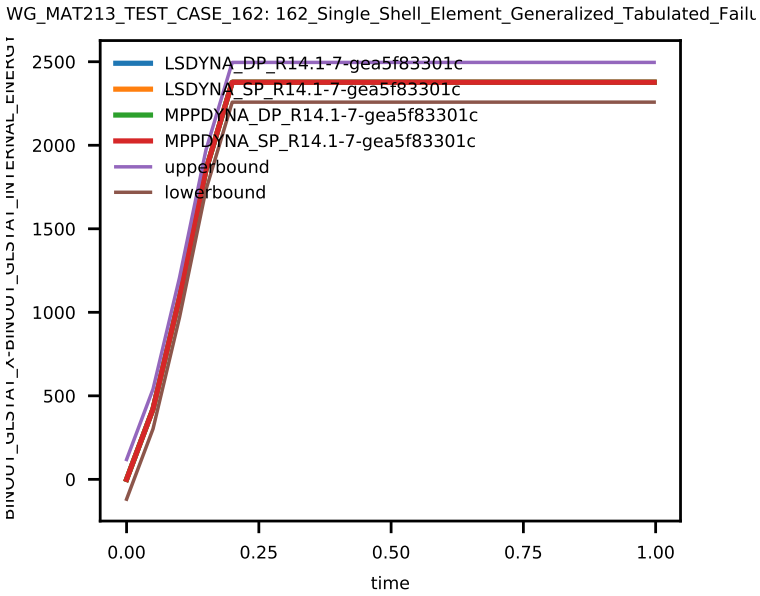

Figure 16: Global Internal Energy.

5.3.17 Test Target 17: Global Kinetic Energy

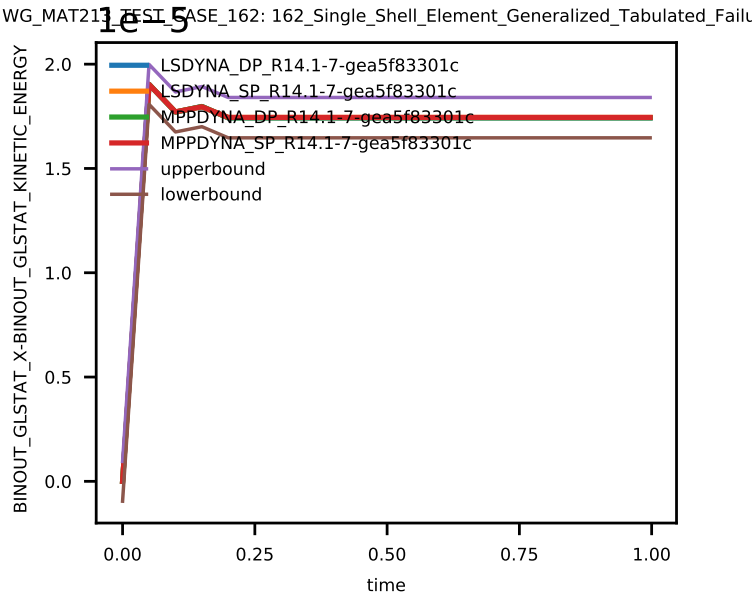

Figure 17: Global Kinetic Energy.

5.3.18 Test Target 18: Global Hourglass Energy

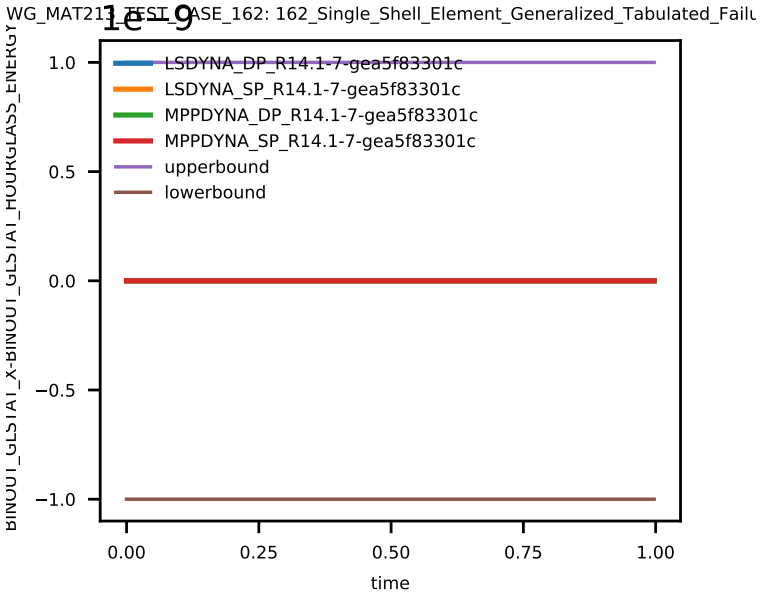

Figure 18: Global Hourglass Energy.

5.3.19 Test Target 19: CPU time

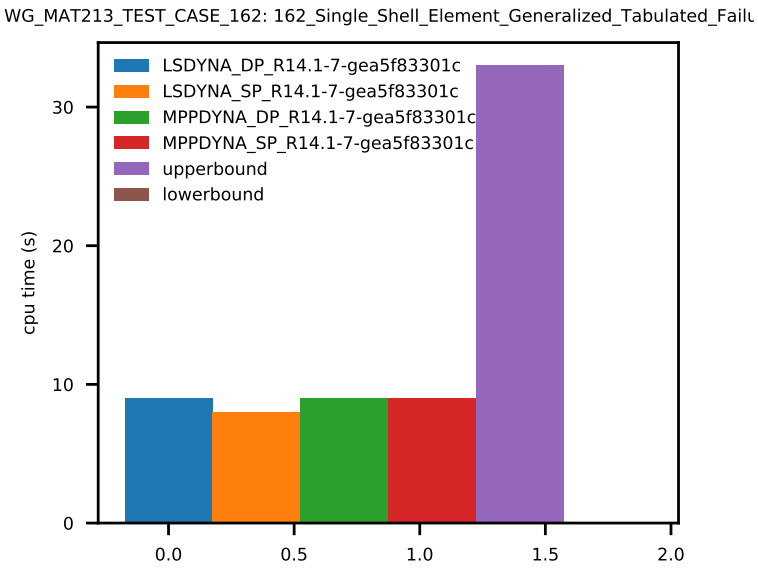

Figure 19: CPU Time.

References