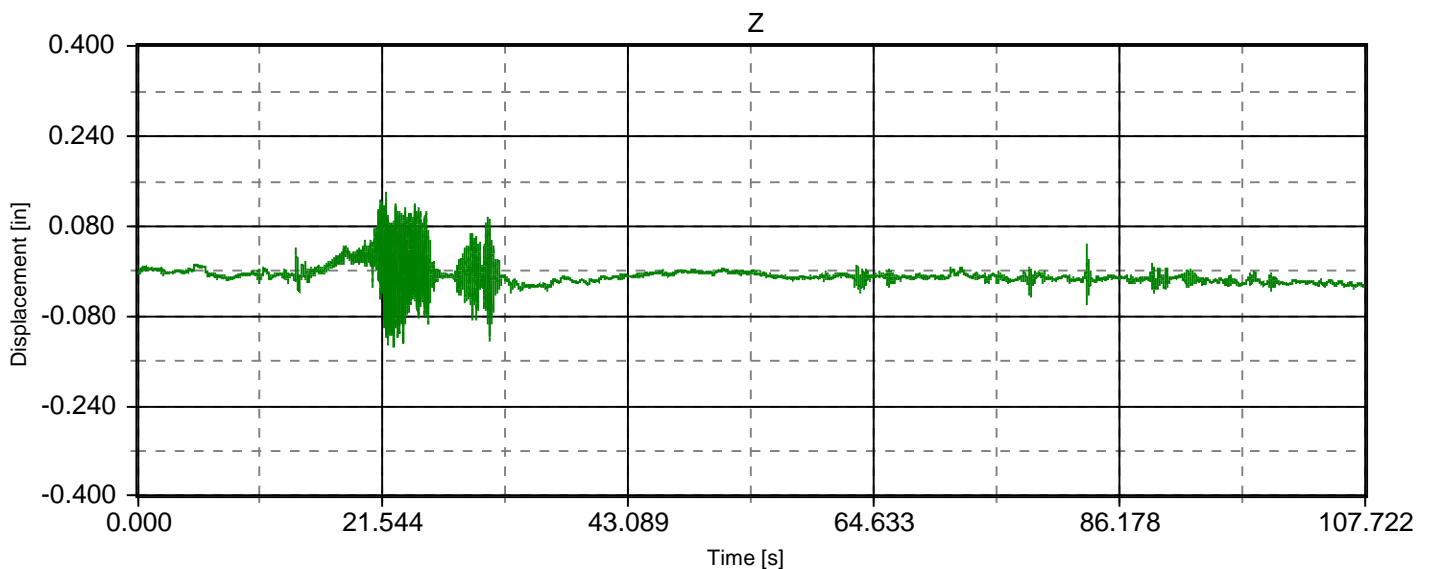
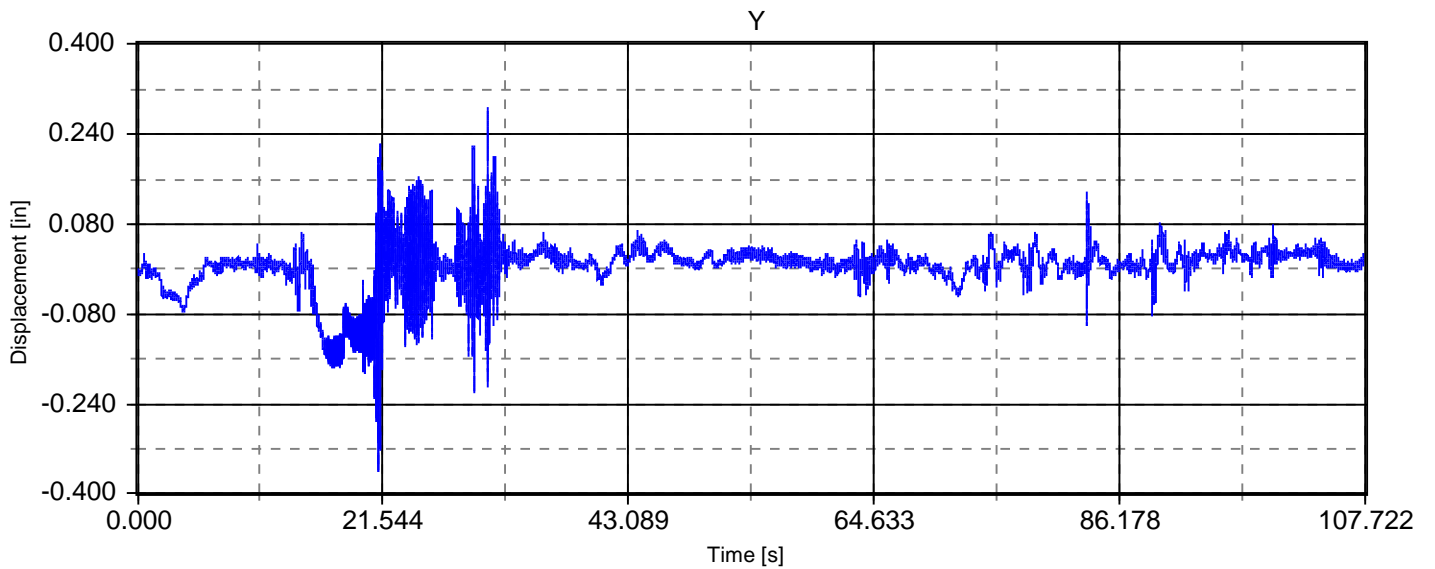
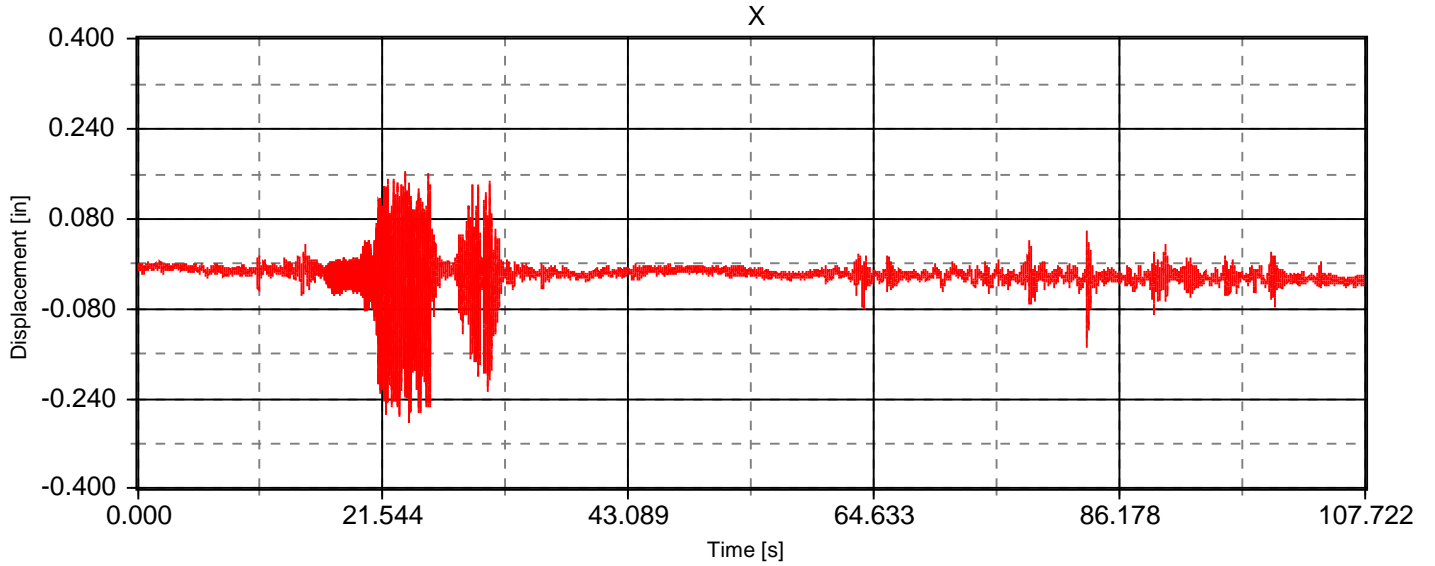
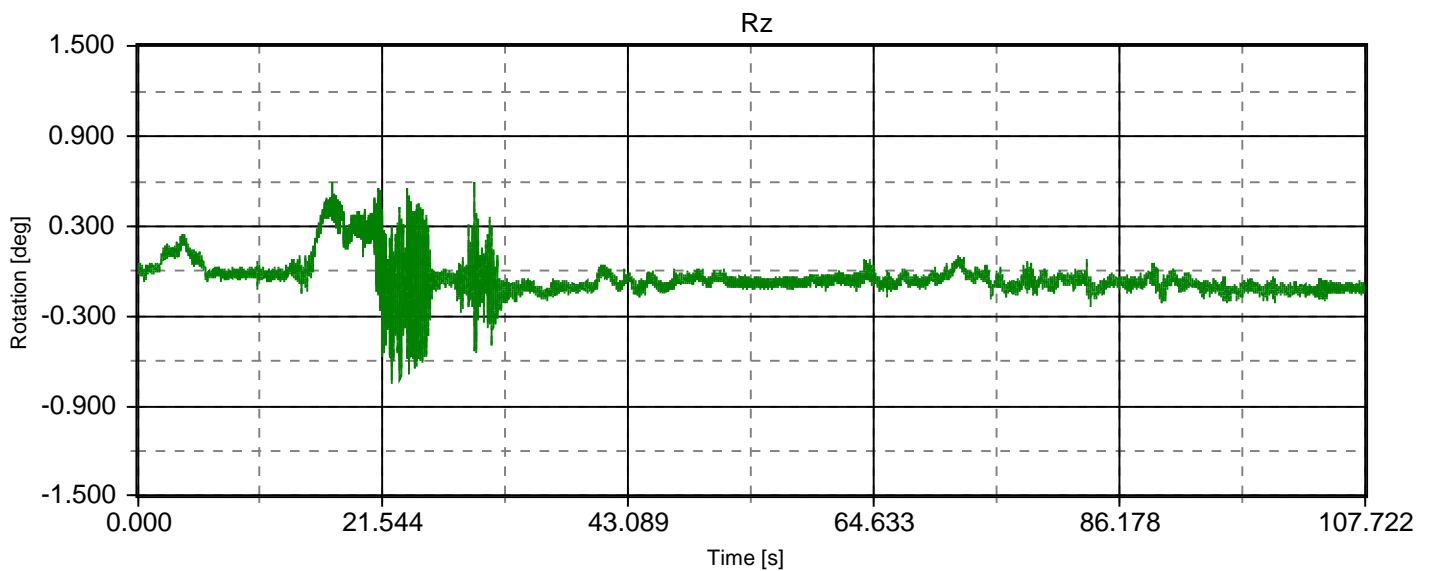
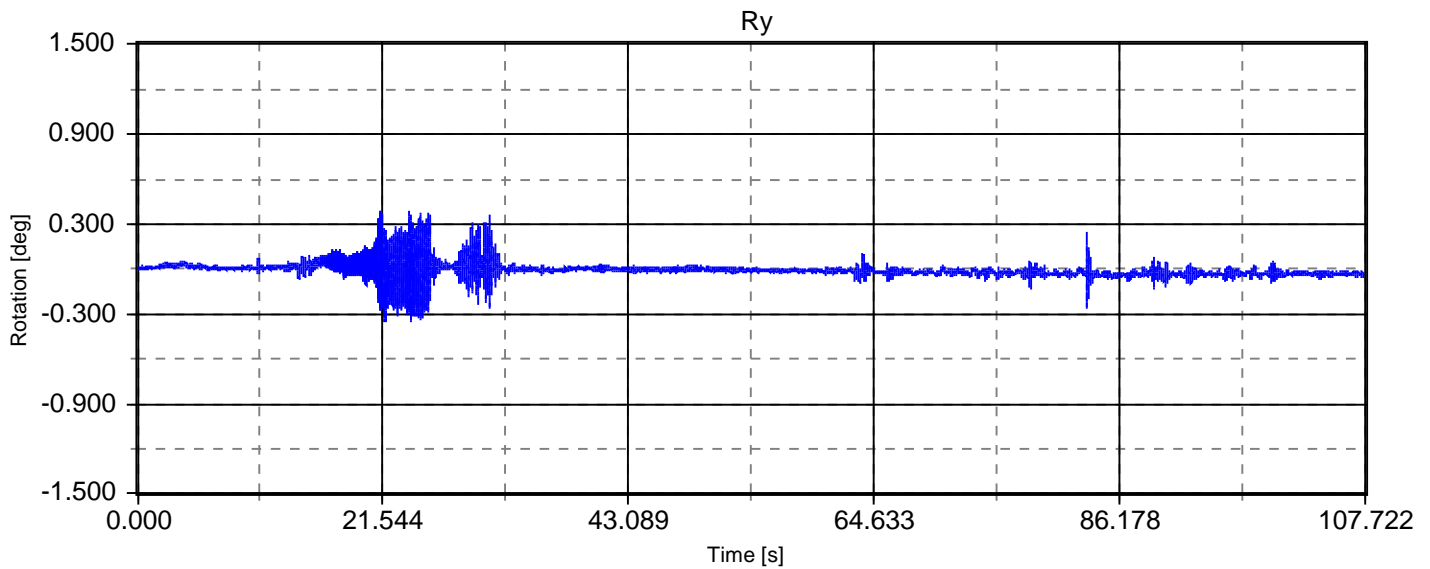
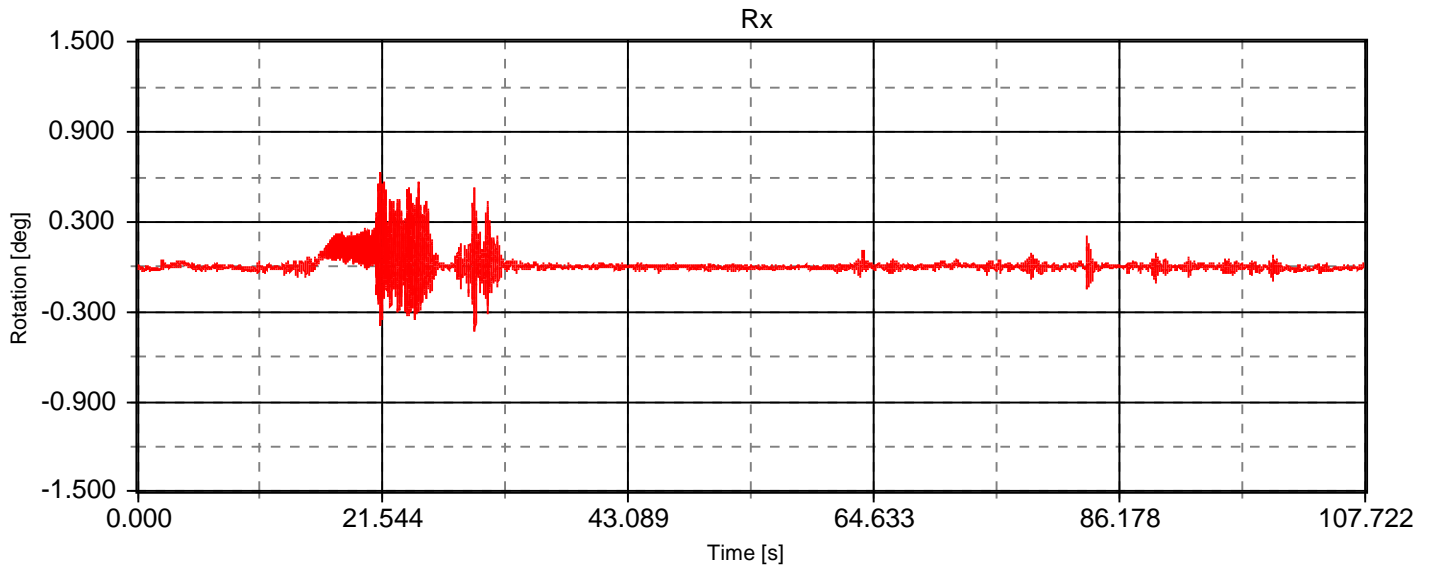
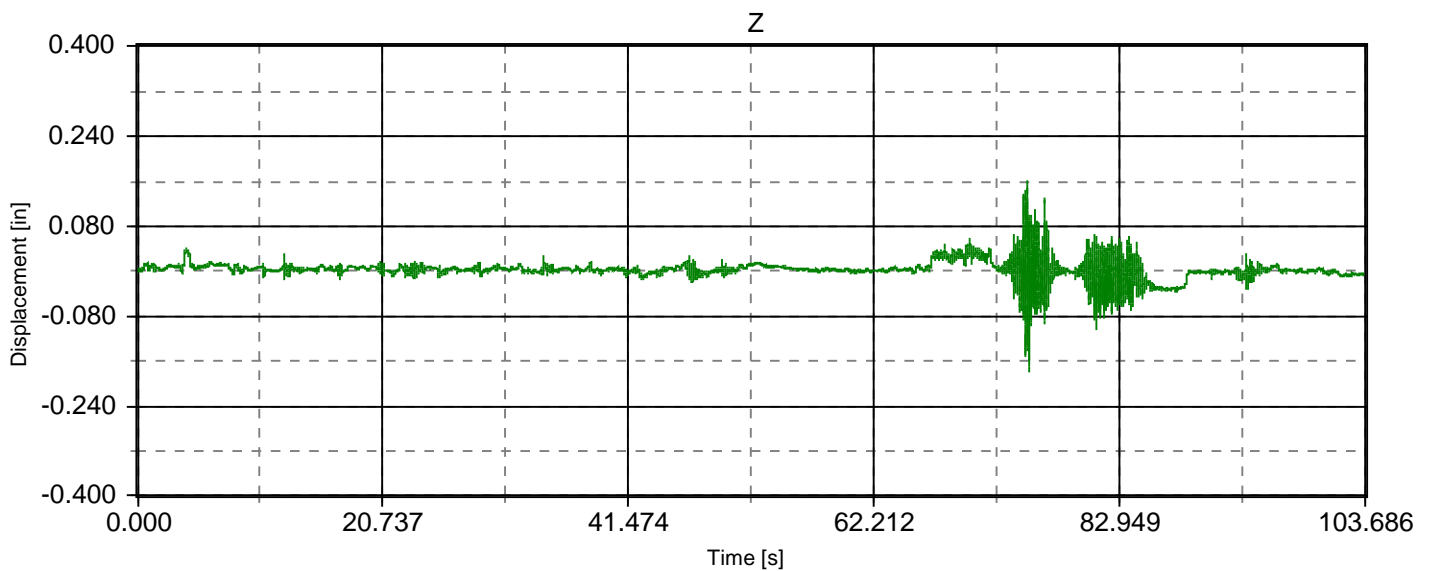
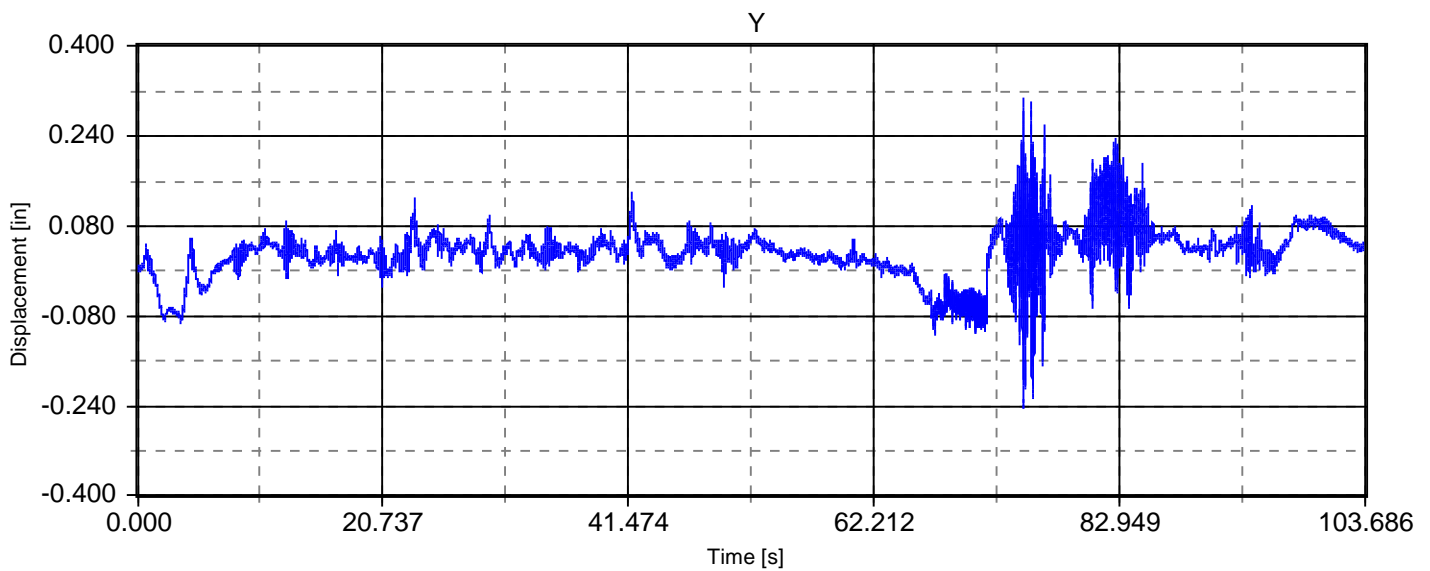
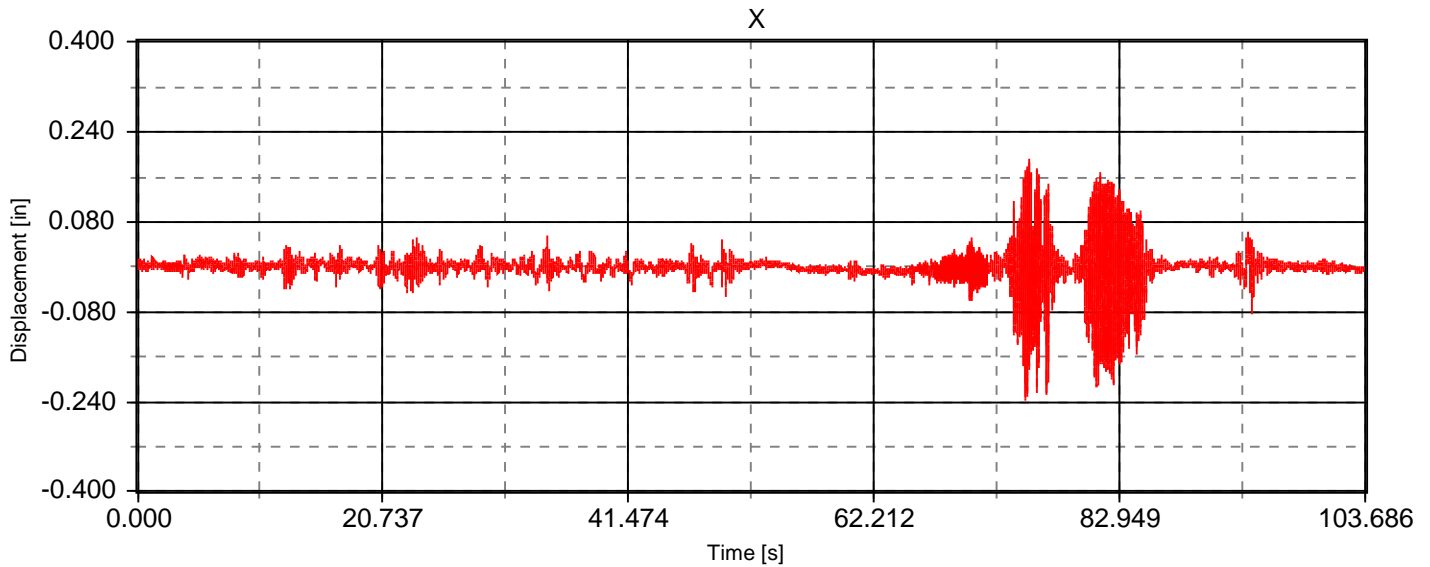


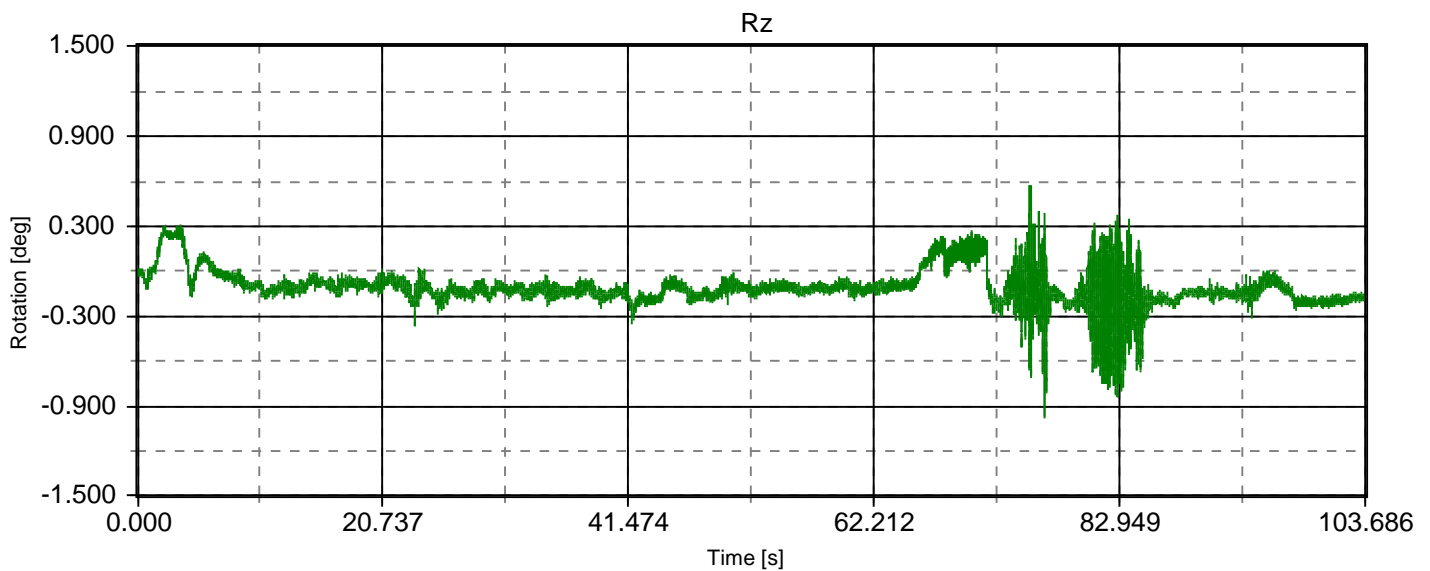
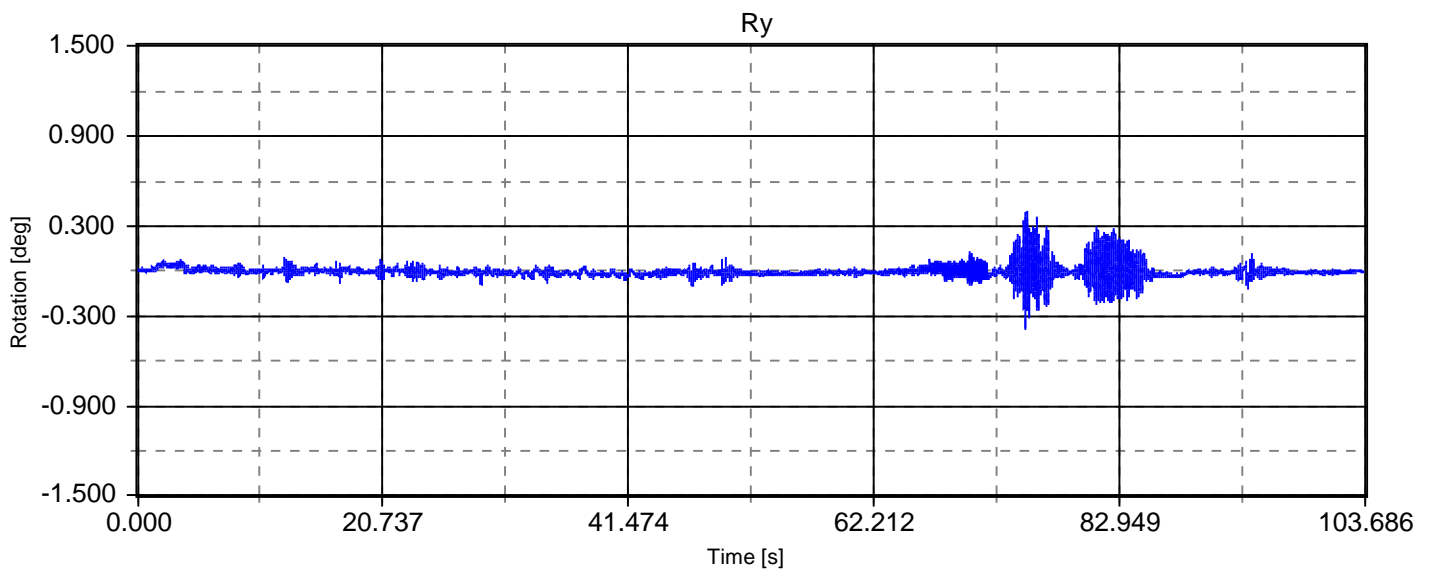
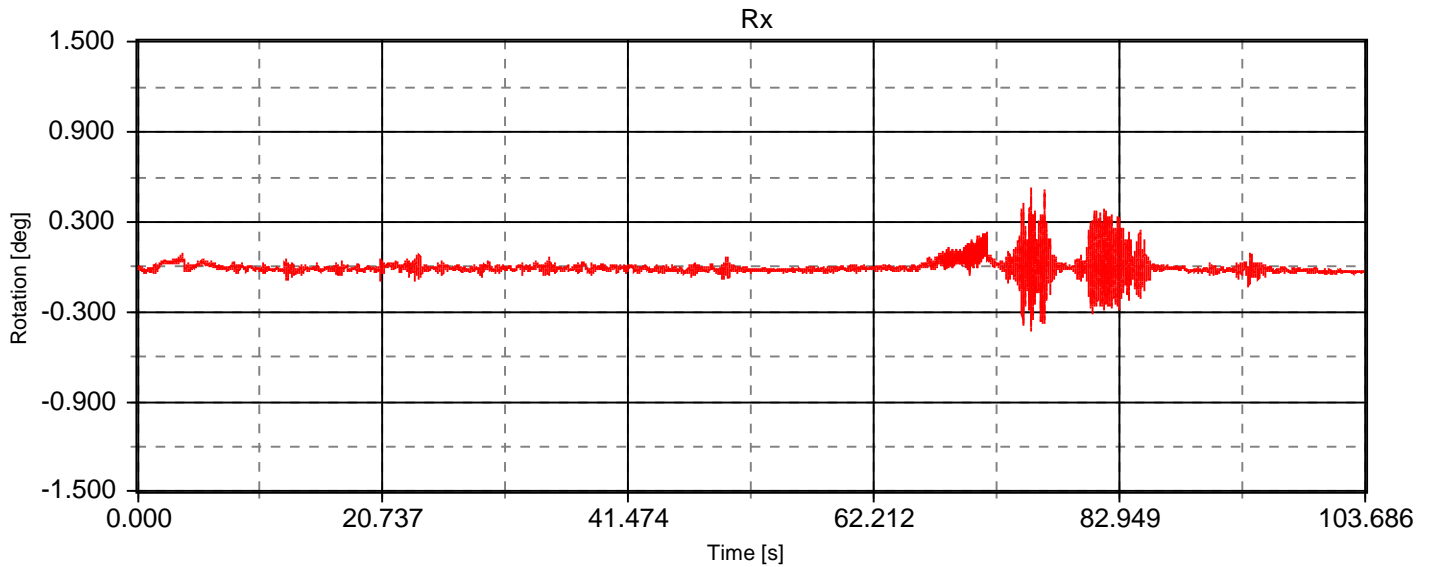
Event #	Description	[inch / deg]	X	Y	Z	Rx	Ry	Rz
E15	NTSD Rubber Isolator - REV Torque Stall	Max	0.020	0.229	0.084	0.14	0.06	0.09
		Min	-0.184	-0.031	-0.006	-0.10	-0.09	-0.72
		Range	0.203	0.260	0.091	0.25	0.15	0.81

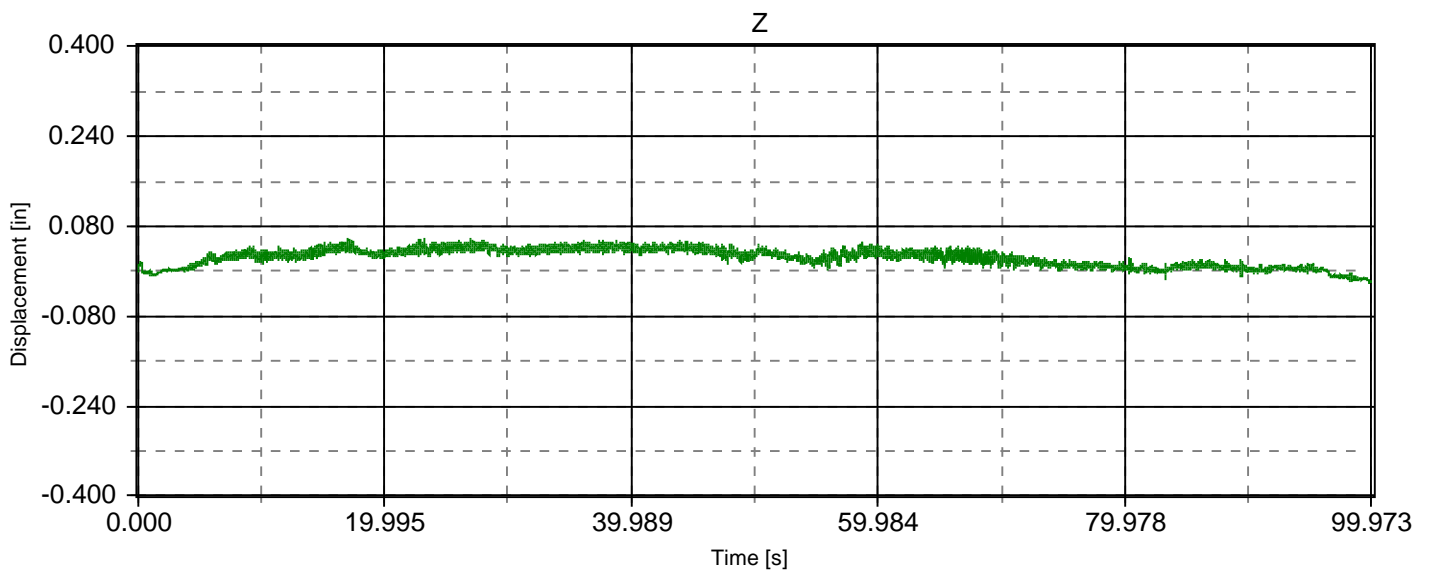
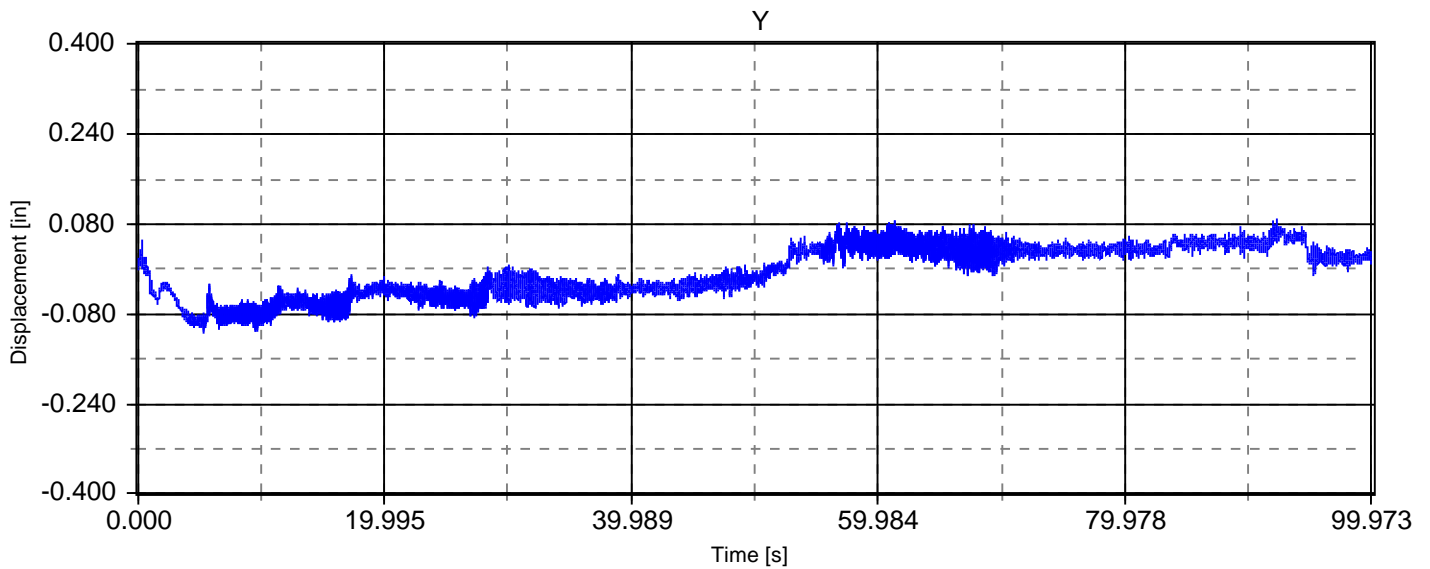
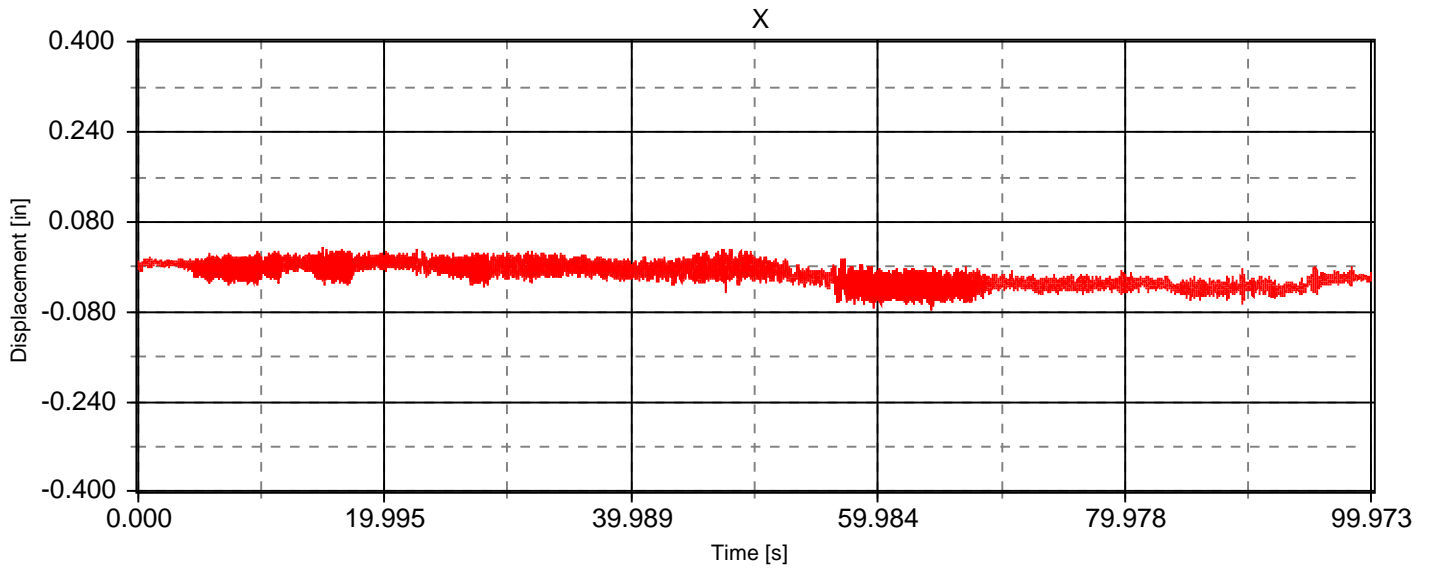
INFORMATION Redacted PURSUANT TO THE FREEDOM OF INFORMATION ACT (FOIA), 5 U.S.C. 552(B)(6)

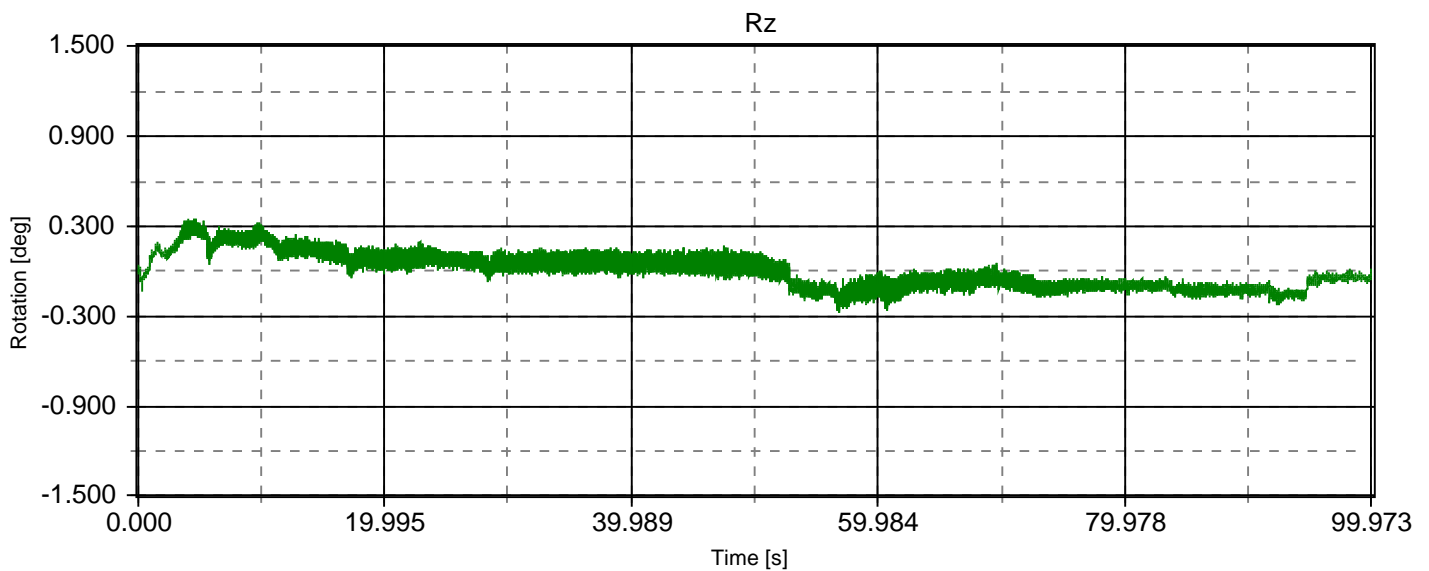
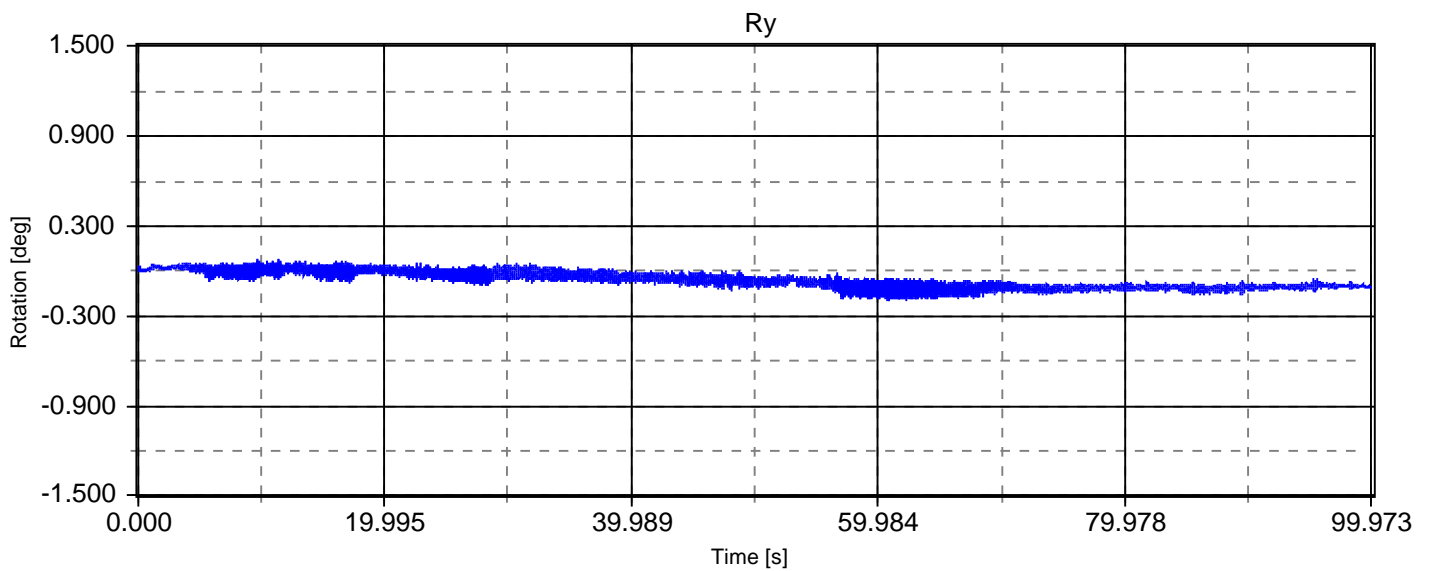
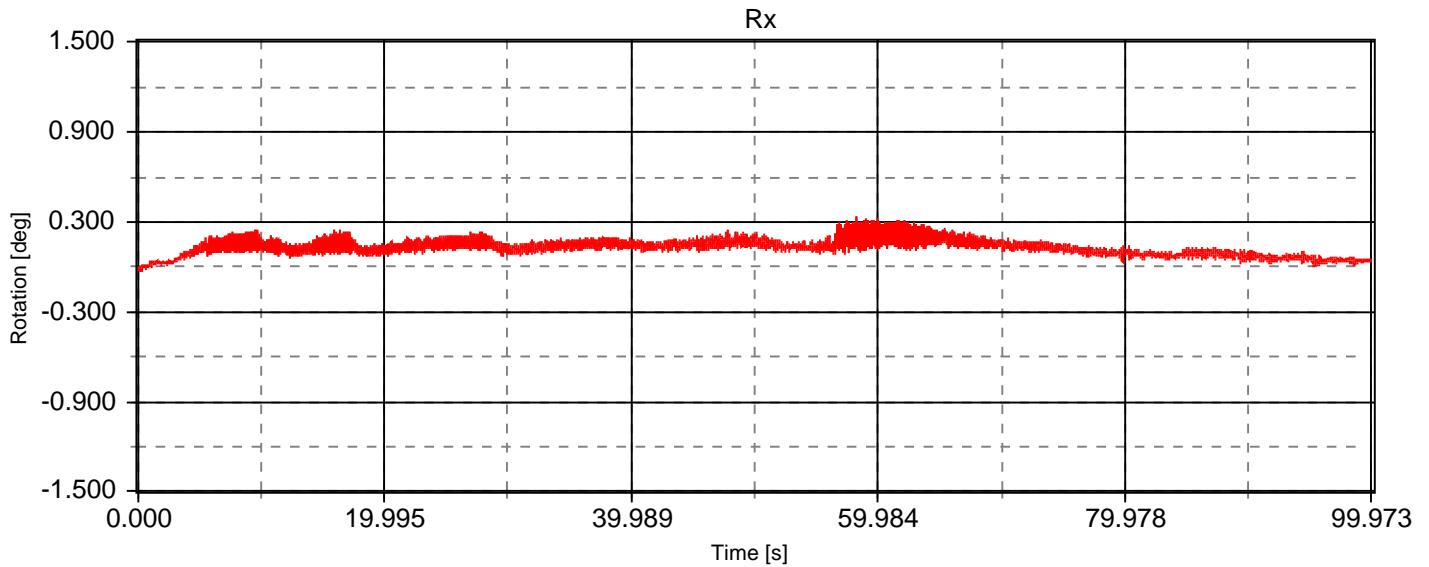


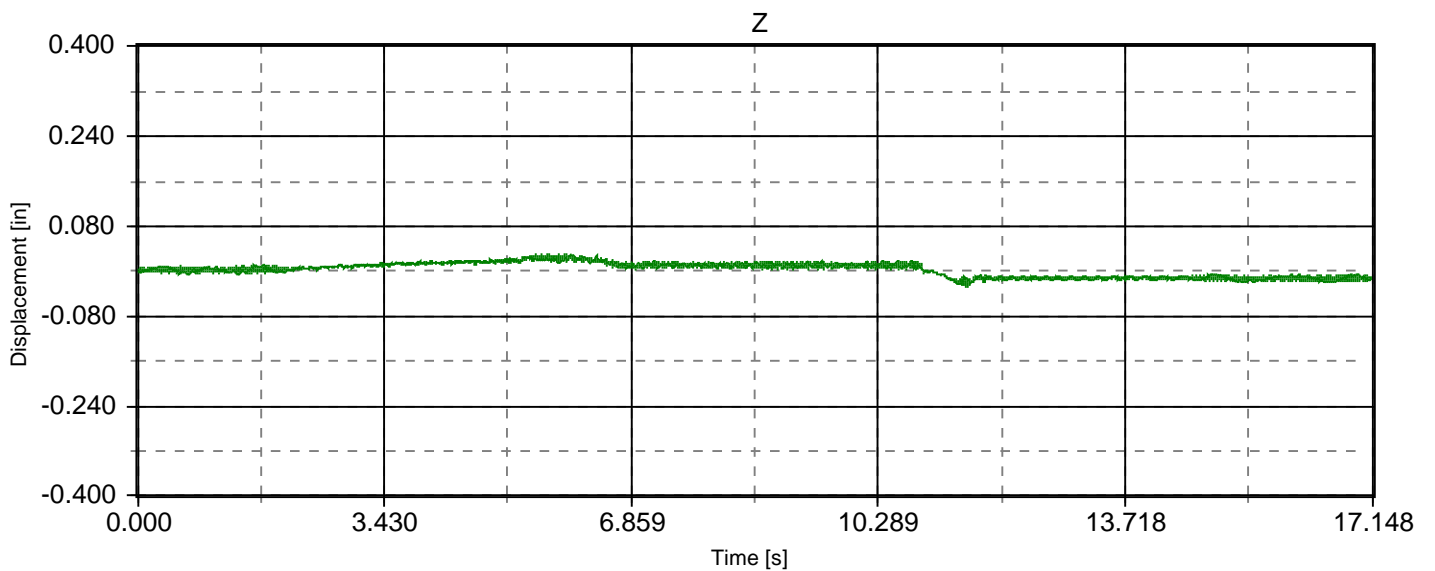
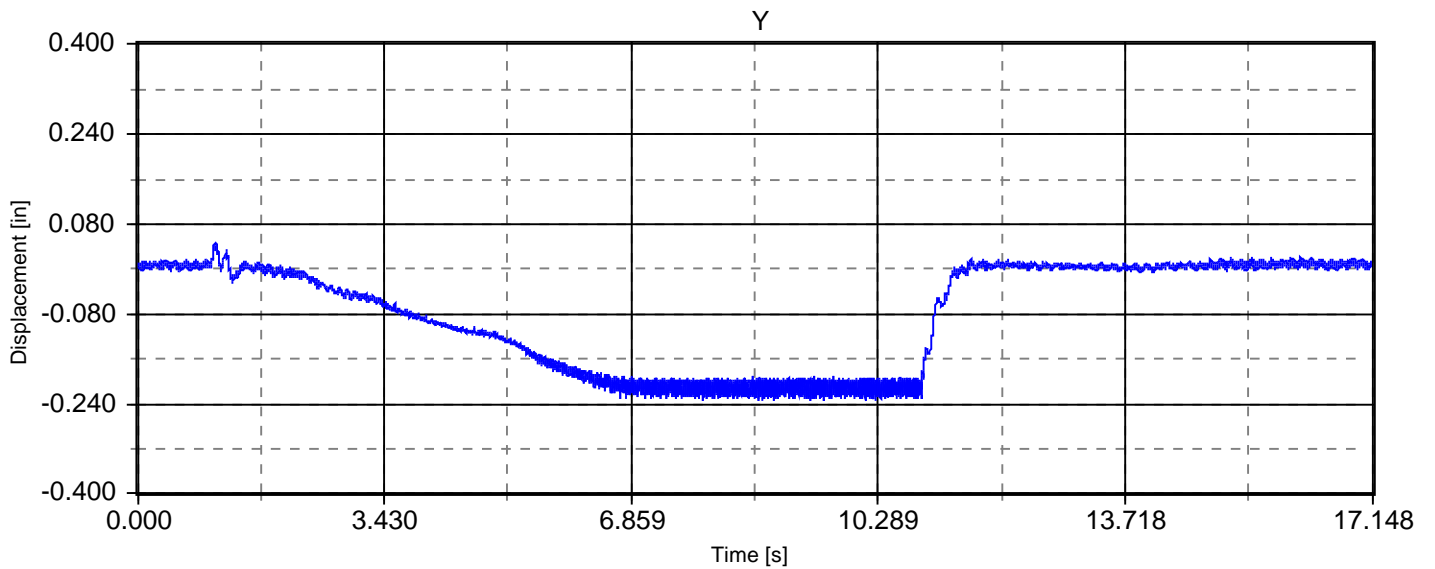
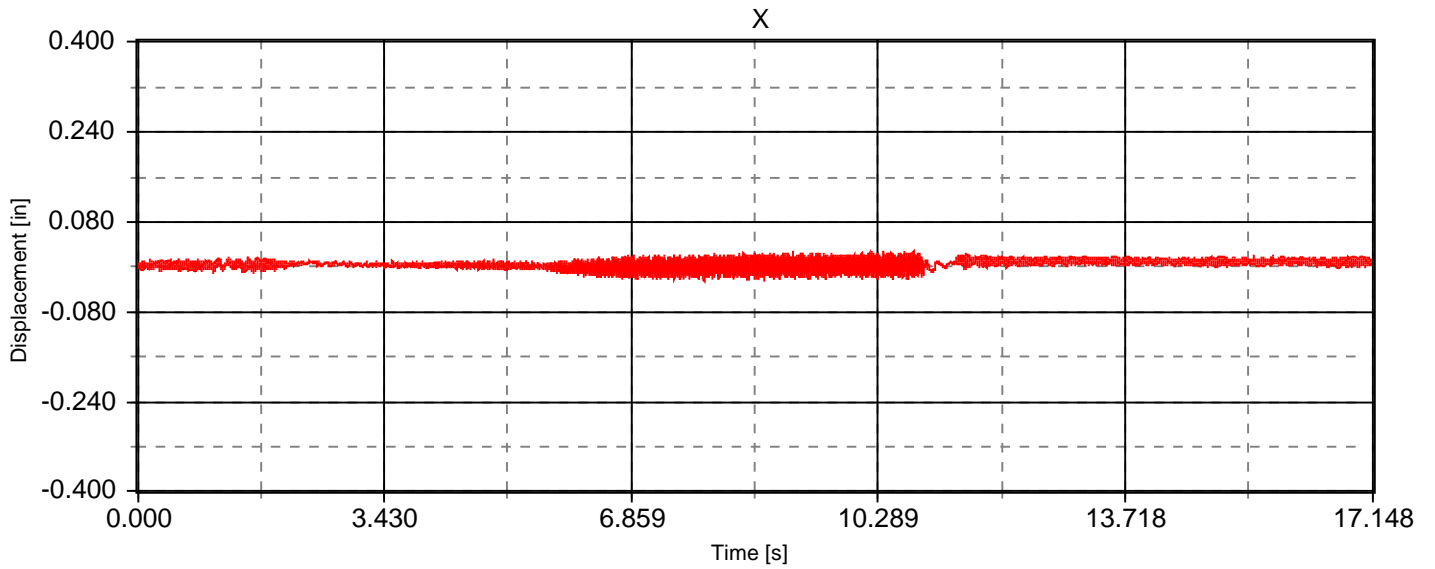


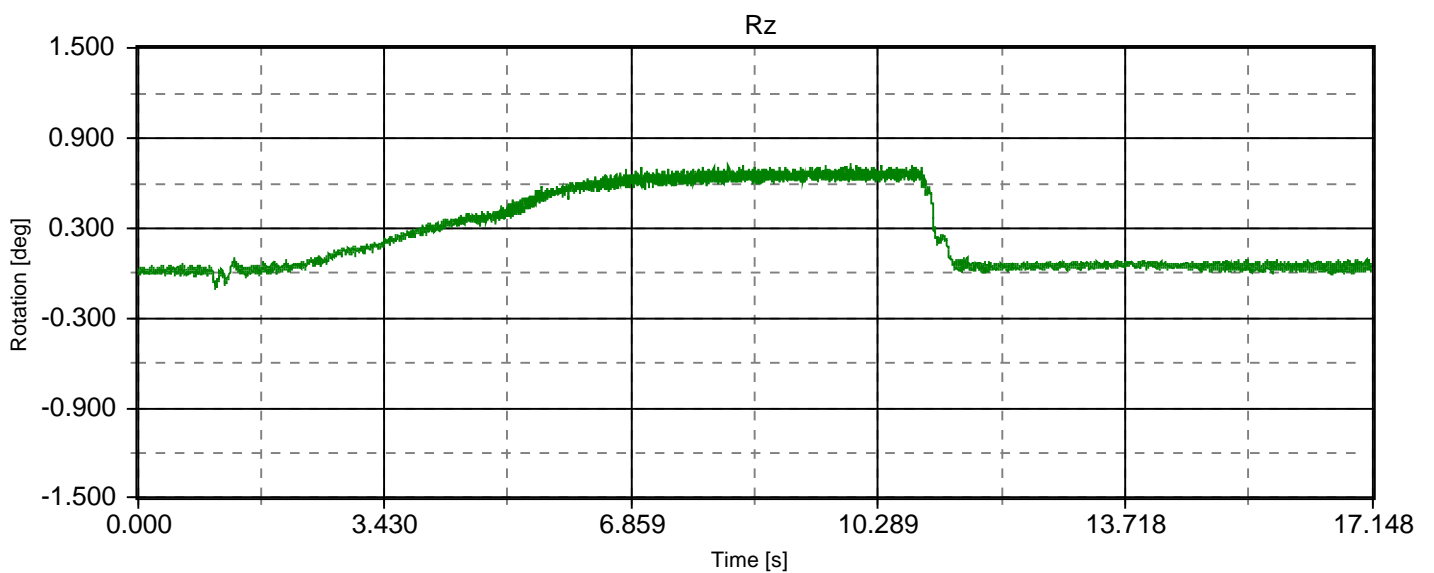
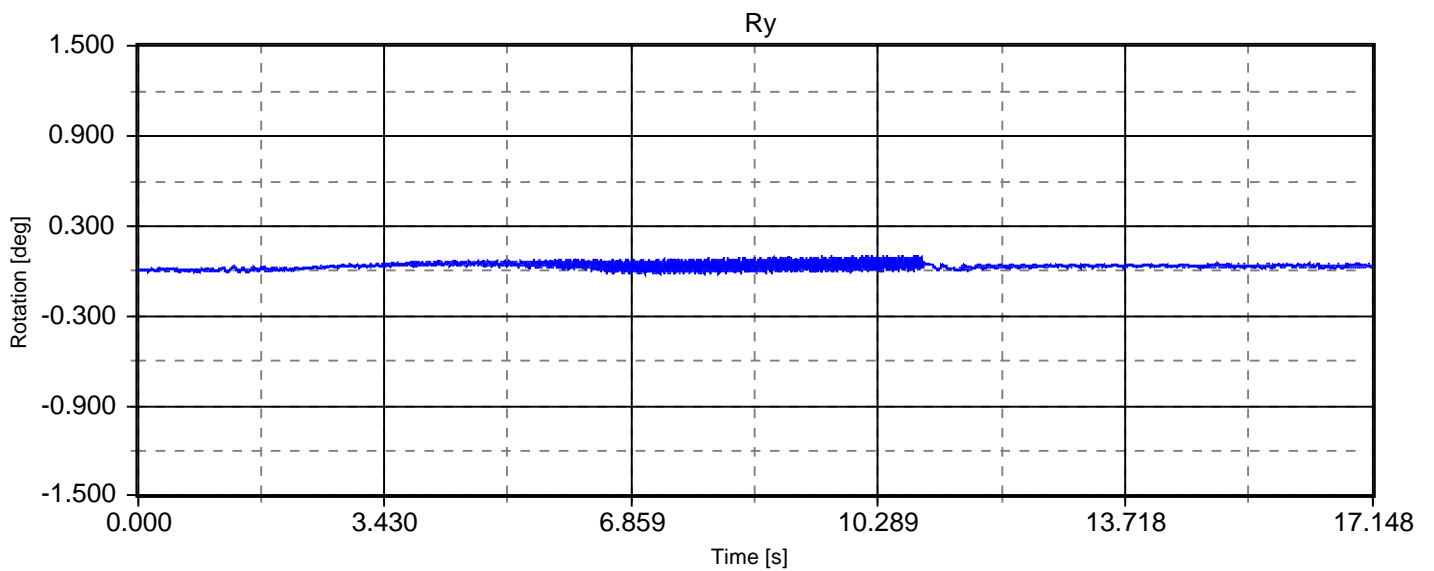
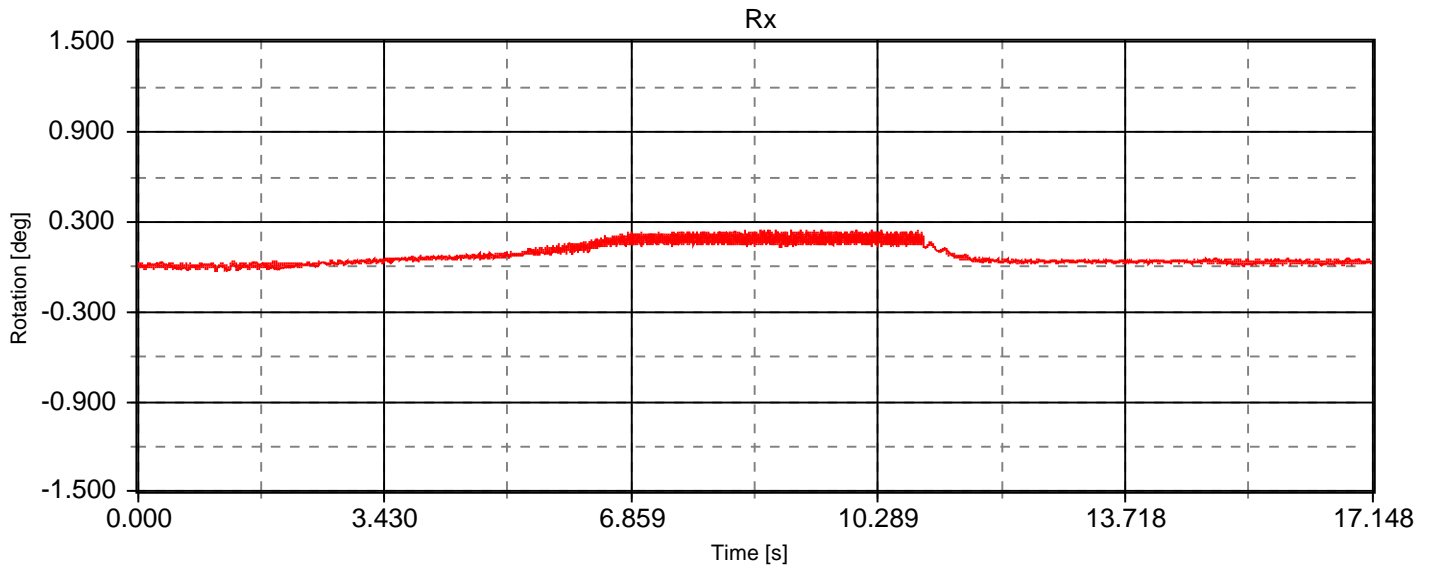


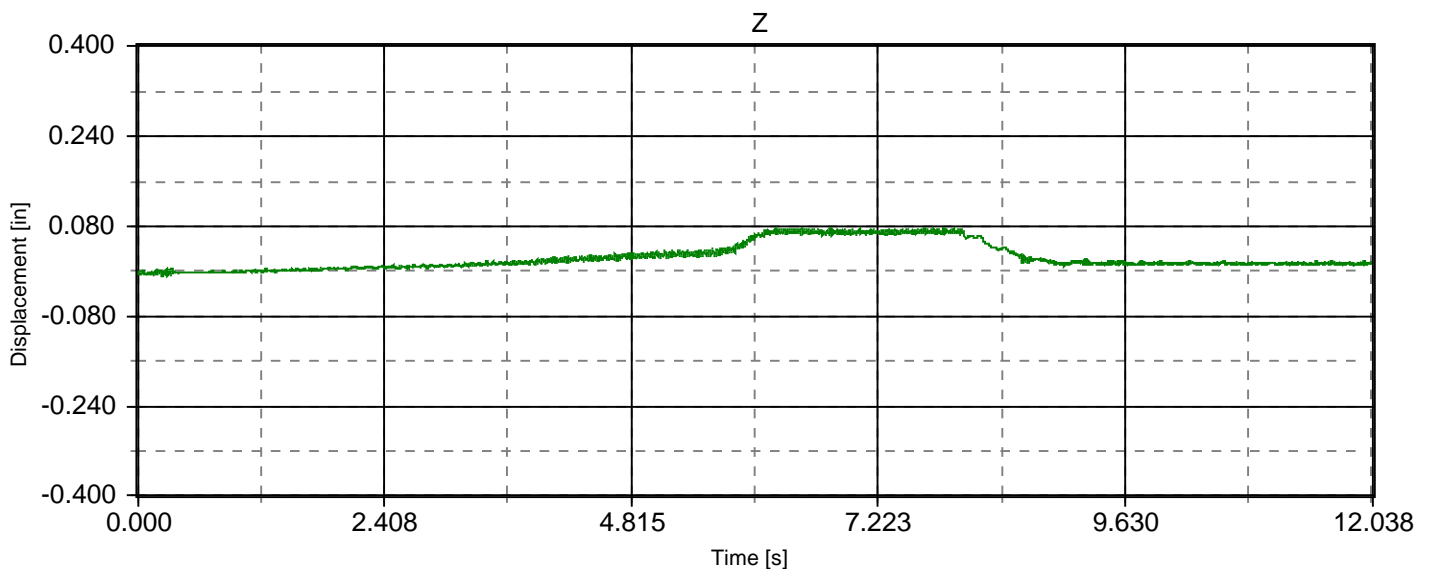
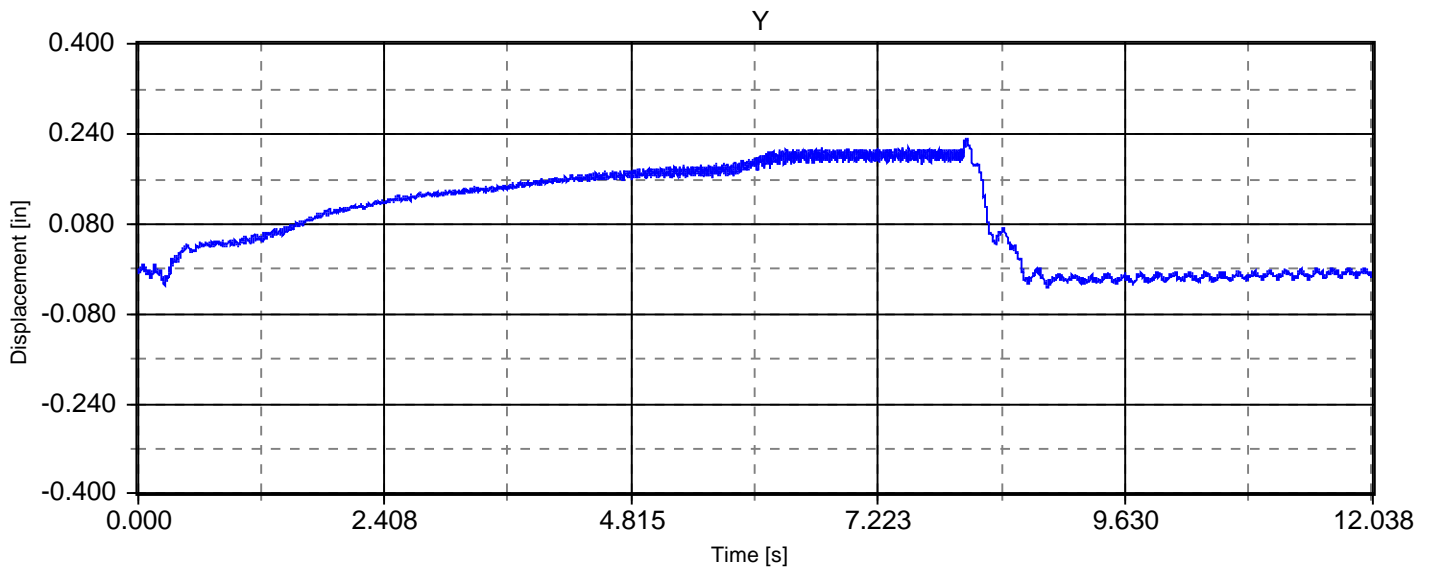
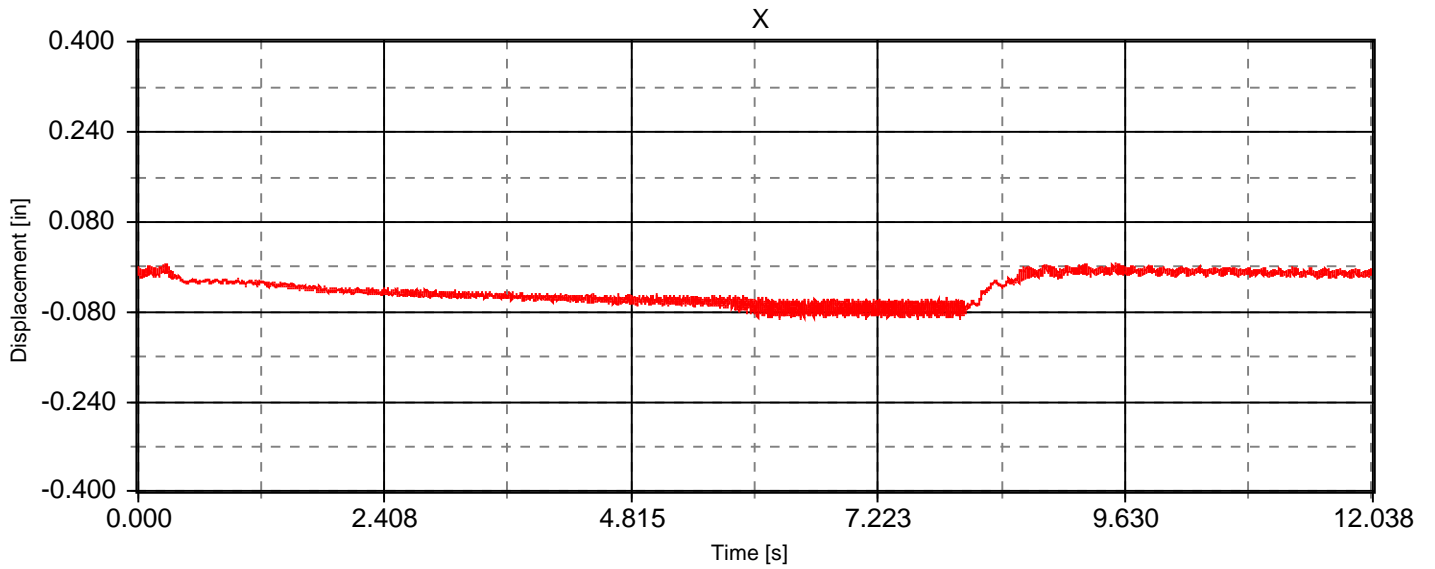


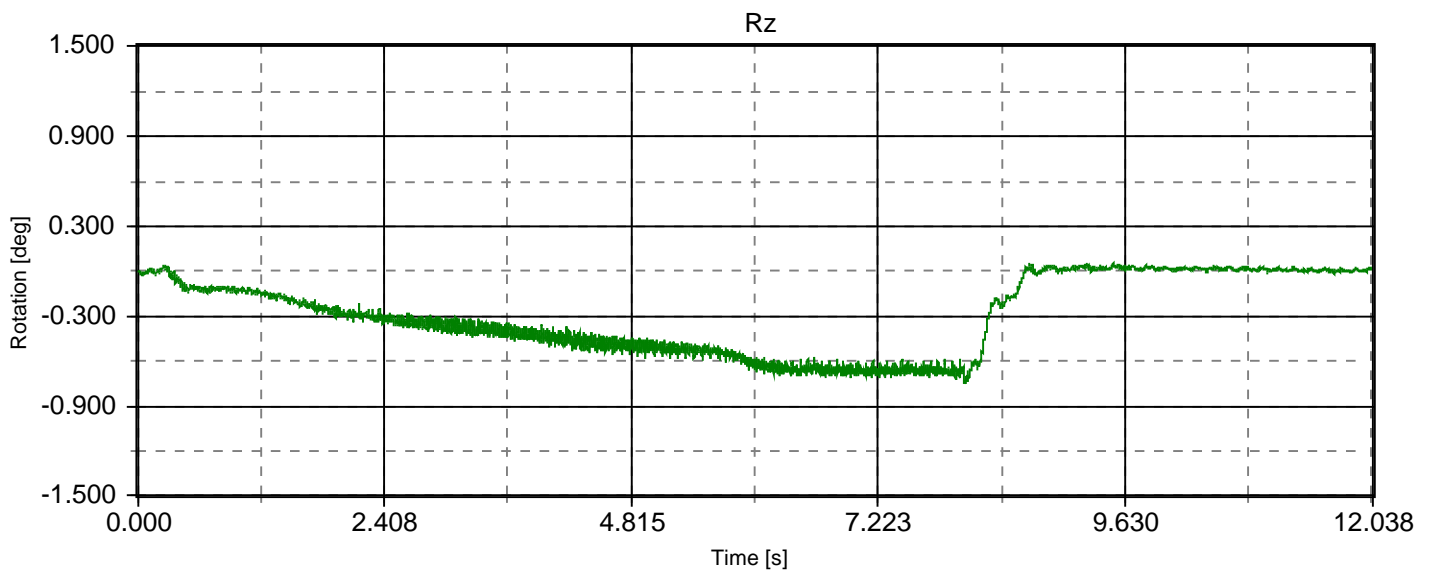
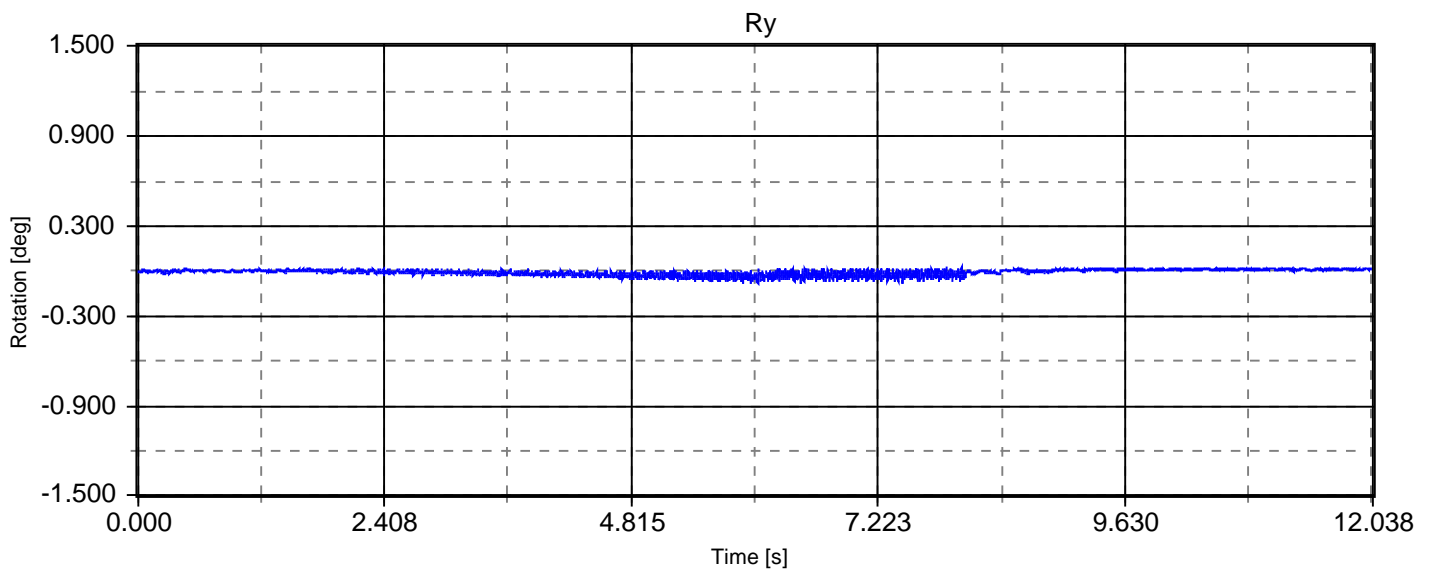
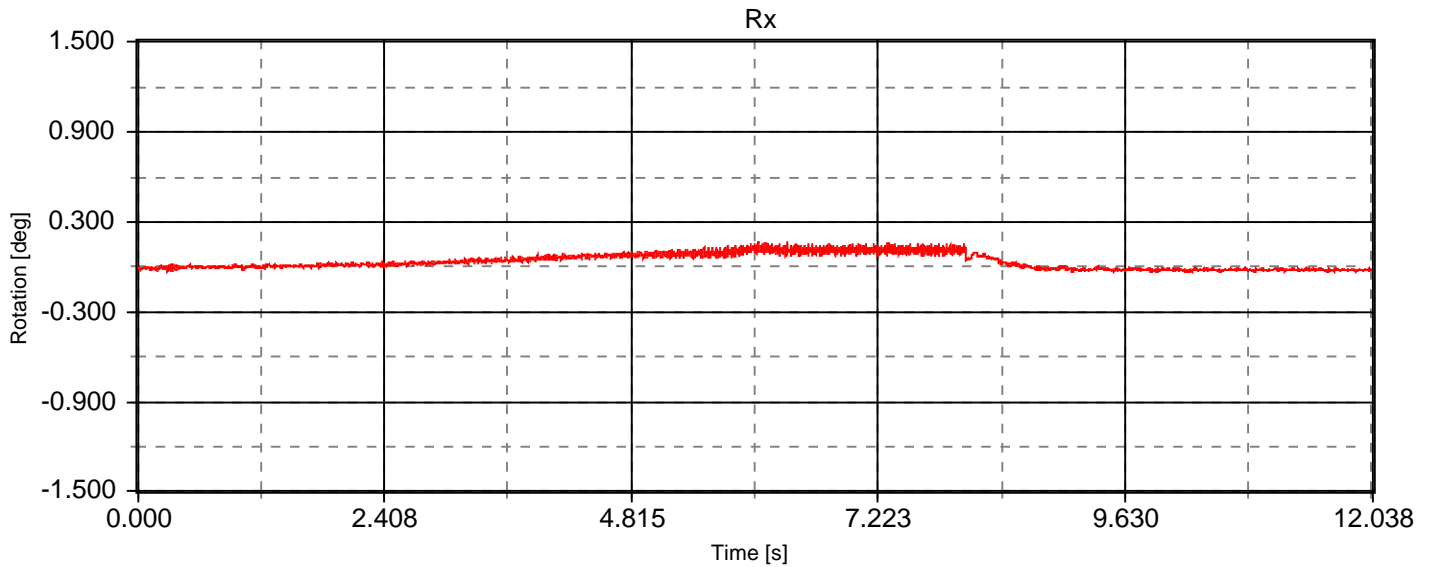


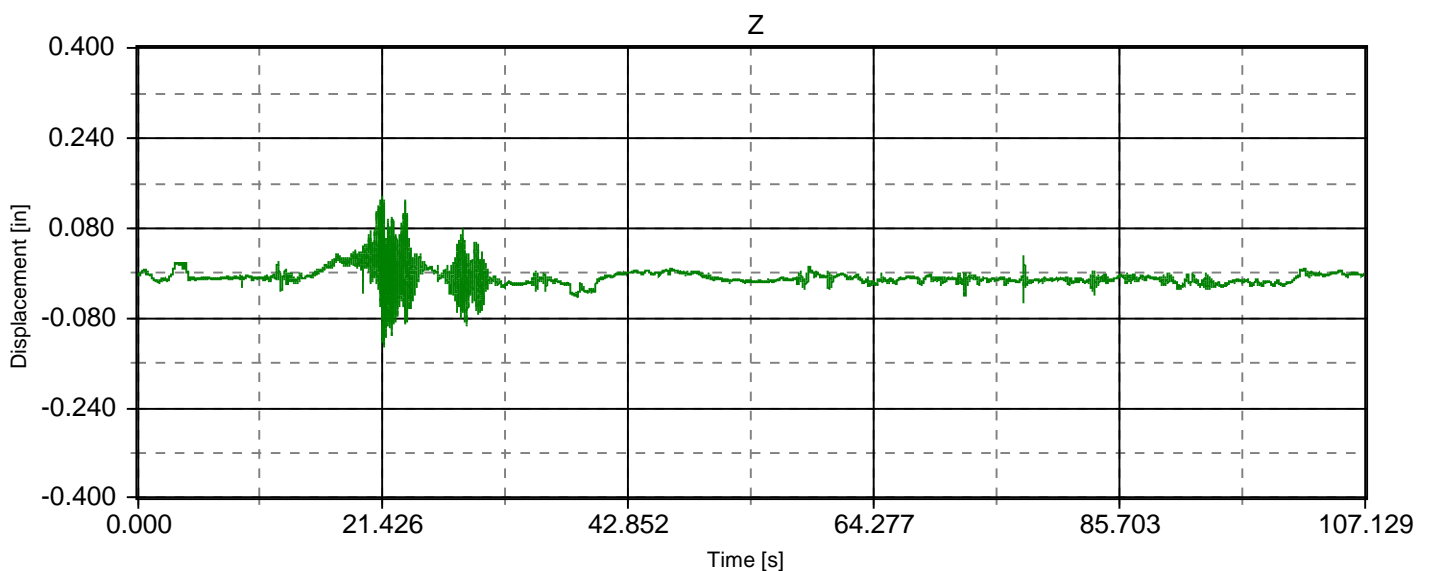
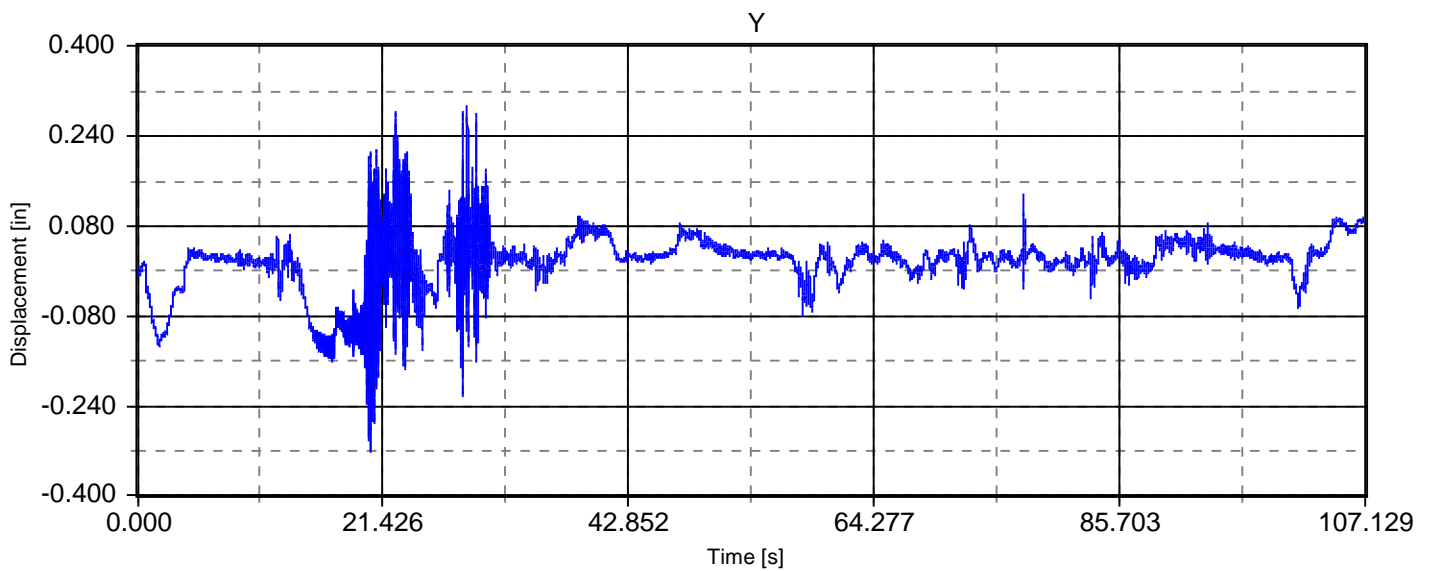
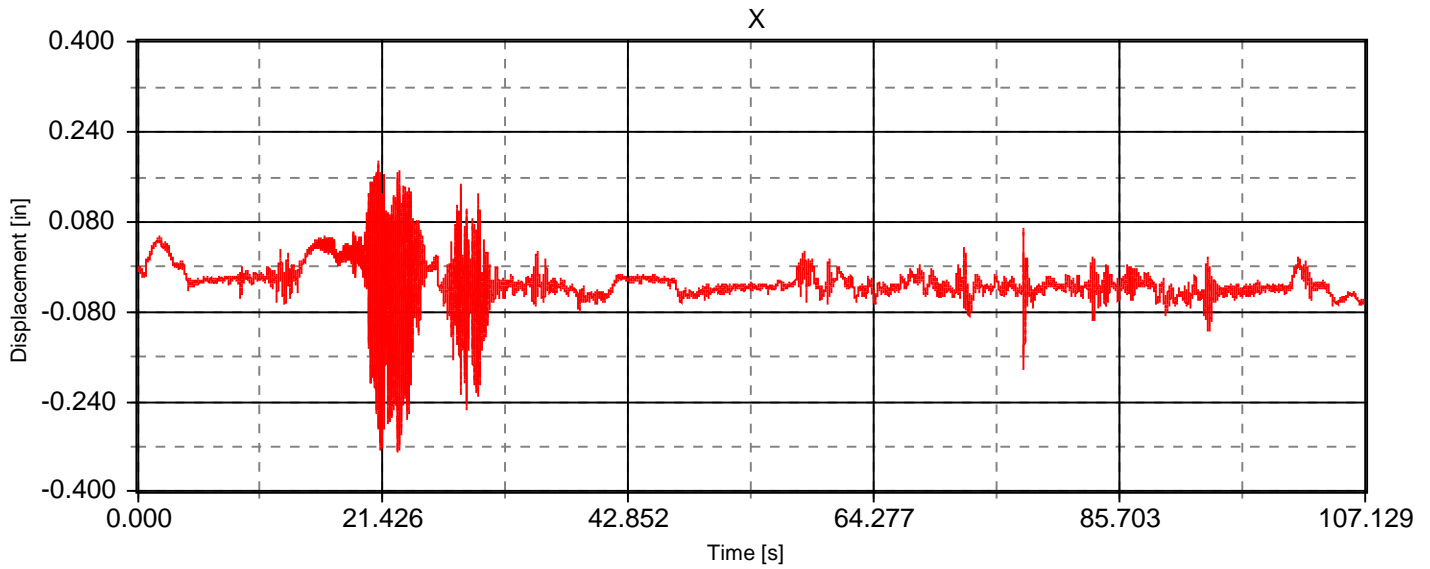


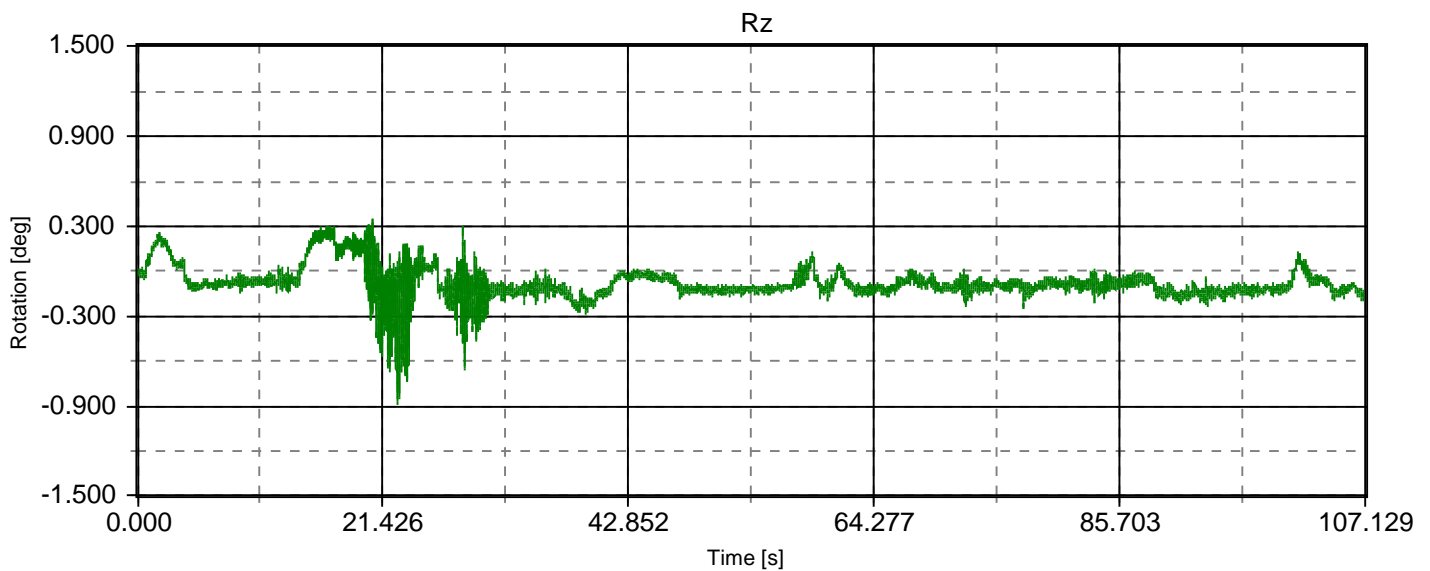
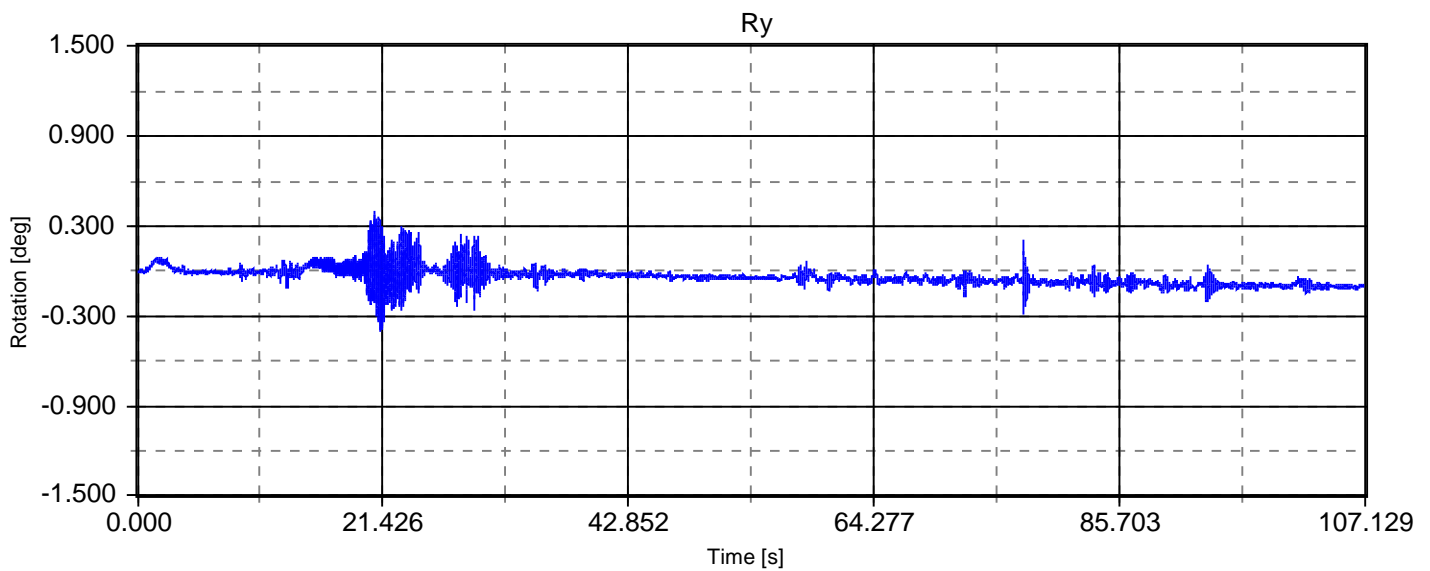
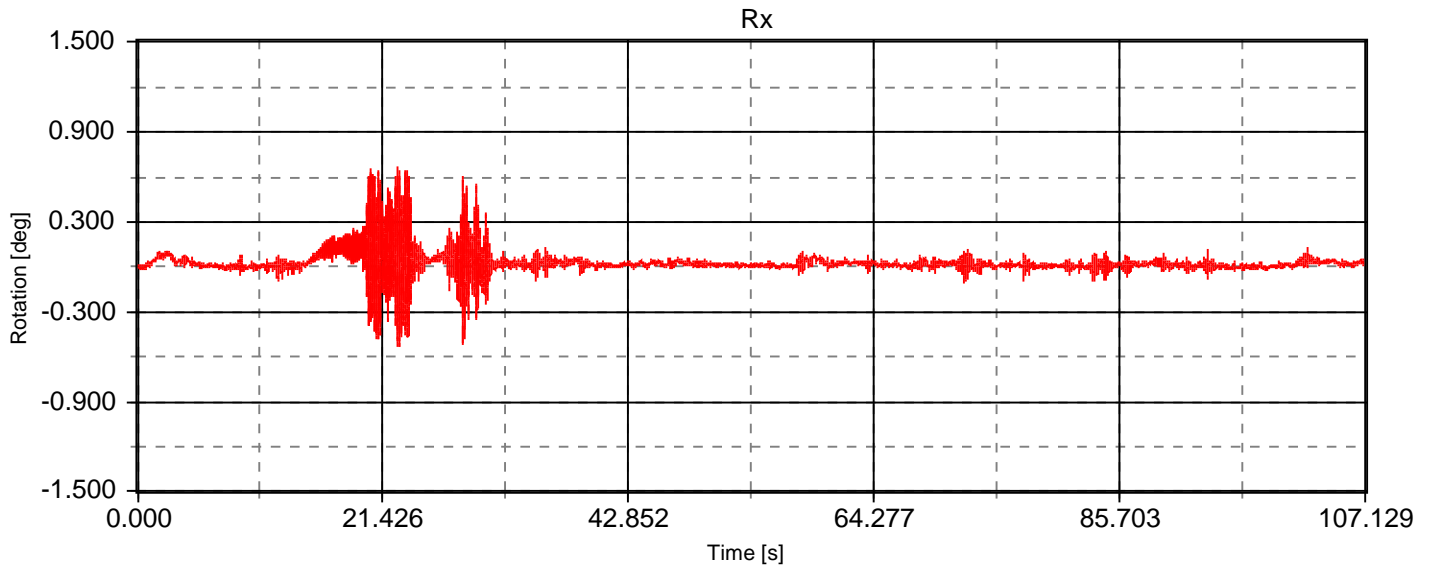


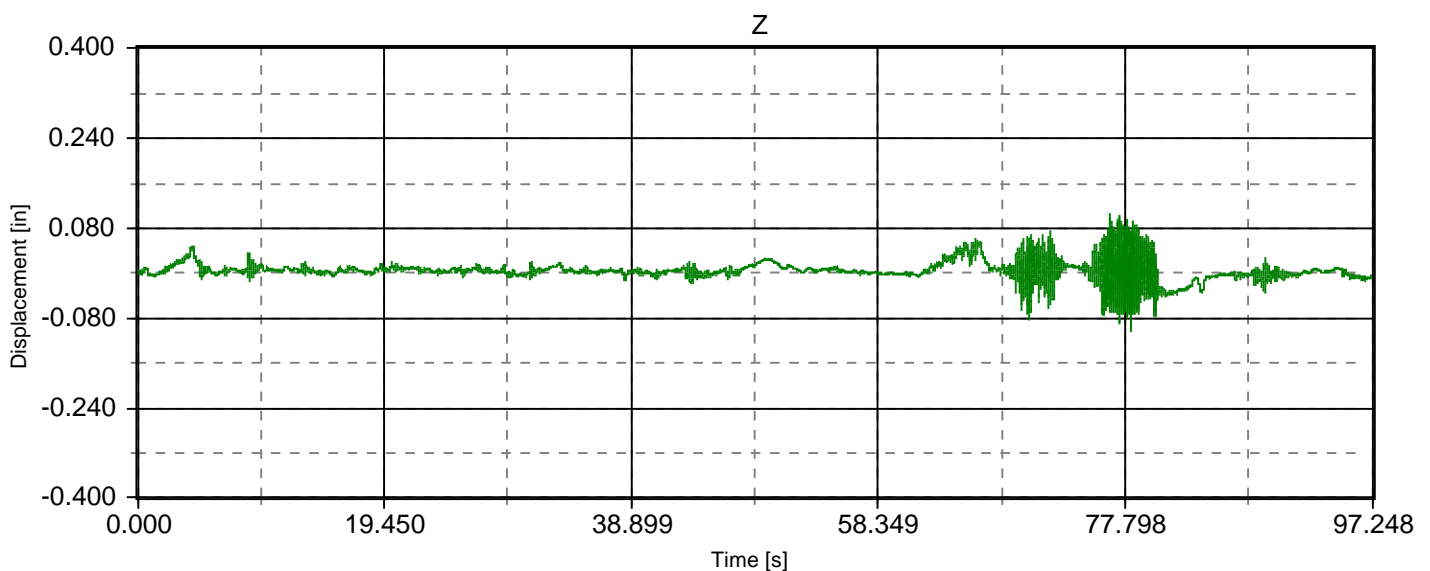
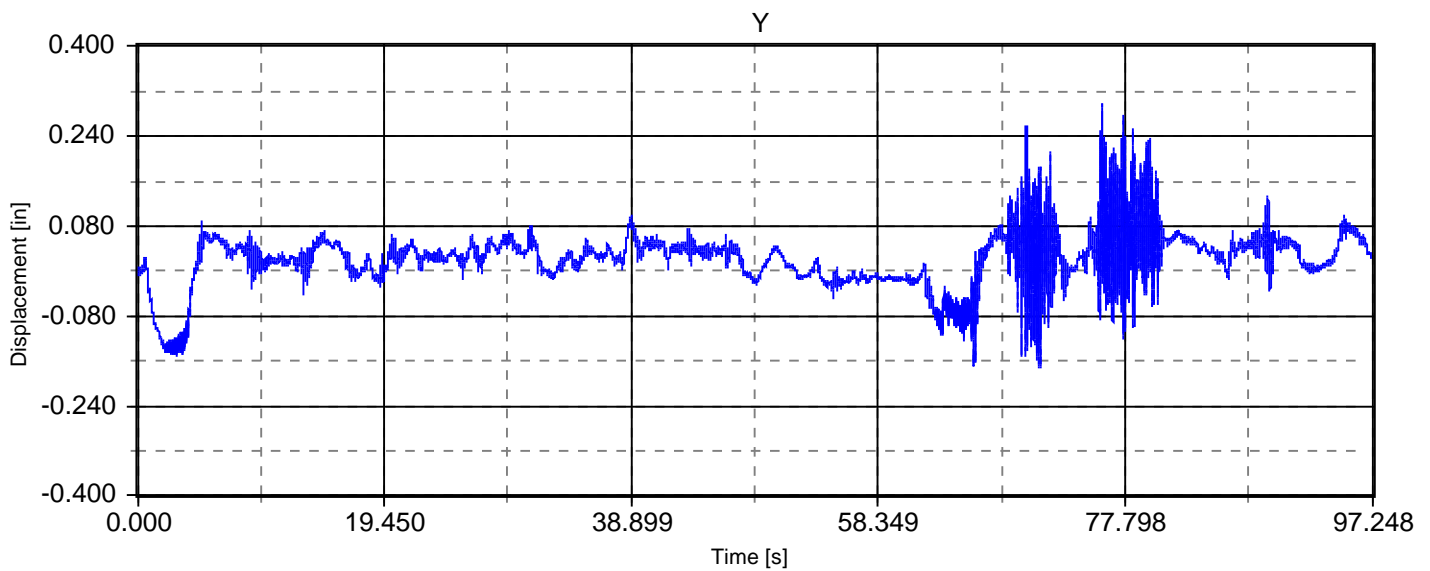
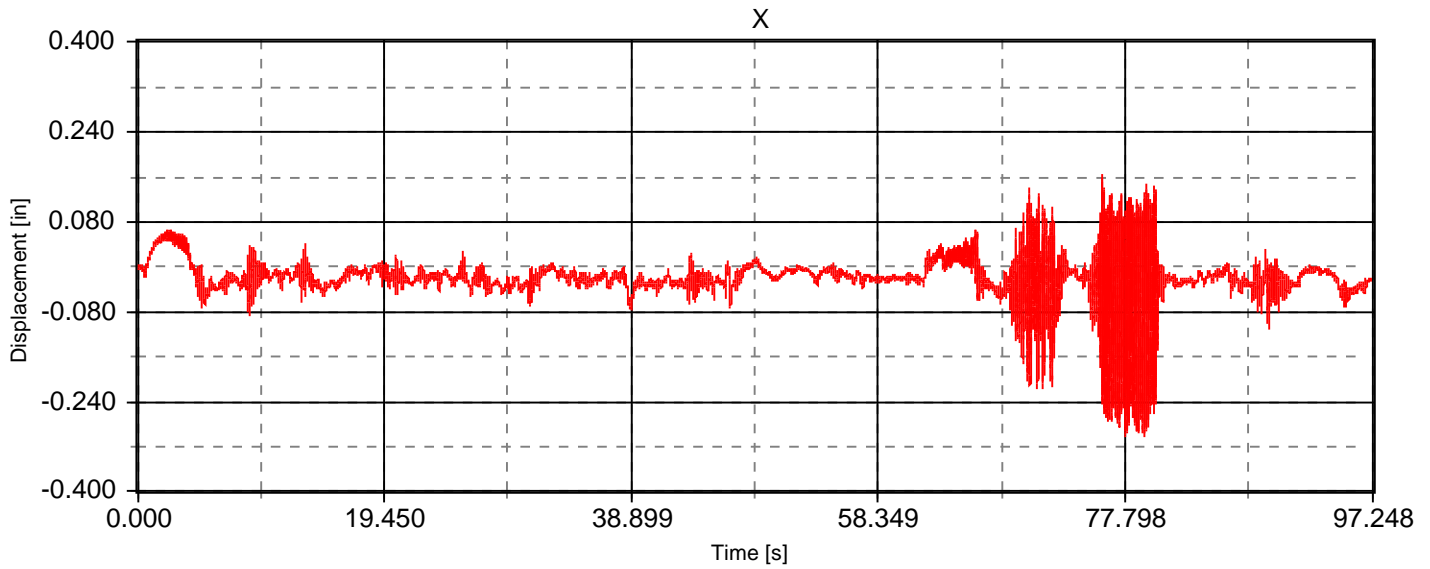


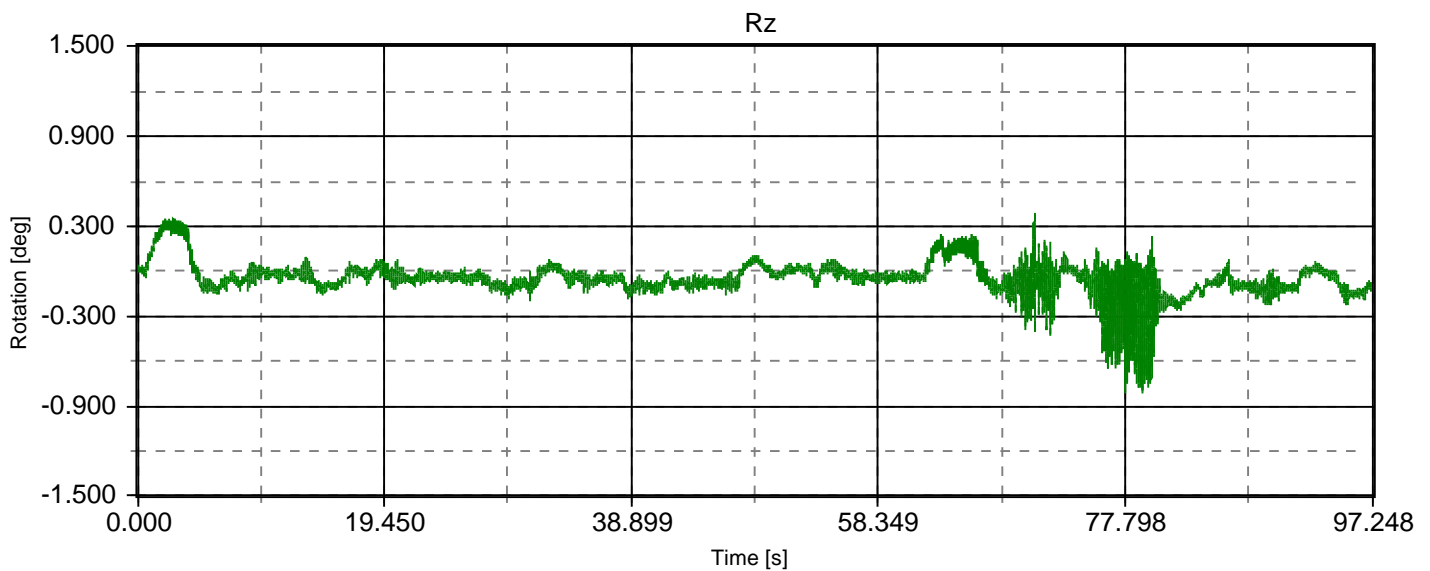
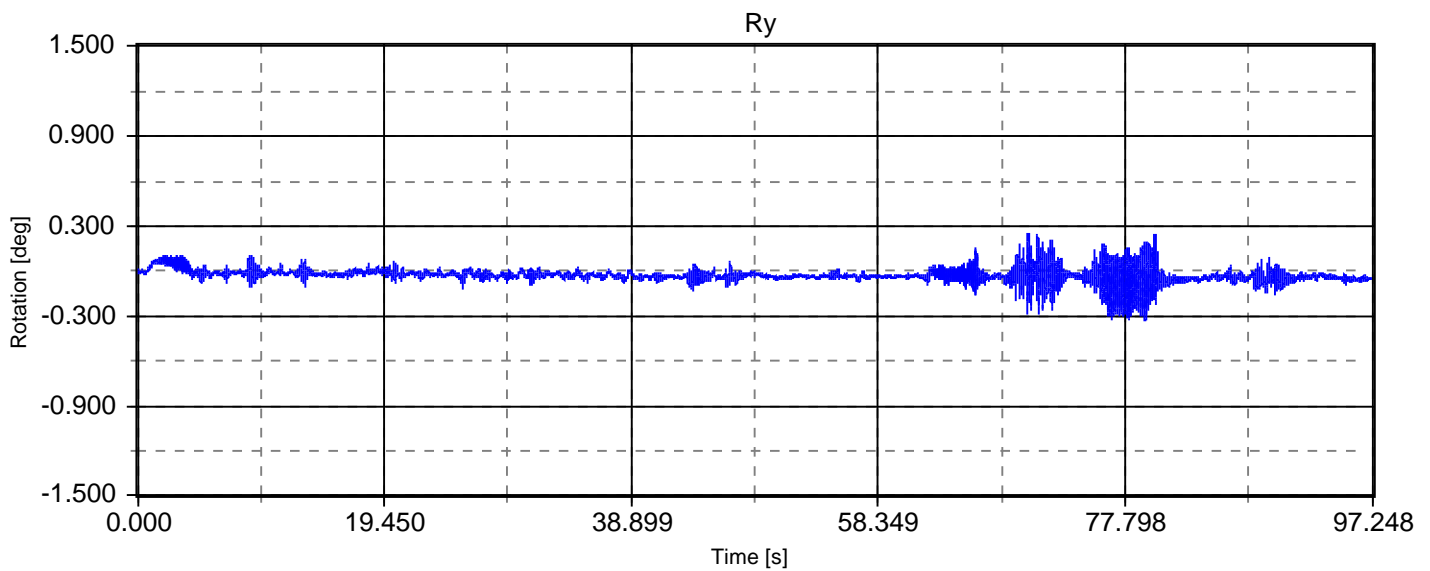
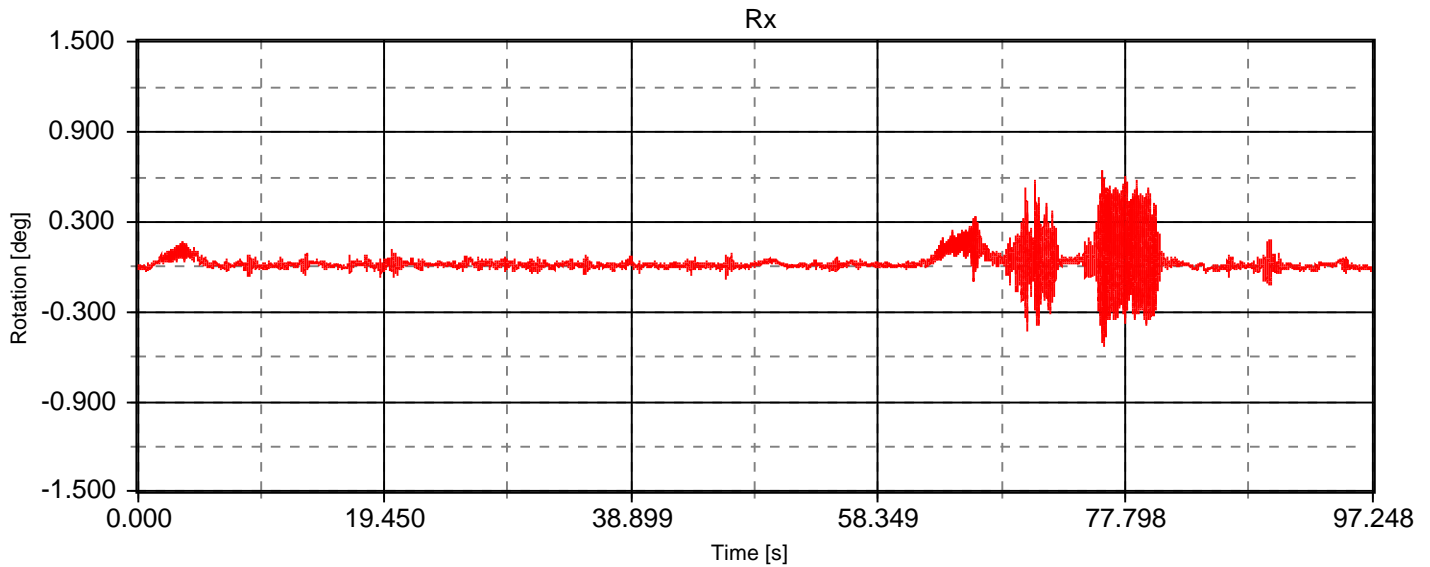


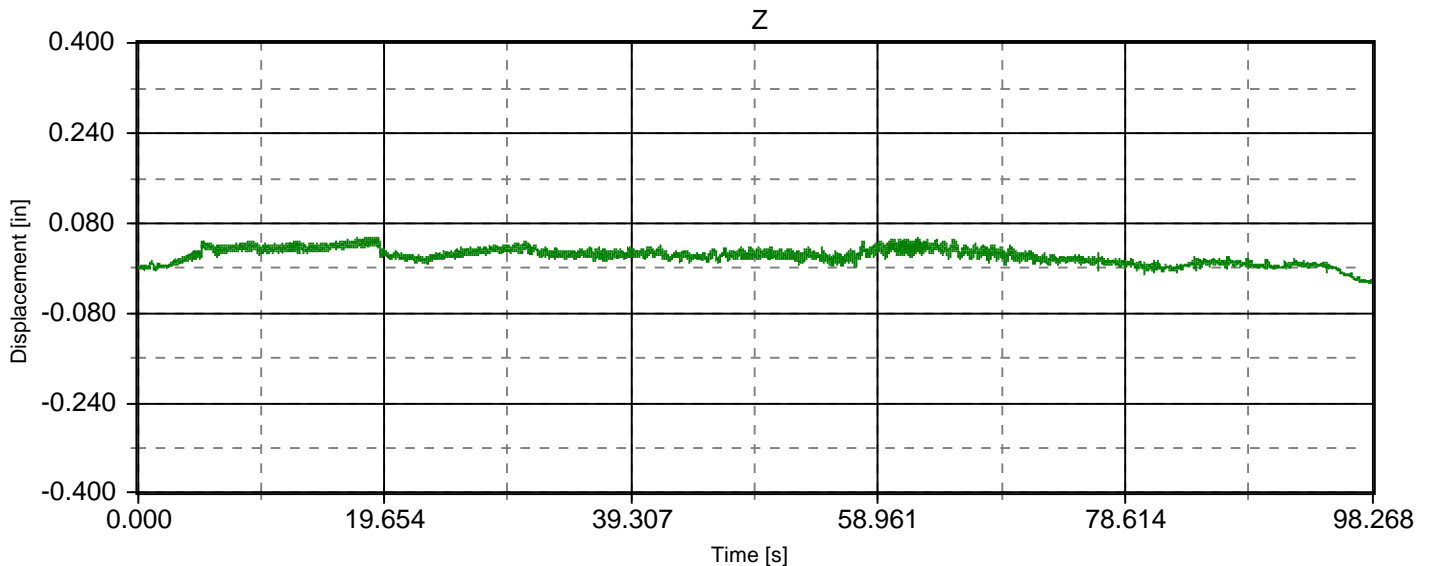
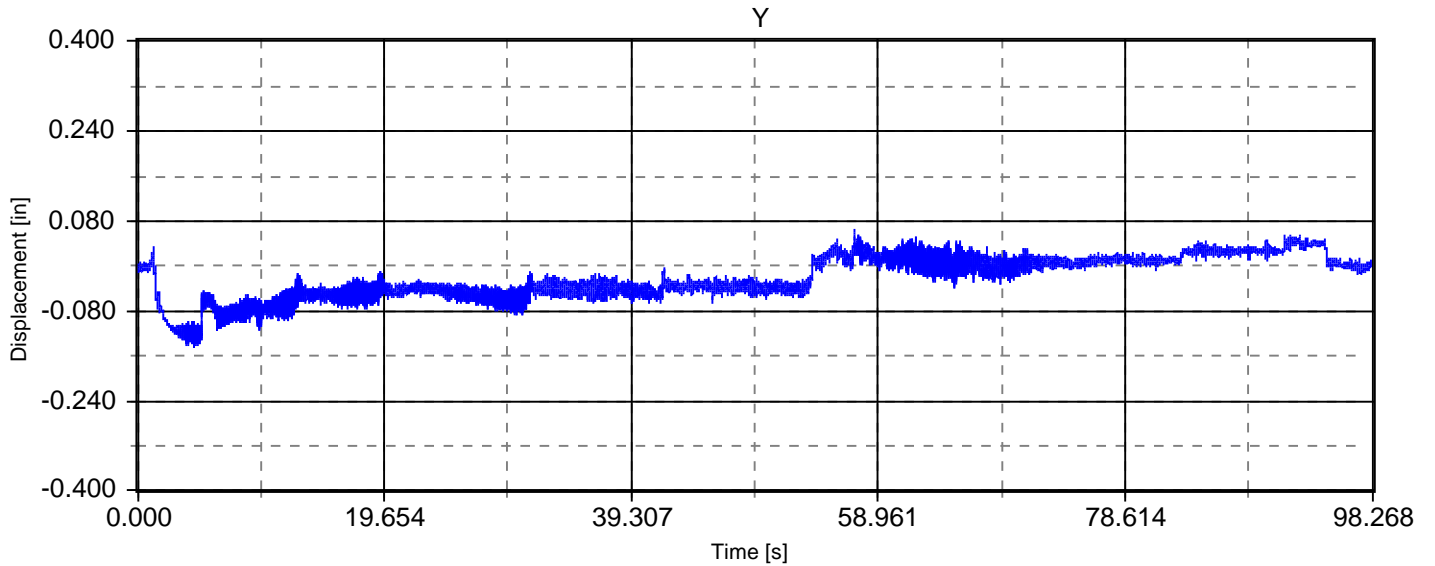
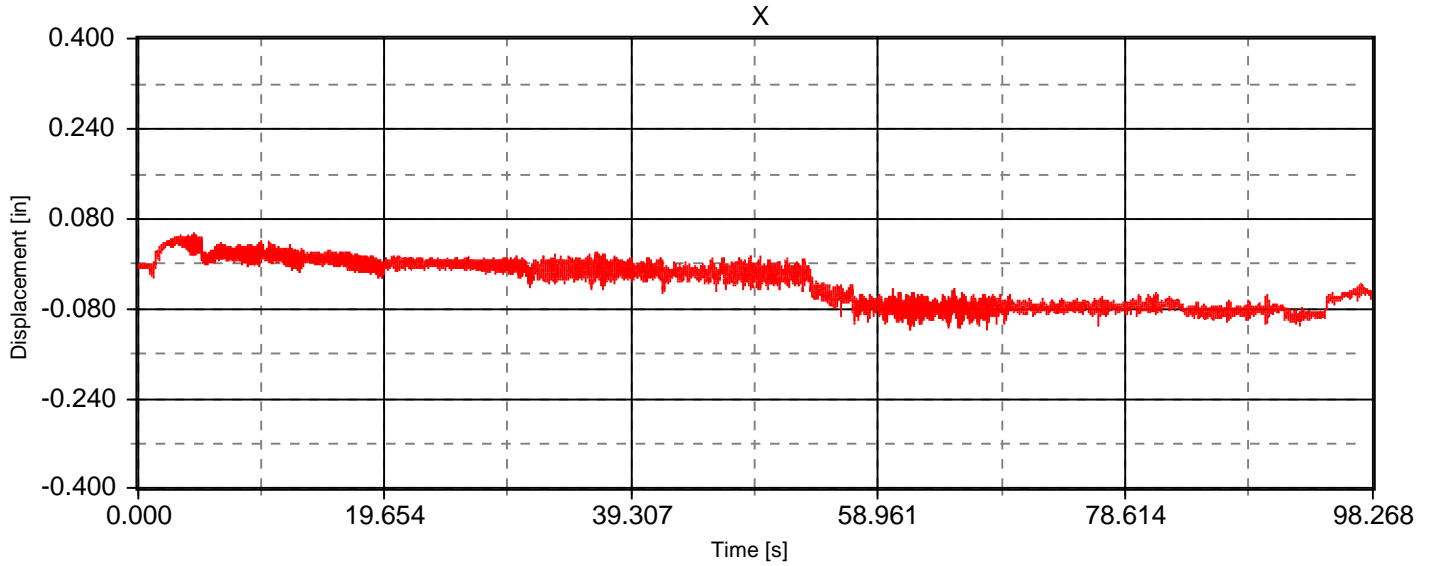


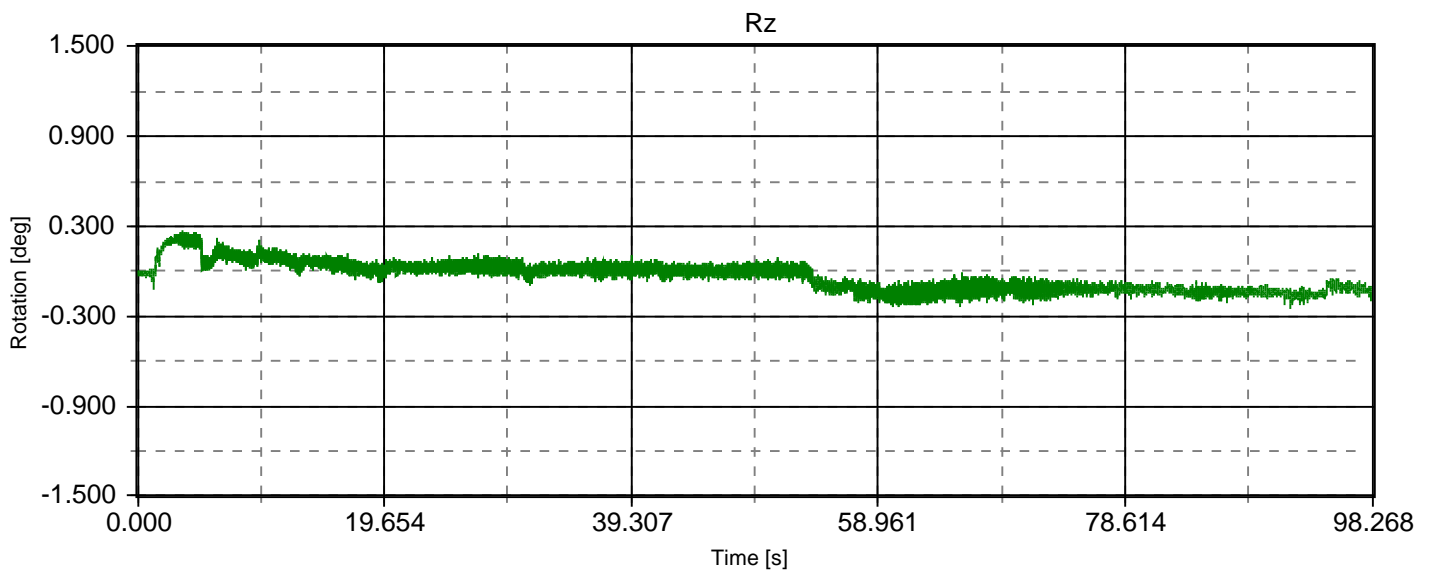
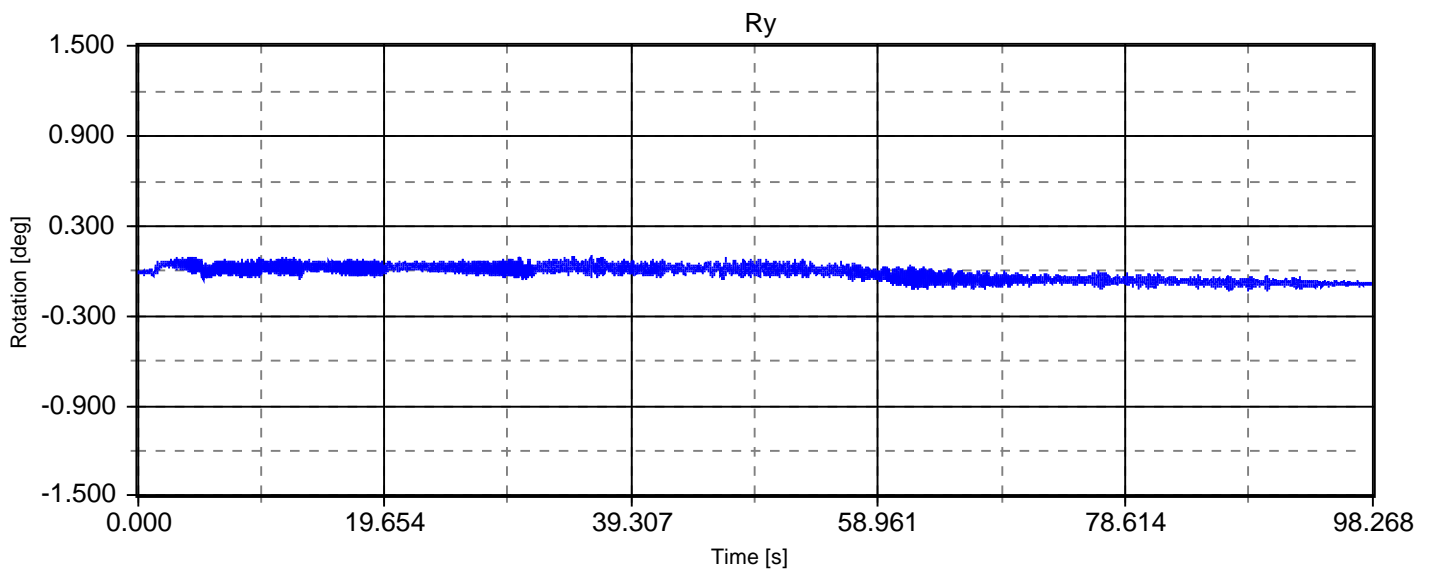
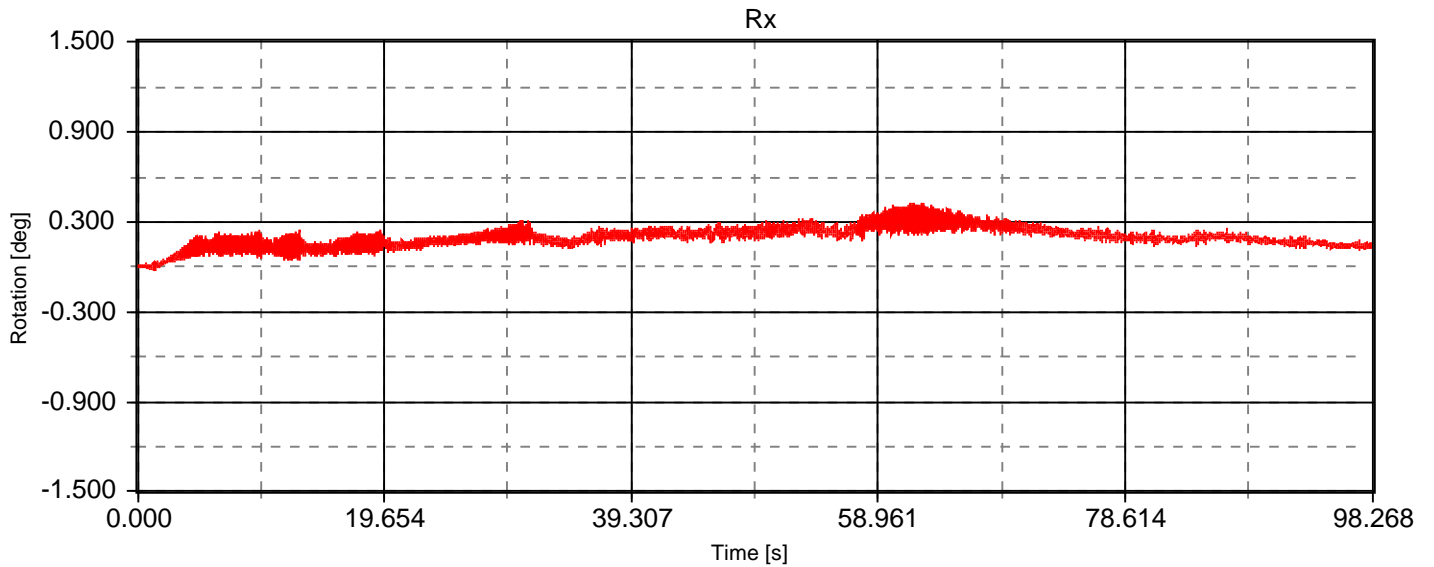


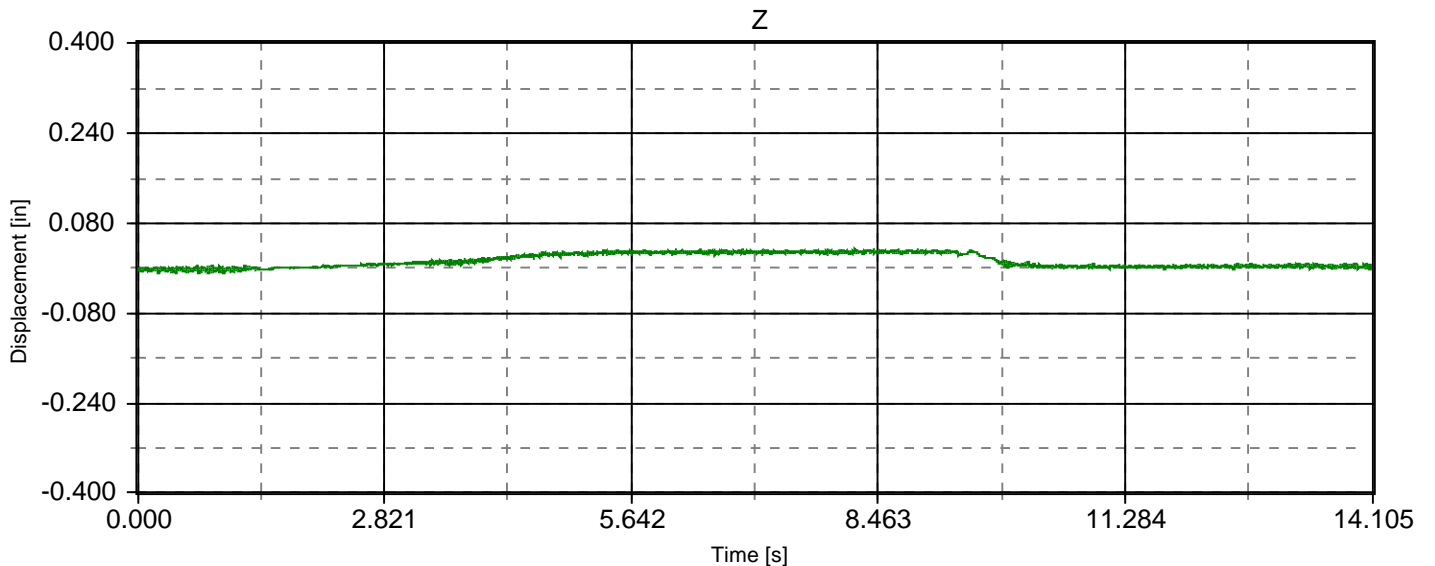
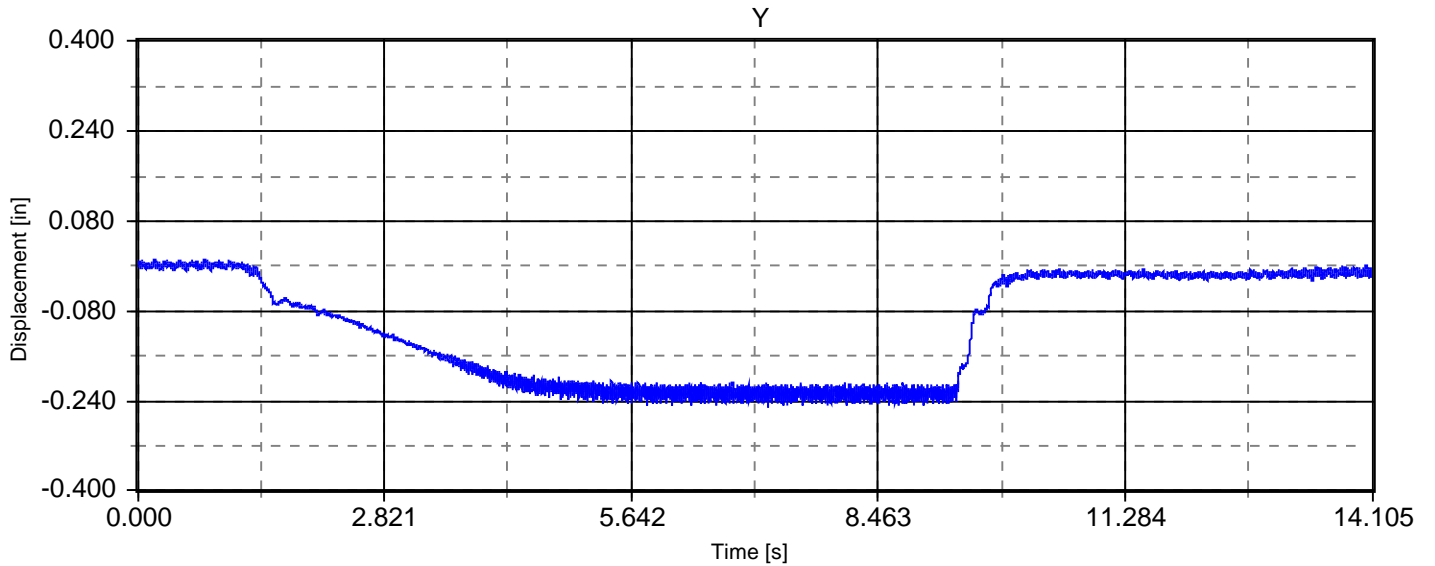
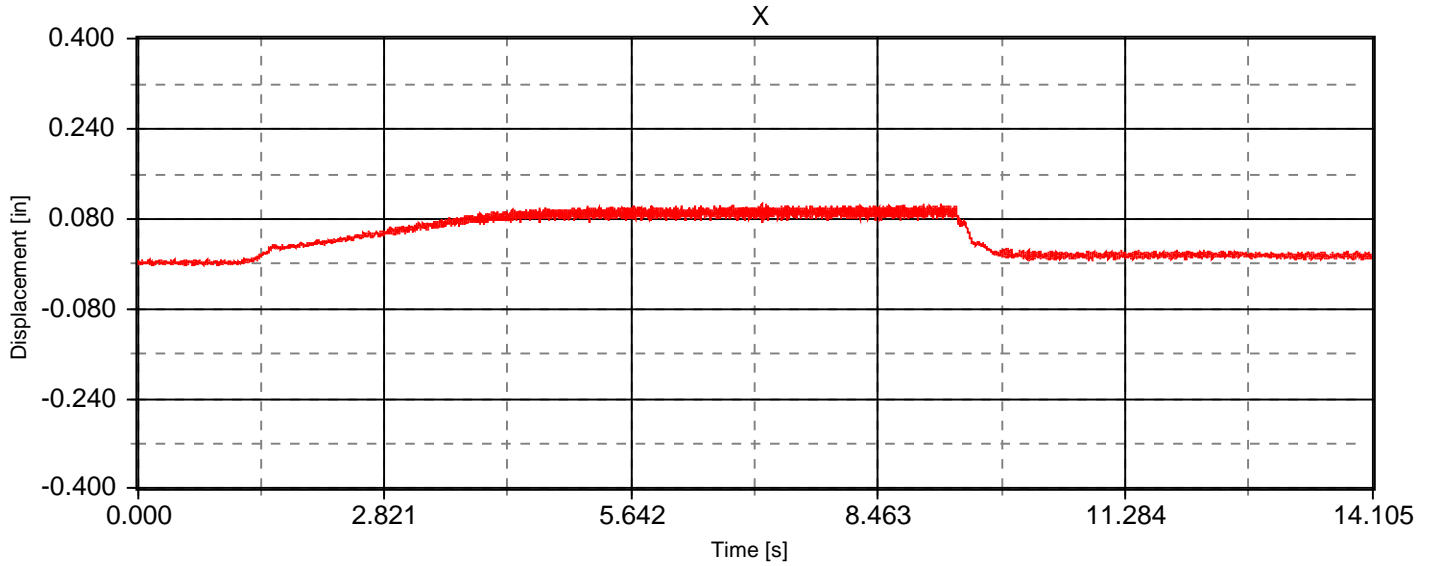


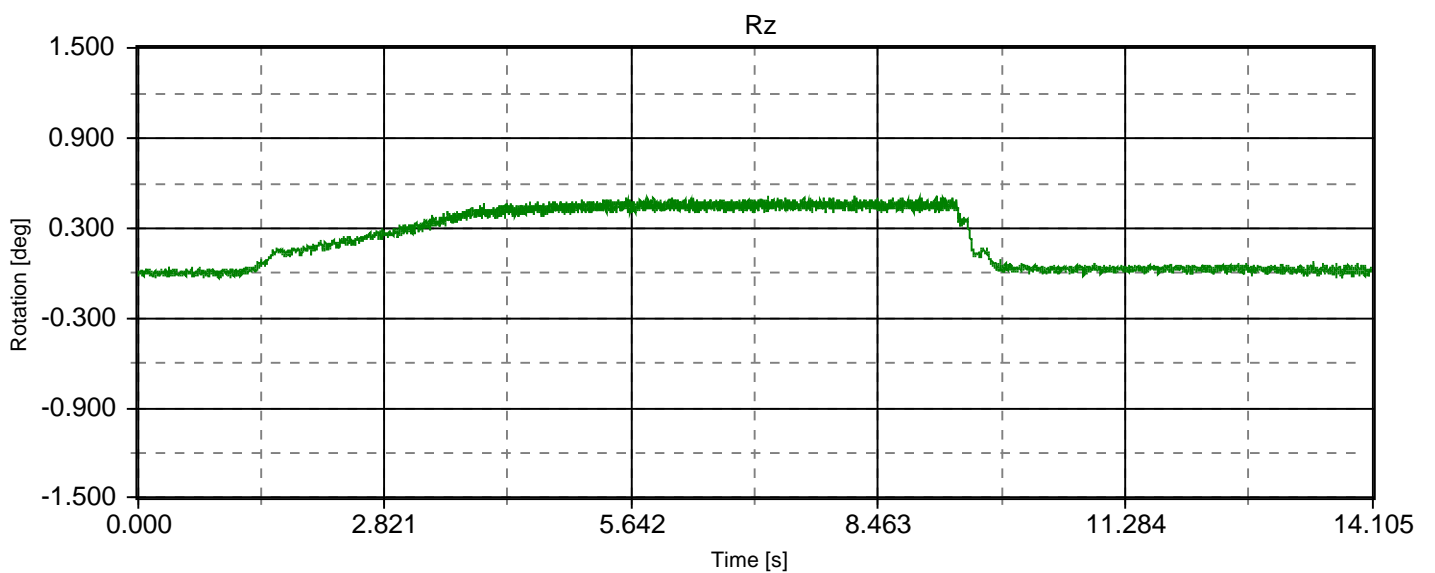
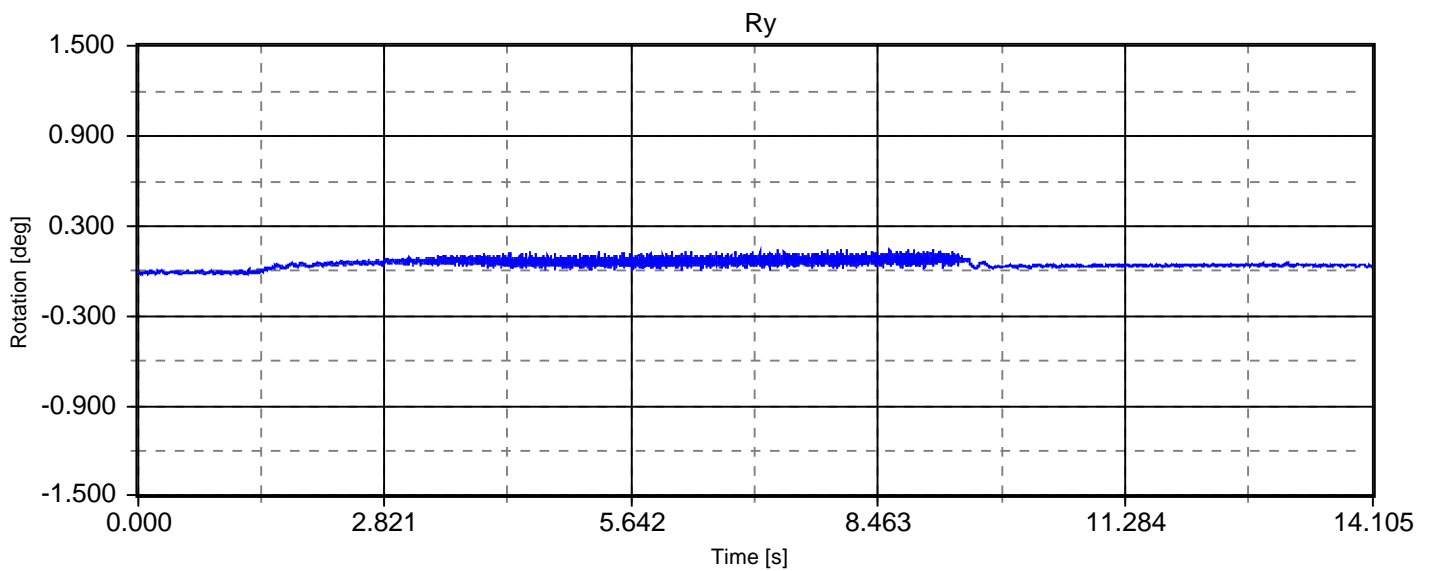
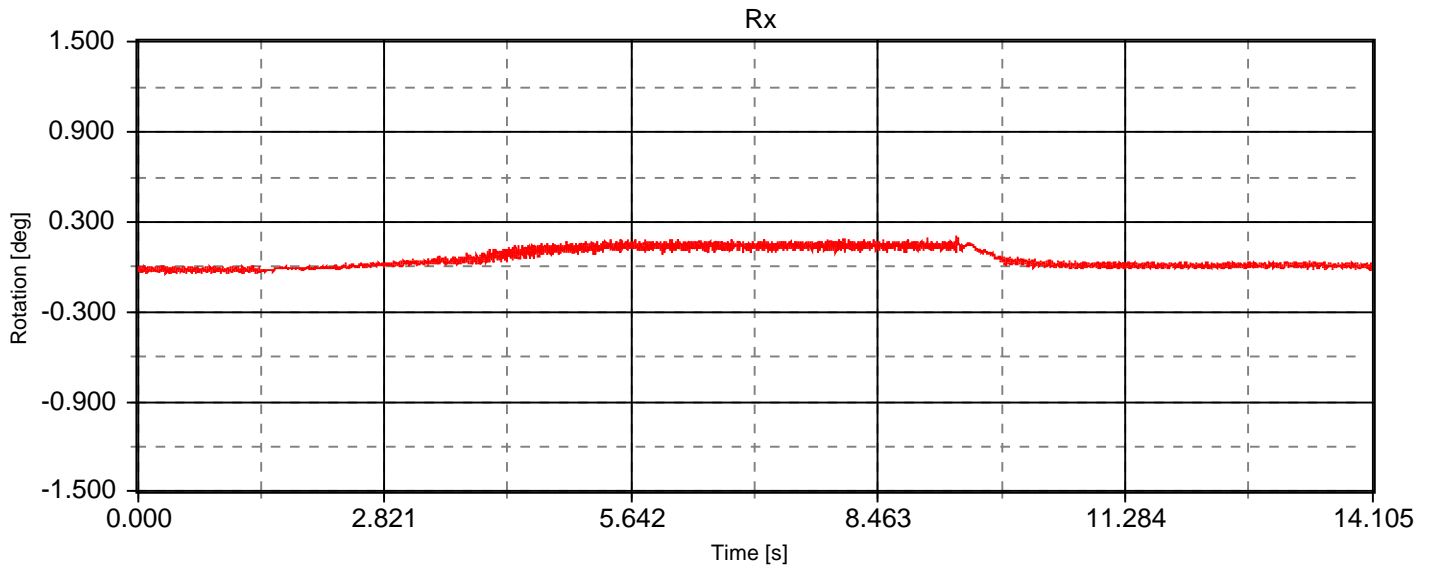


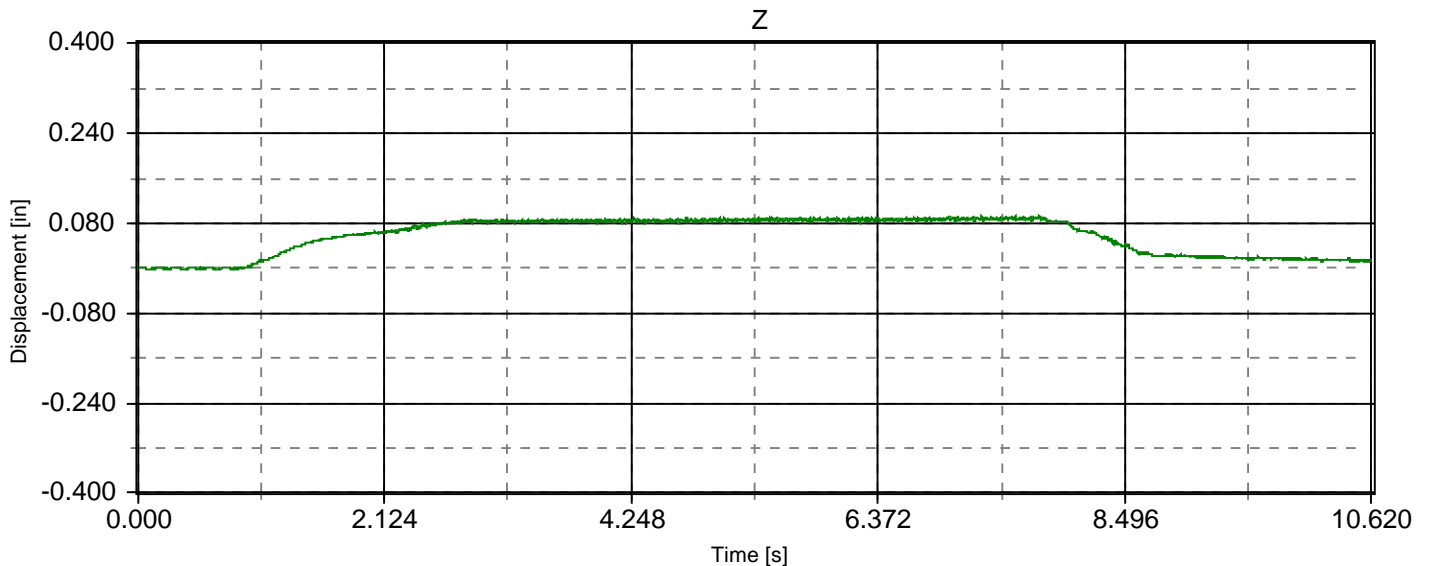
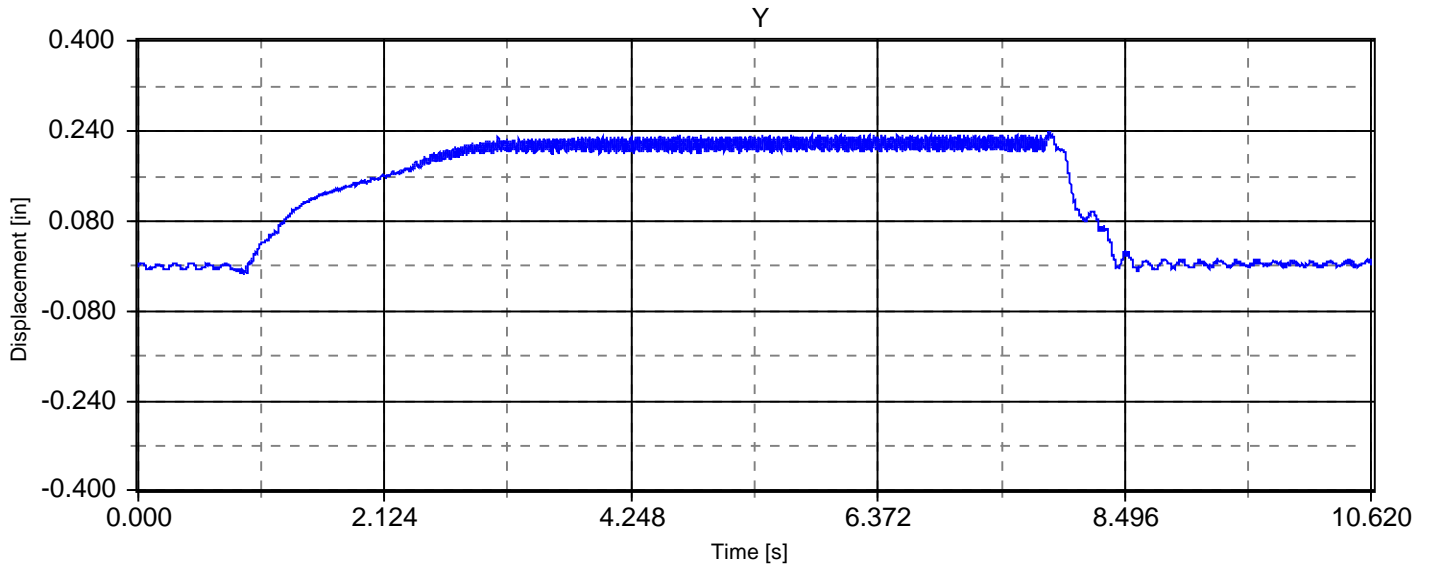
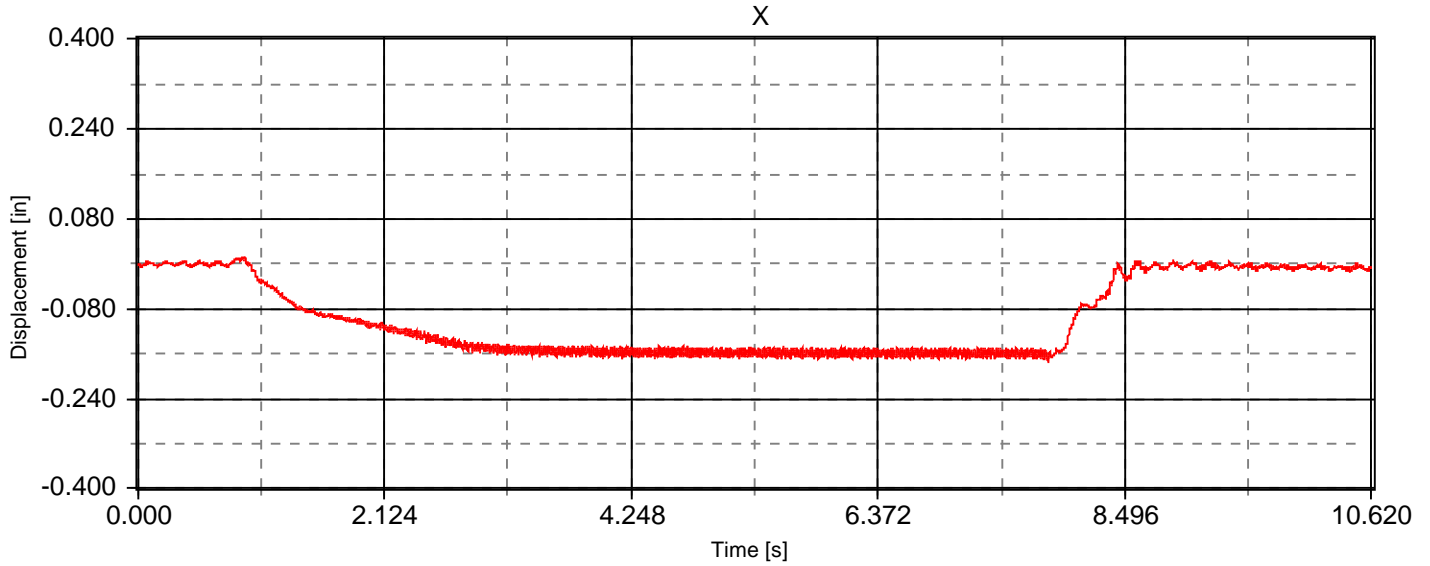


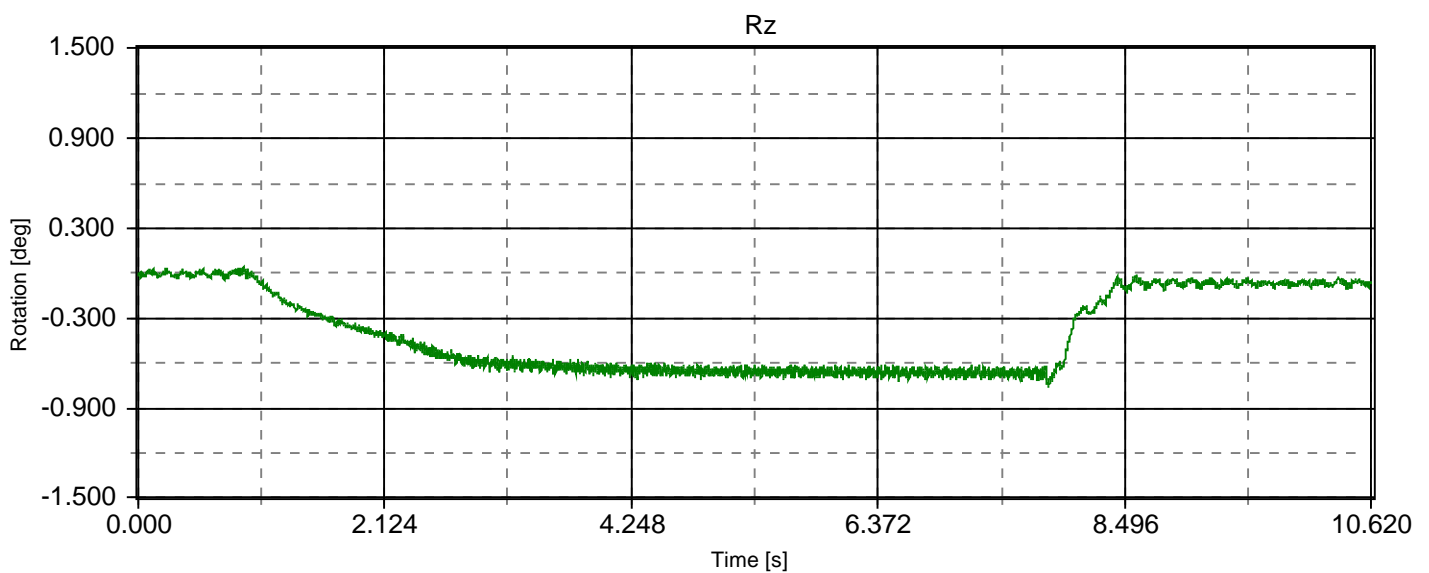
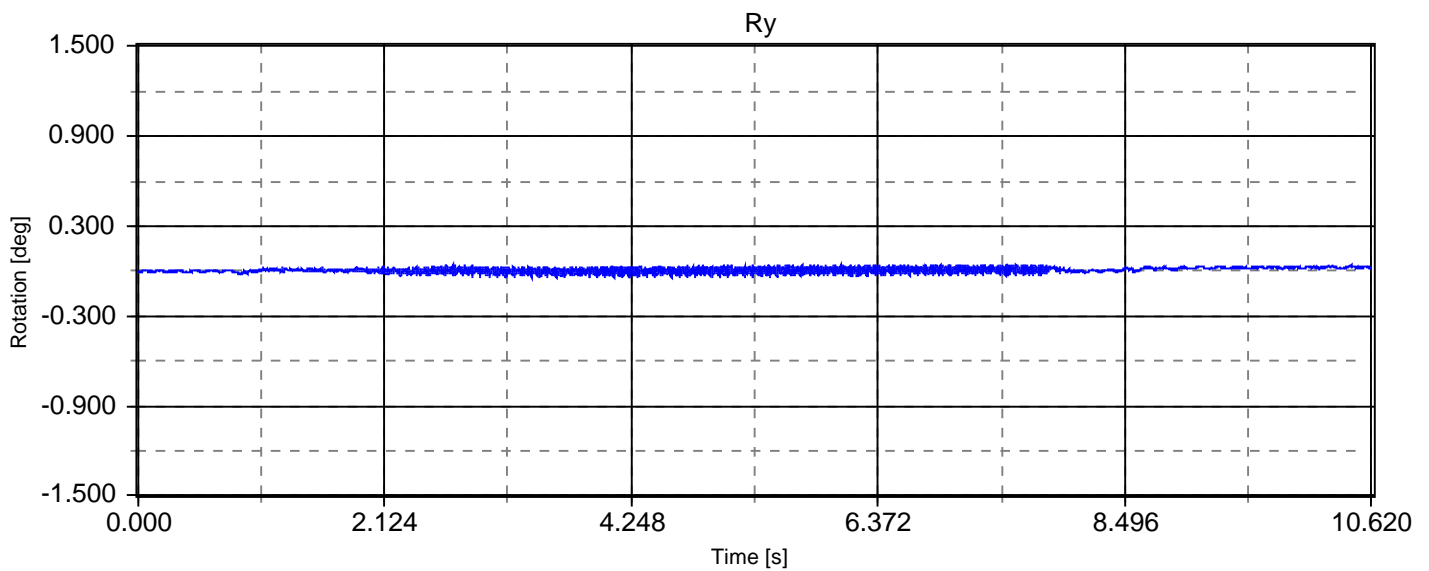
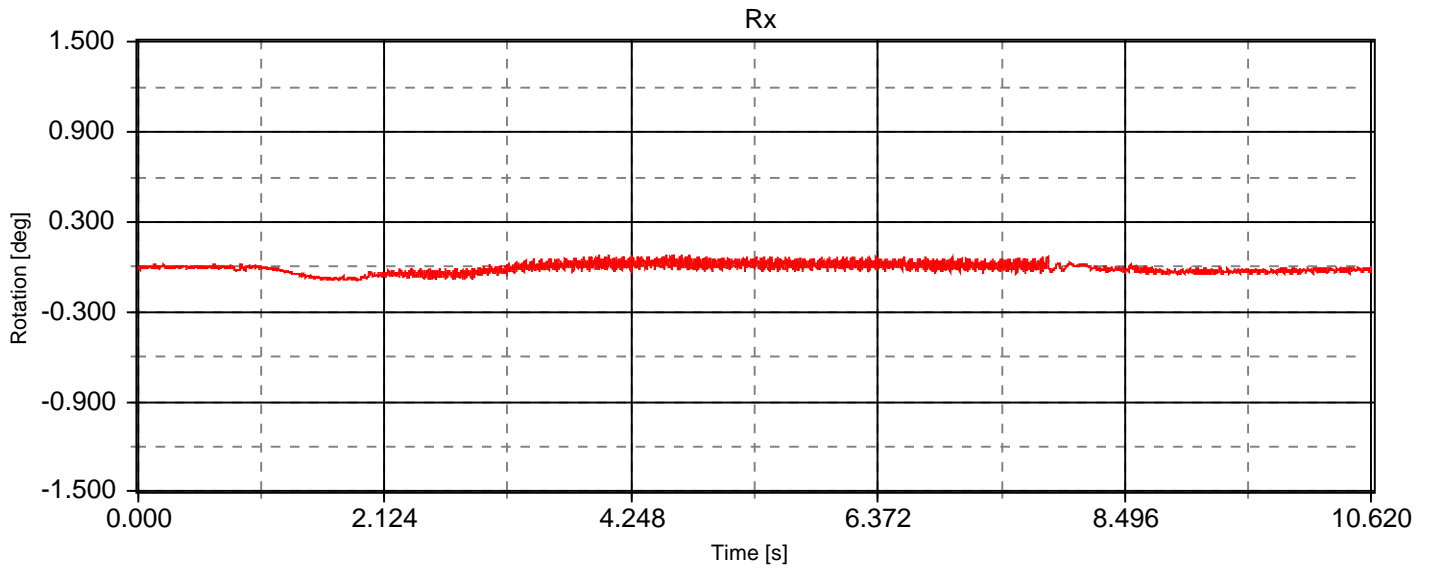


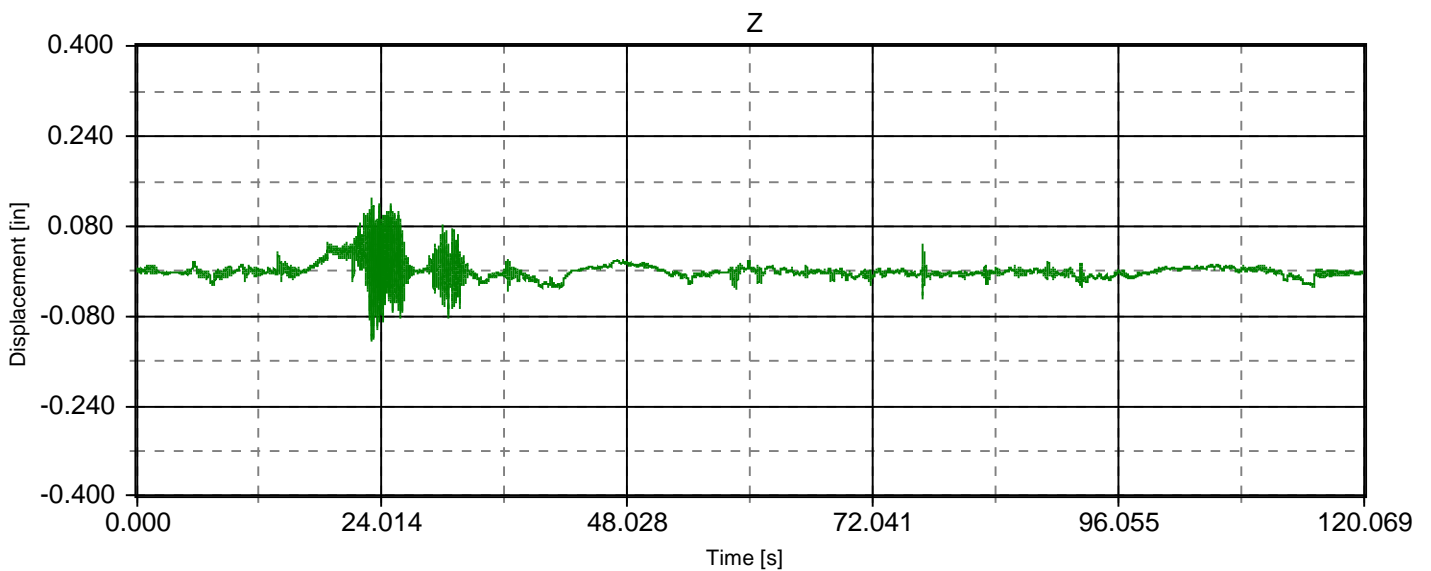
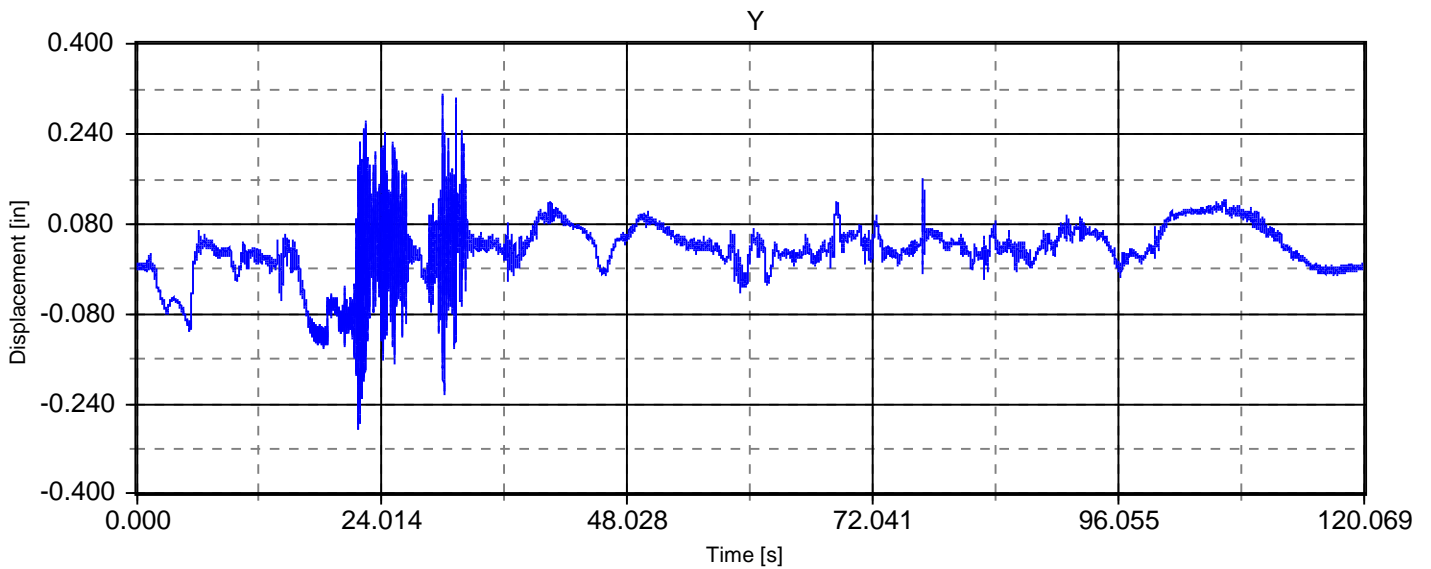
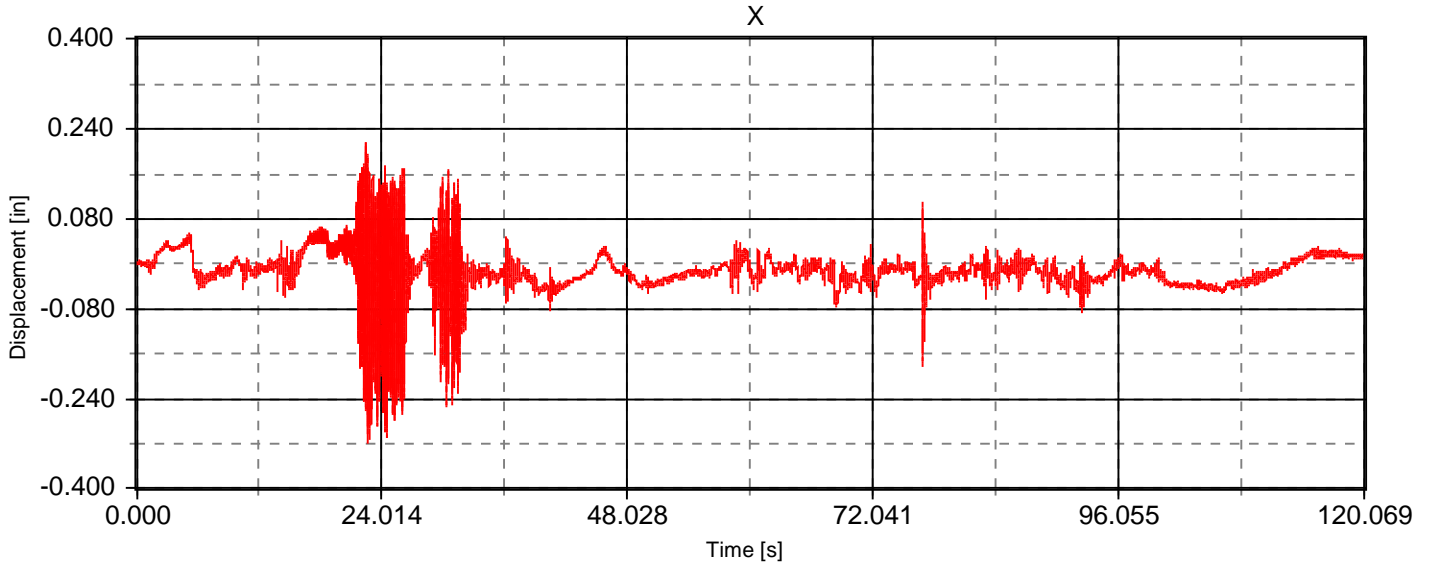


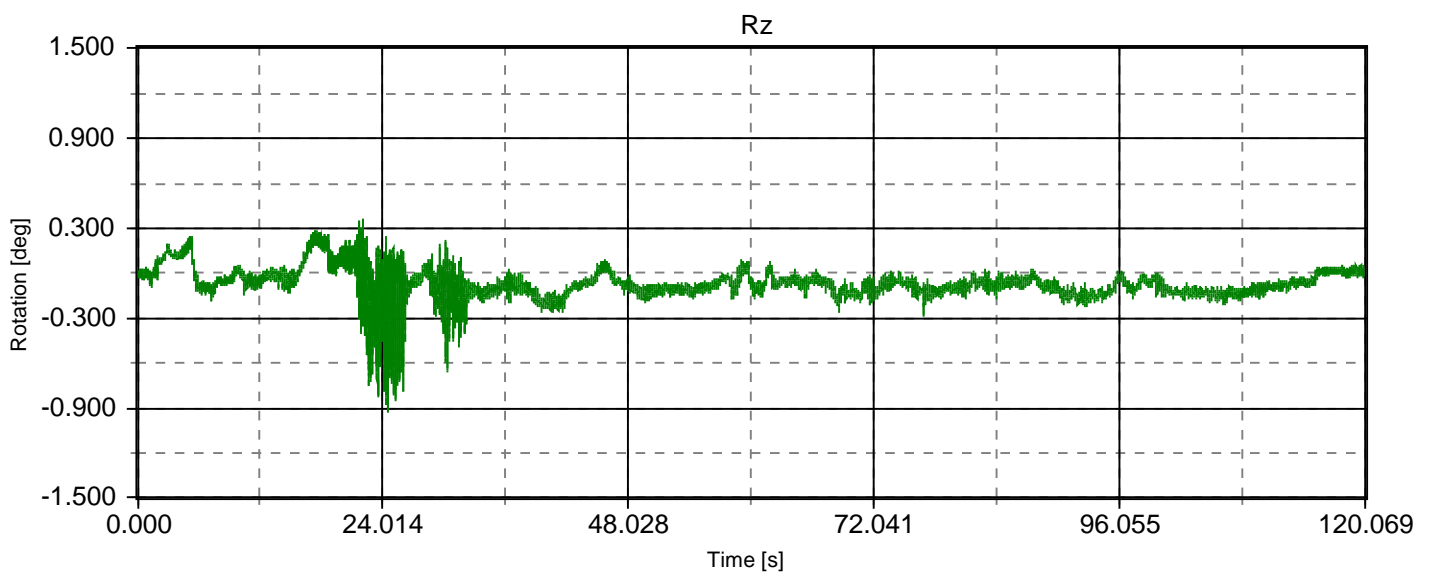
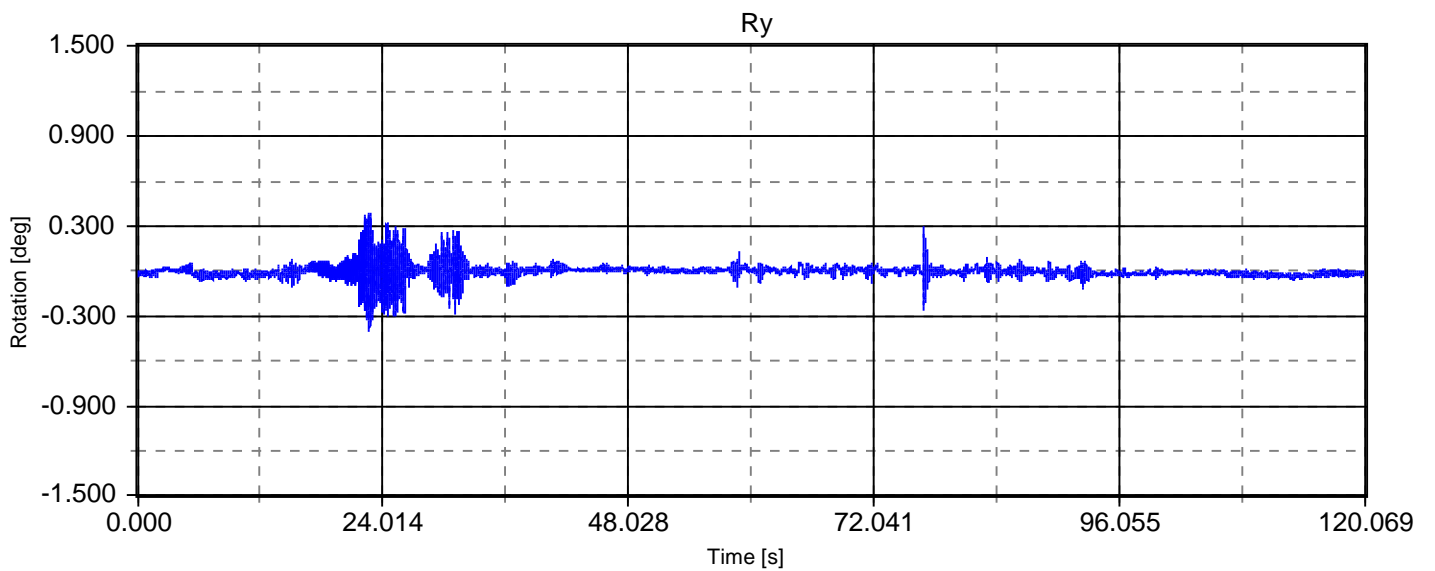
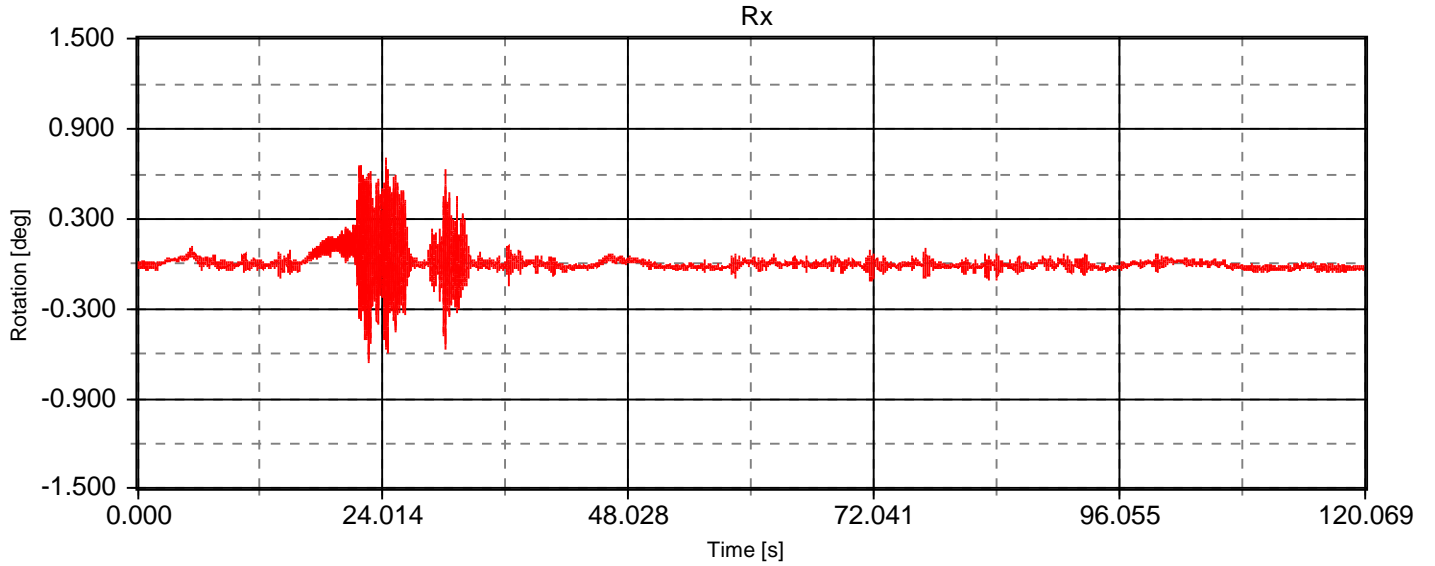


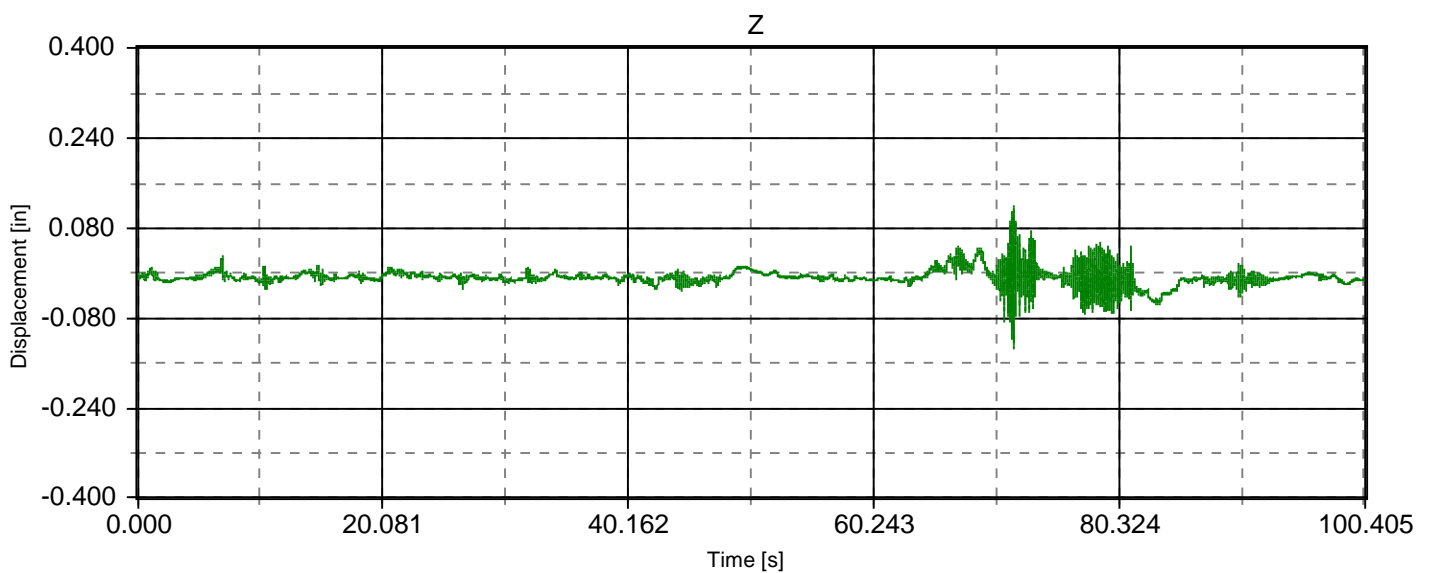
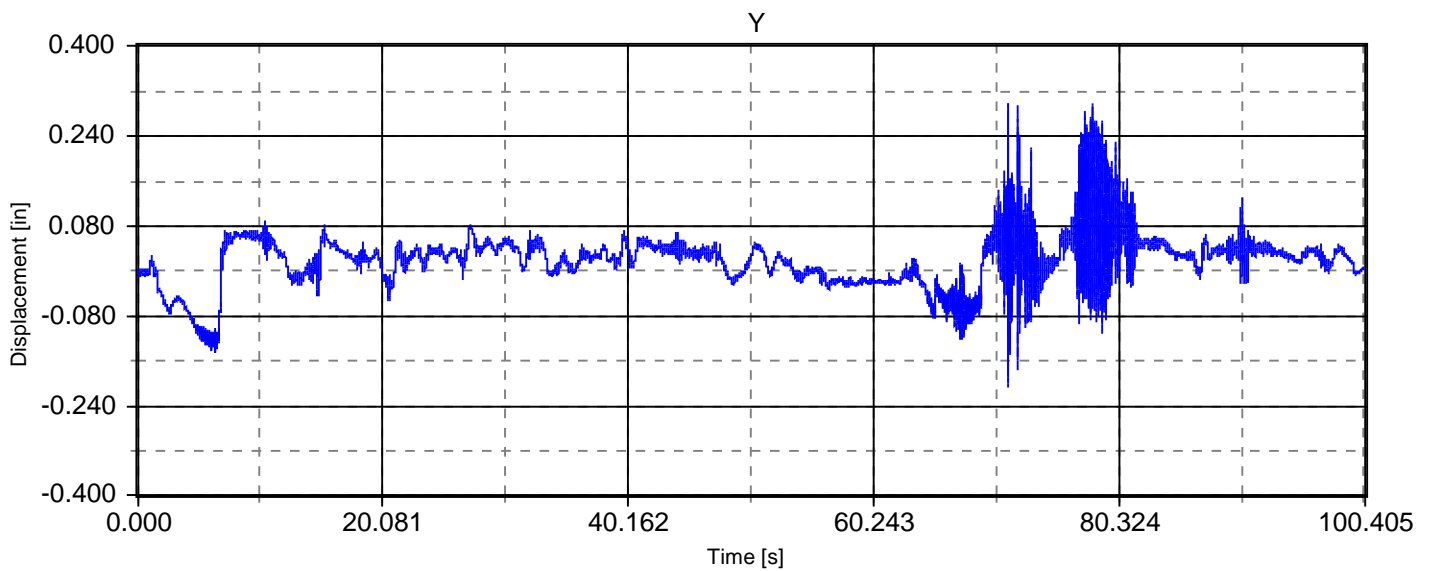
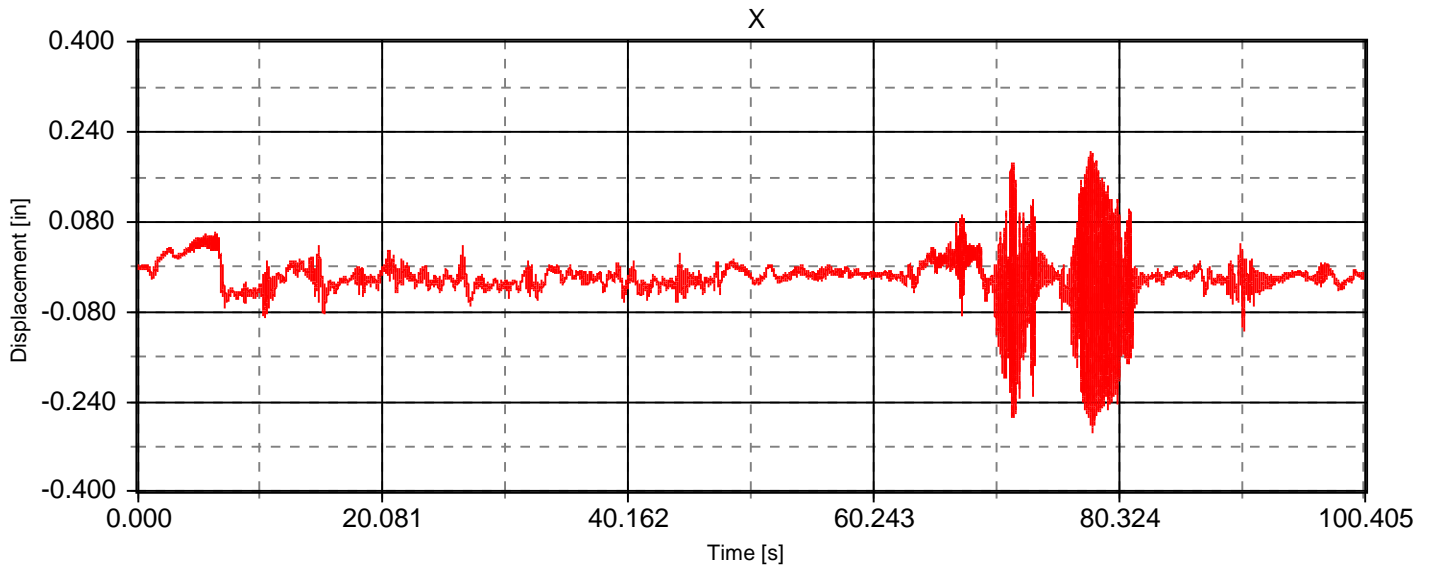


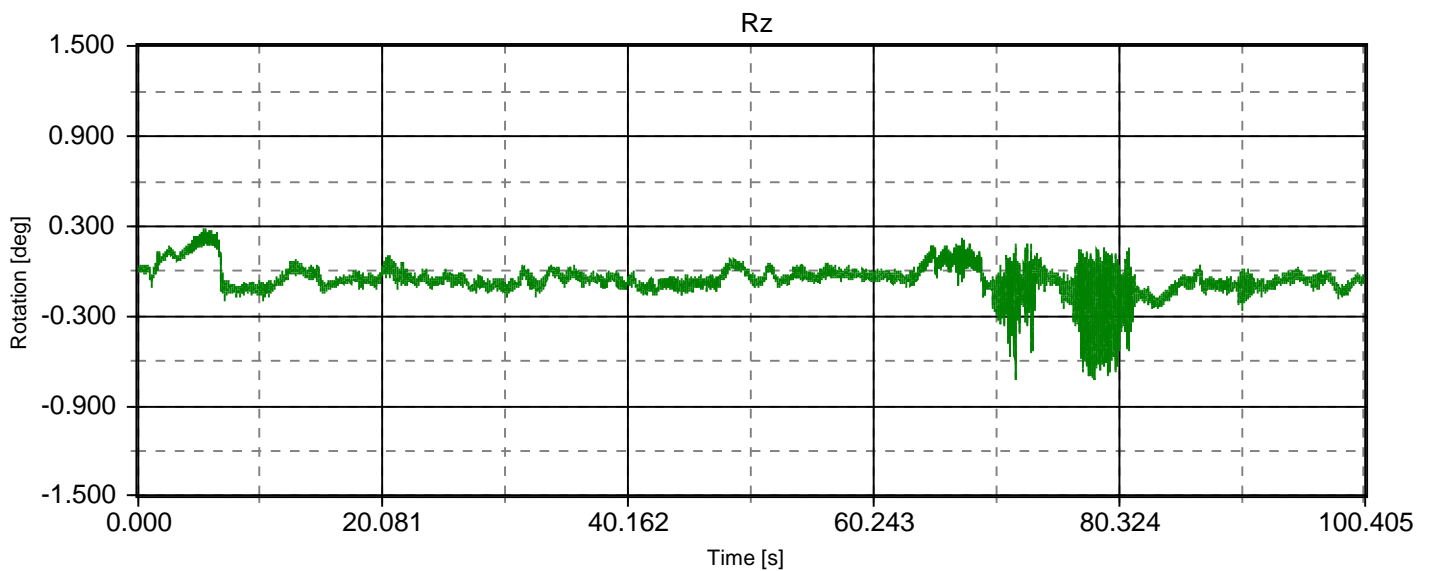
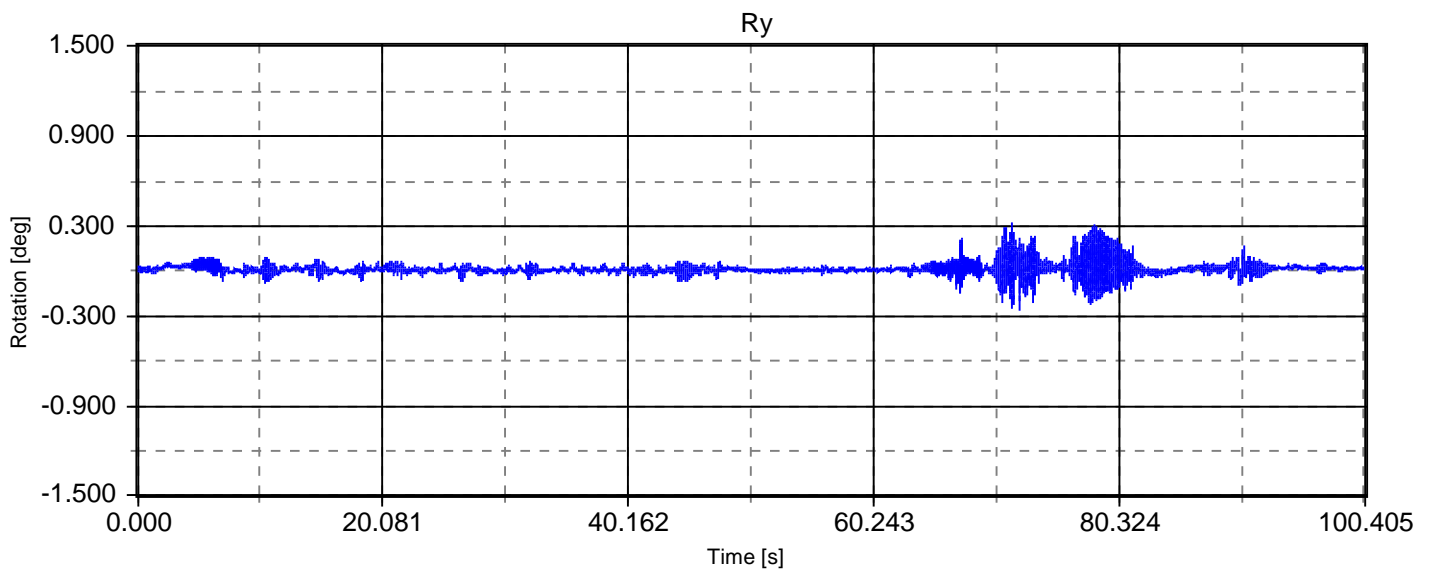
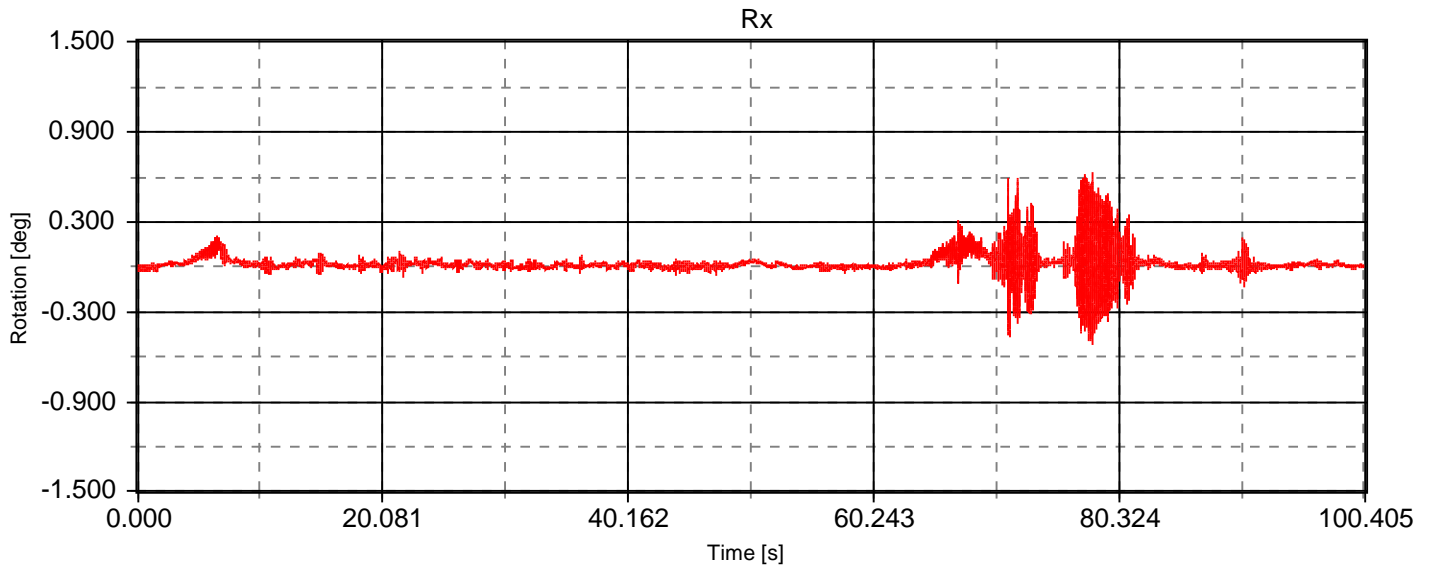


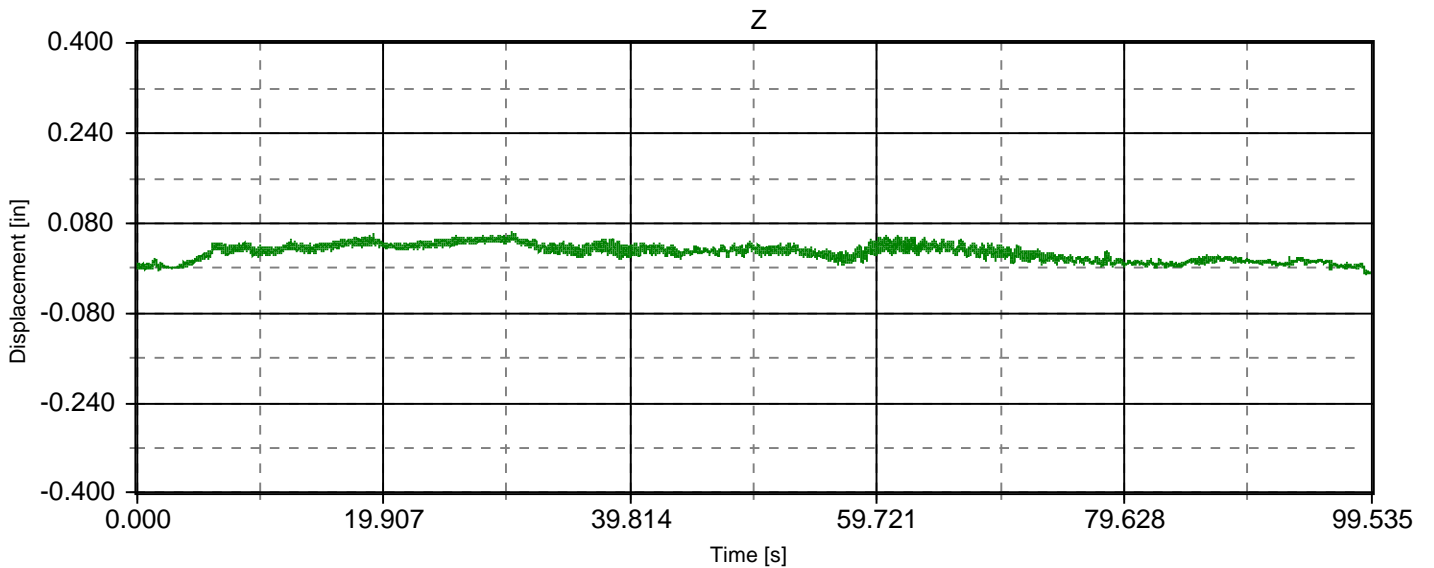
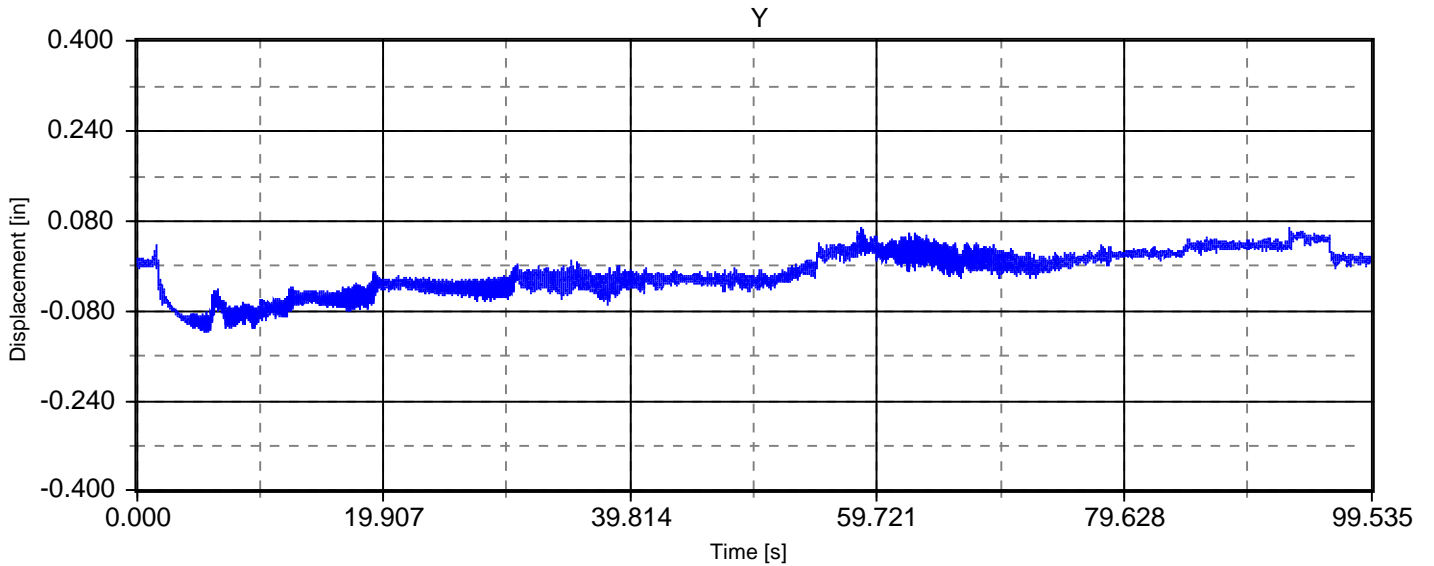
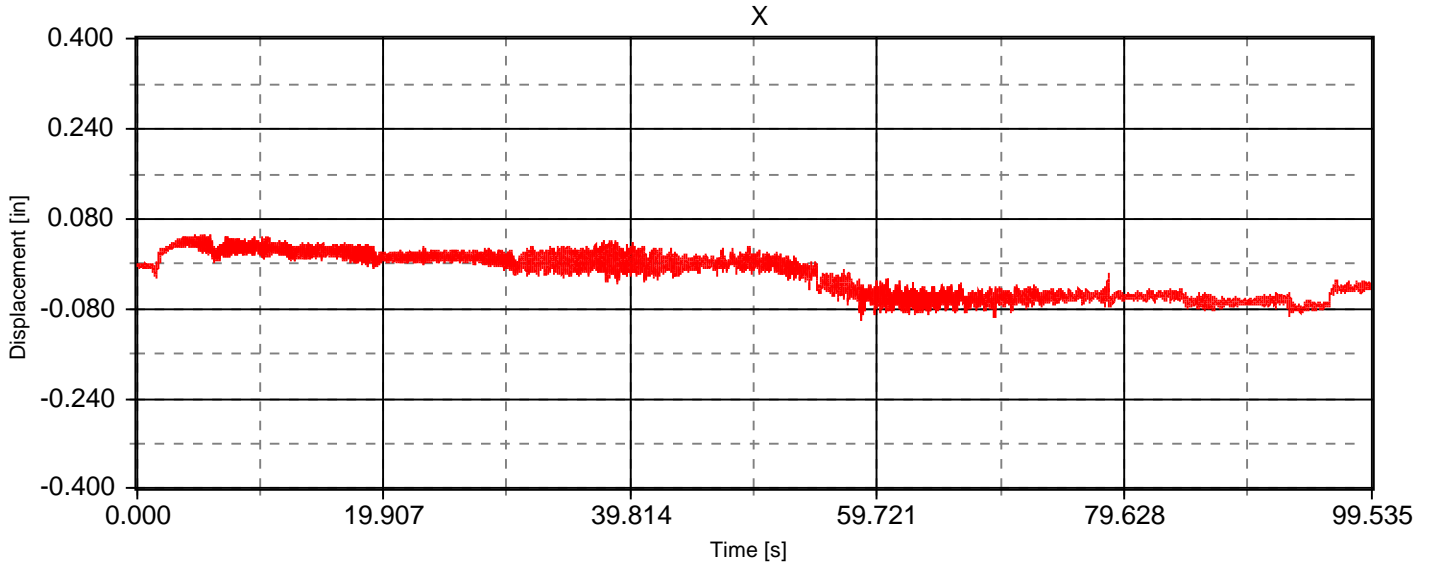


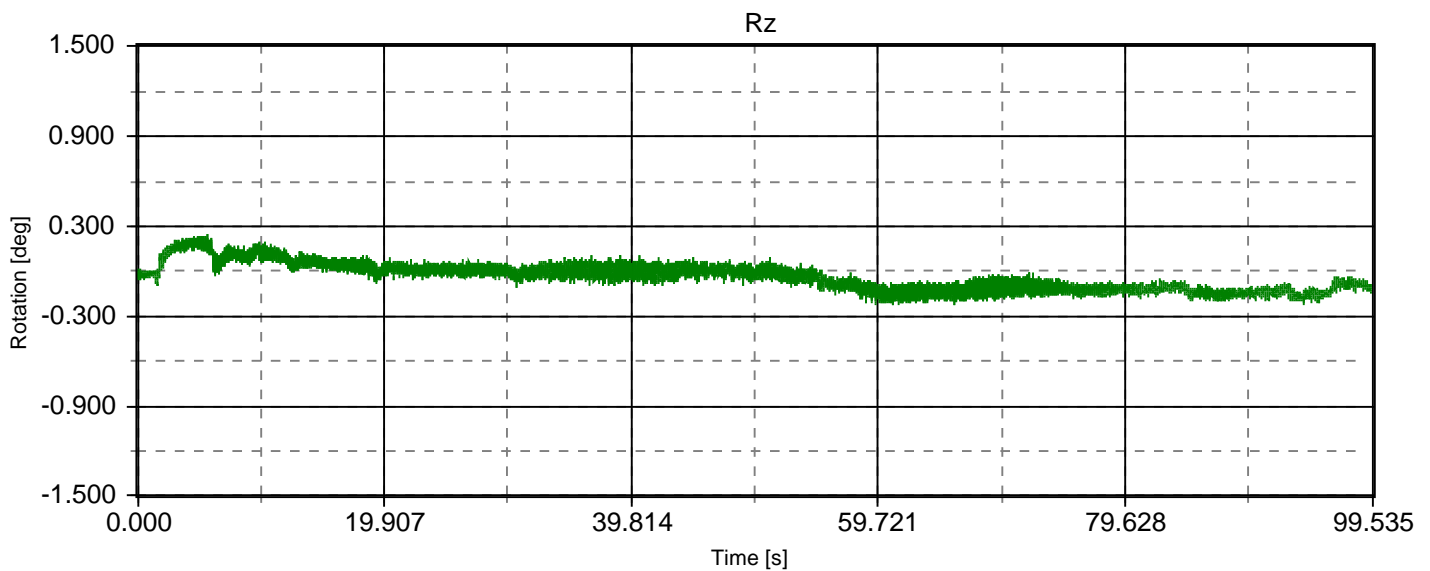
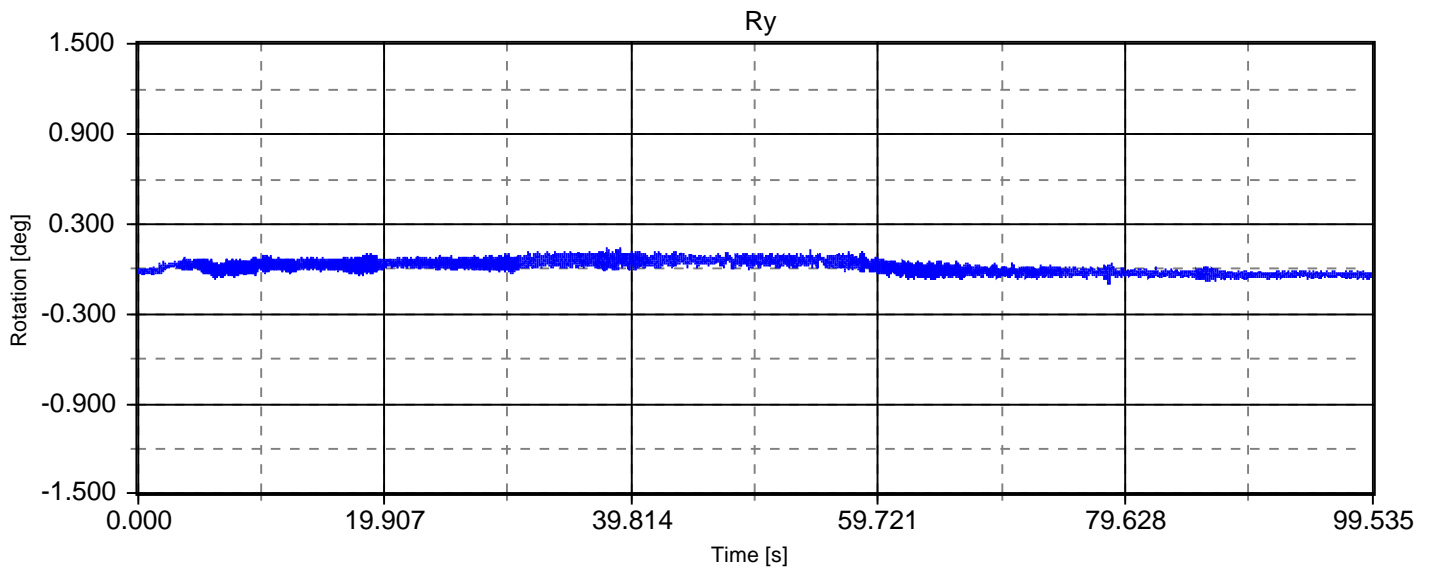
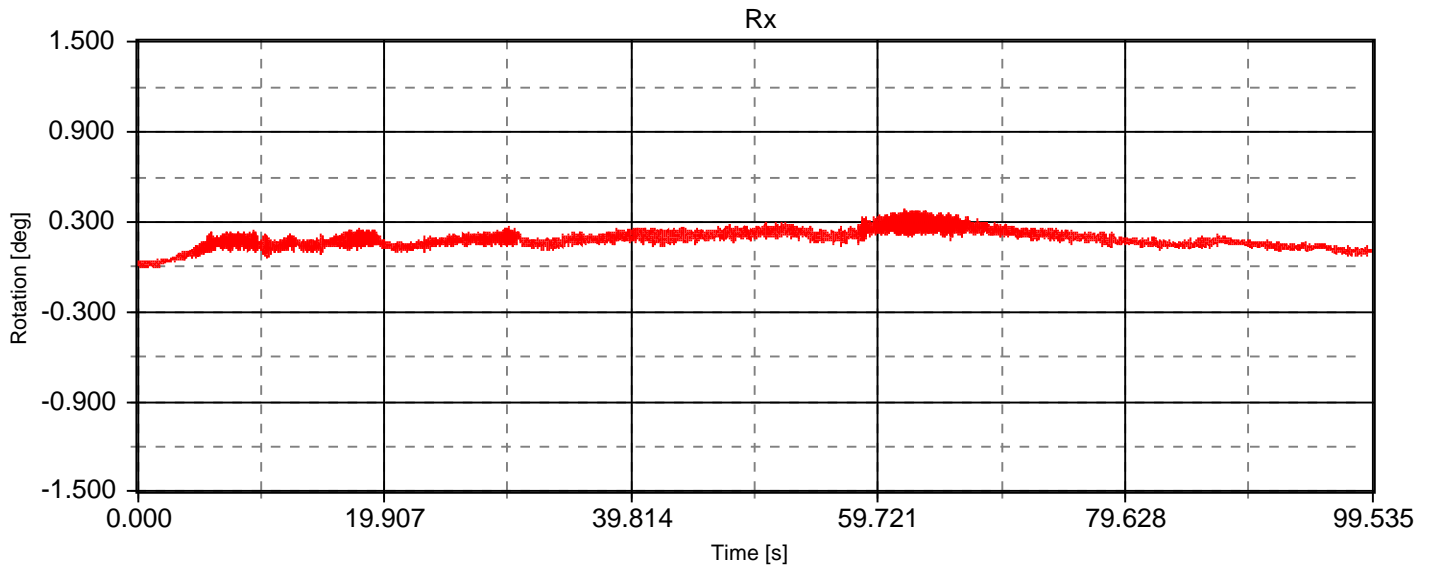


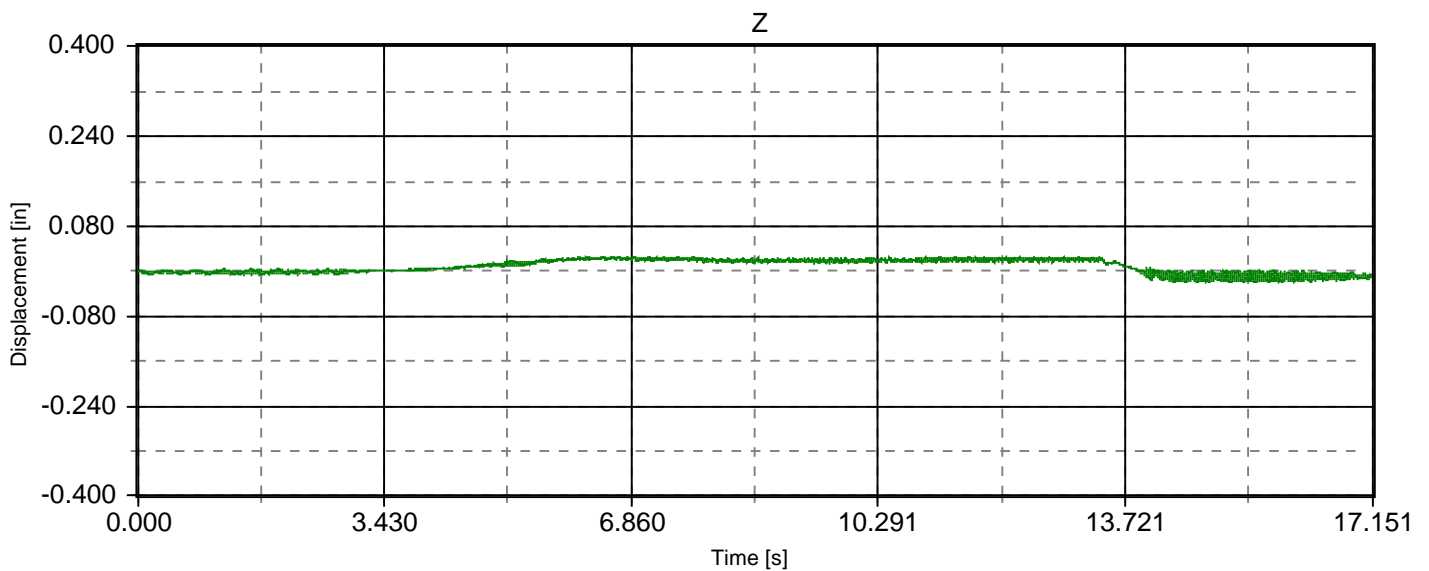
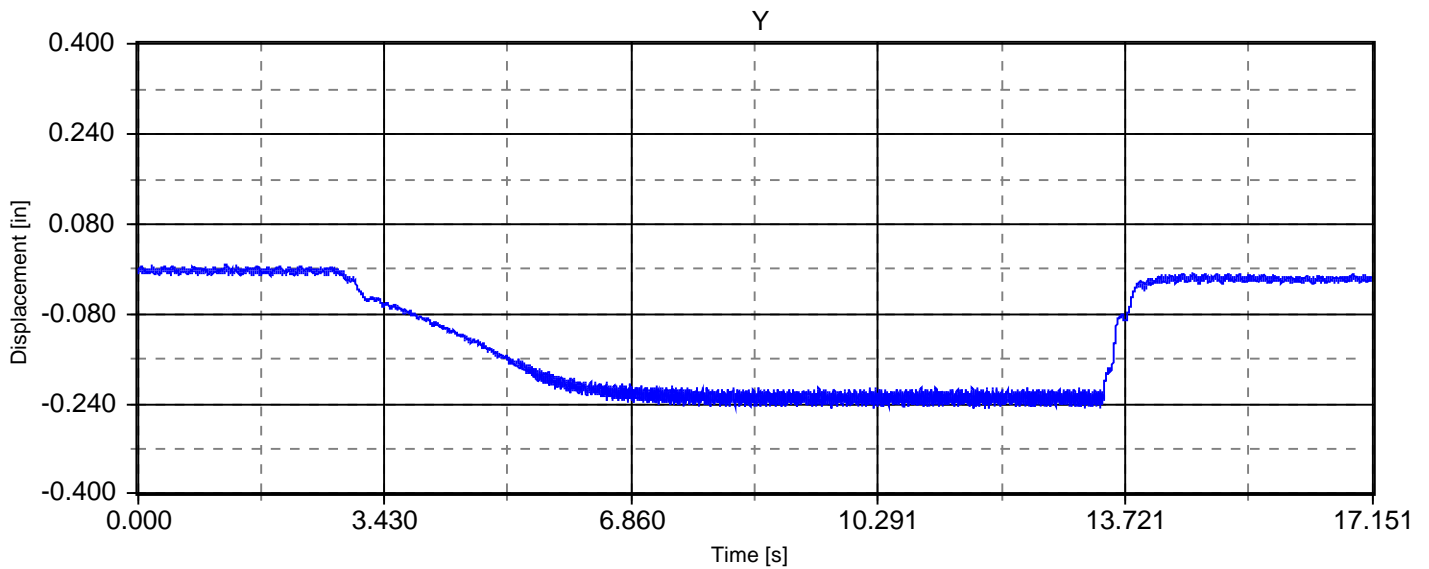
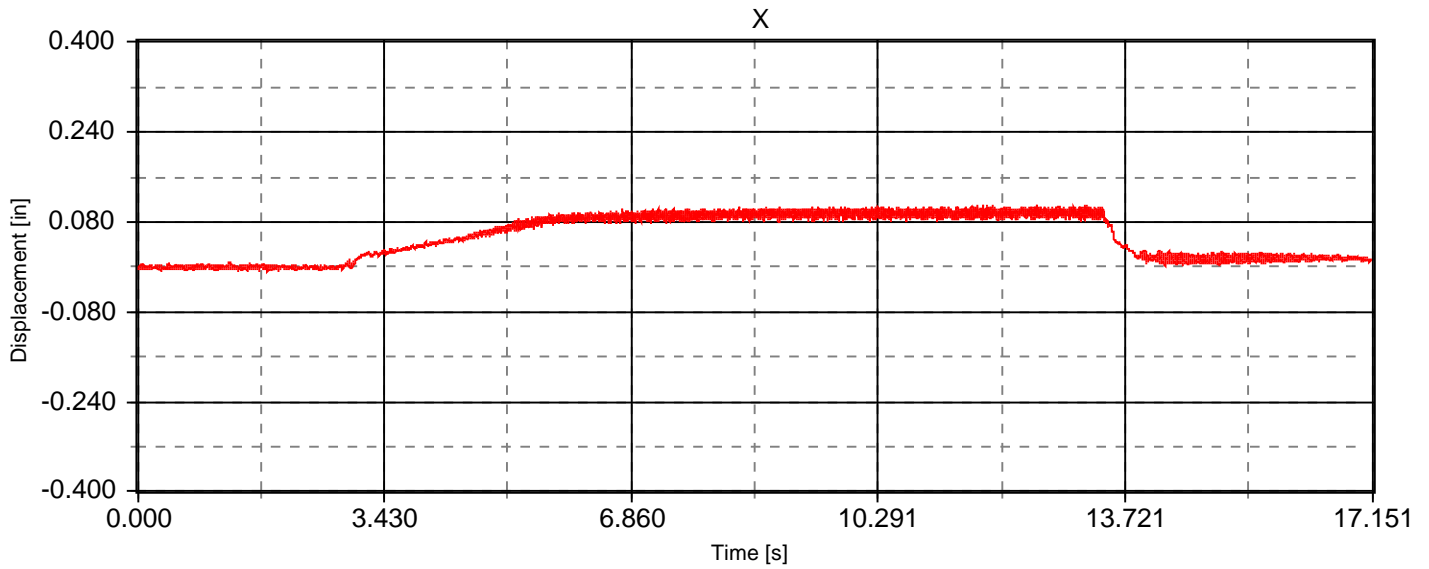


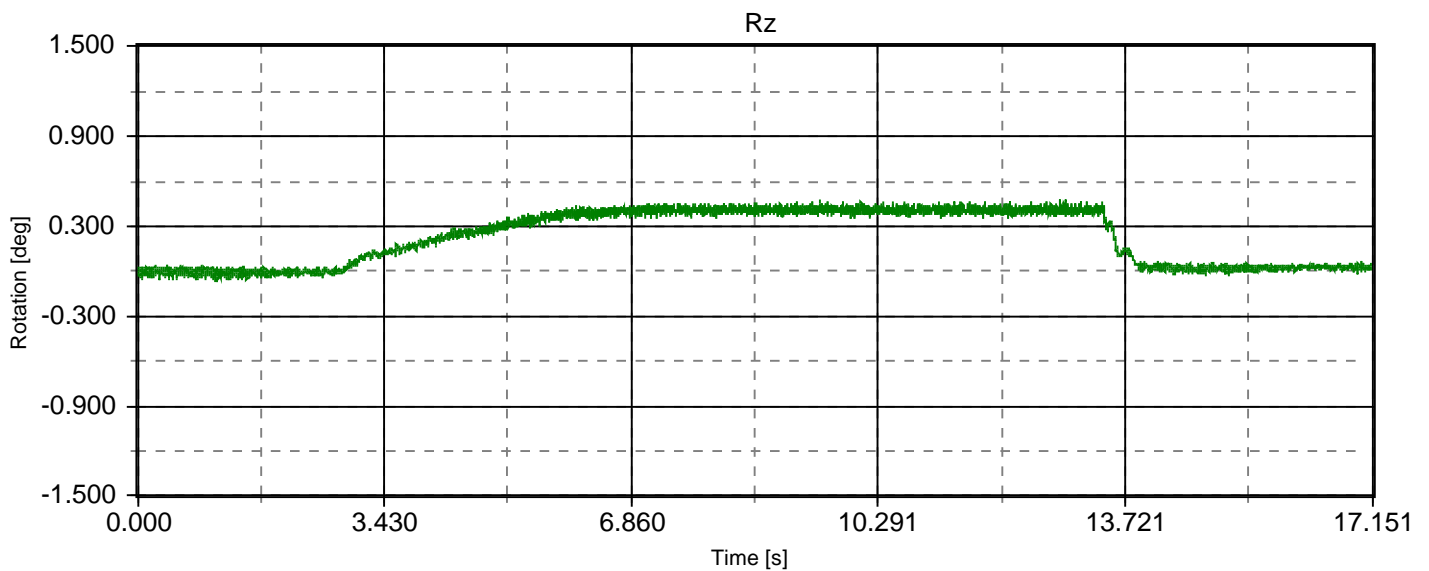
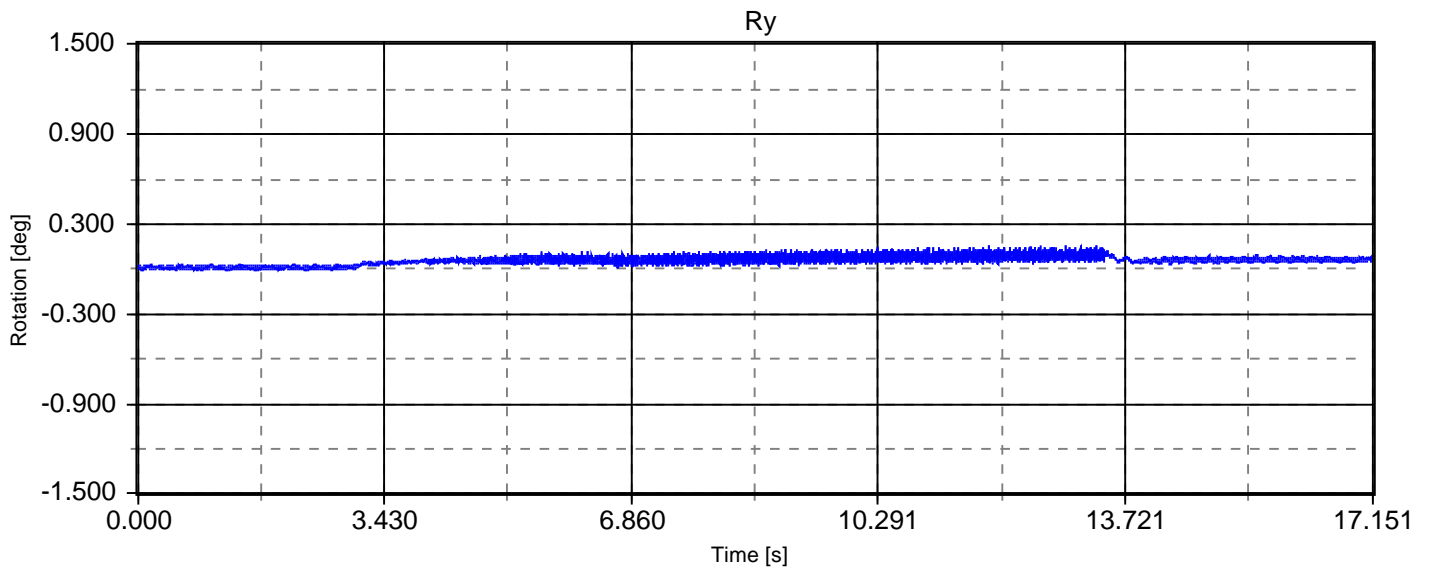
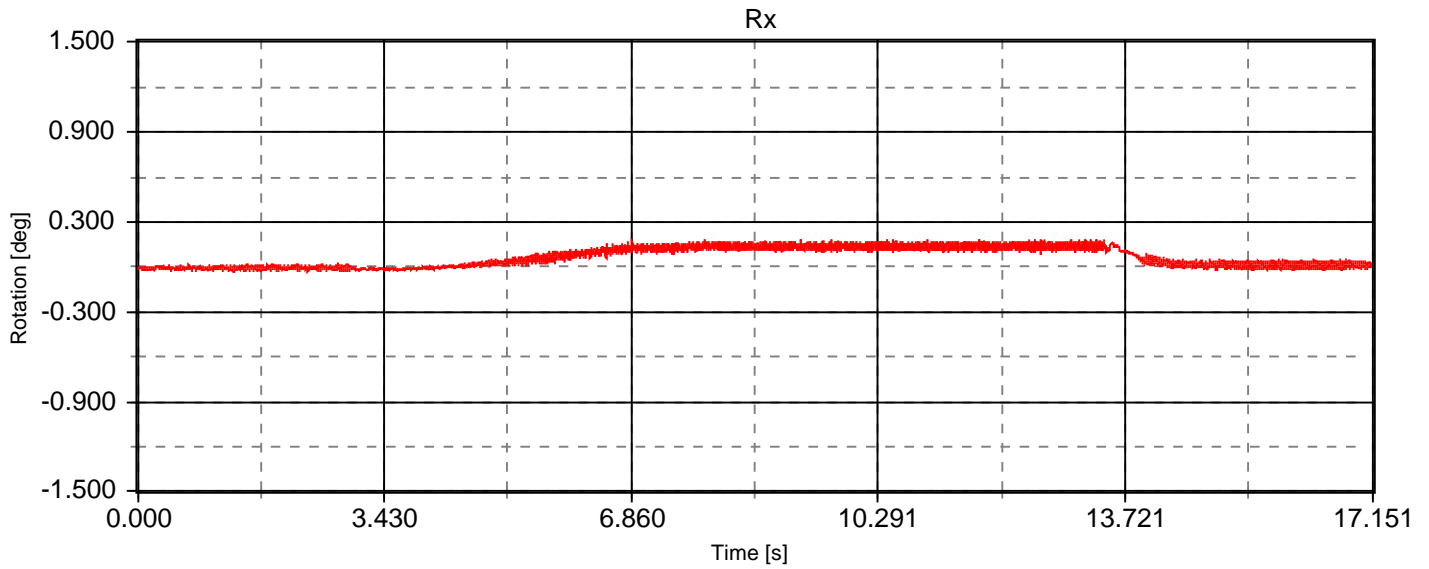


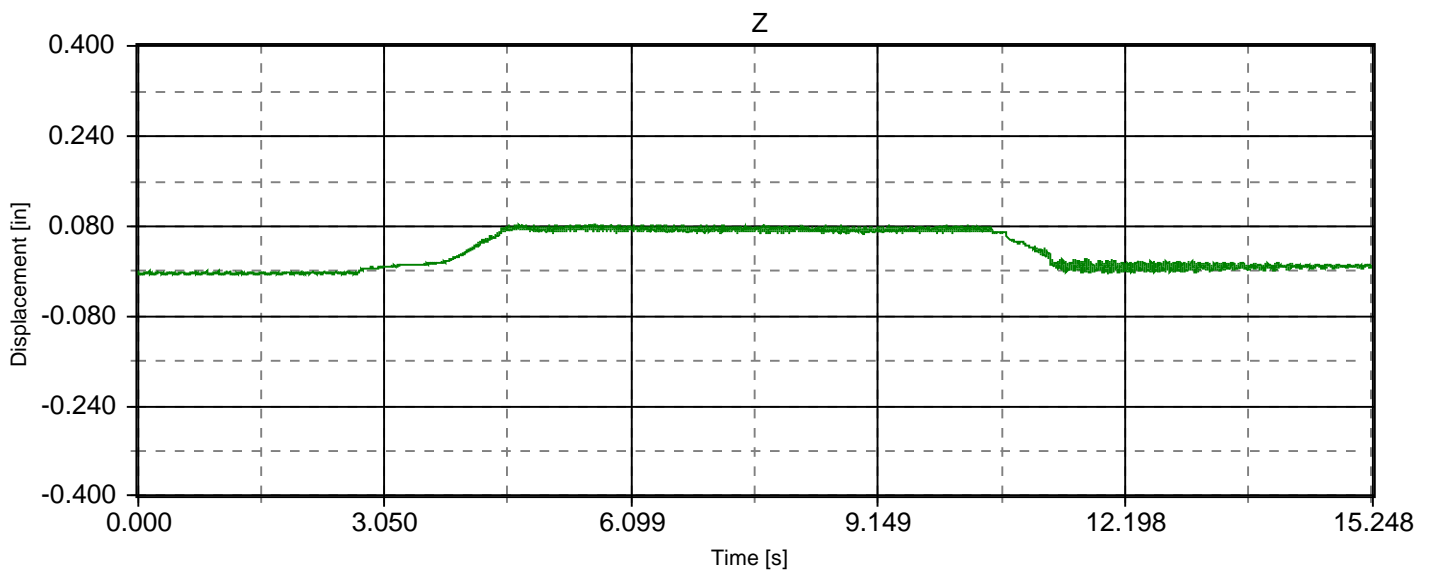
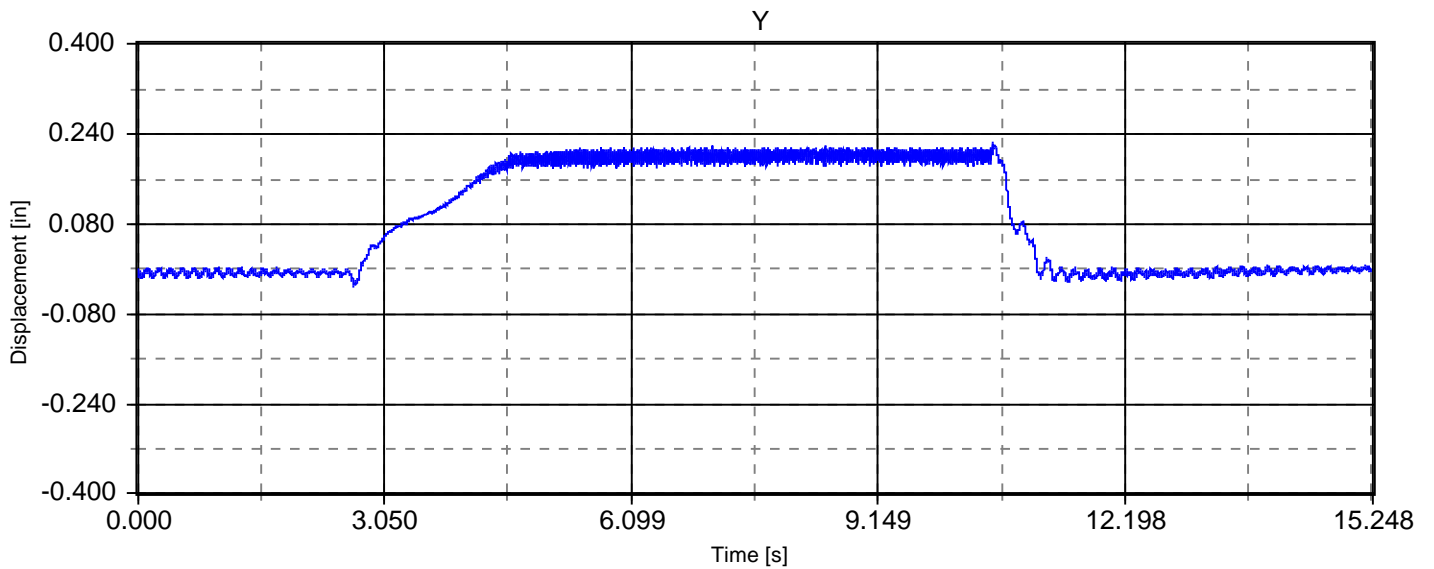
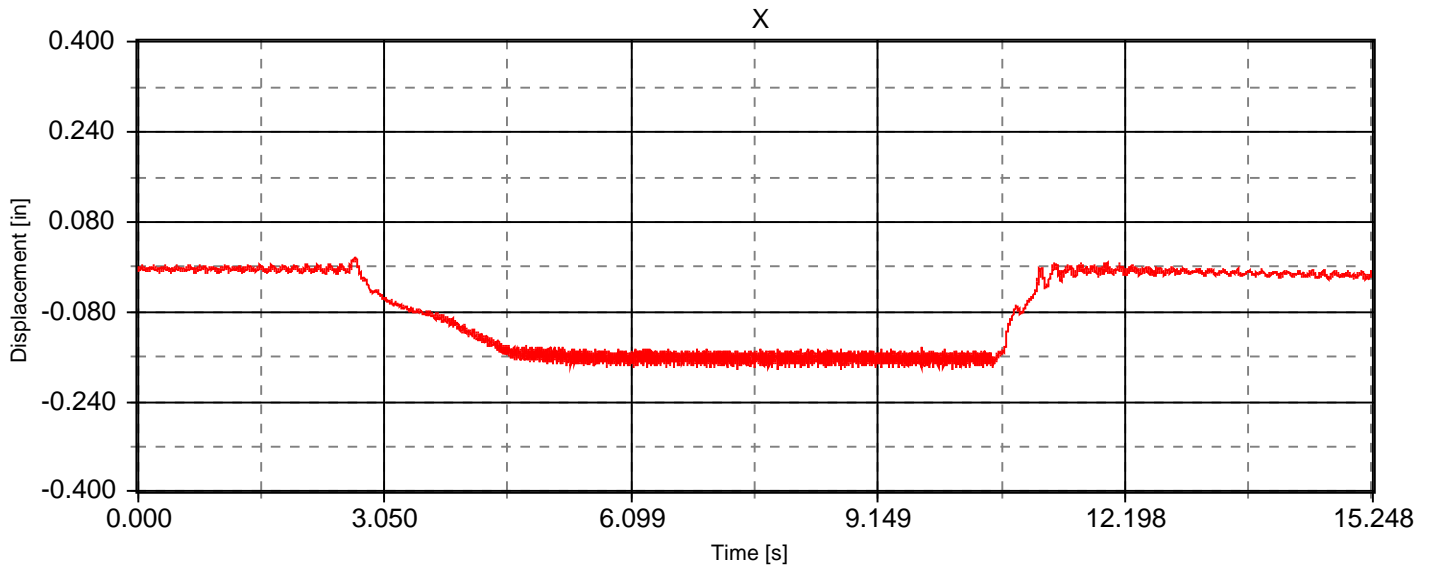


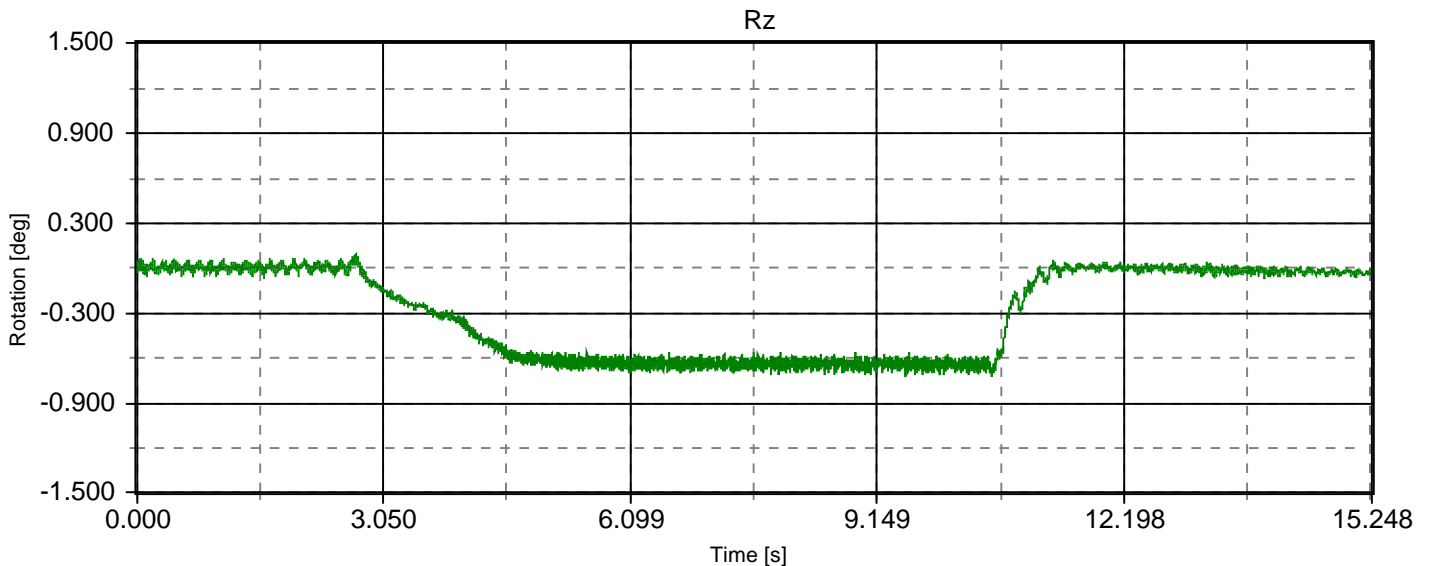
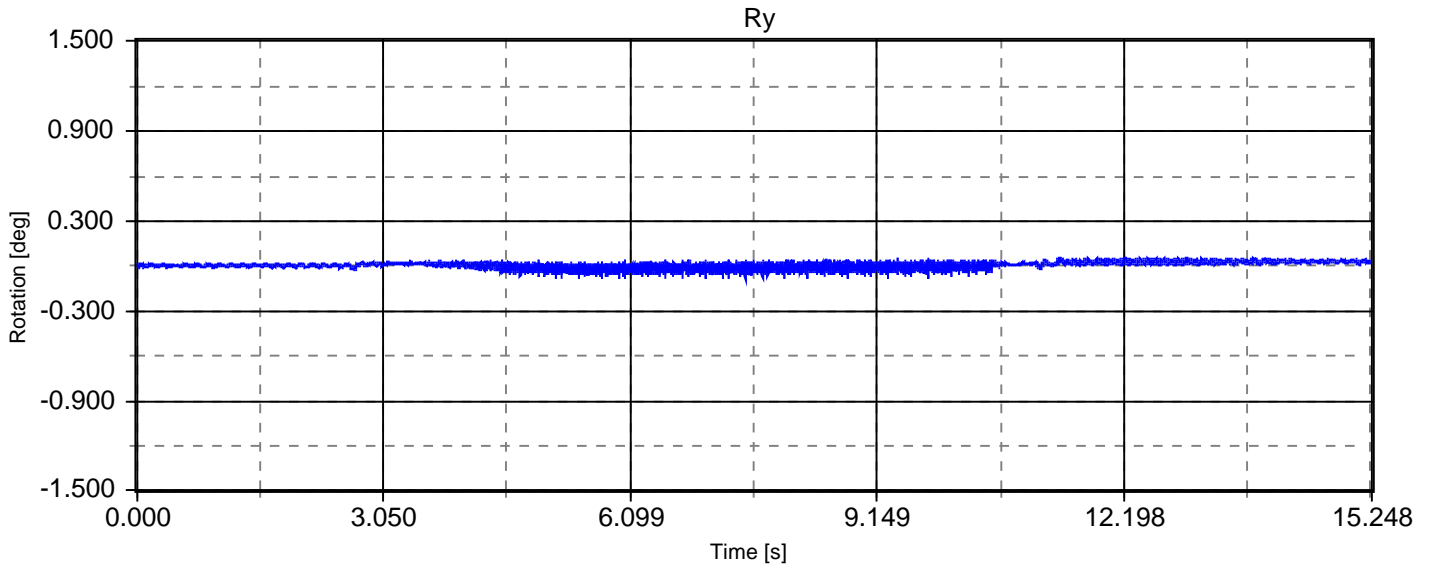
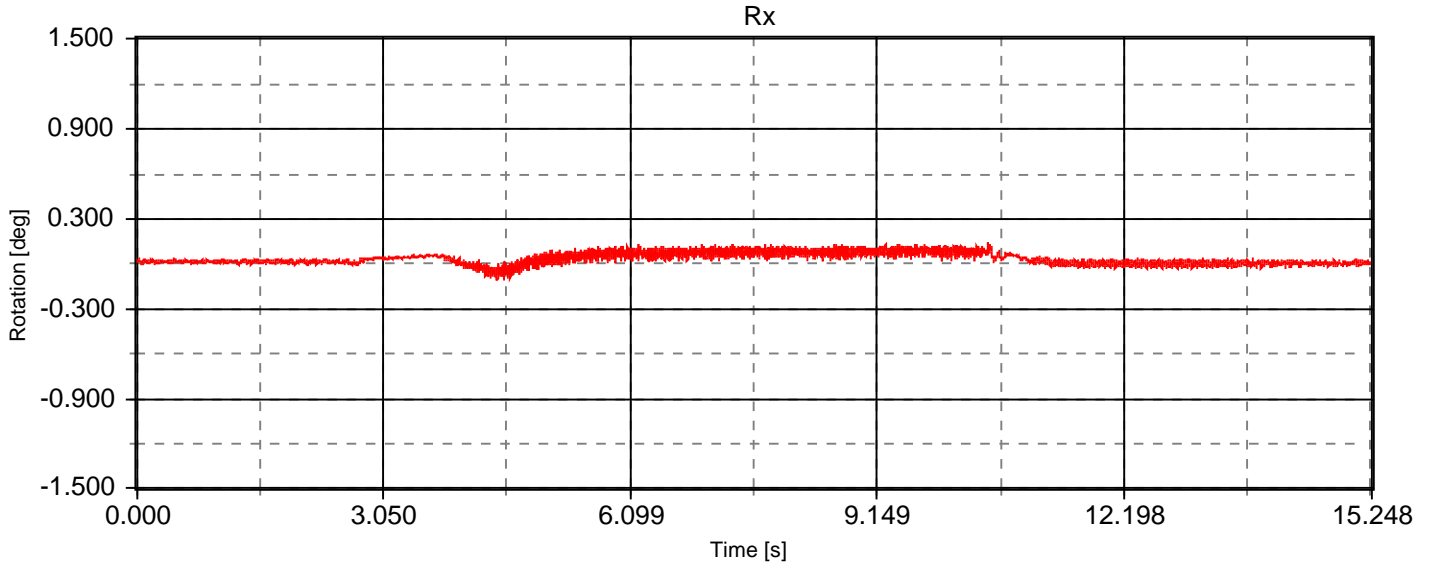












RQ17-007

MCI

12-27-2017

REQUEST 8

MCI RESPONSE TO ODI

RQ17-007

6-17-15 2015-017Clark

Exhaust Bellows Failure

Investigation

CONFIDENTIAL



Reliability Driven™

Engineering Test Reports

TITLE: Exhaust Bellows Failure Investigation

REPORT #: [REDACTED]
DOCUMENT #:

PART/ASSEMBLY #: 08-20-1786

SECTION #: 08



DESCRIPTION: Exhaust down pipe used on D coaches w/ Cummins ISX engines

TESTED BY: Clark Testing

DATE TESTED: June 17, 2015

APPROVED BY:

Kurt Friesen
Paul Fazio

DATE June 19, 2015
DATE June 19, 2015

DISTRIBUTION:

- | | | |
|----|-------------------|----|
| 1. | FILE, ENGINEERING | 5. |
| 2. | FILE, TESTING | 6. |
| 3. | | 7. |
| 4. | | 8. |

COMMENTS:

CONFIDENTIAL

& Proprietary Information of Motor Coach Industries (MCI)
Not to be Further Disclosed without
MCI's Prior Written Consent

Form Rev. D



P.O. #: [REDACTED] Clark Report # [REDACTED]

Exhaust Bellows Failure Investigation

– June 17, 2015 –

By:

Clark Testing, LLC
1801 Route 51 South, Bldg. 9
Jefferson Hills, PA 15025
Phone/Fax: 412-387-1656

snixon@clarktesting.com
www.clarktesting.com

For:

Paul Fazio
Motor Coach Industries Ltd.
1475 Clarence Ave
WINNIPEG, Manitoba R3T 1T5
Phone: [\(204\) 287-4426](tel:(204)287-4426)
Cell: [\(204\) 770-7993](tel:(204)770-7993)
E-mail: Paul.Fazio@MCICoach.com

Prepared by: Joe Turek

Sean Nixon

Exhaust Bellows Failure Investigation

Summary

Visual, chemical and metallurgical examinations were performed on cracked 321 SS exhaust bellows to determine the cause of failure. The bellows were fabricated from 2 layers of welded, 8 mil thick Type 321 SS sheets ($\frac{1}{4}$ to $\frac{1}{2}$ hard temper) that were formed into a corrugated tube. Multiple cracking events were observed in the corrugation bends at the inside surface. No issues were identified with the welds. Fractography confirmed the failure resulted from high cycle reversed bending fatigue that initiated in both the inside and outside sheets at the apex of the inside surface corrugation bends. Metallurgical evaluations identified the Type 321 SS material exhibited numerous, large titanium carbo-nitride [Ti(CN)] inclusion stringers up to 0.0075 inches (7.5 mils) in length. The sheet material composition was out of specification for nickel and chromium; however, it is not believed to have contributed to the failure.

Cracking was caused by large Ti(CN) stringers that created favorable fatigue initiation sites at the corrugation bends, where the incoherent Ti(CN) stringers exceeded the critical flaw size for this application. It is recommended to include a microstructural requirement and to perform chemical over-checks in future ordering specifications to verify the alloy chemistry and eliminate Ti(CN) stringers larger than 0.002 inches (2 mils).

Results and Discussion

Figure 1 is an overall view of the submitted bellows. To assess the bellow material, chemical analysis, hardness and metallography were performed to assess the alloy, grade, and microstructure. Chemical analysis indicated both the inner and outer bellows sheet materials were out of specification for Type 321 SS, with the nickel and chromium low. Allowable product over check analysis variations specified in ASTM A480 are +/- 0.20 for chromium and +/- 0.15 for nickel. See Table 1 for the chemical analysis results. Hardness test results indicated the Type 321 SS exhibited Rockwell C (HRC) of 28.5 in the bends, while the straight sections were HRC 23, consistent with a $\frac{1}{4}$ to $\frac{1}{2}$ hard temper.

Figure 2 is a close up view showing the primary fracture surface, with orientations that shows the cracking was concentrated in the 270° quadrant relative to the oxygen sensor port. Figure 3 is another close up view showing multiple cracks located at the apex of the inside corrugation bend of the 270° orientation.

Fracture examinations were performed using a scanning electron microscope (SEM). Figure 4 is a low

Exhaust Bellows Failure Investigation

magnification SEM image showing the fracture surfaces in the double wall bellows. Figure 5 shows intermediate and high magnification SEM images of the inner sheet fracture surface indicating cracks initiated simultaneously at both the inner and outer surfaces and confirms propagation by high cycle fatigue. Striation step size was measured at 0.4 microns, indicating failure occurred at approximately 500 cycles. Figure 6 shows intermediate and high magnification SEM images of the outer sheet fracture surface where fatigue cracks again were seen to have initiated at both the inner and outer sheet surfaces, and confirms propagation by high cycle fatigue. Striation step size was 0.4 microns, the same as the inner sheet.

Table 1 Bellows chemical analysis results with AISI-SAE Type 321 SS requirements.

Element	Inner Bellows Sheet (wt%)	Outer Bellows Sheet (wt%)	AISI-SAE Type 321 SS Requirements (wt%)
Carbon	0.03	0.02	0.08 max
Sulfur	<0.001	<0.001	0.03 max
Phosphorous	0.028	0.029	0.045 max
Silicon	0.52	0.54	0.75 max
Chromium	16.7	16.7	17.0 - 19.0
Manganese	1.64	1.66	2.0 max
Nickel	8.68	8.59	9.0 – 12.0
Titanium	0.23	0.23	5 x % C min
Molybdenum	0.28	0.28	NA
Niobium	0.02	0.02	NA
Copper	0.34	0.34	NA
Cobalt	0.12	0.12	NA
Aluminum	0.02	0.02	NA
Vanadium	0.10	0.11	NA

Figure 7 shows cross section micrographs that identify numerous inclusion stringers up to 7.5 mils in length in both Type 321 SS sheets. These stringers were present throughout the sheet thickness. Figure 8 shows Ti(CN) inclusion stringers near the corrugation bend surface that opened up during forming. These stringers produced notches that concentrated service stresses, initiating the fatigue cracking that lead to failure.

Exhaust Bellows Failure Investigation

These Ti(CN) stringers are not coherent with the matrix, and are effectively a void from a structural perspective. As sheet materials become thinner, internal defects exert greater influence due to both plane strain conditions and reduced material load bearing cross section. These coarse Ti(CN) inclusions typically form during the casting process, but can be remedied by cropping the top section of the ingot prior to rolling. Also, these carbide stringers can easily be identified by simple metallurgical examinations. Critical flaw sizes for high cycle, low amplitude, reversed bending fatigue due to vibration has been established at 4.5 mils in similar components, and a metallurgical examination prior to material purchase is warranted to ensure stringers are below 2 mils.

Conclusions

- The bellows failed by high cycle, reversed bending fatigue due to vibrational loading.
- The fatigue cracking initiated at large Ti(CN) inclusion stringers located at the apex of the inside surface corrugation bends.
- The inclusion stringers exceeded the critical flaw size for this application.

Recommendations

- Modify ordering data to include microstructural requirement to limit inclusion stringers to 2 mils or less, and perform chemistry over check to verify composition.

Exhaust Bellows Failure Investigation



Figure 1 Overall view of the submitted bellows.



Figure 2 Close up view showing the primary fracture surface with orientations that shows all cracking was concentrated in the 270° quadrant.

Exhaust Bellows Failure Investigation

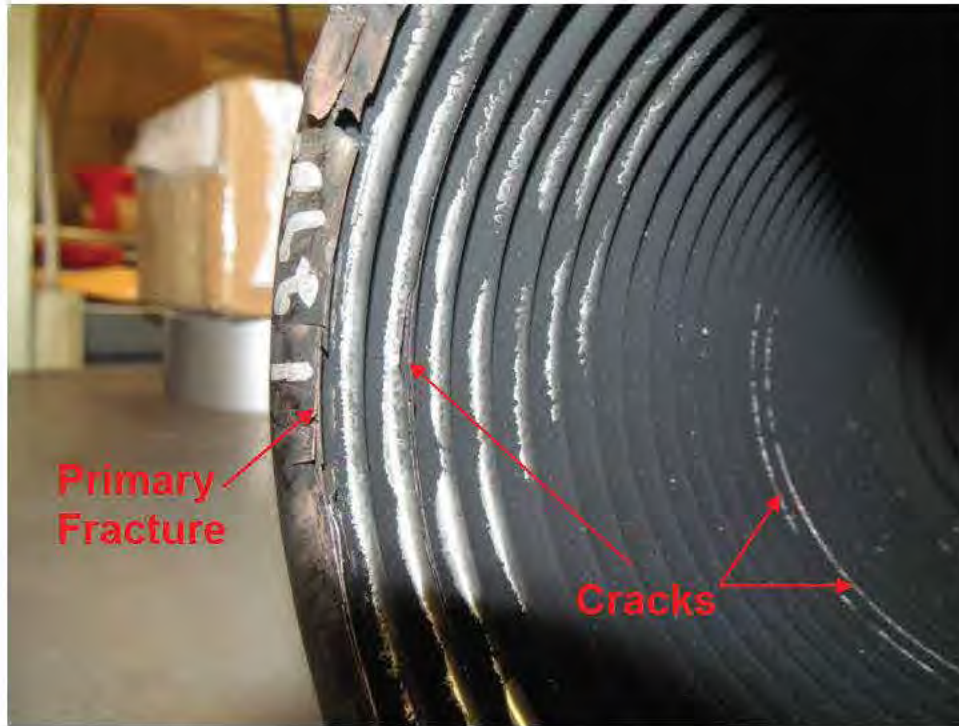


Figure 3 Close up view showing multiple cracks located at the inside corrugation bend at the 270° orientation.

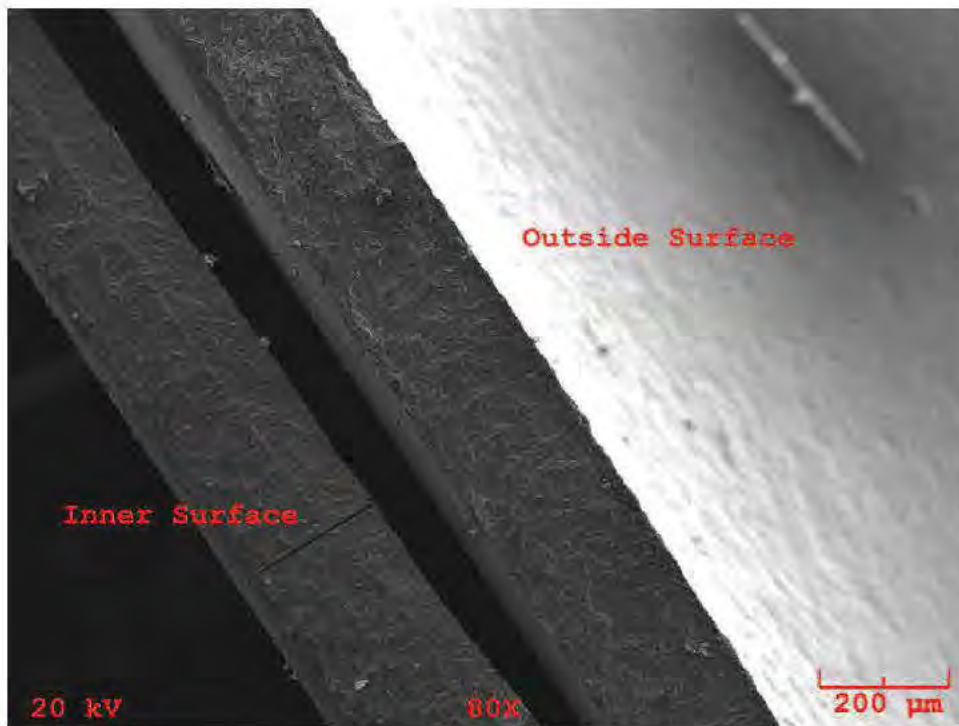


Figure 4 Low magnification SEM image showing fracture surfaces in the double wall bellows.

Exhaust Bellows Failure Investigation

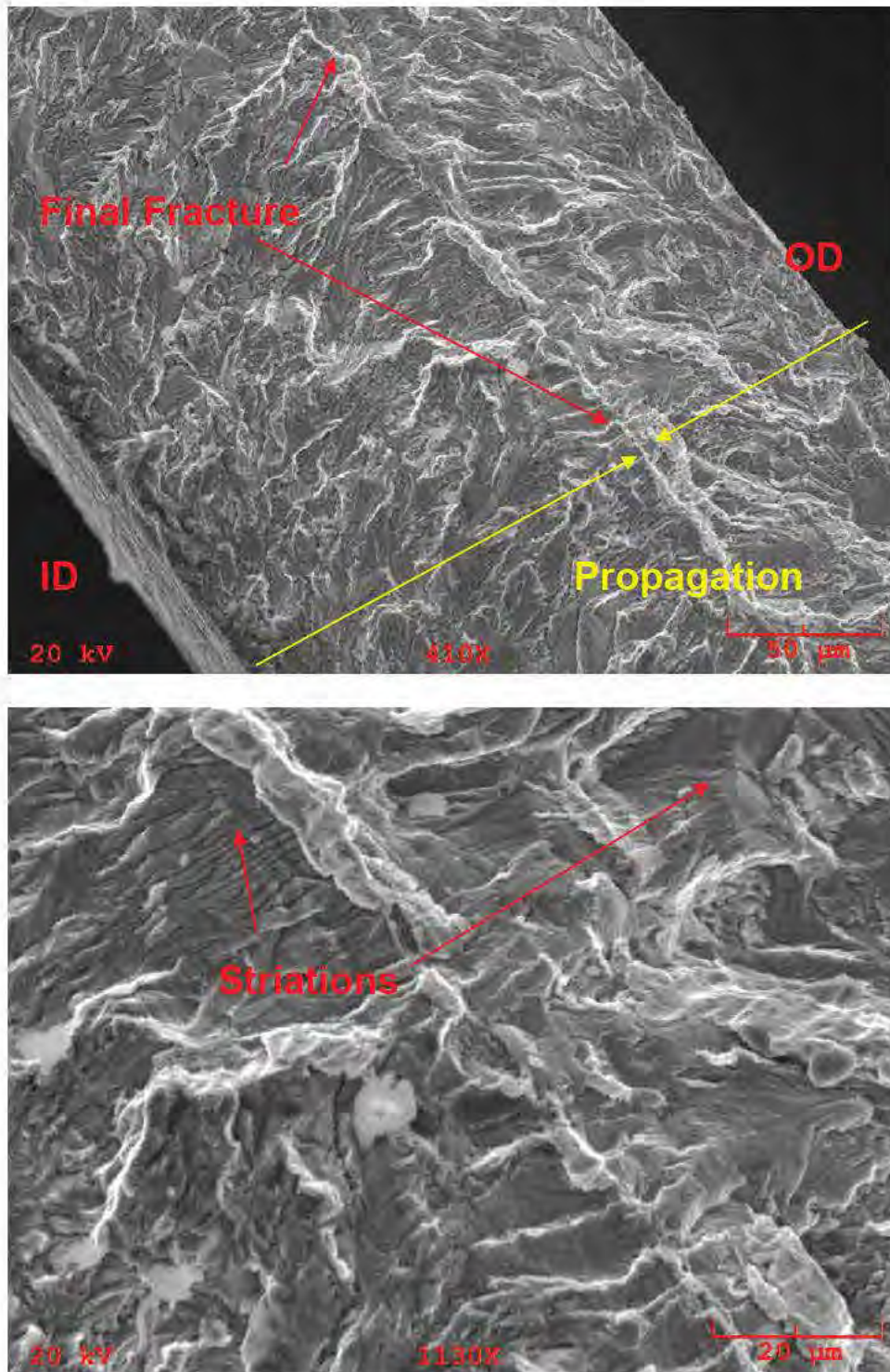


Figure 5 Intermediate and high magnification SEM images of the inner sheet fracture surface showing cracks initiated at both the inner and outer surfaces and confirms propagation by high cycle fatigue. Striation step size was 0.4 microns.

Exhaust Bellows Failure Investigation

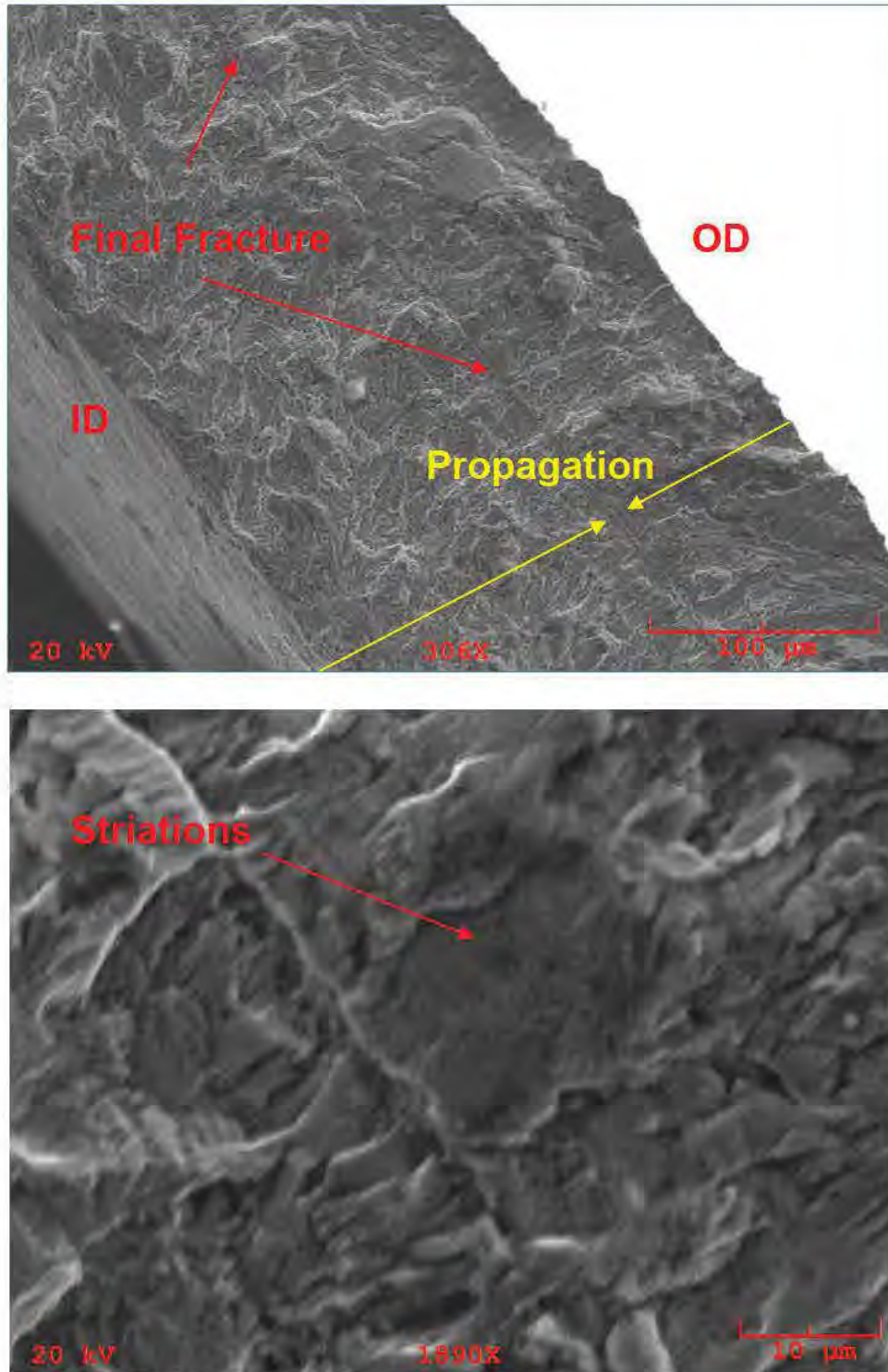
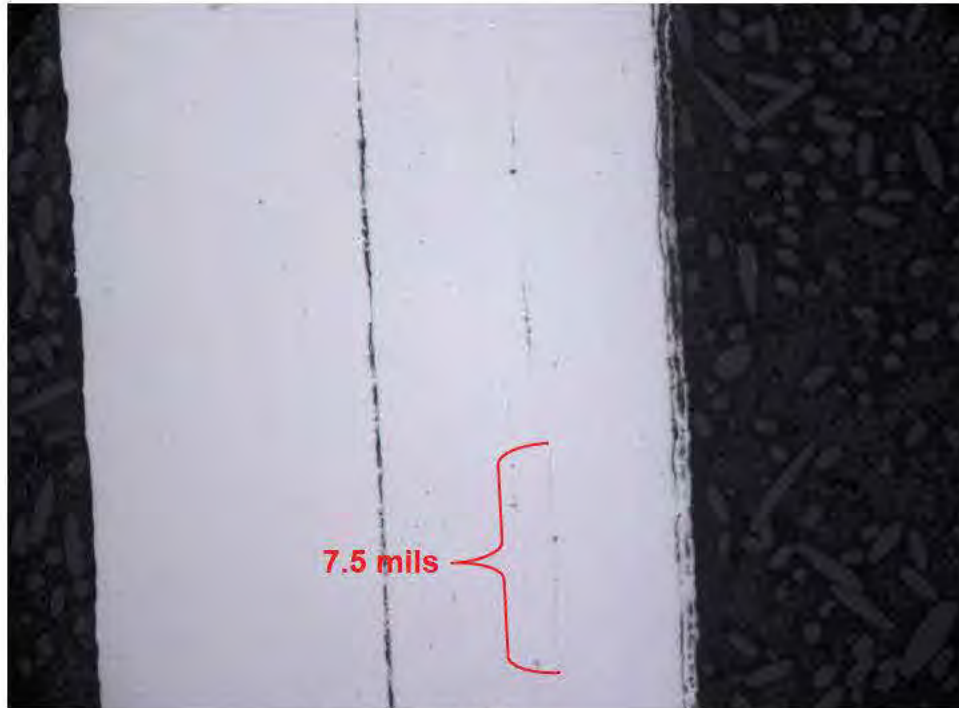


Figure 6 Intermediate and high magnification SEM images of the outer sheet fracture surface showing cracks initiated at both the inner and outer surfaces and confirms propagation by high cycle fatigue. Striation step size was 0.4 microns.

Exhaust Bellows Failure Investigation



As-polished 100x



As-polished 200x

Figure 7 Micrographs showing numerous inclusion stringers up to 7.5 mils in length.

Exhaust Bellows Failure Investigation

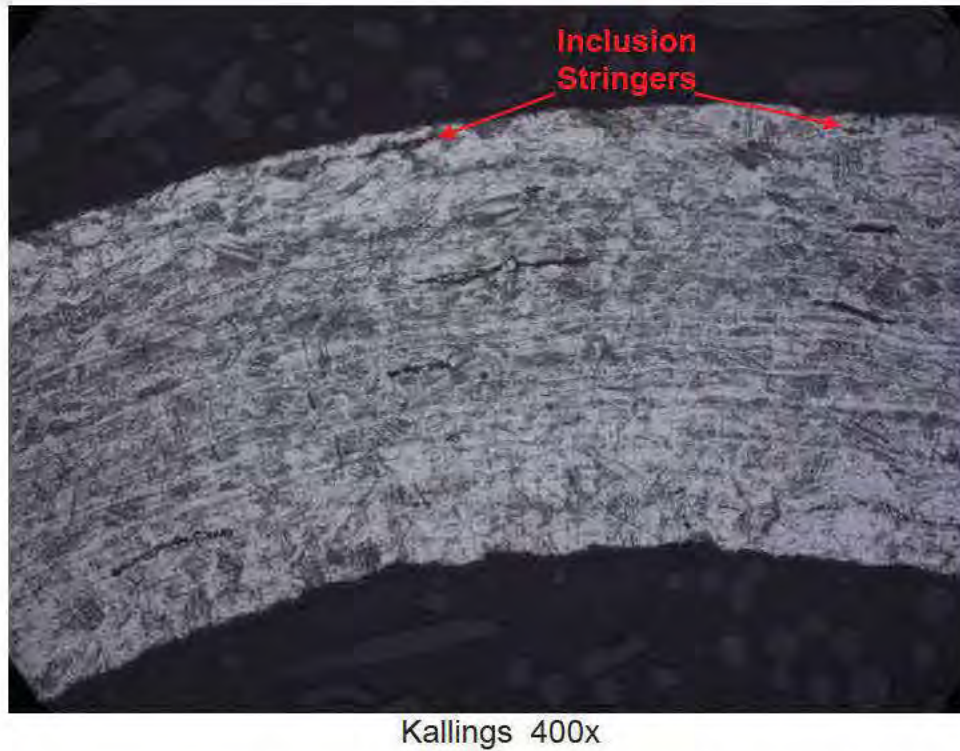


Figure 8 Inclusion stringers near corrugation bend surface that are likely fatigue initiation sites.

– End of Report –

APPENDIX A

Test Results Summary



Clark Testing-Analytical Chemistry

1801 Route 51 South

Jefferson H., PA 15025

Phone: 412-387-1012

Fax: 412-387-1012

06/17/2015

Final

Report of Test Results

Exhaust Bellows Failure Investigation

Contact: Paul Fazio

Tracking Sheet Number: 15-14197

Customer P.O. Number: [REDACTED]

Date Received: 04/24/2015

Address: Motor Coach Industries Ltd. - MCI
Paul Fazio
1475 Clarence Ave.
Winnipeg, Manitoba R3T 1T5
CANADA

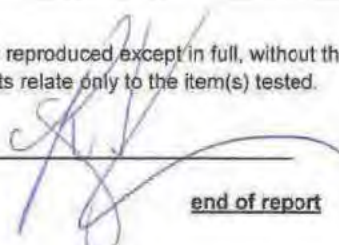
Test Name	Test Method	Analyte	Result	Units	Test Date
Sample No: 1558753	Customer ID:	Cracked SS Bellows			
Failure Analysis		See attached report			
Sample No: 1559011	Customer ID:	Inner layer			
Optical Emission	E1086 or E415	SOP 13-021 or SOP 13-008			
	E1086 or E415	Manganese	1.637	wt. %	05/20
	E1086 or E415	Phosphorus	0.028	wt. %	05/20
	E1086 or E415	Silicon	0.519	wt. %	05/20
	E1086 or E415	Copper	0.335	wt. %	05/20
	E1086 or E415	Nickel	8.679	wt. %	05/20
	E1086 or E415	Chromium	16.78	wt. %	05/20
	E1086 or E415	Molybdenum	0.278	wt. %	05/20
	E1086 or E415	Vanadium	0.104	wt. %	05/20
	E1086 or E415	Titanium	0.226	wt. %	05/20
	E1086 or E415	Aluminum	0.021	wt. %	05/20
	E1086 or E415	Niobium	0.019	wt. %	05/20
Cobalt (OES)	E1086 or E415	Cobalt	0.122	wt. %	05/20
Combustion Carbon	ASTM E1019	Carbon	0.03	wt. %	05/14
Sulfur, Combustion	ASTM E1019	Sulfur	<0.001	wt. %	05/14
Sample No: 1559012	Customer ID:	Outer layer			
Optical Emission	E1086 or E415	SOP 13-021 or SOP 13-008			
	E1086 or E415	Manganese	1.661	wt. %	05/20
	E1086 or E415	Phosphorus	0.029	wt. %	05/20

Test Name	Test Method	Analyte	Result	Units	Test Date
Sample No: 1559012	Customer ID:	Outer layer			
Optical Emission	E1086 or E415	Silicon	0.538	wt. %	05/20
	E1086 or E415	Copper	0.335	wt. %	05/20
	E1086 or E415	Nickel	8.586	wt. %	05/20
	E1086 or E415	Chromium	16.73	wt. %	05/20
	E1086 or E415	Molybdenum	0.260	wt. %	05/20
	E1086 or E415	Vanadium	0.107	wt. %	05/20
	E1086 or E415	Titanium	0.230	wt. %	05/20
	E1086 or E415	Aluminum	0.024	wt. %	05/20
	E1086 or E415	Niobium	0.020	wt. %	05/20
Cobalt (OES)	E1086 or E415	Cobalt	0.123	wt. %	05/20
Combustion Carbon	ASTM E1019	Carbon	0.02	wt. %	05/14
Sulfur, Combustion	ASTM E1019	Sulfur	<0.001	wt. %	05/14

Comments -

This report shall not be reproduced, except in full, without the written approval of Clark Laboratories.
The reported test results relate only to the item(s) tested.

Approved By: _____



end of report

Date: _____

6/17/15.

RQ17-007

MCI

12-27-2017

REQUEST 8

MCI RESPONSE TO ODI

RQ17-007

08-20-1786 Exhaust pipe
investigation Pba Kris

01312013

08-20-1786 Exhaust Pipe Investigation

Exhaust as received in Pembina – relaxed state



Flexible portion is straight

Exhaust blanket is installed on pipe prior to installation in coach



Exhaust pipe and blanket now installed in coach and attached to Cummins ISX engine turbo and DPF muffler

Exhaust pipe as installed in unit 12926 – Coach has been road tested.
Insulation removed to show flexible portion of exhaust.

Flexible portion is no longer straight but has a flexed or slight s-shape and fairly sharp bend at connection point to turbo.



Additional photos of flexible portion of installed exhaust pipe in 12926.



RQ17-007

MCI

12-27-2017

REQUEST 8

MCI RESPONSE TO ODI

RQ17-007

08-20-1786 install 02-05-13

08-20-1786 Exhaust pipe - immediately after coach installation – Unit 12912



Torsional bellows is flexed in two areas after install to engine and DPF.

RQ17-007

MCI

12-27-2017

REQUEST 8

MCI RESPONSE TO ODI

RQ17-007

08-20-1786 Ritz - Adam, Failed

Part Review 01292013



Plastically Deformed bellow

What is causing this deformation?

IMEDIATE ACTION



CORRECT

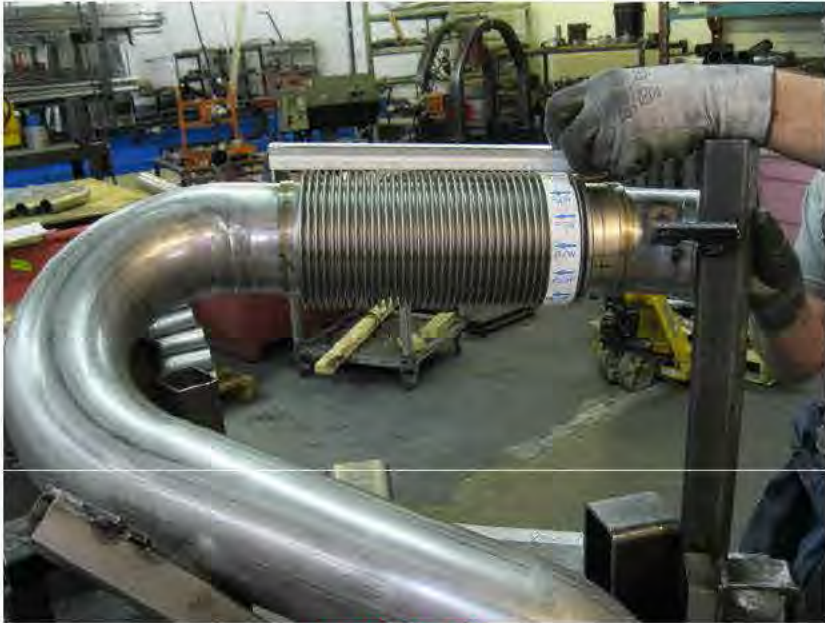


WRONG

INSTALLATION ALIGNMENT INDICATOR (IAI)

PROPER ALIGNMENT OF THIS MARK WILL ENSURE THAT THE BELLOWS IS IN A
'NEUTRAL/ UNFLEXED' STATE AT INSTALLATION.

AFTER INSTALLATION



CORRECT



WRONG

**VERIFY THAT BELLOW IS IN A STRAIGHT
/ NEUTRAL / UNFLEXED POSITION**

THIS PART APPEARS TO BE EXPERIENCEING EXCESSIVE MOVEMENT, POSSIBLY CAUSED BY A ROTATION OF INLET FLANGE. IT IS UNCLEAR IF ROTATION HAS OCCURRED DURING INSTALLATION OR DURING OPERATION.

RQ17-007

MCI

12-27-2017

REQUEST 8

MCI RESPONSE TO ODI

RQ17-007

2015-015 ISX Gas Engine
Bracket & Exhaust System
Vibration

CONFIDENTIAL



Reliability Driven™

Engineering Test Reports

TITLE: ISX-Gas Engine Mounted Bracket
Natural Frequency & Exhaust System
Vibration Measurements

REPORT #: [REDACTED]

DOCUMENT #: [REDACTED]

PART/ASSEMBLY #: 08-20-2475, 04-07-1155, 07-03-1240, 08-01-1459, 08-01-1426

SECTION #: 08, 04, 07

DESCRIPTION: ISX-Gas exhaust system,
engine mounted brackets

TESTED BY: Industrial Technology
Centre

DATE TESTED: May 19, 2015

APPROVED BY:

David Wood
Paul Fazio

David Wood
Paul Fazio

DATE

DATE

Sep 2, 2015
02 SE 15

DISTRIBUTION:

- | | | |
|----|-------------------|----|
| 1. | FILE, ENGINEERING | 5. |
| 2. | FILE, TESTING | 6. |
| 3. | | 7. |
| 4. | | 8. |

COMMENTS: Tests performed on unit #13751 for Cummins Installation Quality Assurance purposes

CONFIDENTIAL

& Proprietary Information of Motor Coach Industries (MCI)
Not to be Further Disclosed without
MCI's Prior Written Consent

Form Rev. D

Report

ISX-G Engine Mounted Bracket Natural Frequency & Exhaust System Vibration Measurements

Report Number **15720-1 Rev B**

Prepared for Mr. David Wood
Mechanical Engineer
Motor Coach Industries
1475 Clarence Avenue
Winnipeg MB R3T 1T5
David.Wood@MCICoach.com

ITC Project Manager Tom Manson, P. Eng.
Mechanical Engineer
E-mail: tmanson@itc.mb.ca
Phone: (204) 480-0346
Fax: (204) 480-0357

Report Date: 2 June 2015 Revised June 3, 2015

Prepared by: T. Manson
Tom Manson, P. Eng.
Mechanical Engineer

Reviewed by: Michael Thomlinson
Michael Thomlinson, M. Sc. P. Eng.
Engineering Manager

Notes:

1. This document contains the expression of the professional opinion of the Industrial Technology Centre (ITC) as to the matters set out herein, using its professional judgement and reasonable care, based on the information available, the methodology, procedures and techniques used, ITC's assumptions and constraints in place at the time of preparation.
2. It is to be read in the context of the Agreement between ITC and the Client. This document is solely for the purpose stated in the Agreement and for the sole and exclusive benefit of the Client, whose remedies are limited to those set out in the Agreement.
3. This document is to be read as a whole, and sections or parts thereof should not be relied upon out of context. This document may not be reproduced, except in full, without written approval of ITC.
4. This document refers only to the particular material, device or other subject referred to in the document. No representation is being made regarding other similar articles.
5. ITC will retain samples for a period of ninety (90) days after testing unless otherwise advised by the client. After this period, samples will be disposed of.
6. Any use of this document by a third party or any reliance on or decisions taken based upon it are the responsibility of the third party. ITC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this document.
7. ITC shall not be used in connection with any advertisements, offer or sale of any product process or service without the prior written consent of ITC.

Introduction

Motor Coach Industries (the client, MCI) asked the Industrial Technology Centre (ITC) to provide assistance in performing impact hammer and vibration testing. ITC was asked to perform an impact hammer test to determine the natural frequency of a number of brackets attached to the Cummins ISX-G engine block. Then a number of driving scenarios were carried out to measure the vibration experienced at the exhaust mount bracket near the back of the bus.

Testing was performed on May 6, 2015, at MCI's service shop in Winnipeg, MB.

Scope of Work

Impact Hammer Testing

ITC used a Bruel and Kjaer (B&K) Impact Hammer to determine the natural frequency of brackets attached to the engine block. ITC placed a triaxial accelerometer on the bracket, then hit the bracket with an impact hammer a total of 5 times. The system measured the impact caused by the hammer, and the resulting vibration in the bracket as measured by the accelerometer. This was repeated in all three directions for each bracket (X-direction along the width of the coach, Y-direction along the length of the coach, and Z-direction vertical). A total of 7 brackets were tested, at the following locations:

- Bracket 1 – mounted to the back vertical face of the engine, supporting alternator power cables.
- Bracket 2 – backmost bracket, at the top of the engine, supporting the engine oil dipstick tube.
- Bracket 3 – 2nd from the back, at the top of the engine, supporting alternator power cables.
- Bracket 4 – “twisted” bracket 2nd from the front, on the top of the engine, supporting the engine oil dipstick tube.
- Bracket 5 – front bracket, on the top of the engine, supporting alternator power cables.
- Bracket 6 – C-clamp style of bracket on the curbside of the coach, supporting the engine oil dipstick tube.
- Bracket 7 – bracket with braided cable attached to it on driver side of coach, at the top of the engine, supporting an engine coolant vent line.

ITC used a template built in to the PULSE system designed by B&K. If an improper hit or a double hit was recorded, it was automatically discarded.



Figure 1: Typical brackets to be tested with the Impact Hammer

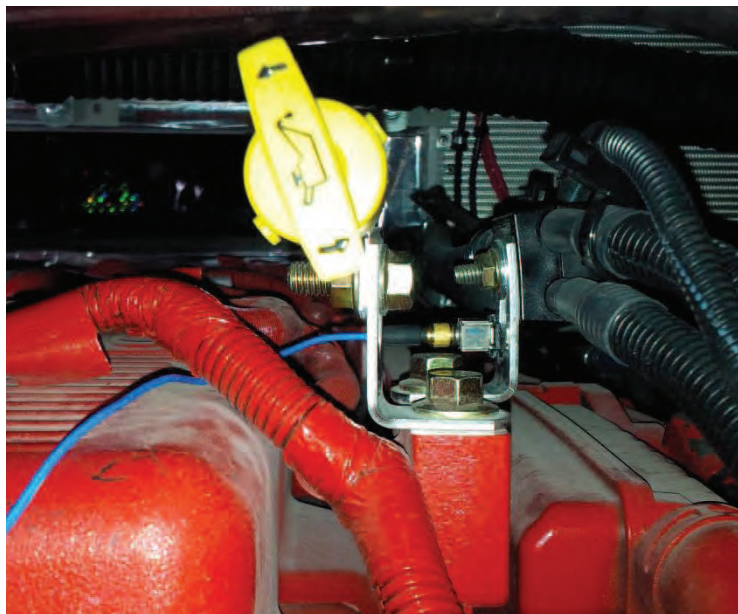


Figure 2: Triaxial accelerometer installed on Bracket #3



Figure 3: Brackets #4 ("twisted") & #5 (with accelerometer installed)

Vibration Testing

A gang of three uniaxial accelerometers were used and mounted on the exhaust mount bracket near the back of the bus. The three accelerometers were oriented along the same axes used for the impact hammer testing, as described above. High temperature uniaxial accelerometers were used due to the hot environment.

MCI performed a series of engine and road tests, as follows:

- Engine sweep from low idle to max RPM (twice)
- Engine shut down
- Engine start up
- Acceleration along Waverly Ave to McGillivray Blvd
- Rough road along Sony Place
- Rough road along Irene Street
- Rough road crossing a railroad (twice)

Acceleration values in m/s^2 were recorded during the testing. ITC performed overall analysis as well as a joint time-frequency analysis for each test.

Maximum G_{RMS} values were calculated and presented in the results section.

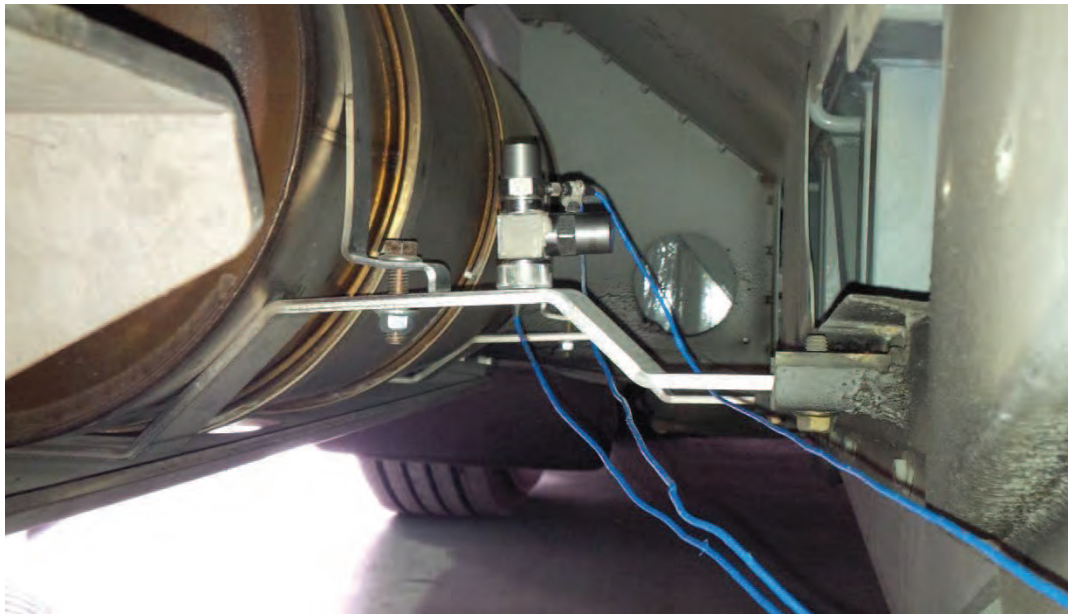


Figure 4: Uniaxial accelerometers ganged together to measure all three axes, mounted to the exhaust mount bracket

Instrumentation

Model Number	Serial Number	Description	Cal. Date
PULSE 3560C	2454345	PULSE System	2015-04-13
PCB J353B33	127133	Uniaxial Accelerometer	Before Use
PCB J353B33	127134	Uniaxial Accelerometer	Before Use
PCB J353B33	38575	Uniaxial Accelerometer	Before Use
B&K 8206	56113	B&K Impact Hammer	Before Use
B&K 4524A	33365	B&K Triaxial Accelerometer	Before Use

Results

Impact Hammer Testing

The following table lists the natural frequency and magnitude for each bracket, in all three directions.

Table 1: Impact Hammer Frequency Response Results

Bracket	Direction	Frequency (Hz)	Level (m/s ²)/N	Comments
1 – Rear Back of Engine	XX	1497	8.43	Soft Peak
	YY	1588	9.38	Soft Peak
	ZZ	1452	5.88	Higher Peak > 1600 Hz
2 – Top Rear Bracket	XX	1486	35.20	
	YY	1479	3.67	Flat Curve
	ZZ	1218	1.77	
3 – Top 2 nd from Rear Bracket	XX	1311	8.65	Many Resonances
	YY	1331	2.28	Higher Peak > 1600 Hz
	ZZ	992	5.29	Higher Peak > 1600 Hz
4 – Top 2 nd from Front Bracket	XX	1019	8.29	Higher Peak > 1600 Hz
	YY	774	18.00	
	ZZ	913	13.70	Higher Peak > 1600 Hz
5 – Top Front Bracket	XX	981	14.30	
	YY	600	2.16	Higher Peak > 1600 Hz
	ZZ	933	1.27	Higher Peak > 1600 Hz
6 – Curb Side Dipstick Bracket	XX	403	21.80	
	YY	1375	3.98	
	ZZ	396	9.71	
7 – Driver Side Braided Bracket	XX	335	45.90	
	YY	872	44.40	
	ZZ	1562	20.30	

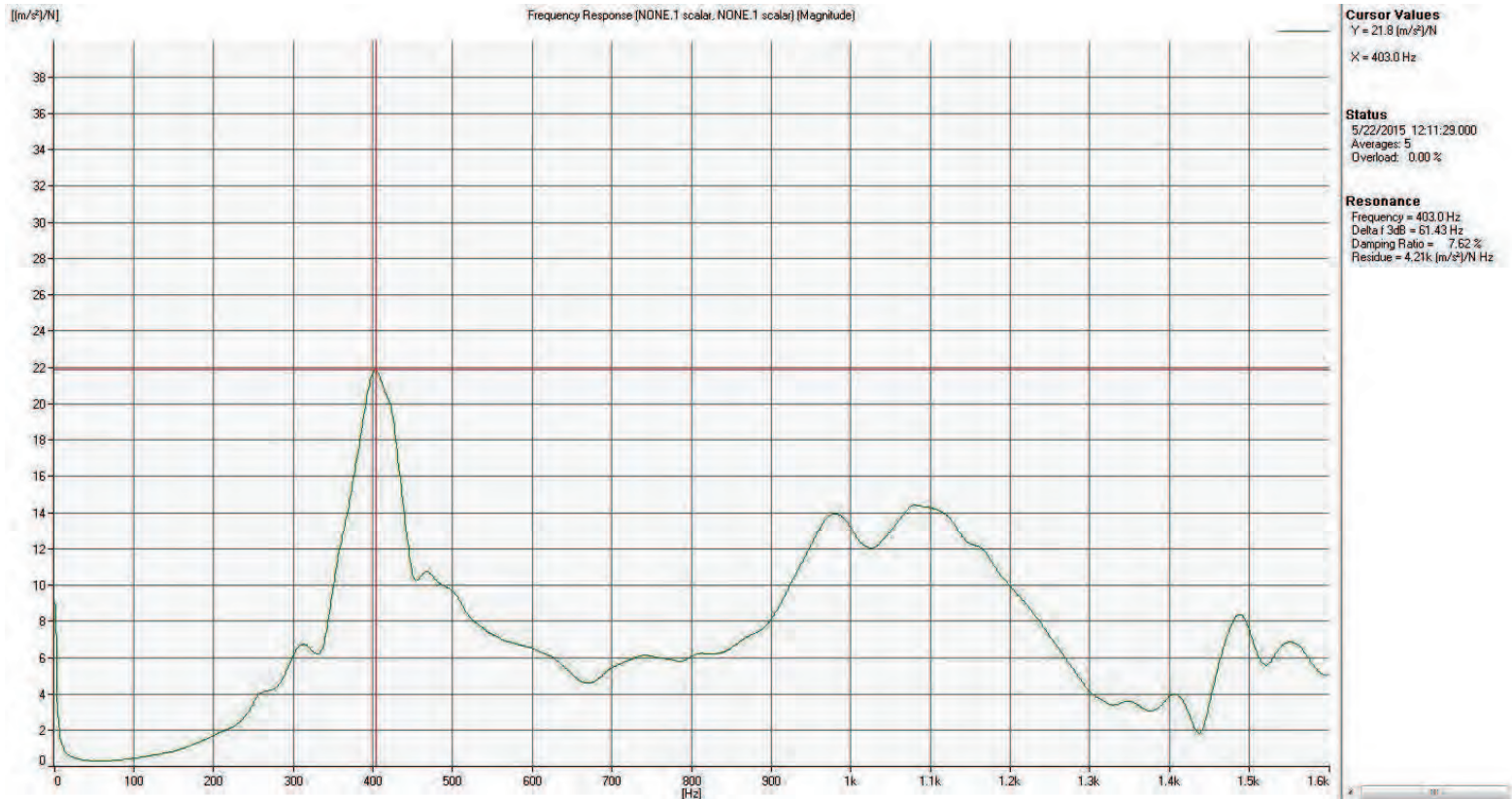


Figure 5: Typical frequency response curve (Bracket 6 XX direction)

A range of 1600 Hz was requested by the client, to focus on lower frequencies which have a greater effect on the strength and lifetime of structural components.

Table 2: GRMS Values for Exhaust Mount Bracket

Event	Direction	Max G _{RMS}	98 th %
Sweep 001	X	0.3514	0.3457
	Y	0.3533	0.3423
	Z	0.3897	0.3781
Sweep 002	X	0.3640	0.3497
	Y	0.3622	0.3452
	Z	0.3920	0.3787
Engine Shut Off	X	0.1465	0.1319
	Y	0.1415	0.1248
	Z	0.1564	0.1350
Engine Start Up	X	0.1775	0.1550
	Y	0.1581	0.1447
	Z	0.1788	0.1600
Waverly Acceleration	X	0.4092	0.3544
	Y	0.3934	0.3397
	Z	0.4361	0.3771
Sony Service Road	X	0.4526	0.4165
	Y	0.4350	0.3946
	Z	0.4793	0.4597
Rough Road – Irene Street	X	0.4054	0.3809
	Y	0.6822	0.3954
	Z	0.4401	0.4229
Railroad 001	X	0.4439	0.4075
	Y	0.4210	0.3883
	Z	0.4740	0.4384
Railroad 002	X	0.2899	0.2614
	Y	0.2889	0.2514
	Z	0.3320	0.2878

Vibration Testing of Exhaust Mount Bracket

Screenshots of the overall acceleration and JTFA of each axis follows.

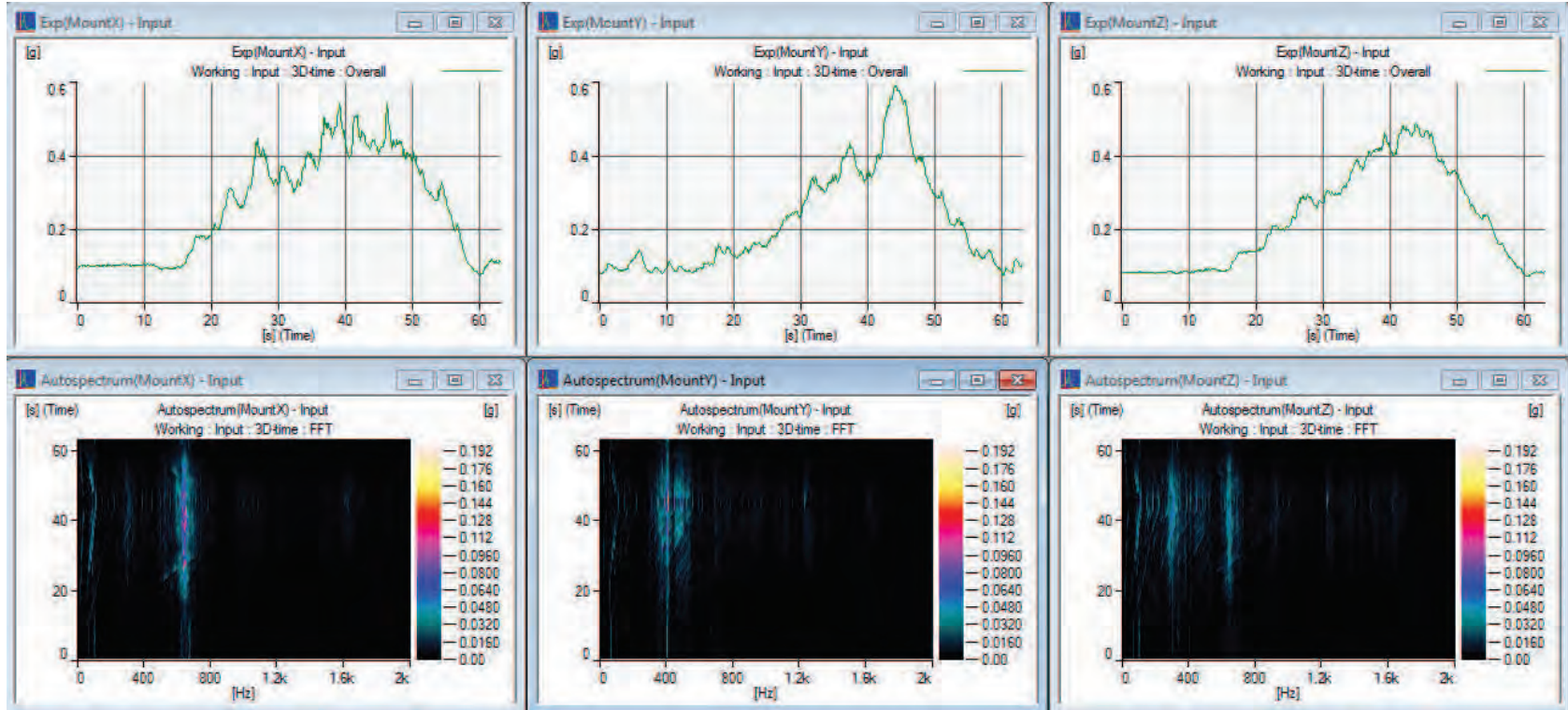


Figure 6: Engine Sweep from Low Idle to Max RPM 001

Report: ISX-G Engine Mounted Bracket Natural Frequency & Exhaust System Vibration Measurements

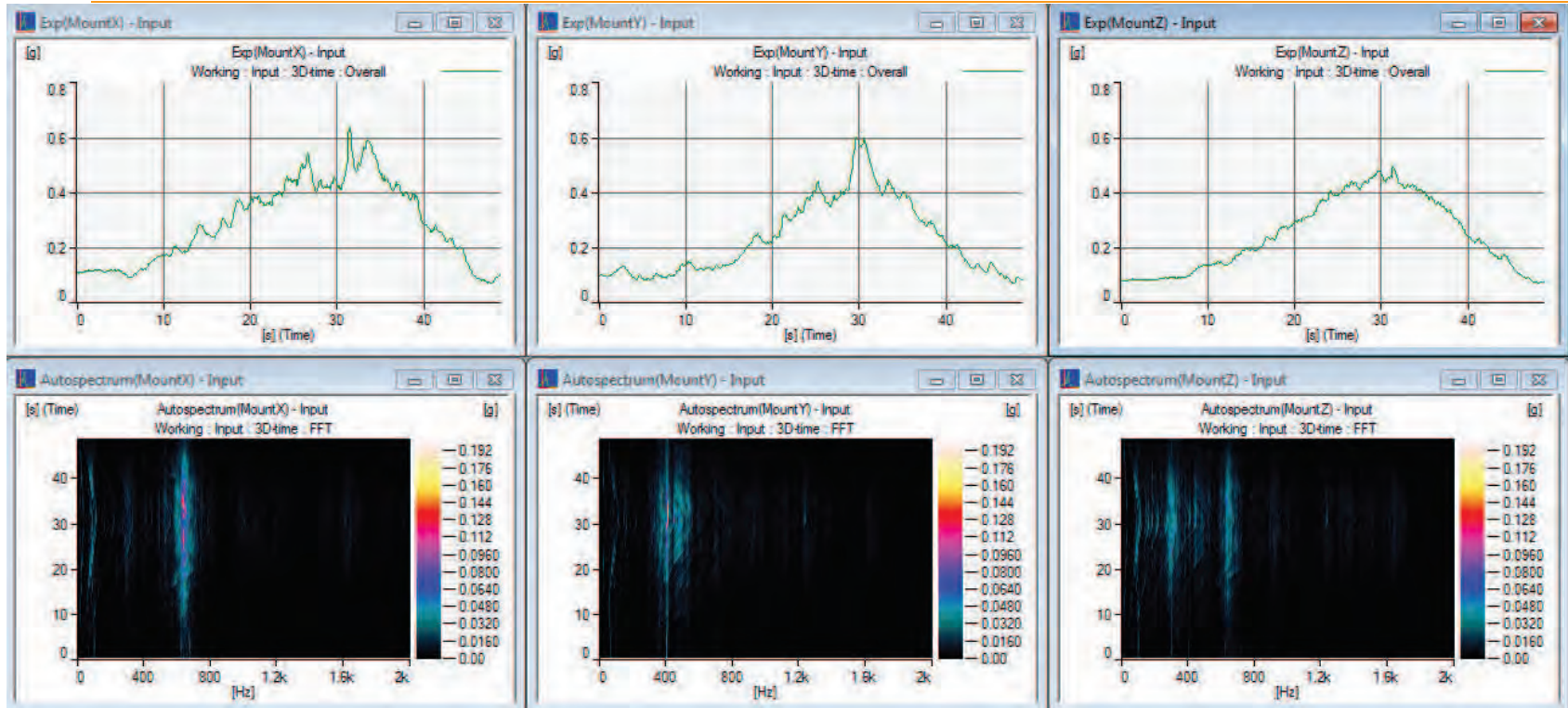


Figure 7: Engine Sweep from Low Idle to Max RPM 002

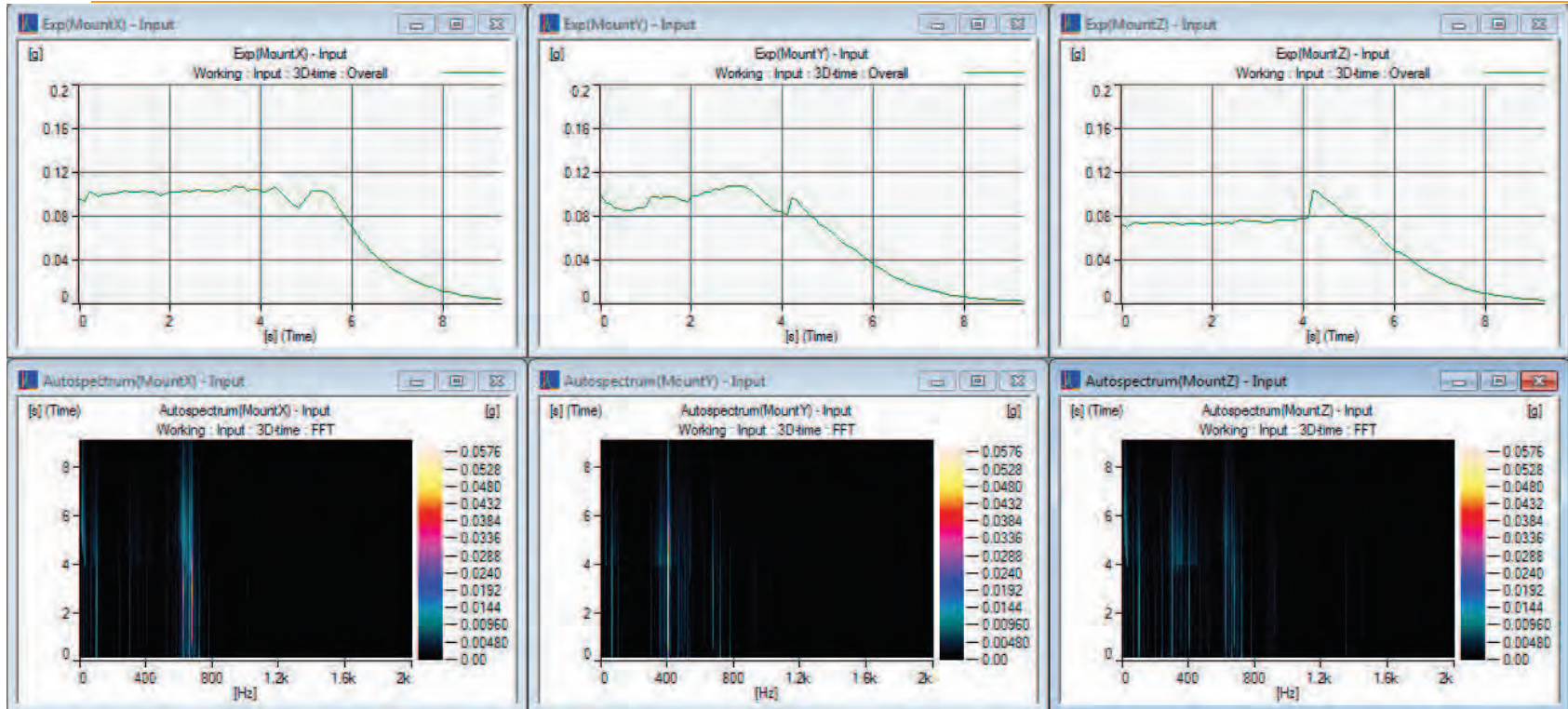


Figure 8: Engine Shut Off

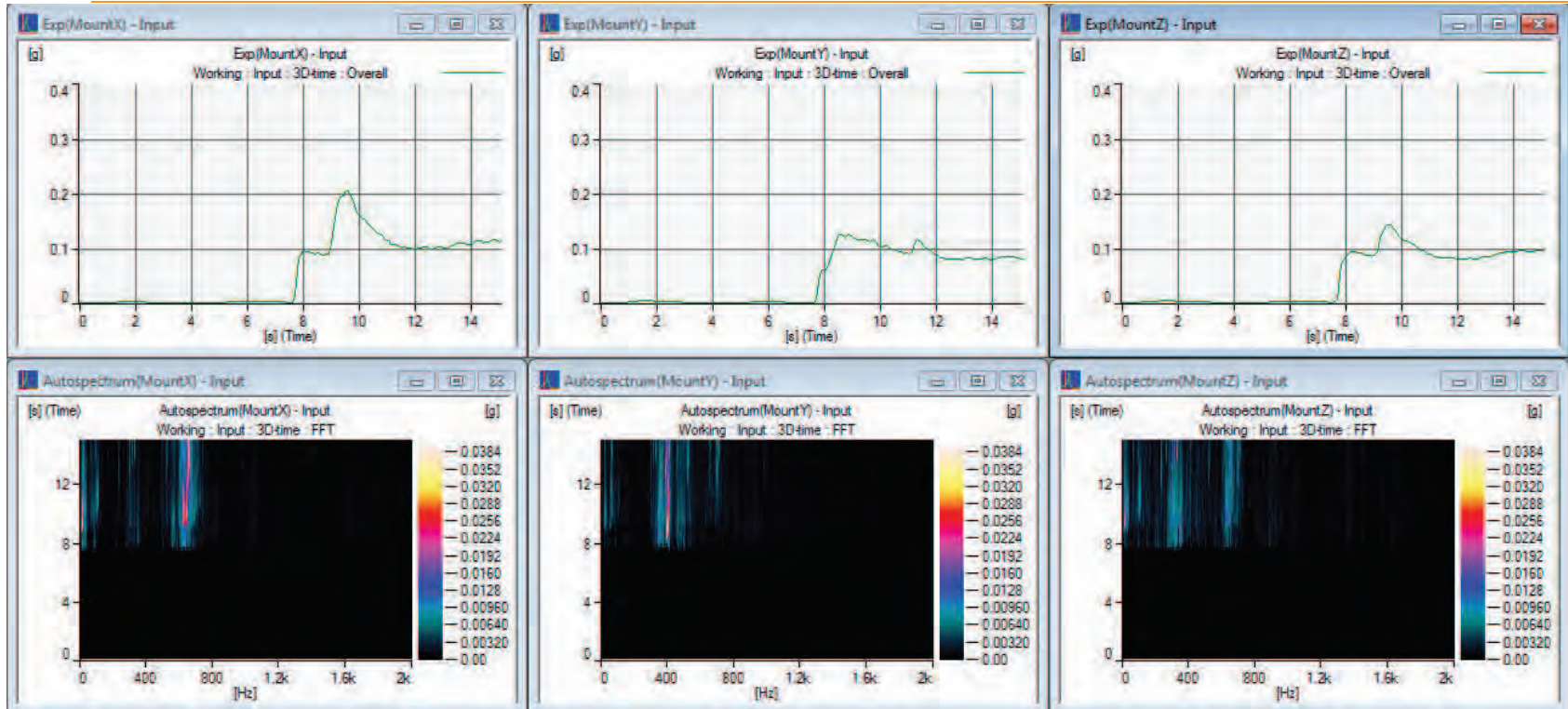


Figure 9: Engine Start Up

Report: ISX-G Engine Mounted Bracket Natural Frequency & Exhaust System Vibration Measurements

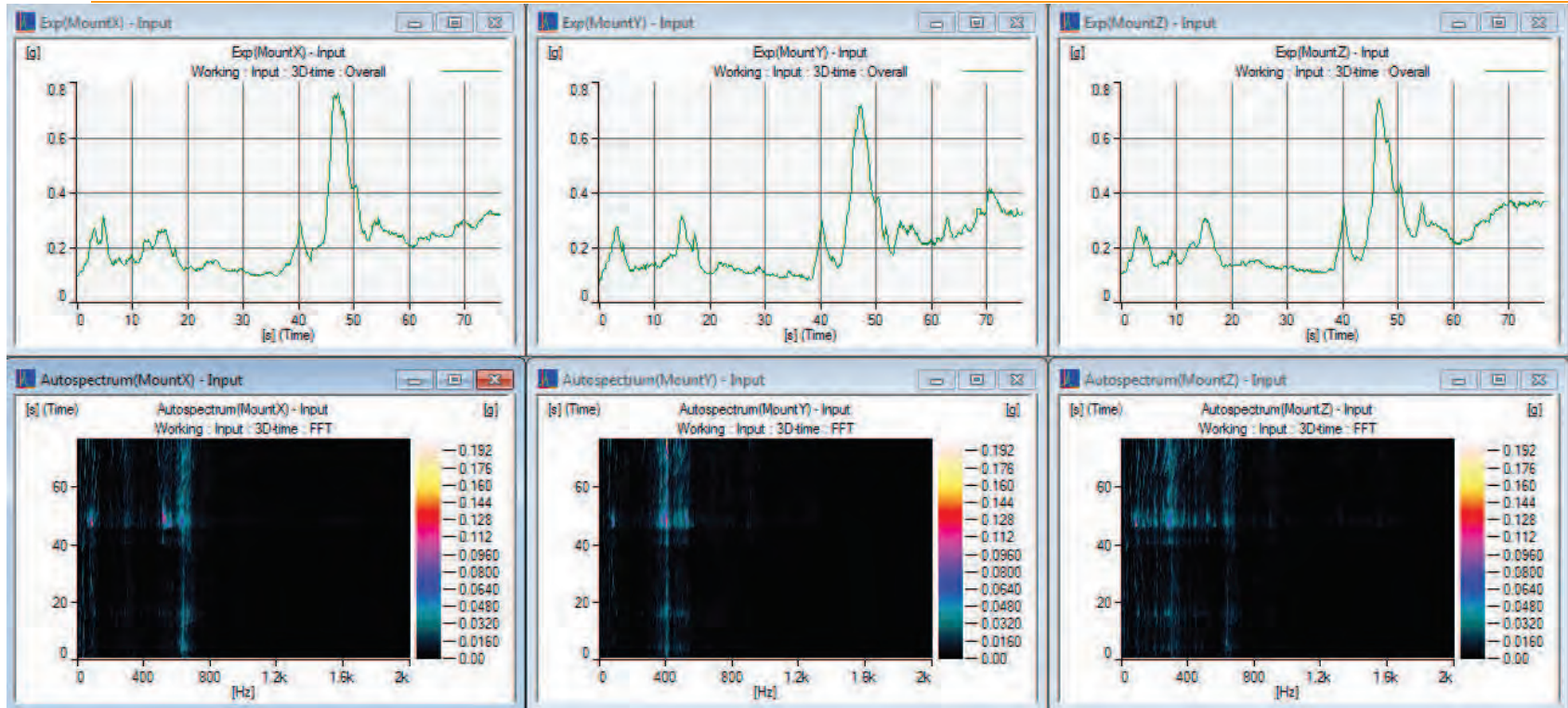


Figure 10: Acceleration along Waverly Ave. to McGillivray Blvd.

Report: ISX-G Engine Mounted Bracket Natural Frequency & Exhaust System Vibration Measurements

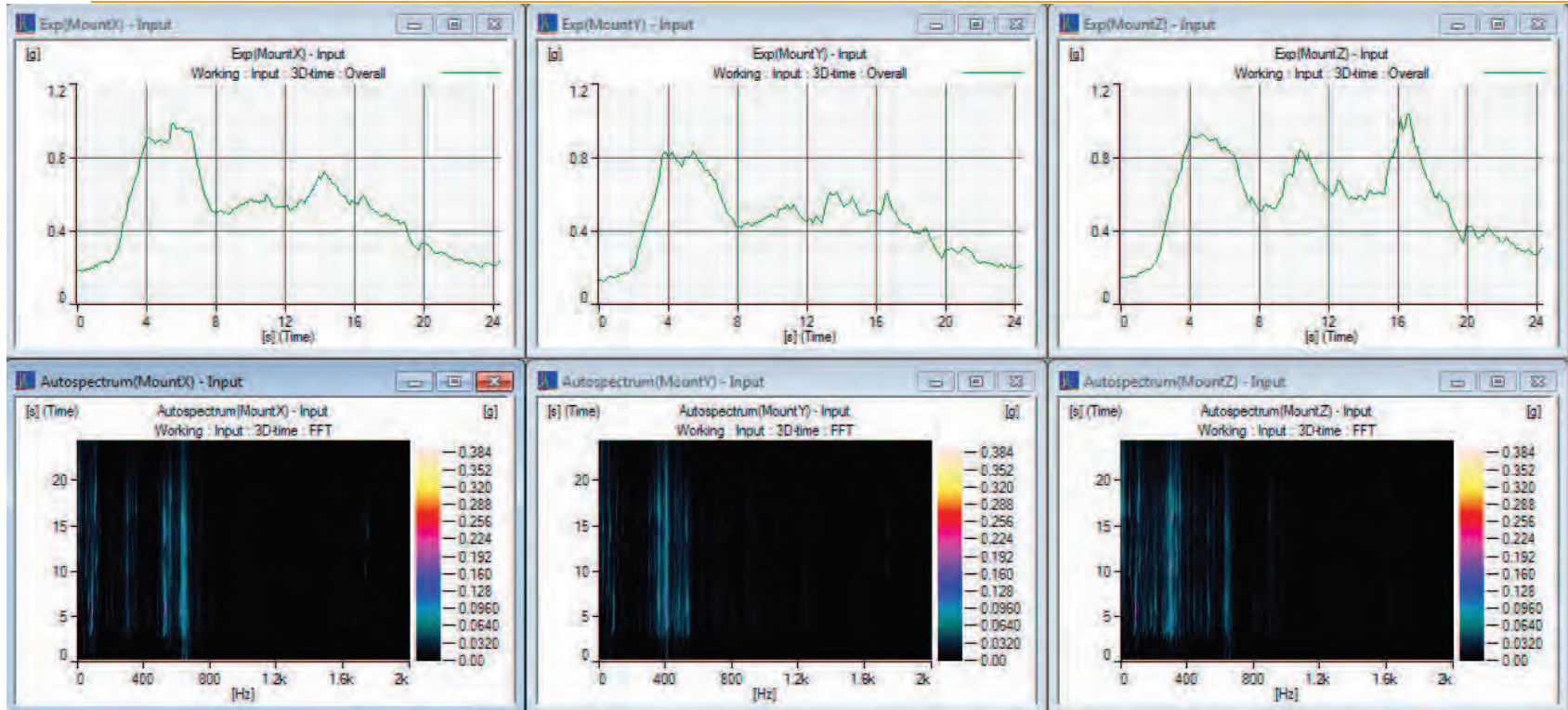


Figure 11: Rough Road – Sony Place Service Road

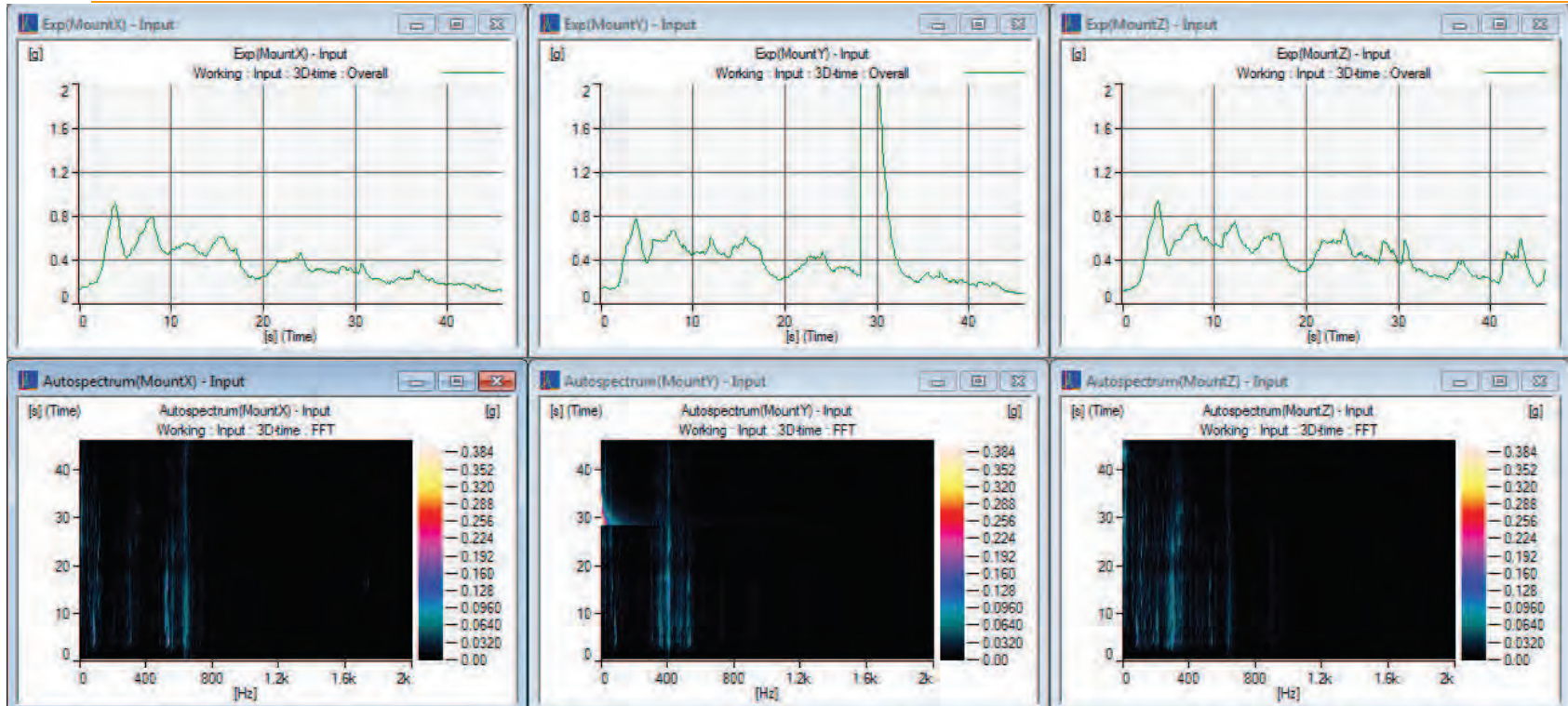


Figure 12: Rough Road – Irene Street Service Road

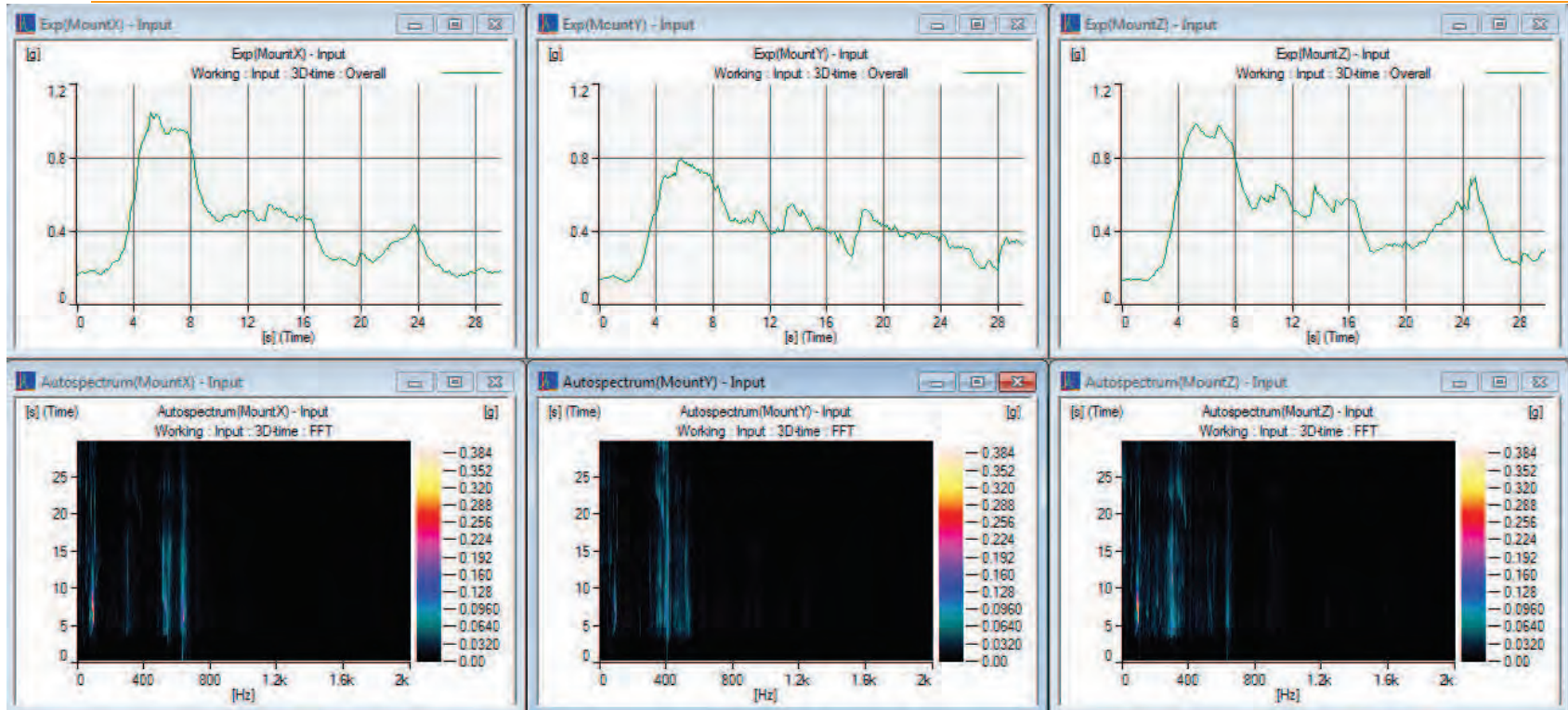


Figure 13: Vibration over a Rail Crossing 001

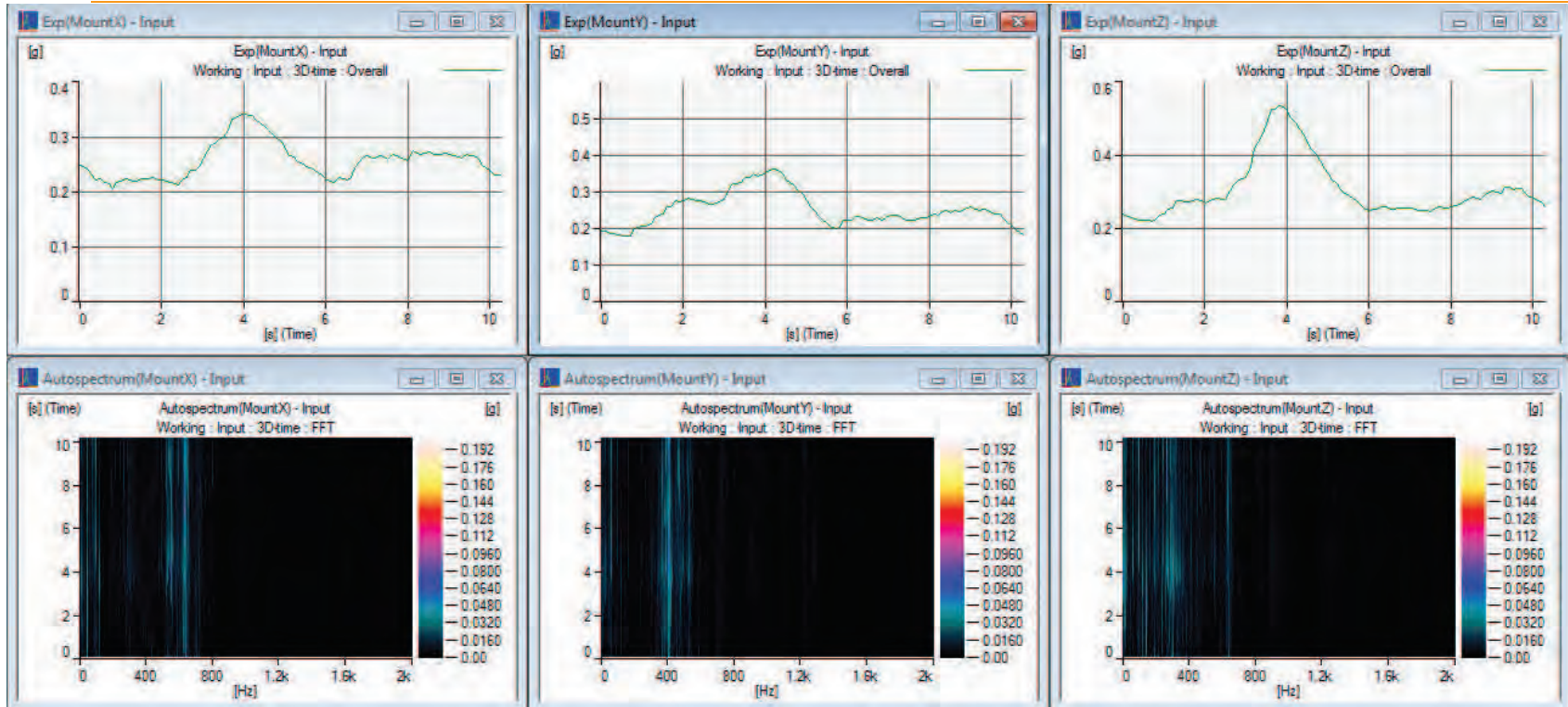


Figure 14: Vibration over a Rail Crossing 002

RQ17-007

MCI

12-27-2017

REQUEST 8

MCI RESPONSE TO ODI

RQ17-007

Cummins ISX Exhaust Bellows

Review 08Feb13



Reliability Driven™

CONFIDENTIAL

CUMMINS ISX D EXHAUST BELLOWS REVIEW

MEETING NAME: Exhaust bellows install review 08-20-1786 on unit 12920	Date: February 8, 2013
	Time: 9:00 - 10:30 am
Location: Proto Shop MCI Winnipeg	

Objective(s): Review the installation of the exhaust bellows on the Cummins ISX engine for D-coach

Attendees:

<u>K Falk</u> ✓	<u>JP Pelletier</u> ✓
<u>J Ragazzi</u> ✓	<u>C Bularca</u> ✓
<u>A Lazcano</u> ✓	<u>D Magas</u> ✓
<u>R Polyakov</u> ✓	<u>Adam T (Ritz)</u> ✓
<u>M Shirk-Heath</u> ✓	<u>Rick (Ritz)</u> ✓
<u>T Loewen</u> ✓	<u>Tom (Ritz)</u> ✓

Distribution:

<u>J Widme</u>	✓ Participant
<u>B Malcolm</u>	x Absent
<u>D Rowe</u>	e Excused
<u>B Couch</u>	c Copy
<u>G Trudeau</u>	
<u> </u>	

Background

MCI had reports of 7 failed exhaust bellows pipes (p/n 08-20-1786) reported on D-model coaches. Failed parts were returned to the supplier (Ritz) and reviewed with the sub-supplier (Truflex). The analysis returned to MCI (see FEF-13-03 and NCR02330) by Ritz and Truflex concluded the failure was caused by installation misalignment.

Short term containment in the factory (MCI Pembina) is required and Priority 1 has recommended a bulletin be raised to inspect, adjust (when necessary), and (when necessary) replace misaligned exhaust pipes. The population of affected coaches has not been determined at this time. The first bellows failure is unit 12637.

Item	Decision/Action/Notes	Status	Owner	Due Date
1	Obtain rigid pipe as Go/No-Go gauge for Pembina installation from Ritz	Closed	K Falk	Feb 15/13
2	Review and implemented installation changes in Pembina	Open	M Shirk Heath	Feb 22/13
3	Add additional adjustment to Support Bracket 08-20-1979	Open	R Polyakov	Feb 29/13
4	Review design of bellows with Truflex and determine if an improvement is available	Open	A Lazcano	Feb 29/13
5	Update MCI drawing to include alignment marks on torsional end of bellows to elbow.	Open	A Lazcano	Feb 29/13
6	Release procedure/bulletin for the field.	Open	JP Pelletier	Feb 22/13
7	Arrange to inspect all coaches in Pembina for misalignment and rework as required prior to delivery.	Open	J Widme	Feb 22/13

RQ17-007

MCI

12-27-2017

REQUEST 8

MCI RESPONSE TO ODI

RQ17-007

Field Escalation Form



Field Escalation Form

Created by **Bruce Malcolm** on 01/08/2013

System Document

Form Number	FEF-13-03
Customer Name	Southwest Metro Transit
Customer State	MN (Two letter abbreviation format)
TSM	Dan Filan, Robert Strangways
Coach Down	Yes
Priority Level	Red
Make	MCI
Model	D4500
VIN #	██████████ ██████████ ██████████ ██████████ ██████████ ██████████ ██████████ ██████████
Mileage	14445
0 - 90 Day	
Part # / Description	Failed Exhaust Pipe 08-20-1786 (Ritz), 08-20-1787 (Tru-Flex)
Failed Parts Needed	Received
Monitor	
Supplier	RITZ MACHINE WORKS INC
Complaint	Broken exhaust pipe. The customer has concerns about the rest of the fleet Dillion's Bus Service Coach USA reported the same problem (FEF-13-32)
Cause	Installation and Alignment Procedure used by MCI.
Correction	Verify alignment of exhaust bellows by visual inspection , reinstall correctly. Replace if permanently deformed. See Priority#1 PR1-13-0001.

Date Reviewed w/Eng	
MCI Category	08
Reviewed With	
Assigned To	QA
Name	JP Pelletier
Target Completion Date	02/01/2013
Difficulty Rating	2
ECN # (if req'd)	
Factory Cut In (if req'd)	12949
Service Report Created?	Yes

Report #	██████████ ██████████ ██████████
Final Resolution	Inspect per Procedure 8-30. Replace any deformed/damaged bellows assemblies under warranty.
Completion Date	02/26/2013
Comments	<p>03/19/13 08:47:42 AM - Bruce Malcolm: Deleware Transit reported a failure on 12628, 64163 miles 919 fleet # replacement part on order Customer to inspect the 5 sister coaches</p> <p>03/01/13 10:22:31 AM - Guy Trudeau: Email, Michael to Guy, 02/27/2013 08:20 AM attached is the list of coaches that have been checked in PBA to date. (attached to FEF, Pba Flex pipe Check.pdf).</p> <p>02/26/13 08:23:42 AM - JP Pelletier: Procudure 8-30 was released to inspect affected coach population . Cut-in online in Pembina unit 12949. Opened on Priority 1 (ref PR1-13-0001). Issue closed.</p> <p>02/25/13 01:30:42 PM - Guy Trudeau: Email, Michael to Jerry, 02/14/2013 08:32 AM This is what has been done, and when cut in will happen (12949, Denver, Pba Line Cut-In). I have attached in a file, the list of coaches in PBA to be checked and or reworked , along with changing to the new bracket 08-20-2350. (Table attached to FEF).</p> <p>Email, Jane B to Jeery W, 02/14/2013 07:21 AM Item Master has been created for 08-20-2350.</p> <p>Email, Jerry W, to Michael, 02/14/2013 03:45 AM Michael. Please supply the unit# cut in for the changed line process & where Bryan started checking coaches in the Prep Shop.</p> <p>Email, Alvaro to Michael, 02/13/2013 03:52 PM Mike, You will receive on tomorrow's morning truck the new bracket with more adjustment (large slots) see attach drawing. It will replace: 08-20-1919 and 08-20-2240. (attached to FEF).</p> <p>Email, Kris to Michael, 02/13/2013 03:06 PM To clarify the question of residue seen today at the torsional joint of the exhaust pipe (08-20-1786) you and George looked at in the prep shop - here is the email response from Mike Teso at Tru-Flex (along with the photo I took):</p> <p>Kris, good afternoon. The blackened area which you see on the seam of the torsional joint is completely normal. During the manufacturing process, a one ply sleeve with a strip of brass covered with high temperature lubricant is inserted into a hydro-formed bellows. Then, the component is placed inside of another hydro-former and the area of the brass and lubricant is formed into one more corrugation which captures the lube a dissimilar metals inside. This allows for the torsion to take place. Over time, the lube may seep out of the torsional seam but that is to be expected. Also, if compressed to 4.5psi - the leak rate is only around .01 scfm, well below the EPA regs. Let me know if you have any other questions.</p> <p>Email, Michael to Guy, 02/13/2013 02:58 PM I now have the tool pipe in my possession. Use will commence on 2/14/2013 with the first build for the day.</p> <p>02/20/13 03:54:48 PM - JP Pelletier: Inspection procedure to be released on Internal Bulletin. 352 units affected and require visual inspection for misalignment (Axial, Angular, or Lateral). If bellows is misaligned and permanently deformed, replacement should be ordered.</p> <p>02/13/13 11:51:04 AM - Guy Trudeau: Email, JP to Distrubtion List, 02/13/2013 11:18 AM Here are actions from Feb 8 meeting. I will be following up on these with owners. (copy attached to FEF, 'Cummins ISX Exhaust Bellows Review 08Feb13.pdf)</p> <p>02/13/13 11:25:04 AM - Guy Trudeau: Email, Guy to JP, 02/13/2013 10:57 AM The Ritz supplied, rigid Go/NoGo exhaust pipe, was inspected by DimLab (Camelia) and Passed, then it was assigned a tool number, 26892, and shipped to Pembina, on Monday morning 02/11/2013. Kris confirms the pipe is in Pembina, ready to use.</p> <p>Email, JP to Jerry, 02/13/2013 10:16 AM A meeting was held with Ritz on</p>

Friday, Feb 8, in Winnipeg to review the ISX Exhaust Bellows installation . Following that meeting the following is to be implemented immediately for short term containment. In addition any coaches in Pembina should be inspected and if any bellows misalignment exceeded 1/4" is present, the pipe and/or dpf will require adjustment. The pipe also needs to be inspected out of the coach as it is possible that it has already been permanently deformed once the engine has been run .

1. A rigid Go/No-Go pipe was provided to MCI by Ritz . This pipe needs to be used as a verification to determine if the turbo flange and the dpf flange are located properly for the exhaust pipe assembly to mount . This pipe was going to the Dim Lab, then was to be entered in the Calibration System and shipped to Pembina for use as a tool (see photo DSC00122).

2. The blanket over the bellows should be partially pulled back at install . The bellows requires visual verification after assembly so that it has been installed straight. Any misalignment exceeding 1/4" (axial, angular, or lateral) needs to be corrected before clamping the pipe assembly in its final position (see photo of a straight bellows DSC00134).

Please note, even if the position of the flanges on the turbo & dpf are in the correct location, it is possible to misalign the exhaust pipe bellows at install . That is why the visual check is required . Refer to the attached file for an example with photos. (attached to FEF,). Longer term containment is planned. I will send out a second communication detailing that . If you have any questions please call me .

Meeting, RFS, 02/13/2013 9:30 AM George M, stated no changes to the exhaust pipe installation had been cut-in at Pba, they need the new brackets, and instructions /direction on how to proceed with new installs and how to inspect /action off-line /completed coaches. Bryan C, requested JP supply instructions and action plan to Pba . Lawrence to confirm new bracket specs and Larry R, to supply the brackets.

Call, Guy to Kris, 02/13/2013, 9:15AM Please provide the coach cut-in of the revised /corrected 'exhaust pipe' installation procedure. Kris & George M, had just discussed this item. No changes /corrections had been cut-in. George was expecting some new mounting brackets . Kris had already received the rigid exhaust pipe /go nogo tool. No instructions /direction have been received. Guy then called Bruce M, requesting he follow-up with Engineering on the bracket and instructions to Pba .

02/12/13 05:20:02 PM - Guy Trudeau: Email, JP to Guy, 02/08/2013 01:19 PM To second what Kris has said, we have an installation problem. There are changes to the design that could improve it but there is no reason to believe the current part and design is inadequate , if properly assembled without misalignment of the exhaust pipe (specifically misaligning the bellows).

Email, Kris to Guy, 02/08/2013 12:34 PM No Goto Meeting necessary. After review this morning this is an installation issue with some design change necessary on the hanging bracket. Engineering is working on modifying the bracket to add more adjustment and Michael Shirk - Heath (Manufacturing Engineer from Pba) will address installation procedure at Pba .

Email, JP to Guy, 02/08/2013 11:30 AM We know path forward. A call will be set up Monday.

Email, Guy to Kris, JP, 02/08/2013 10:40 AM When is the gotomeeting? No invite received.

Email, Bruce to Kris, 02/07/2013 01:40 PM Yes, We also want to make sure that the parts are mfgd. to print prior to our meeting tomorrow .

Email, Kris to Bruce, 02/07/2013 12:55 PM Cammie just called from the Dim Lab and explained a couple of exhaust pipes were dropped off in her area. Can you please clarify what needs to be measured /done with them to Cammy? During our phone conference yesterday with Ritz , Tru-Flex and MCI, Guy asked that Cammy try and measure the distance between the engine turbo outlet and the DPF inlet on the engineering coach . Is this not necessary?

Email, Kris to JP, 02/07/2013 10:31 AM I should be able to make it - same time 9:00am? Can you please set up the GoTo Meeting conference call (tentative time) for tomorrow and send invites to everyone from yesterday and

per Guy can you also invite Dan Besserer , Bruce Malcolm, Dan Filan and Darrin Thorpe ?

Email, JP to Kris, Michael, etc, 02/07/2013 10:11 AM The meeting with Ritz is moved to Winnipeg (proto shop) tomorrow (02/08/2013). Are you gents able to make it, lunch will be provided.

Email, JP Meeting Invitation, in Pembina, 02/08/2013 9:00-11:00AM Terry - please forward to Ritz & TruFlex. Others - Please plan to attend or send a delegate who is familiar with the installation. 8 reported failures on the 08-20-1786 Exhaust Pipe. Refer to FEF-13-03. Proposed Agenda: - Introductions, - Update on failure analysis, - Review current production installation, - Path forward for Field Units & Factory, - Review Actions and Establish target dates, - Wrap-Up

Email, Dan B, to Guy, 02/06/2013 03:52 PM I am good with that Guy.

Email from Guy to Kris, 02/06/2013 04:08 PM Please invite/add, Bruce and Dan to this Friday's follow-up GoToMeeting review of the exhaust pipe issue. Possibly add Dan Filan and Darrin Thorpe, if Dan Besserer agrees.

Email, Ritz, Rick Illnisky to Kris, 02/06/2013 01:39 PM Attached .pdf copy of the Try-Flex failure analysis report on the two MCI pipes returned on 'Ritz RMA 5115'. Extracts from the Tru-Flex report:

CONCLUSIONS: • Both of the returned parts failed from a large amount of installation misalignment. This caused stress on the end corrugations. The failures occurred between the first and second corrugations. This is normal as this is the first point at which the bellows can move. The stress from the misalignment combined with the motion/vibration resulted in premature failure.

• Part # 1 showed more deformation on the outlet end of the bellows. It also appears to have ran for a period of time post-failure and resulted in the crack propagating into the third corrugation as well as wearing on the exhaust tube.

• Part #2 showed more deformation at the inlet end than Part #1 did. This resulted in two cracks between the first and second corrugations. These cracks appear to have started at the inside and the outside of the bend and then propagated around until the nearly met.

RECOMMENDATIONS: • The installation alignment needs to be improved.

• Tru-Flex has send photos of an installation tool to Ritz for reference. • Ritz and MCI should work on completing the design information sheet to capture more information about the application. • Tru-Flex to participate as needed if alternate designs are needed.

Email, Roman to Lawrence, Please see attached proposition for a bracket with longer slot: (attached .jpg to FEF, ISX Support Bracket). Do we need to order some for prototype?

Email, Lawrence to JP, 02/06/2013 01:21 PM This should work. We could also make a new "L" bracket with a longer slot to give more adjustment range. Hi Roman, Please do up a CAD image of a "L" bracket with a longer slot for us to view. We probably need to cut-in with this immediately on-line.

Email, GoToMeeting Invitation, from Kris, 02/06/2013 1:00-2:00 PM I just want to have a quick informational meeting (using GoTo Meeting) this afternoon to make sure we are prepared for Friday's review at the Pembina plant. That way if something still needs to be done in preparation for Friday, we still have time to complete it. If I have missed anyone on the invite list please forward this to them.

Email, JP to Lawrence, 02/06/2013 10:39 AM Seeking Engineering feedback on the first coach repair at Dillon's on the exhaust pipe. Bruce and I spoke to George Brown (MCI TSM on site). He stated that if he attached pipe 08-20-1786 to turbo, clamped, then installed to dpf, clamped, the bracket is off considerably. He used 5 washers as shims, this allowed the exhaust pipe to be installed without misalignment (axial/lateral/angular) of the bellows. Please review and advise.

Email, George B. to Steve, Bruce, 02/06/2013 10:03 AM As per our conversation, here are a few more pics (attached to FEF, District 6 Waldorf). With dropping the clamp down approximately one half inch there is less stress

on the bellow. I rubber shock absorber of some sort may also work .
Email, Kris to Lawrence, 02/06/2013 10:29 AM For informational purposes - please see attachment of photo (attached to FEF, 08-20-1786 install 02-05-13) I took of the installed exhaust pipe in unit 12912. After installation, the torsional bellows is not in a relaxed straight position, but instead is flexed at two different points - quite sharply nearest the turbo connection.

Email, Kris to Guy, Already making arrangements so I can be here Friday . I am also planning a GoTo Meeting for this afternoon (will copy you on the invite) with all parties just to make sure everything is in place for the Friday visit.

Email, JP to Guy, 02/06/2013 06:44 AM We have a meeting set up in Pembina with Ritz & Truflex to review the installation .

Email, Lawrence to Guy, 02/05/2013 12:29 PM Roman and George can support this if needed in Pembina .

Email, Kris to Chris T, Just left you as voicemail as well . Can you please issue a first article (PQE) purchase order to Ritz for 1 pc. of exhaust pipe 08-20-1786. I spoke to Adam already and the part should be ready to ship later today with FAI paperwork to MCI Wpg Dim lab. Hi Cammy, Can you please perform an audit on this exhaust pipe ASAP when you receive and ship to me in Pembina by Thursday 2/7/13? You should receive the parts tomorrow - per Adam they are shipping later today . This is very HOT as we have been experiencing some field issues with this pipe . Ritz, along with MCI engineering will be in Pembina to look at installation of this exhaust pipe this Thursday or Friday. Thank you all for your efforts to expedite this .

Email, Guy to Kris, 02/05/2013 11:30 AM Thanks for following up. Send me a meeting invite, if I am able I might just call in using Skype voice calling . In the FEF you will see the FAI on 08-20-1786 was never done. This must get done /approved this week. Call Ritz, Adam, tell him to rush a FAI sample with paperwork to DimLab, Camelia, asap. This same part or its certified twin should be in Pembina when the trial fit-up review meeting is held. SQA Pba should file the FAI on this part number . Apparently the Buyer never asked for an FAI (or Syteline never issued an FAI order action message to the Buyer)?

Email, Kris to Guy, 02/05/2013 10:42 AM Yes, this issue is on the top of my plate. I spoke with Ritz yesterday and again 1/2 hour ago - they indicated Truflex received the pipe late Friday and are investigating . They hope to have analysis from Truflex by the end of today 2/5/13. They also mentioned about coming down Friday but Pembina plant regular production is off that day . I will touch base with Terry L. to see if this is the best day for analysis . Once I know Truflex analysis is complete I will schedule a SIP style meeting with all parties - Ritz, Truflex, MCI engineering, Terry Loewen, J.P. Pelletier. I am also reviewing a Pembina installation today as well to see if there is inherent stress applied right at the install. Previous investigation was of a coach that had been road tested and I want to see if there is a difference at initial install .

Email, Guy to Kris, 02/05/2013 10:02 AM Look at FEF-13-03, I spent some time Friday, updating the issue. Please make a follow-up call to Ritz, Adam Teeter, and to Tru-Flex, Scott, and get the latest status on their analysis of the two failed pipes we sent them for analysis . I had asked Jose to schedule a SIP style GoToMeeting with Ritz , Tru-Flex and MCI as soon as Tru-Flex had done their failure analysis, probably Wed or Thur, this week.

But Jose is stretched too thin this week. This has become the HOT issue !!! For your info, Terry Loewen says he is planning to have both suppliers and our Engineering at Pembina by this Friday to review the issue and design .

Email, Terry to Guy, 02/05/2013 09:39 AM JP came by yesterday , We will try to have a meeting with Ritz and Truflex at PBA on Friday . They will have some suggestions on how to redesign to prevent this issue . I agree with you, and have provided guidance to Ritz to not go crazy on building stock of the current pipe.

02/12/13 03:11:49 PM - Guy Trudeau: Email, Guy to Lawrence, 02/05/2013 09:36 AM As discussed, and now confirmed by observation in Pembina , by Kris, the exhaust pipe 08-20-1786, is twisted at initial install. Could be enough to create a problem. This has been identified as an issue /concern by

Ritz. They offered to go to Pba to optimise the installed geometry (specs) of the pipe. This would require Engineering support. My concern is, we are sending the field the same exhaust pipes as replacements (no change, no fix). Kris can coordinate, assist.

Email, JP to David, 02/04/2013 07:08 PM Spoke to Terry Loewen and we will be arranging a visit with Ritz in Pembina later this week or early next week.

Email from Jerry to Kris, 02/04/2013 02:34 PM Yes, please work with Brent and George.

Email from Kris to Jerry, 02/04/2013 02:23 PM We (SQA) are investigating this issue as well. For investigation purposes, could we install an exhaust pipe (08-20-1786) on the D line without the insulation blanket to more easily monitor the orientation of the muffler as it goes through run out and road test ?

Email from Michael to JP, Jerry, 02/04/2013 12:32 PM Problems for the reference coaches are from May 2012 thru July of 2012, coach 12692 PBA online 4/10/2012, RTS 5/15/2012, coach 12737 PBA online 6/4/2012, RTS 7/12/2012. Coaches up to 12845 PBA online 9/26/2012, RTS 11/11/2012 may be exposed to this type of failure. This coach was the last ISX coach built prior to the complete resolution of the issues. Corrective actions were implemented during the first weeks of November 2012. All issues were resolved on or before 11/21/2012. ISX production with the solutions implemented, commenced with coach 12911 PBA online 11/27/2012. The following is a list of corrective actions that resolved the fitment of the engine exhaust tube to the DPF unit.

1) 3/4 inch short length of rear coach frame in "Y" has been extend by up to 1/2 inch via weld fixture improvements.

2) out of location exhaust pipe bracket location on coach frame has been resolved via modification to drilling fixture.

3) lengthened slots in "Y" on rear mounting bracket to compensate for short length of frame.

4) 08-20-1808 bracket formed backwards - vendor corrective action implemented, part is on receiving inspection.

5) added angle gage to DPF assembly fixture to properly orientate the barrel.

6) DPF assembly fixture modified to properly locate reactor tube

7) Supplier provided DPF frame had dimensional issues, 1st article inspection verified supplier corrected the issues

8) DPF Frame put on receiving inspection audit plan, verified supplier issues were resolved on a sustained basis.

Email, JP to David, 02/04/2013 11:15 AM Note 8 failures reported to date on 352 units built (as of Jan 28/13), FR of 2.3%. Other reponses from JP to David are in "Quotes", below.

(1) Have we changed or revived our installation method. "There have been changes made to installation. We have encountered problems installing the aftertreatment exhaust. Pembina is supplying me a summary with dates on any changes made to the process. I have the ECN changes documented and am compiling DDRs (deviations) on parts in this installation."

(2) Was there any other change in process in-house or at supplier (besides changing to Tru-Flex 1 year ago) "I believe we have made modifications to the aftertreatment frame"

(3) Who is coordinating the replacement parts being shipped to the correct locations on time. "Dan B & Service Parts."

(4) Have we visited Ritz or has Ritz been at MCI. "Will follow up with SQA. Part(s) have been returned for analysis to Ritz."

Is it OK to keep building coaches ? what about NY bid are these pipes no good ? "Not used on ISL engine for NY bid."

Email, JP to Jerry, Michael, 02/04/2013 10:45 AM Actually looks like the 2010 install is D08-20-1952, not 2304 (2013).

Email, Jerry to Michael, 02/04/2013 10:34 AM I think you kept track of the changes and issues on the ISX frame & installation issues. Will you please supply information to JP. Brad, did we have issues with this pipe ?

Email, JP to Jerry W, 02/04/2013 08:55 AM Please forward any changes to installation processes for this installation, by date or unit number if

possible, including any changes to fixtures (in-house and at suppliers). I understand we have had some challenges with this installation and a sequence of events/changes is needed. We are seeing failures of the 08-20-1786 pipe assembly in the field on the following units to date : 12692, 12693, 12695, 12697, 12728, 12729, 12737.

Email, David to Guy, JP, 02/04/2013 07:50 AM This has become a serious issue, and now Dillon's Bus Service, reporting same problem. I reviewed all the reports from the investigation and have some questions .

(1) Have we changed or revived our installation method .

(2) Was there any other change in process in-house or at supplier (besides changing to Tru-Flex 1 year ago)

(3) Who is coordinating the replacement parts being shipped to the correct locations on time.

(4) Have we visited Ritz or has Ritz been at MCI .

We have had this for almost a month now, Investigating the problem is one action, but short term containment and supporting the customer is not being performed quick enough. Please advise me our action plan to resolve Short Term countermeasure and customer. Is it OK to keep building coaches ? what about NY bid are these pipes no good ?

Email, Dan to Daid, 02/03/2013 02:45 PM This issue has now surfaced @ Coach USA in the Dillons fleet. We have pipes on order from the Vendor to drop ship. Late Friday the pipes that were to arrive at the Customer Wednesday had still not arrived and we found they were stuck in Customs . Oakman has sent and email to Rick as he told me in our conversation late Friday, some how Oakman feels we knew this was systemic problem and did not inform Coach USA in time nor did we order the amount of pipes that would be required. My plan is to have all of the Coach USA pipes changed to the new version (line up marks on pipe). Bob Kaylor will be supplying a fleet list and location of all potential affected units .

Should be concerned with the NYCT fleet ? we should be proactive if there is any chance we could have failures. Let me know your thoughts. I have been exchanging emails with Rick and explained that I will keep him up to speed .

02/01/13 12:45:51 PM - Guy Trudeau: Guy added a shortcut link to SQA issue report directory NCR02330, which contains photos, Supplier and SQA reports, .pdf copies of email communication, etc.

Email Kris to Guy, 01/31/2013 Here are the pictures of what we found at Pembina with the exhaust pipe so far. (attached to FEF)

Conf Call Guy to Lawrence, 01/29/2013 05:20 PM Advised Lawrence of actions underway with Ritz and Tru-Flex to determine root cause of two in-field exhaust pipe failures, and the initial report from Ritz, suggesting installation alignment concerns, my request for SQA Pba, to examine installed pipes, and Ritz's offer to go to Pembina to help optimize /design /tweak the pipe geometry.

Conf call, Guy and Ritz, Adam, Tom and Rick, 01/29/2013 03:50 PM Ritz received both failed exhaust pipes late Monday 01/28. They completed a review of both pipes. They emailed a PowerPoint documents with photos and notes of their observations (attached to FEF). Ritz observed both pipes were plastically deformed, at the bellows, by more then .25", and the short elbow end were rotated, suggesting misalignment at installation . We briefly reviewed the Tru-Flex website, and found technical data related to deflection versus life (attached to FEF). Ritz is forwarding both pipes to Tru -Flex, ETA in 4-5 days. I will arrange for SQA, Pba, Kris & Brad, to inspect actual exhaust pipe alignment on new D ISX coaches , and report back with photos. Ritz offered to go to Pembina and help determine the optimum geometry for the exhaust pipe. Guy explained this type of action , if required, would be coordinated by MCI Engineering.

Top10 meeting, 01/28/2013 01:30 PM Guy & Bruce suggested adding this exhaust pipe issue FEF-13-03, to Top10. JP noted the issue was discussed /added to Priority 1, 01/25/2013, PR1-13-0001, Initiator: Terry Fordyce, 6 failures to 01/25, 12692, 12695, 12697, 12728, 12729., on 01/25/2013 10:30 AM, and would be added to QRB on 01/29/2013. <<Guy added Priority1 details on 01/31>>

Email, Guy to Bruce, 01/25/2013 03:28PM The two failed Ritz, Exhaust Pipes, 08-20-1786, (field returns, 12737 at 11,500 miles & 127??) were retrieved (by SQA) from the MCI Engineering Shop, this afternoon, and are in West Receiving for pickup by Ritz . Both pipes failed in the 'torsional bellow' section, 08-20-1787. Both failures occurred at the first corrugation of the torsional bellows. One failed at the inlet end, the other at the outlet end, of the bellows. MCI specifies use of a belows from Tru-Flex. Ritz, Adam Teeter, confirmed they (only) use the bellows specified by MCI on these pipes . Adam said Ritz only started using Tru -Flex bellows last year (Cummins ISX, 2010 Engine, see below) at MCI request. Adam and I called Tru-Flex, Janet, reported the issue, and received an RMA: 5115. Ritz will examine both failres Monday and ship them on to Tru -Flex for failure analysis by their Engineer, Scott Swank. We also sent photos of the both failures to Ritz and True-Flex. Bruce, I advise we collect all failed pipes from the field for analysis by Tru-Flex & Ritz, and MCI, until the root cause is confirmed.

Email, Guy to Saggi, Kevin, 01/25/2013 03:38 PM Final Answer: hold pipes in West Receiving for Pickup by RITZ .

Email, Bruce to Guy, JP, 01/25/2013 More failures in the field, Dan Filan has the coaches down. Did the failed parts get returned to the supplier any answers? Also on Priority 1. JP, Think we should review at Top 10.

Email, Bruce to Guy, 01/17/2013 09:32 AM I have the 2 failed exhaust pipes. Return to RITZ ??

Email, Guy to Saggi, Long, Jose, 01/09/2013 04:53 PM Failed parts are on their way to Winnipeg, for analysis by MCI and Ritz. Long, if Harkamal is not in (on training), please contact Ritz and advise them of the issue . This issue looks similar to failures you followed up on a couple years back . Please pull that data /NCR and send it to Harkamal and me .

Email, Strangways to Bruce, 01/09/2013 04:27PM Tracking number: [REDACTED] . Shipment contains 2 ea exhaust pipes and 1 ea blanket. Steve please get these to Bruce Malcolm. Warranty Dept there are three claims in for broken pipes at Southwest Metro Transit . I'm shipping these components direct to the Engineers to be inspected . So the customer can not return them to you.

Email, Guy to Saggi, Jose, 01/09/2013 02:54 PM ... Ask Ritz to review the attached report (field failure) and advise on what they suspect the cause is , and corrective /preventive action.

Email, Bruce to Guy, JP, Jim, 01/08/2013 11:11 AM Need to review with the supplier. Customer has now had 3 failures and is concerned with the fleet. Pictures on FEF Form. Robert Strangways will be on site tomorrow . Note: We had a similar issue on QRB see attached file for previous failures from Series 60 engines.

01/30/13 10:24:01 AM - Bruce Malcolm: 3 moreUnits filed at Dillion's:
12695- mileage 24,547
12693- mileage 27,725
12692- mileage 21,311

01/25/13 10:28:26 AM - Bruce Malcolm: In Q for Priority 1

01/25/13 10:26:07 AM - Bruce Malcolm: Here is the information on the Dillion's /CUSA units that are down at their White Plains MD location for the exhaust pipe issue.
Unit 12728
Mileage: 25,578
Unit 12729
Mileage: 26.078
Unit 12697
Mileage: 27,211

01/17/13 02:39:39 PM - Bruce Malcolm: Parts have been returned to Winnipeg. Supplier review required

01/08/13 11:04:09 AM - Bruce Malcolm: 2 additional failures reported Bob to be on site Jan 9, 2013

Attachments



08-20-1786 vin list 4feb13.xlsx

attached are photos of the cracked exhaust pipe for 12628 owned and operated by Delaware Transit Corp division of Delaware Department of Transportation The warranty claim in CCS for the replacement pipe is 1363697566964. I sent the customer the installation procedure and advised them to inspect and report the findings on the other (5) coaches one of the units in Blackwood with an electrical issue I will have it inspected while its there. Dan Filan



IMAG0379.jpg IMAG0380.jpg



PBA flex pipe check.pdf QA flex pipe sign off matrix Pba 02-26-13.pdf

Unit number	CUSTOMER NAME	Coach Model	Eng Type	DPF flex pipe inspected	Inspector
12920	ENGINEERING COACH D13-01	D4505	ISX 425	Engr'ng team in WPG	
12933	DENVER RTD	D4500	ISX 425	Mike S/H Gearge M, Insp	
12949	DENVER RTD	D4500	ISX 425	PBA Line cut in	



08-20-2350_dwg.pdf dpf pipe check.xlsx



ISX Report.docx Cummins ISX Exhaust Bellows Review 08Feb13.pdf



Ritz Machine RMA 5115.pdf ISX-Exhaust pipe support bracket (longer).jpg



DSC00122.JPG DSC00134.JPG



District 6 Waldorf-20130206-00236.jpg



District 6 Waldorf-20130206-00239.jpg



District 6 Waldorf-20130206-00240.jpg

<http://www.tru-flex.com/Exhaust/torsionalbellows.php>



08-20-1786 Ritz - Adam, Failed Part Review 01292013.pdf



Motion-vs.-Life-Charts - Tru-Flex.pdf



08-20-1786 Exhaust pipe investigation Pba Kris 01312013.pdf



08-20-1787_b.pdf 08-20-1786_c.pdf NCR02330 Exhaust Pipe.Ink



NCR02330_Matrix.Ink



_ Cummins ISX Exhaust Bellows - Containment plan for Pembina.pdf



08-20-1786 install 02-05-13.pdf



12737 exhaust pipe a.JPG 12737 exhaust b.JPG



ISX-Exhaust pipe support bracket (longer).jpg



Tru-Flex Failed Part Review - Ritz Machine RMA 5115.pdf



Audit 27459_08-20-1786_Rev C.pdf

From: Adam Teeter [mailto:ritzm@ritzmachine.com]



08-20-1786 FAILURE.pdf

Table issued by JP in Email: 02/04/2013 11:15 AM

Unit	Failur	Mileag	On Pba	Off Prep
12637	Y	68811	6-Feb-12	7-Mar-12
12692	Y	21311	10-Apr-12	10-May-12
12693	Y	27725	11-Apr-12	10-May-12
12695	Y	24547	12-Apr-12	15-May-12
12697	Y	27211	17-Apr-12	16-May-12
12728	Y	25578	22-May-12	21-Jun-12
12729	Y	26078	23-May-12	25-Jun-12
12737	Y	14445	4-Jun-12	2-Jul-12



08-20-1786 vin list 4feb13.xlsx proc 8-30.pdf IMAG0379.jpg IMAG0380.jpg

[Access Control Section](#)

[Edit History](#)

RQ17-007

MCI

12-27-2017

REQUEST 8

MCI RESPONSE TO ODI

RQ17-007

IMG_0033



RQ17-007

MCI

12-27-2017

REQUEST 8

MCI RESPONSE TO ODI

RQ17-007

ISX Report

Subject: ISX Exhaust Installation Review

Meeting date: Feb 8, 2013

Actions:

DPF to turbo relation was qualified in sample coach using RITZ manufactured tool. Production sample of part #08-20-1786 was installed next and found to fit properly. A demonstration was performed to duplicate a part that would have been rotated away from its neutral position and installed. This rotation produced a similar deformation of the bellows that was found in the failed parts.

Findings:

Based on reports from Truflex on the failure analysis and our discussions with MCI staff, it appears that the root cause of failures is from a misalignment of the assembly most likely upon installation that exceeds the design limits of the bellows. This misalignment will come in the form of a rotational deviation from true position or a possible problem with the DPF/turbo location.

Installation Recommendations:

Qualify DPF/turbo relation with tool. Tool supplied by RITZ has been inspected and forwarded to Kris in Pembina to qualify all current coach builds.

Install exhaust without blanket and inspect for straightness according to Truflex guidelines. Re-install blanket and re-assemble ensuring rotational marks are still lined up. Blanket is difficult to install after assembly but it is determined that it can at least stay partially opened for maximum visibility.

Install exhaust in sequence so bracket does not affect position of bellows. This should be attached last once the bellows is determined to be straight.

Field Inspection Recommendations:

Any failed exhaust must have the DPF/turbo relationship checked. Once this is qualified, a replacement part can be installed using the installation guidelines suggested above and to be further developed in cooperation with MCI and Truflex. All other coaches should be subject to a periodic maintenance check that would involve an inspection of the bellows condition. All suspicious assemblies should have the bellows assembly removed, visually inspected and pressure tested as all failures will not be visible as seen with one of the returned parts.

Other Recommendations:

Need to:

- Establish documented installation instructions and distribute to production and spare parts.
- Re-design mating bracket (in process by MCI).
- Supply tool to all installers to check DPF/turbo location.
- Revise drawing to reflect current geometry.
- Study re-design of part and consider alternate bellows with liner. The lined bellows adds a 2nd level of containment in the event of a bellows failure.

RQ17-007

MCI

12-27-2017

REQUEST 8

MCI RESPONSE TO ODI

RQ17-007

PBA flex pipe check

Unit number	CUSTOMER NAME	Coach Model	Eng Type	DPF flex pipe inspected after rework		Date
				Production Inspector	Inspector	
12797	NY DOC	D40ISTV	ISX 425			
12798	NY DOC	D40ISTV	ISX 425			
12799	NY DOC	D40ISTV	ISX 425			
12800	NY DOC	D40ISTV	ISX 425			
12801	NY DOC	D40ISTV	ISX 425			
12802	NY DOC	D40ISTV	ISX 425			
12803	NY DOC	D40ISTV	ISX 425			
12804	NY DOC	D40ISTV	ISX 425			
12805	NY DOC	D40ISTV	ISX 425			
12806	NY DOC	D40ISTV	ISX 425			
12807	NY DOC	D40ISTV	ISX 425			
12808	NY DOC	D40ISTV	ISX 425			
12809	NY DOC	D40ISTV	ISX 425			
12810	NY DOC	D40ISTV	ISX 425	2084	QA	2-20-13
12811	NY DOC	D40ISTV	ISX 425	2084	QA	2-25-13
12812	NY DOC	D40ISTV	ISX 425			
12813	NY DOC	D40ISTV	ISX 425			
12845	DENVER RTD PILOT	D4500	ISX 425			
12913	GSA - VA DALLAS	D4005	ISX 425			
12914	GSA - VA DALLAS	D4005	ISX 425			
12920	ENGINEERING COACH D13-01	D4505	ISX 425	Engr'ng team in WPG		2/8/2013
12930	DENVER RTD	D4500	ISX 425	2084	QA	2/20/13
12931	DENVER RTD	D4500	ISX 425	2084	QA30	2/14/13
12932	DENVER RTD	D4500	ISX 425	2084	QA62	2/21/13
12933	DENVER RTD	D4500	ISX 425	Mike S/H Gearge M, Inspectors		2/13/2013
12934	DENVER RTD	D4500	ISX 425	2084	QA62	2-25-13
12935	DENVER RTD	D4500	ISX 425	2084	QA64	2-26-13
12936	DENVER RTD	D4500	ISX 425	2084	QA62	2-27-13
12937	DENVER RTD	D4500	ISX 425			
12938	DENVER RTD	D4500	ISX 425	2084	QA64	2-22-13
12939	DENVER RTD	D4500	ISX 425	2084	QA64	2-22-13
12940	DENVER RTD	D4500	ISX 425			
12941	DENVER RTD	D4500	ISX 425			
12942	DENVER RTD	D4500	ISX 425			
12912	GSA- US AIR FORCE ACADEMY	D4505	ISX 425			
12943	DENVER RTD	D4500	ISX 425			
12944	DENVER RTD	D4500	ISX 425			
12945	DENVER RTD	D4500	ISX 425			
12946	DENVER RTD	D4500	ISX 425			
12947	DENVER RTD	D4500	ISX 425			
12948	DENVER RTD	D4500	ISX 425			

RQ17-007

MCI

12-27-2017

REQUEST 8

MCI RESPONSE TO ODI

RQ17-007

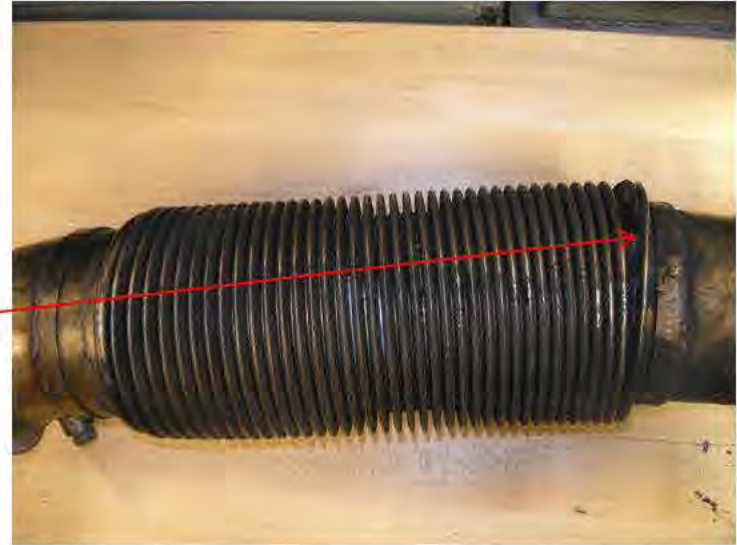
Ritz Machine RMA 5115

Ritz Machine – RMA 5115

Two parts returned for review.

Part #1 – showed signs of a large installation misalignment. Appears to have been on the order of 1" to 1.5". This bellows failed at the outlet end of the bellows and had completely separated.

The misalignment on Part#1 indicates that more bending was occurring from the misalignment at the outlet end. It also appears from the amount of soot on this part that it is possible that it ran for a period of time before it was detected.



Part #2 – also showed signs of a large installation misalignment. This appears to have been on the order of approximately 1.5" to 2". The failure point is at the inlet end of the bellows, in the valley between the first and second corrugations. There were two cracks found, each 180° opposed. One on the inside of the bend and one on the outside of the bend.

The misalignment on Part#2 shows more deformation from misalignment on the inlet end than the outlet end. This is why there are two different failure modes between Part #1 and Part #2



Part #1



Note amount of deformation in second corrugation.

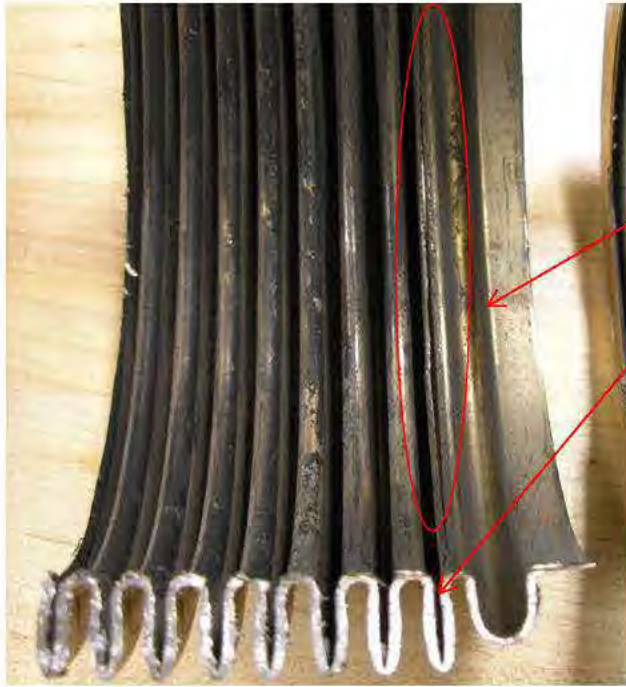
Section from inside of bend at outlet end. Crack propagated around entire circumference.

Wear area on bellows is most likely from post-failure contact with the exhaust tube.

Section from outside of bend at outlet end. Crack propagated around entire circumference.



Part #2



Cracking on
inside of bend at
inlet.
Note amount of
compression in
second
corrugation.



Cracking on
outside of bend.



There were no indications of contact
or wear between the torsional sleeve
And the bellows. This is further
indication that the failure was purely
fatigue from misalignment and
motion.



Conclusions

- Both of the returned parts failed from a large amount of installation misalignment. This caused stress on the end corrugations. The failures occurred between the first and second corrugations. This is normal as this is the first point at which the bellows can move. The stress from the misalignment combined with the motion/vibration resulted in premature failure.
- Part # 1 showed more deformation on the outlet end of the bellows. It also appears to have ran for a period of time post-failure and resulted in the crack propagating into the third corrugation as well as wearing on the exhaust tube.
- Part #2 showed more deformation at the inlet end than Part #1 did. This resulted in two cracks between the first and second corrugations. These cracks appear to have started at the inside and the outside of the bend and then propagated around until the nearly met.

Recommendations

- The installation alignment needs to be improved.
- Tru-Flex has send photos of an installation tool to Ritz for reference.
- Ritz and MCI should work on completing the design information sheet to capture more information about the application.
- Tru-Flex to participate as needed if alternate designs are needed.

RQ17-007

MCI

12-27-2017

REQUEST 8

MCI RESPONSE TO ODI

RQ17-007

Ritz report - Wpg visit 02-08-
2013

Subject: ISX Exhaust Installation Review

Meeting date: Feb 8, 2013

Actions:

DPF to turbo relation was qualified in sample coach using RITZ manufactured tool. Production sample of part #08-20-1786 was installed next and found to fit properly. A demonstration was performed to duplicate a part that would have been rotated away from its neutral position and installed. This rotation produced a similar deformation of the bellows that was found in the failed parts.

Findings:

Based on reports from Truflex on the failure analysis and our discussions with MCI staff, it appears that the root cause of failures is from a misalignment of the assembly most likely upon installation that exceeds the design limits of the bellows. This misalignment will come in the form of a rotational deviation from true position or a possible problem with the DPF/turbo location.

Installation Recommendations:

Qualify DPF/turbo relation with tool. Tool supplied by RITZ has been inspected and forwarded to Kris in Pembina to qualify all current coach builds.

Install exhaust without blanket and inspect for straightness according to Truflex guidelines. Re-install blanket and re-assemble ensuring rotational marks are still lined up. Blanket is difficult to install after assembly but it is determined that it can at least stay partially opened for maximum visibility.

Install exhaust in sequence so bracket does not affect position of bellows. This should be attached last once the bellows is determined to be straight.

Field Inspection Recommendations:

Any failed exhaust must have the DPF/turbo relationship checked. Once this is qualified, a replacement part can be installed using the installation guidelines suggested above and to be further developed in cooperation with MCI and Truflex. All other coaches should be subject to a periodic maintenance check that would involve an inspection of the bellows condition. All suspicious assemblies should have the bellows assembly removed, visually inspected and pressure tested as all failures will not be visible as seen with one of the returned parts.

Other Recommendations:

Need to:

- Establish documented installation instructions and distribute to production and spare parts.
- Re-design mating bracket (in process by MCI).
- Supply tool to all installers to check DPF/turbo location.
- Revise drawing to reflect current geometry.
- Study re-design of part and consider alternate bellows with liner. The lined bellows adds a 2nd level of containment in the event of a bellows failure.

RQ17-007

MCI

12-27-2017

REQUEST 8

MCI RESPONSE TO ODI

RQ17-007

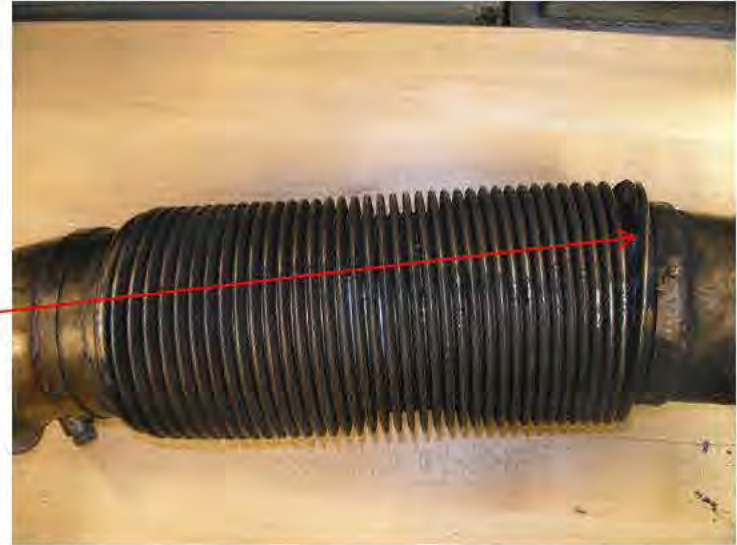
Tru-Flex Failed Part Review -
Ritz Machine RMA 5115

Ritz Machine – RMA 5115

Two parts returned for review.

Part #1 – showed signs of a large installation misalignment. Appears to have been on the order of 1" to 1.5". This bellows failed at the outlet end of the bellows and had completely separated.

The misalignment on Part#1 indicates that more bending was occurring from the misalignment at the outlet end. It also appears from the amount of soot on this part that it is possible that it ran for a period of time before it was detected.



Part #2 – also showed signs of a large installation misalignment. This appears to have been on the order of approximately 1.5" to 2". The failure point is at the inlet end of the bellows, in the valley between the first and second corrugations. There were two cracks found, each 180° opposed. One on the inside of the bend and one on the outside of the bend.

The misalignment on Part#2 shows more deformation from misalignment on the inlet end than the outlet end. This is why there are two different failure modes between Part #1 and Part #2



Part #1

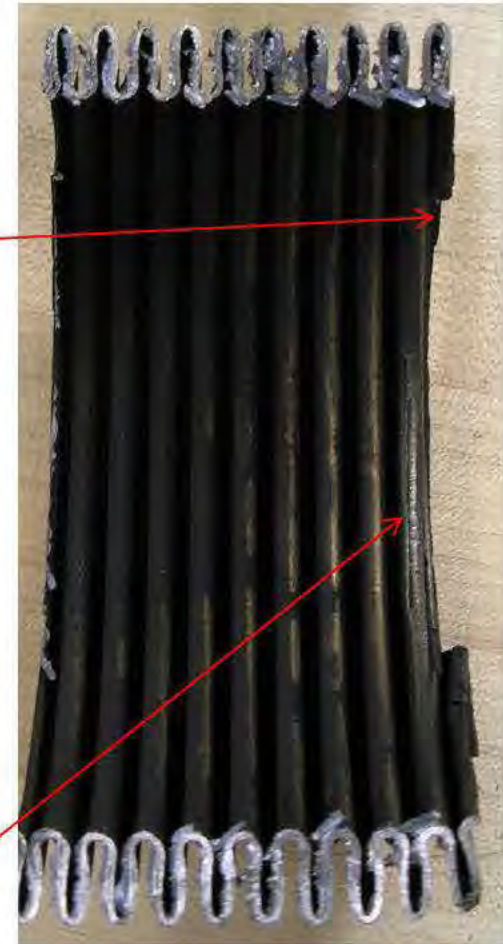


Note amount of deformation in second corrugation.

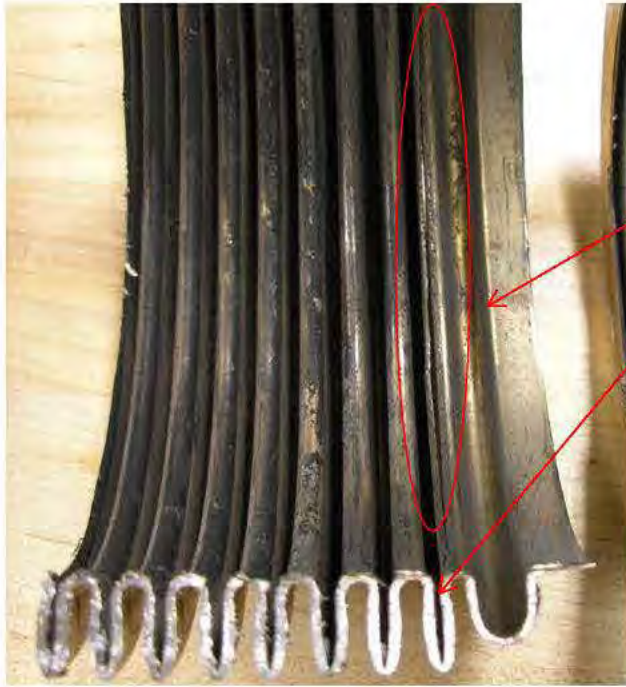
Section from inside of bend at outlet end. Crack propagated around entire circumference.

Wear area on bellows is most likely from post-failure contact with the exhaust tube.

Section from outside of bend at outlet end. Crack propagated around entire circumference.



Part #2



Cracking on
inside of bend at
inlet.
Note amount of
compression in
second
corrugation.



Cracking on
outside of bend.



There were no indications of contact
or wear between the torsional sleeve
And the bellows. This is further
indication that the failure was purely
fatigue from misalignment and
motion.



Conclusions

- Both of the returned parts failed from a large amount of installation misalignment. This caused stress on the end corrugations. The failures occurred between the first and second corrugations. This is normal as this is the first point at which the bellows can move. The stress from the misalignment combined with the motion/vibration resulted in premature failure.
- Part # 1 showed more deformation on the outlet end of the bellows. It also appears to have ran for a period of time post-failure and resulted in the crack propagating into the third corrugation as well as wearing on the exhaust tube.
- Part #2 showed more deformation at the inlet end than Part #1 did. This resulted in two cracks between the first and second corrugations. These cracks appear to have started at the inside and the outside of the bend and then propagated around until the nearly met.

Recommendations

- The installation alignment needs to be improved.
- Tru-Flex has send photos of an installation tool to Ritz for reference.
- Ritz and MCI should work on completing the design information sheet to capture more information about the application.
- Tru-Flex to participate as needed if alternate designs are needed.