

# TEST CASE DOCUMENTATION AND TESTING RESULTS

TEST CASE ID AWG-MAT\_213-131

\*MAT\_213 Test Case 131: Single Solid Element - Off-axis

Tested with LS-DYNA® R14.0 Revision 461-gee93a457ac

Tuesday 29<sup>th</sup> November, 2022



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# **1 Introduction**

## **1.1 Purpose of this Document**

This document specifies the test case AWG-MAT\_213-131. 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 131: Single Solid Element - Off-axis    |
| Test Case ID             | AWG-MAT_213-131  |
| 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_SET |
| 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\_213-131 is verification of the \*MAT\_213 T800/F3900 input for solid elements.

### **3.2 Test Case Description**

This test case is a single solid element verification model for T800/F3900 with off-axis 1-2 plane tensile loading. The test case details include:

- Load controlled
- Deformation only
- Visco-plastic assumption (VEVP=0)



### 3.3 Model Description

A single solid element test case using \*MAT\_213 with load control; deformation only; and visco-plastic assumption (VEVP=0).

| Model information |   |
|-------------------|---|
| Nodes             | 8   |
| Solid Elements    | 1   |
| Parts             | 1   |
| Materials         | 1   |
| Unit System       | inch (length), second (time), lbf-s <sup>2</sup> /in (mass), pound (force), psi (stress), Celsius (temperature) |

Table 2: FEA Model Information

| Model information |                                     |
|-------------------|-------------------------------------|
| Test Case ID      | Input Deck Name                     |
| 1                 | 131_Single_Solid_Element_Off_axis_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                 | Strain xx       | 1               | Element        | 1            | binout/elout   |
| 2                 | Strain yy       | 1               | Element        | 1            | binout/elout   |
| 3                 | Strain zz       | 1               | Element        | 1            | binout/elout   |
| 4                 | Strain xy       | 1               | Element        | 1            | binout/elout   |
| 5                 | Strain yz       | 1               | Element        | 1            | binout/elout   |
| 6                 | Strain zx       | 1               | Element        | 1            | binout/elout   |
| 7                 | Internal Energy |                 |                |              | binout/glstat  |
| 8                 | Kinetic Energy  |                 |                |              | binout/glstat  |
| 9                 | 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\_213-131.

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 <sup>1</sup> |
|---------------|------------------|---|---|------------------------------|
| cdcvdce7mbu01 | CentOS 7.9       | Intel <sup>®</sup> Xeon <sup>®</sup><br>E5- 2680 v4 @ 2.40GHz | Platform MPI ISV Edition<br>08.3.0.2 [10692] Linux x86-64 | 4                            |

<sup>1</sup> 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 <sup>1</sup> | Precision <sup>2</sup> | executable                   |
|----------------------|---------|---------|-----------------|----------------------------|------------------------|------------------------------|
| LS-DYNA <sup>®</sup> | 971     | R14.0   | 461-gee93a457ac | SMP                        | SP                     | ls971.461-gee93a457ac.R14.0  |
| LS-DYNA <sup>®</sup> | 971     | R14.0   | 461-gee93a457ac | SMP                        | DP                     | ld971.461-gee93a457ac.R14.0  |
| LS-DYNA <sup>®</sup> | 971     | R14.0   | 461-gee93a457ac | MPP                        | SP                     | mpp971.461-gee93a457ac.R14.0 |
| LS-DYNA <sup>®</sup> | 971     | R14.0   | 461-gee93a457ac | MPP                        | DP                     | mpd971.461-gee93a457ac.R14.0 |

<sup>1</sup> MPP = Massively Parallel Processing, SMP = Symmetric Multiprocessing

<sup>2</sup> SP = single precision, DP = double precision

Table 6: Tested LS-DYNA<sup>®</sup> version

## 5.2 Results Summary

Table 7 contains the results of the Test Case ID AWG-MAT\_213-131 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                | <b>PASS</b> |

Table 7: Results summary for Test Case ID AWG-MAT\_213-131

### **5.3 Result Details**

The following subsections contain detailed results for the Test Case ID AWG-MAT\_213-131 for LS-DYNA® R14.0 Revision 461-gee93a457ac.

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: Solid Element Strain xx

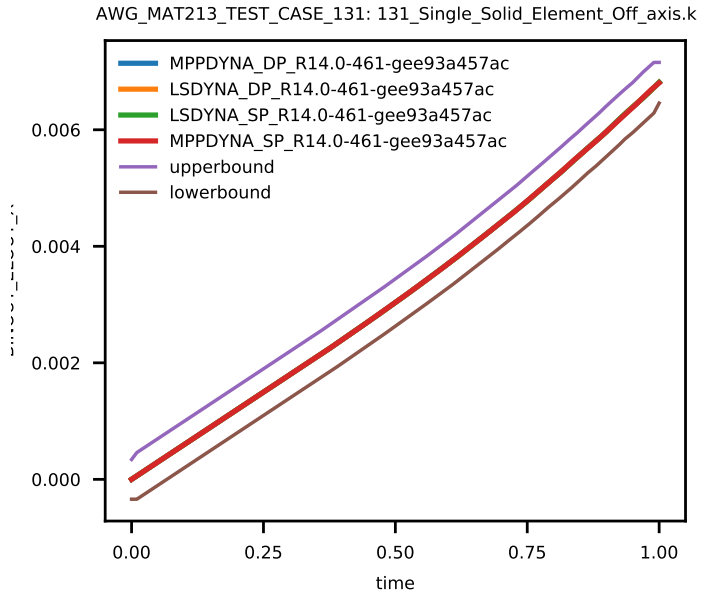


Figure 1: Solid Element Strain xx.

### 5.3.2 Test Target 2: Solid Element Strain yy

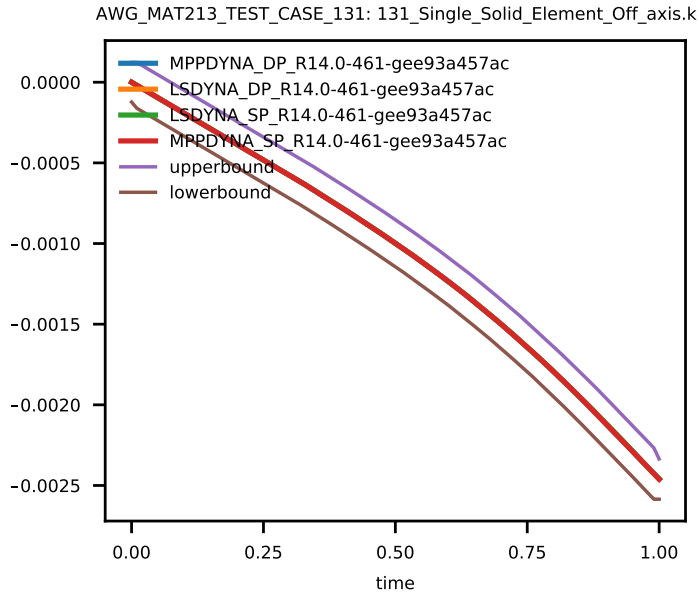


Figure 2: Solid Element Strain yy.



### 5.3.3 Test Target 3: Solid Element Strain zz

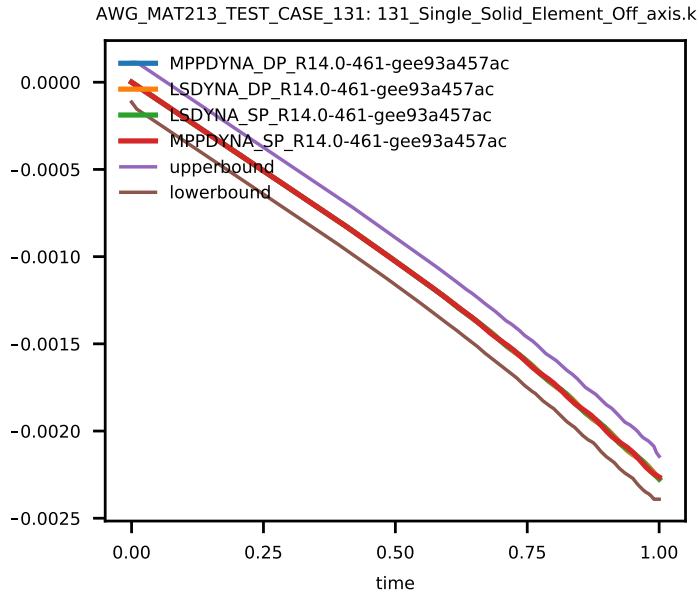


Figure 3: Solid Element Strain zz.

### 5.3.4 Test Target 4: Solid Element Strain xy

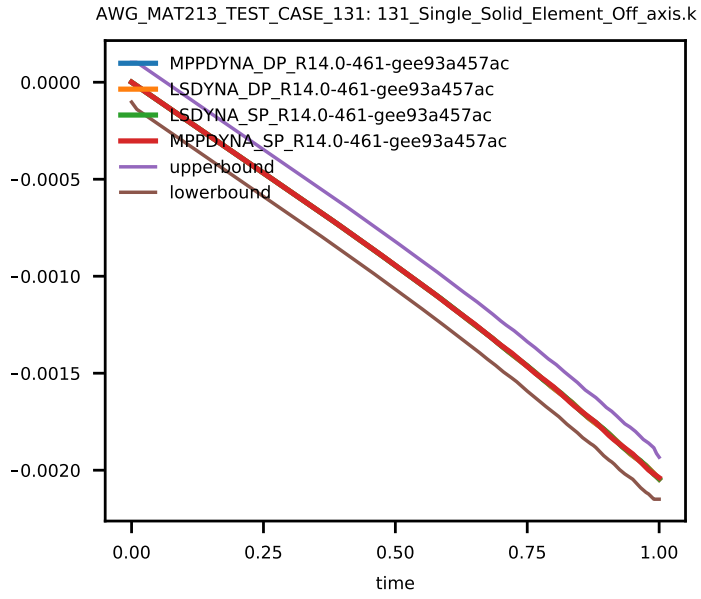


Figure 4: Solid Element Strain xy.

### 5.3.5 Test Target 5: Solid Element Strain yz

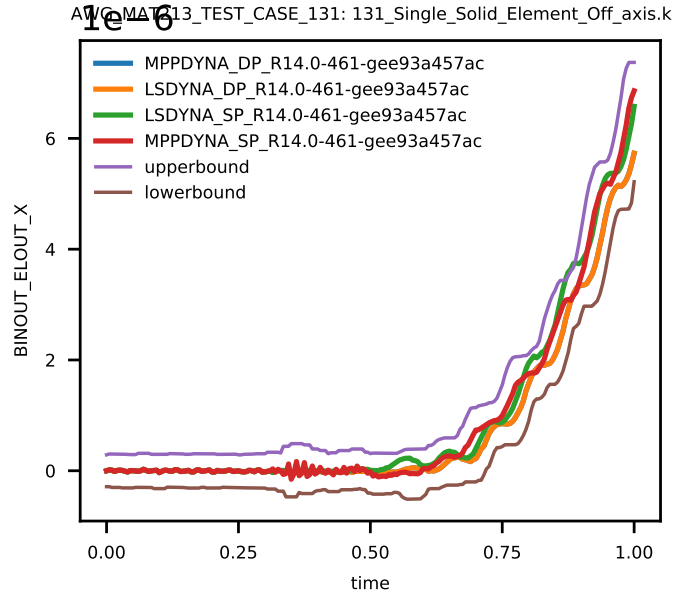


Figure 5: Solid Element Strain yz.

### 5.3.6 Test Target 6: Solid Element Strain zx

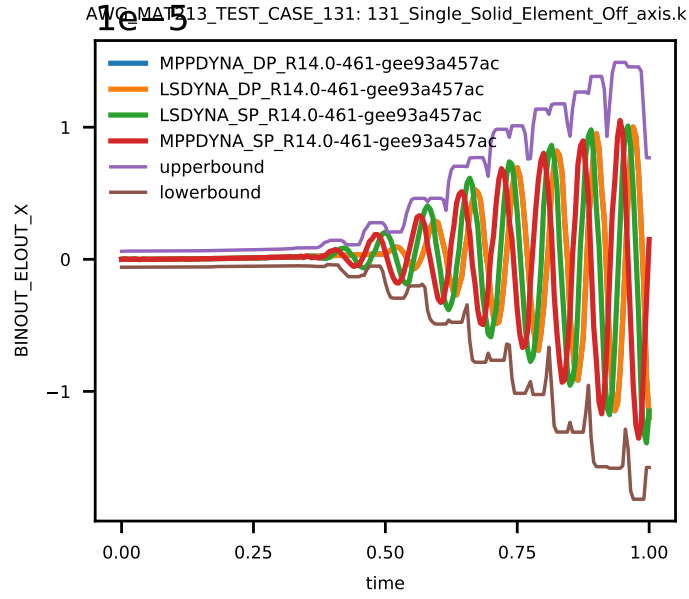


Figure 6: Solid Element Strain zx.

### 5.3.7 Test Target 7: Global Internal Energy

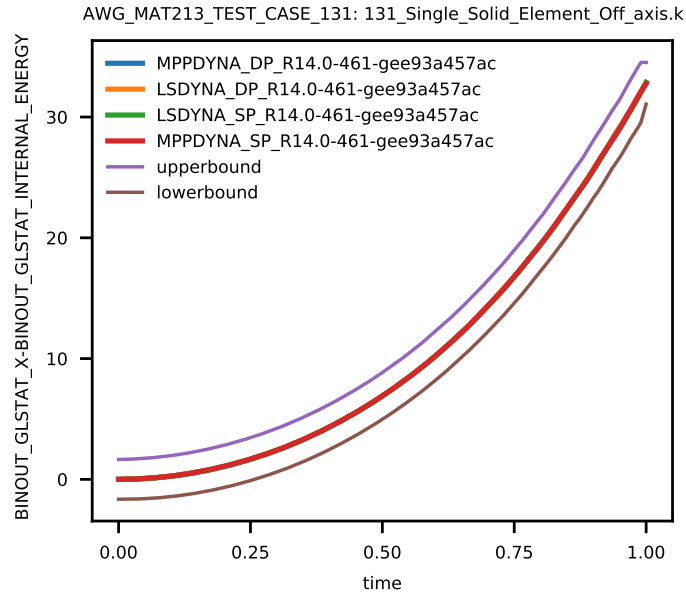


Figure 7: Global Internal Energy.

### 5.3.8 Test Target 8: Global Kinetic Energy

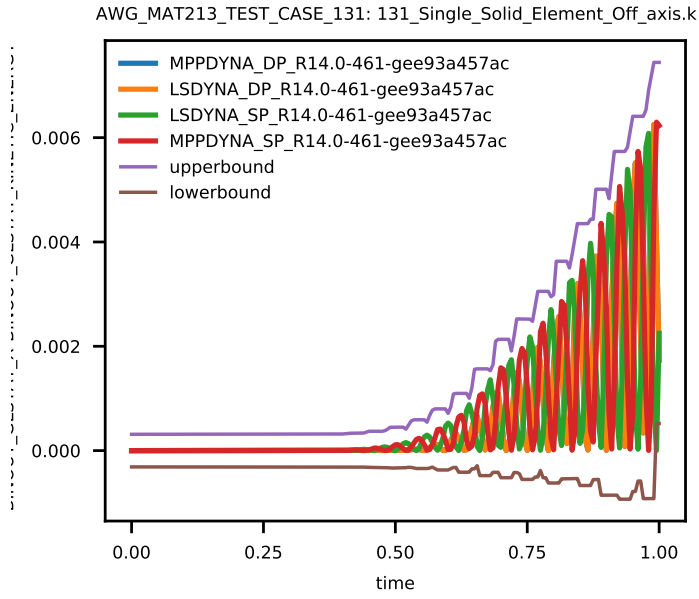


Figure 8: Global Kinetic Energy.

### 5.3.9 Test Target 9: CPU time

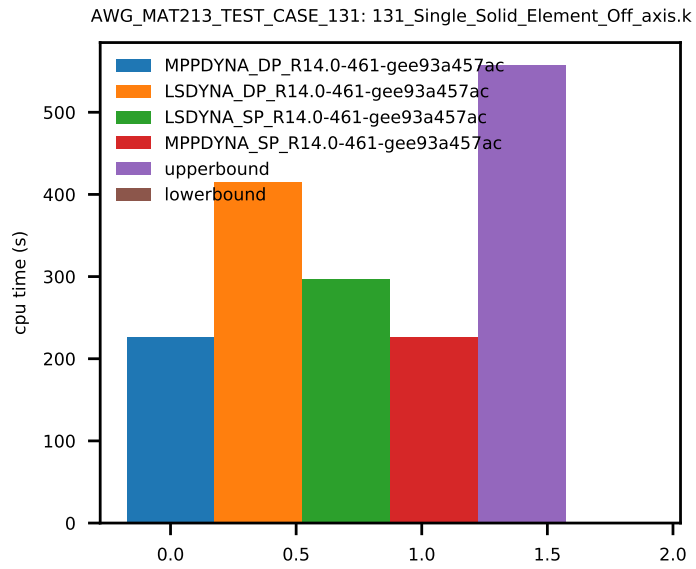


Figure 9: CPU Time.

## References