

# TEST CASE DOCUMENTATION AND TESTING RESULTS

ANSYS-QA-LS-DYNA-AWG-CI-5-8

TEST CASE ID AWG-CI-3

Seat Belt Stretch Test Simulation

Tested with LS-DYNA® R13.2 Revision 28-gcc52f96e9d

Wednesday 16<sup>th</sup> April, 2025



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# **1 Introduction**

## **1.1 Purpose of this Document**

This document specifies the test case AWG-CI-3. 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           | Seat Belt Stretch Test Simulation |
| Test Case ID             | AWG-CI-3                          |
| Test Case Status         | active                            |
| Test Case Classification | Verification                      |
| Test Case Source         | Collins Aerospace                 |
| Tested Keyword           | *MAT_FABRIC                       |
| 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-3 is the comparison of force-deflection results from quad and tria shell elements with tensile test data from a seat belt stretch test.

### 3.2 Test Case Description

Force-deflection data from a seat belt stretch test was used to define \*MAT\_FABRIC input. This material input was then used in a model of the test to compare the analytical cross-section forces at the center of the seat belt using both quad and tria shell elements with the test force-deflection data. In the analysis, the top belt is meshed with tria shell elements and the three meshes below use quad shell elements (See Figure 1 ). The tria and middle shell element meshes are stretched to the test deflection while the top and bottom shell element meshes are stretched to +30% and -30% of the test deflection, respectively.

LS-DYNA keyword deck by LS-PrePost

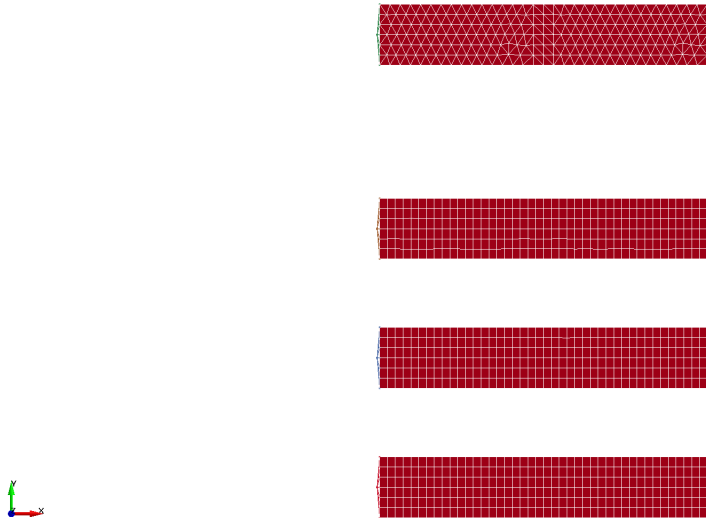


Figure 1: Seat Belt Model

### 3.3 Model Description

A seat belt with dimensions 254 mm long by 27 mm wide by 1.25 mm thick is modeled with tria and quad shell elements (See Figure 1 ). Using \*BOUNDARY\_PRESCRIBED\_MOTION\_NODE input, the tria and middle quad shell element models are stretched to the test deflection of 25.4 mm, while the top and bottom shell element meshes are stretched to 33 mm (+30%) and 17.8 mm (-30%) of the test deflection, respectively. The total deflection is determined from nodes on each end of the belt and the load is extracted from the cross-section force at the center of each belt. These results are compared to actual test data.

The model specifications can be found in Table 2. The material definitions and their parameters can be found in the input deck. The input deck name is listed in Table 3.

| FEA Model information |                                               |
|-----------------------|-----------------------------------------------|
| Nodes                 | 1180                                          |
| Solid elements        | 0                                             |
| Shell elements        | 1152                                          |
| Beam elements         | 0                                             |
| Material type list    | MAT_34                                        |
| Parts                 | 1                                             |
| Units                 | mm (length), ms (time), kg (mass), kn (force) |

Table 2: FEA Model Information

|                  |
|------------------|
| Input Deck Name  |
| Seat.Belt.Test.k |

Table 3: Specification of the 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. The test case targets are x force at the sections 1-4 (sections 1-4 are defined as the middle planes of the bottom-top belts in figure 1) .

| Test Case Targets |         |                |               |                     |
|-------------------|---------|----------------|---------------|---------------------|
| Target number     | output  | component type | components id | retrieved from      |
| 1                 | secforc | x force        | 1             | binout/secforc file |
| 2                 | secforc | x force        | 2             | binout/secforc file |
| 3                 | secforc | x force        | 3             | binout/secforc file |
| 4                 | secforc | x force        | 4             | binout/secforc file |

Table 4: Test Case targets for Test Case ID AWG-CI-3

## 4.2 Pass/Fail Criteria

These are the Pass/Fail criteria used for the Test Case ID AWG-CI-3.

The 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® R10.2 Revision 134743 binaries by the following process:

- For a specific test case target, interpolate the data from different platform and executable (R10.2 Revision 134743) 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 (R10.2 Revision 134743) 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 <sup>1</sup> |
|---------------|------------------|-----------------------------------|-----------------------|------------------------------|
| cdcvdce7mbu01 | CentOS 7.9       | Intel® Xeon® Gold 6238R @ 2.20GHz | Platform MPI 08.3.0.2 | 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® | 971     | R13.2   | 28-gcc52f96e9d | SMP                        | SP                     | ls971.28-gcc52f96e9d.R13.2  |
| LS-DYNA® | 971     | R13.2   | 28-gcc52f96e9d | SMP                        | DP                     | ld971.28-gcc52f96e9d.R13.2  |
| LS-DYNA® | 971     | R13.2   | 28-gcc52f96e9d | MPP                        | SP                     | mpp971.28-gcc52f96e9d.R13.2 |
| LS-DYNA® | 971     | R13.2   | 28-gcc52f96e9d | MPP                        | DP                     | mpd971.28-gcc52f96e9d.R13.2 |

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

<sup>2</sup> 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-3 completed with all combinations of software and hardware defined in section 5.1 (4 \* 2 total cases).

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

The table 7 validation 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.

| Test Case ID | PASS/FAILED |
|--------------|-------------|
| 1            | <b>PASS</b> |

Table 7: Results summary for Test Case ID AWG-CI-3

### 5.3 Result Details

The following subsections contain detailed results for the Test Case ID AWG-CI-3 for LS-DYNA® R13.2 Revision 28-gcc52f96e9d.

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.

#### Example for title:

*Title:*

'AWG\_CI\_TEST\_CASE\_3: Seat\_Belt\_Test.k' states the test case ID 3 and name of the input deck.

5.3.1 Test Target 1

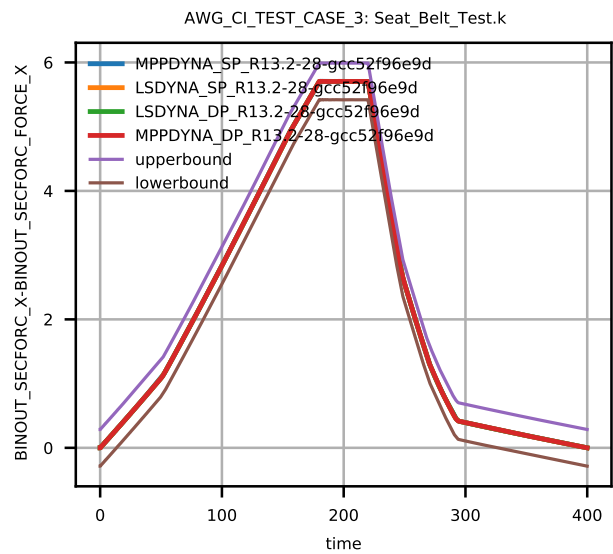


Figure 2: Cross platform results, x force at the section 1

5.3.2 Test Target 2

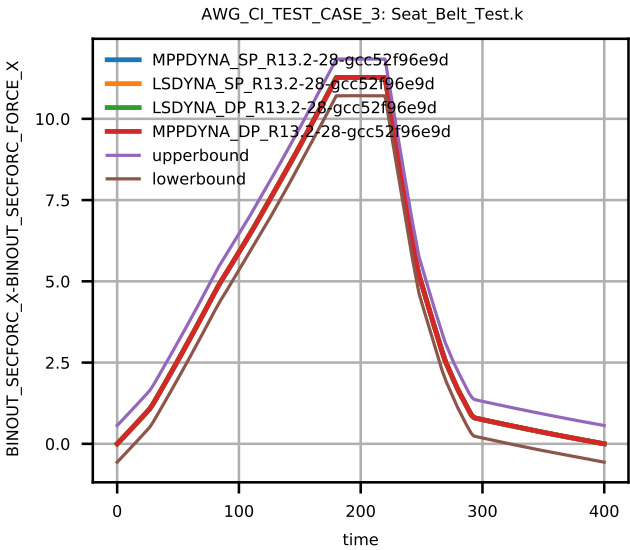


Figure 3: Cross platform results, x force at the section 2

5.3.3 Test Target 3

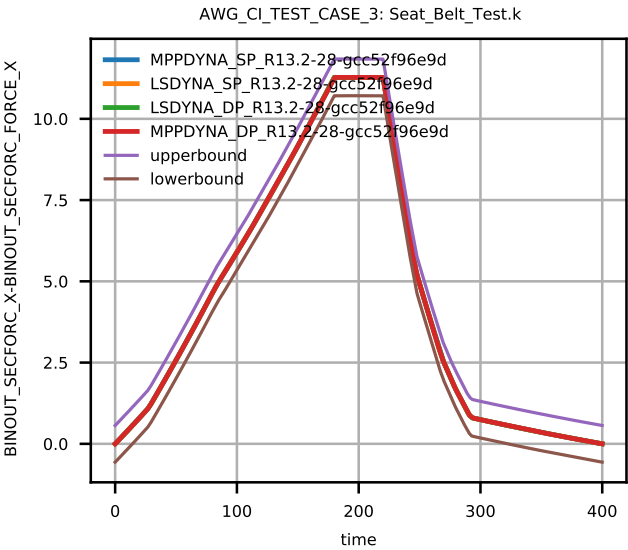


Figure 4: Cross platform results, x force at the section 3

5.3.4 Test Target 4

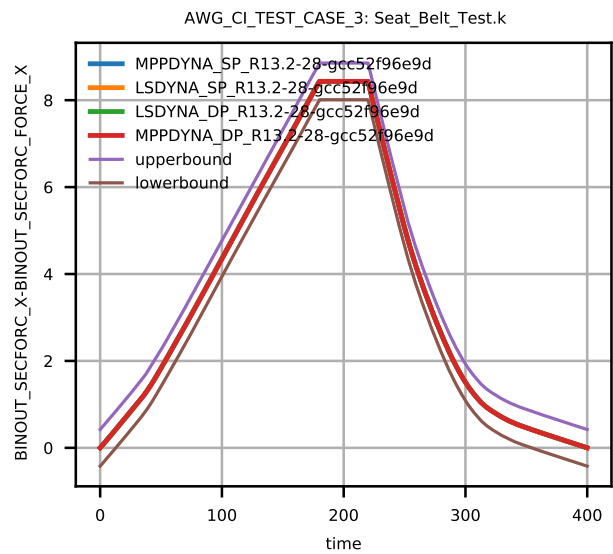


Figure 5: Cross platform results, x force at the section 4

5.3.5 CPU time

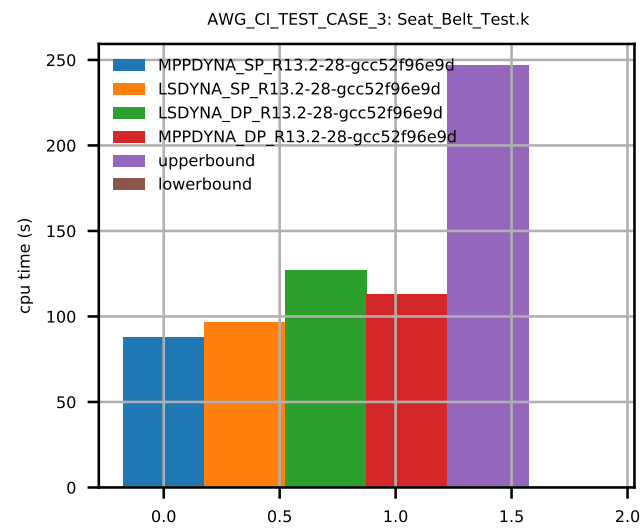


Figure 6: Cross platform results, CPU time (s)

## References