Biorid Pelvis & Jacket Corridor Development

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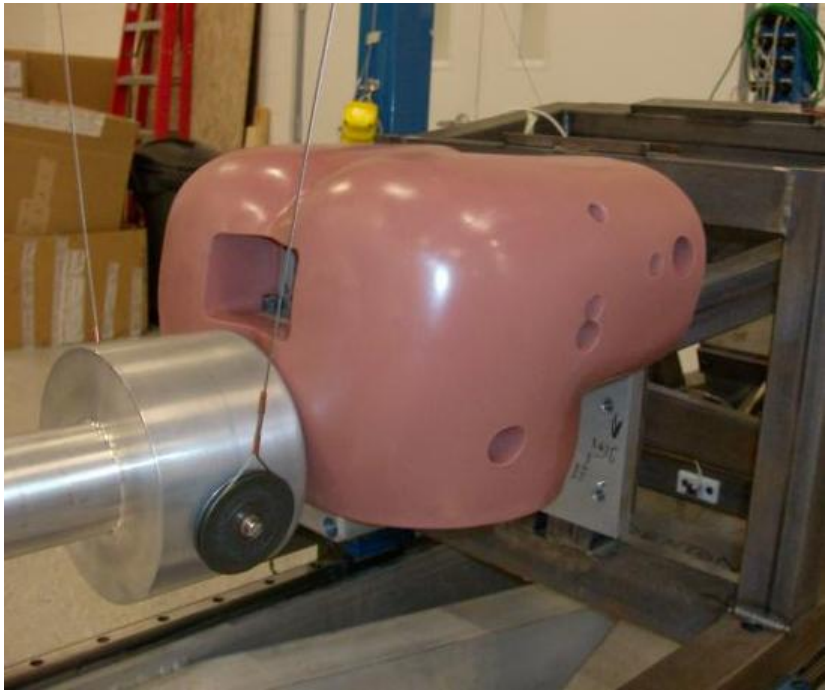
Pelvis Impact



BioRID Pelvis test Corridor

- Develop corridor around the 4 baseline pelvis' used in the BAST seat test study.
- Test each pelvis by impacting on the back of pelvis
- Test each pelvis by impacting on the bottom of pelvis
- Will these corridors indicate differences between the (4) original pelvis'?
- Compare corridor to current production

BioRID Pelvis test Corridor

- Collected data from Humanetics Huron prior to shipping to BAST, repeat tests from BAST, post tests from Humanetics Heidelberg and post tests from Humanetics Huron.
  - Pelvis Bottom – 30 tests
    - Reduced to 21 after confirmation of difference in test method followed
  - Pelvis Back – 30 tests
    - Reduced to 21 after confirmation of difference in test method followed

BioRID Pelvis Test Corridor

- Statistical analysis was conducted on the each of the parameters collected
- The mean +/- 2 standard deviations was used to create the proposed test corridor.
- Rounded to 3 significant digits

BioRID Test Corridor

Peak Pendulum Force

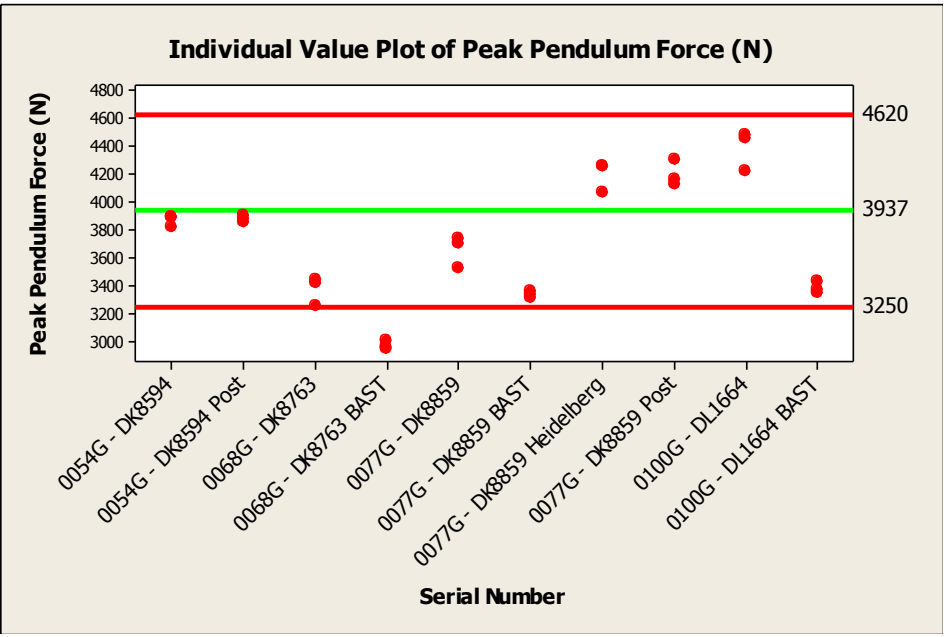
- Pelvis Bottom
  - Mean = 3937 N
  - Standard Deviation = 343 N
  - (17% of Mean)
- Proposed Corridor
  (3250 N – 4620 N)

- Pelvis Back
  - Mean = 2100 N
  - Standard Deviation = 120 N
  - (11.4% of Mean)
- Proposed Corridor
  (1860 N – 2340 N)

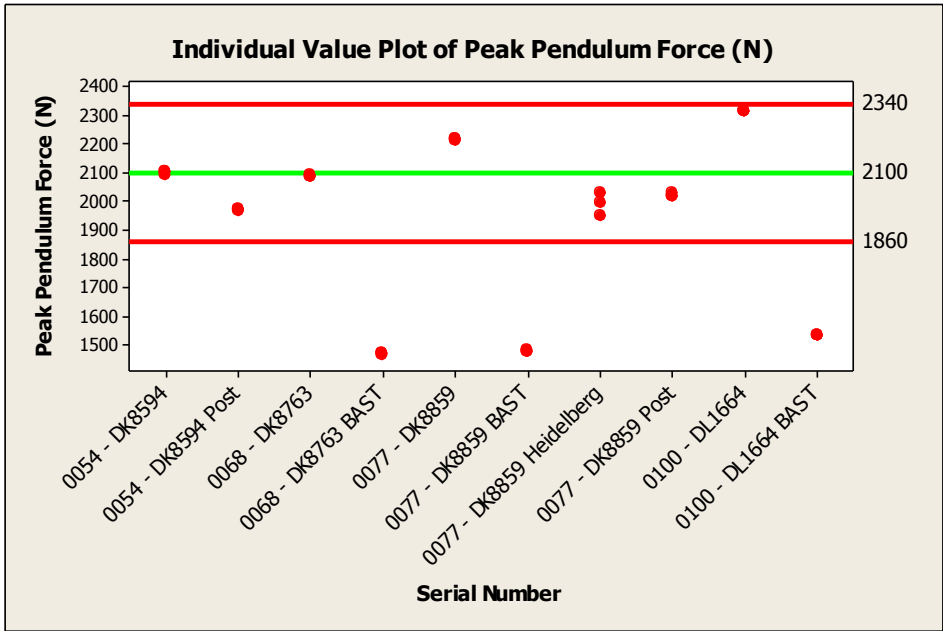
BioRID Test Corridor

Peak Pendulum Force

Pelvis Bottom



Pelvis Back



* BAST data not included in analysis

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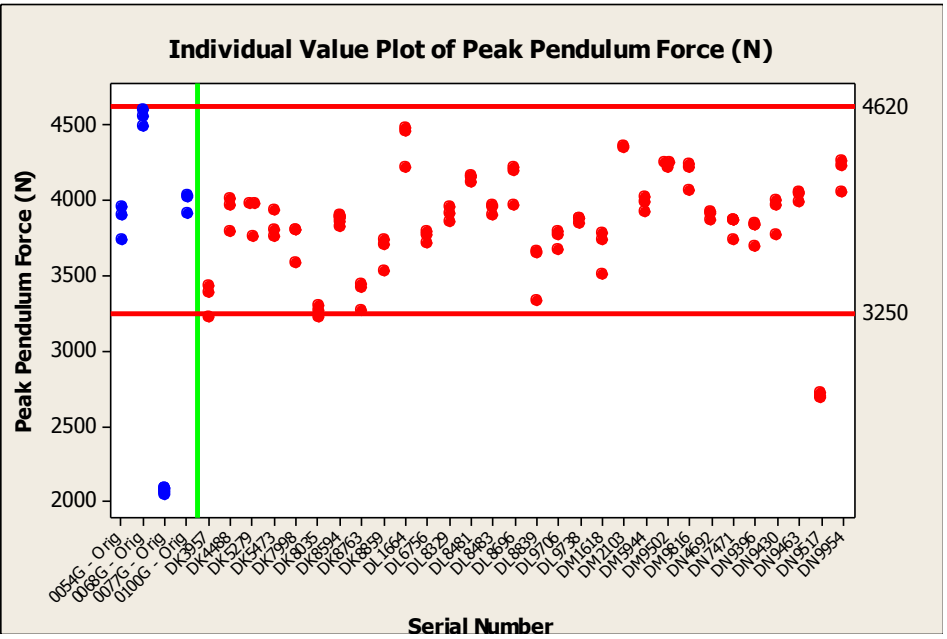
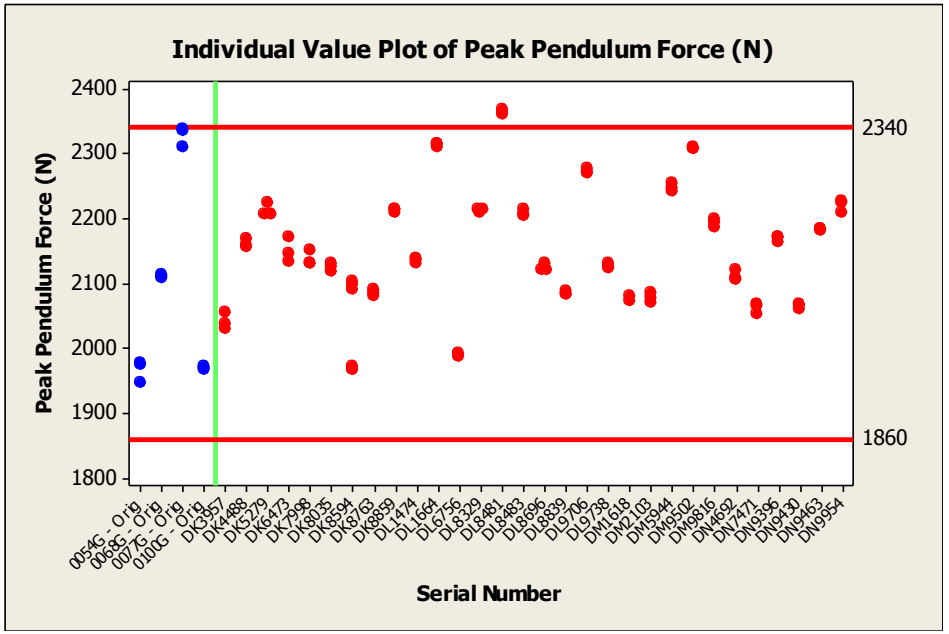
BioRID Test Corridor

Peak Pendulum Force

Pelvis Bottom Population



Pelvis Back Population



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BioRID Test Corridor

Peak Sled Acceleration

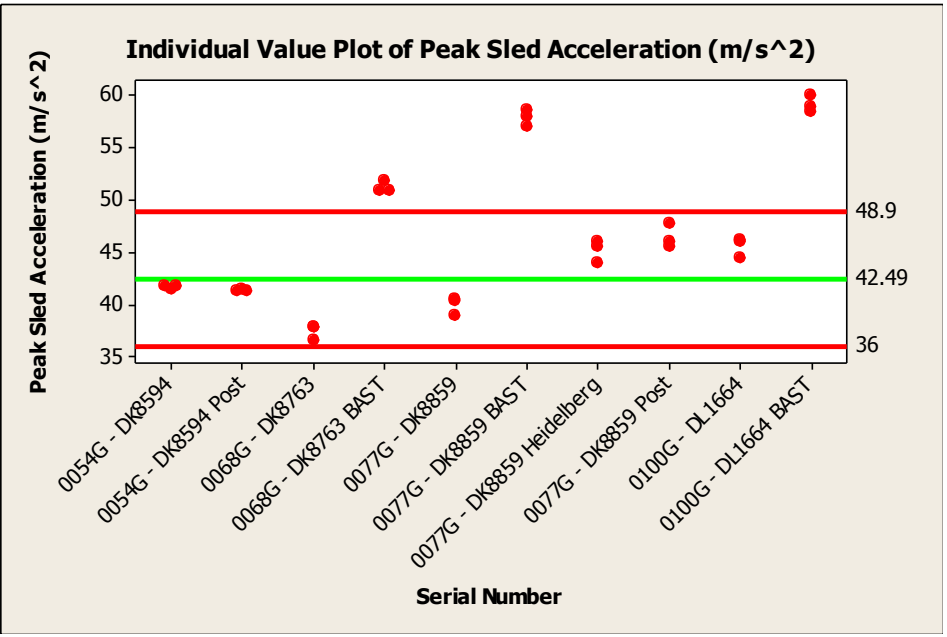
- Pelvis Bottom
  - Mean = 42.49 m/s^2
  - Standard Deviation = 3.228 m/s^2
  - (15.2% of Mean)
- Proposed Corridor
  (48.9 m/s^2 – 36.0 m/s^2)

- Pelvis Back
  - Mean = 23.06 m/s^2
  - Standard Deviation = 1.37 m/s^2
  - (11.9% of Mean)
- Proposed Corridor
  (20.3 m/s^2 – 25.8 m/s^2)

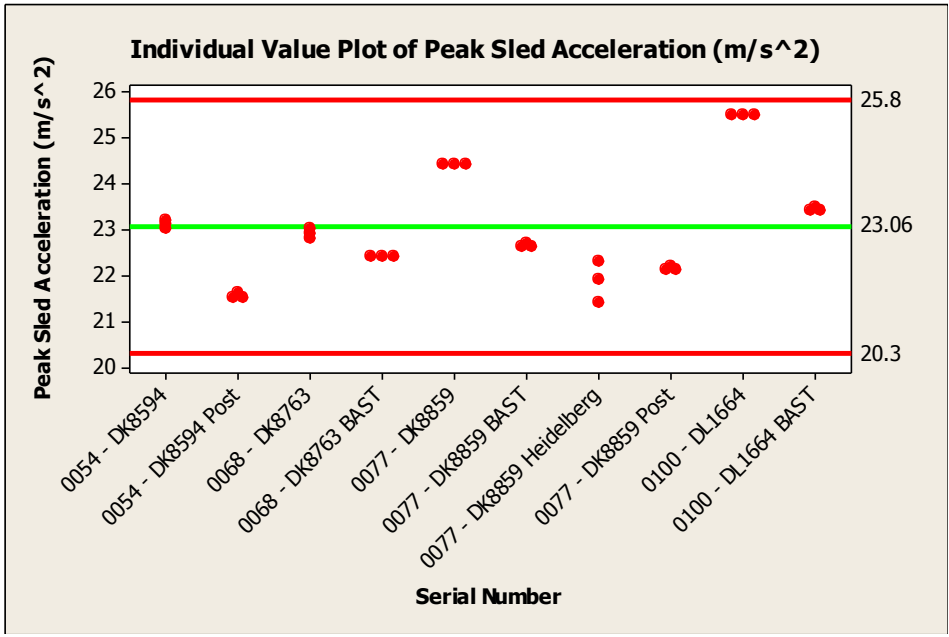
BioRID Test Corridor

Peak Sled Acceleration

Pelvis Bottom



Pelvis Back



* BAST data not included in analysis

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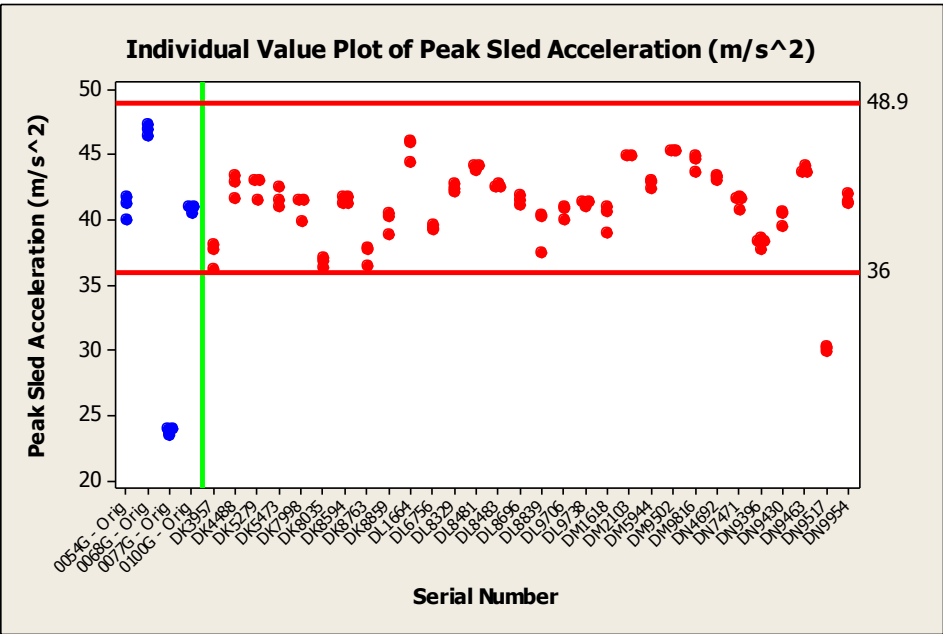
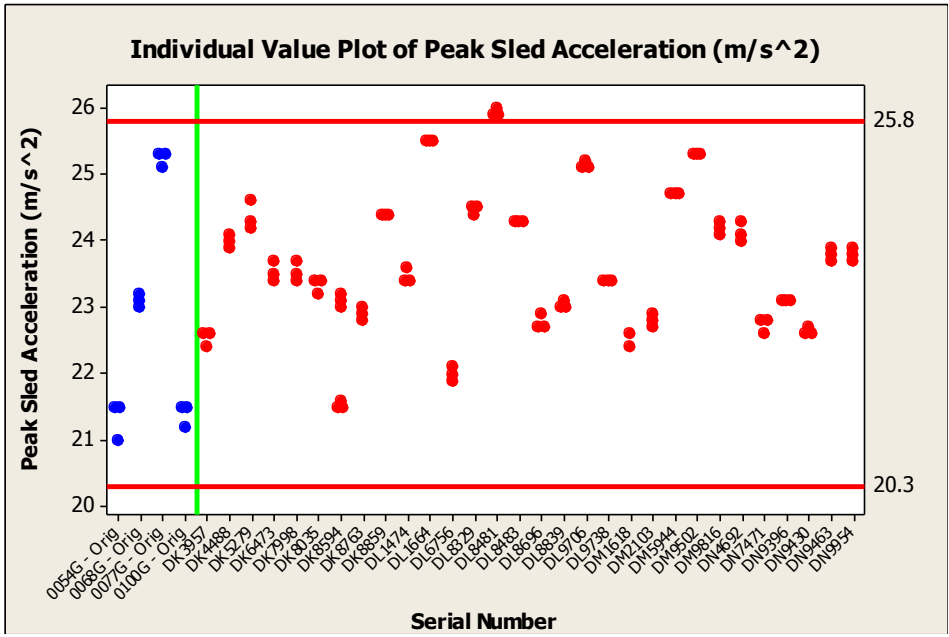
BioRID Test Corridor

Peak Sled Acceleration

Pelvis Bottom Population



Pelvis Back Population



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BioRID Test Corridor

Peak Sled Velocity

- Pelvis Bottom
  - Peak Sled Velocity
    - Mean = 0.350 m/s
    - Standard Deviation = 0.0123 m/s
  - (7.0% of Mean)

- Pelvis Back
  - Pendulum Force
    - Mean = 0.340 m/s
    - Standard Deviation = 0.0107 m/s
    - (6.3% of Mean)

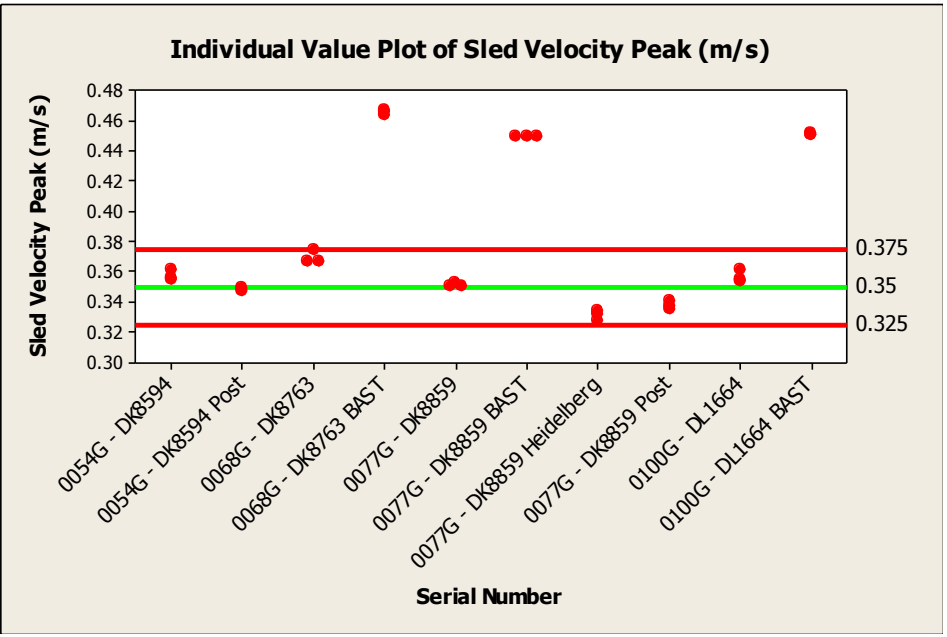
- Proposed Corridor (0.375 m/s – 0.325 m/s)

- Proposed Corridor (0.361 m/s – 0.319 m/s)

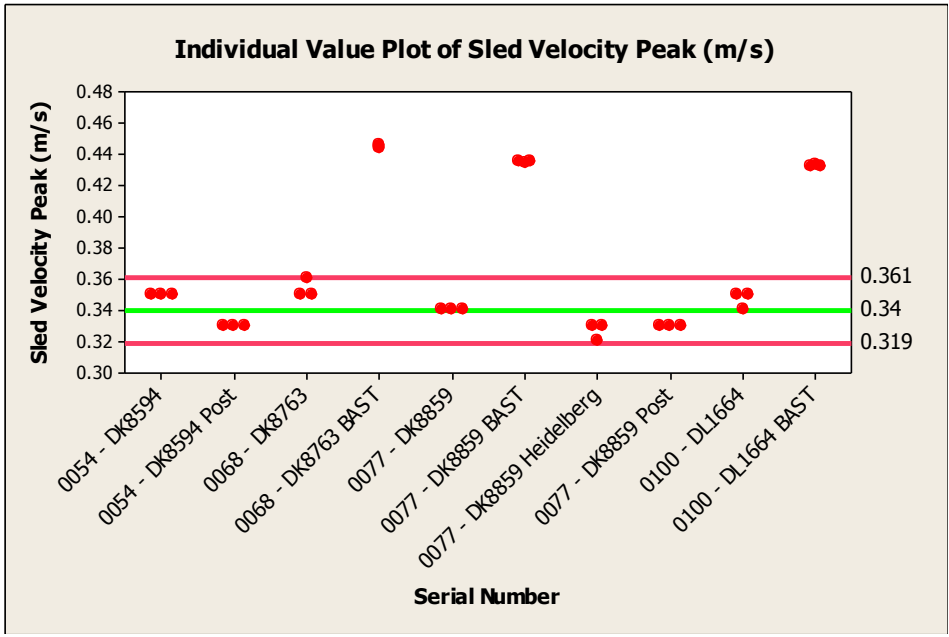
BioRID Test Corridor

Peak Sled Velocity

Pelvis Bottom



Pelvis Back



* BAST data not included in analysis

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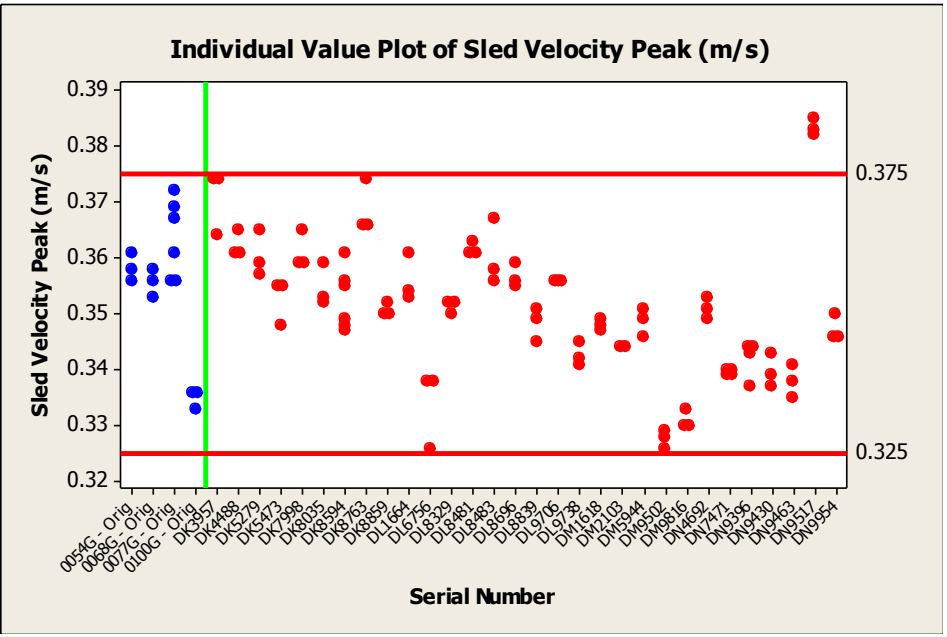
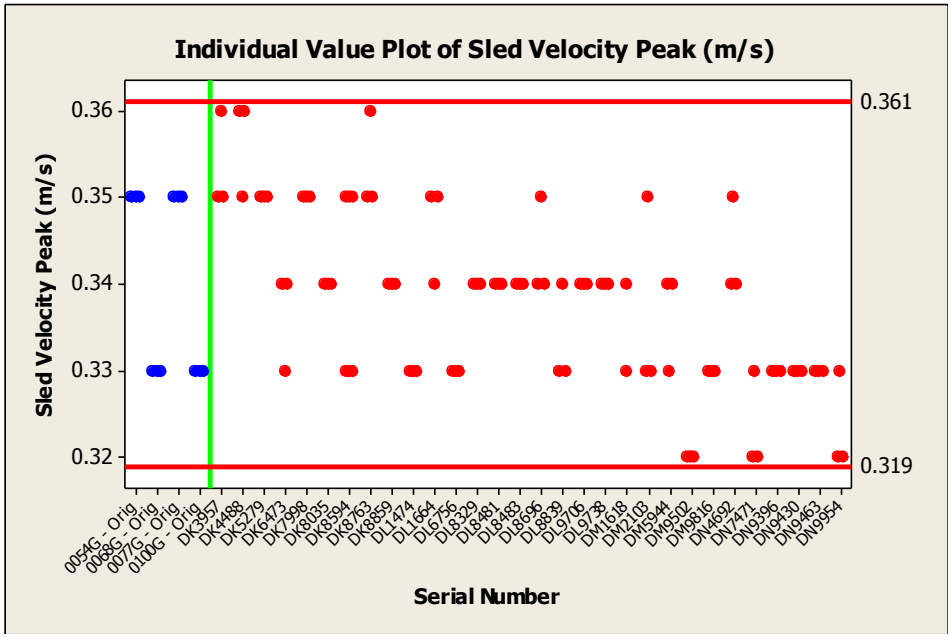
BioRID Test Corridor

Peak Sled Velocity

Pelvis Bottom Population



Pelvis Back Population



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BioRID Test Corridor

Peak Pelvis Compression

- Pelvis Bottom
  - Mean = 18.65 mm
  - Standard Deviation = 0.448 mm
  - (4.8% of Mean)
- Proposed Corridor (17.8 mm – 19.5 mm)

- Pelvis Back
  - Mean = 21.98 mm
  - Standard Deviation = 0.601 mm
  - (5.5% of Mean)
- Proposed Corridor (20.8 mm – 23.2 mm)

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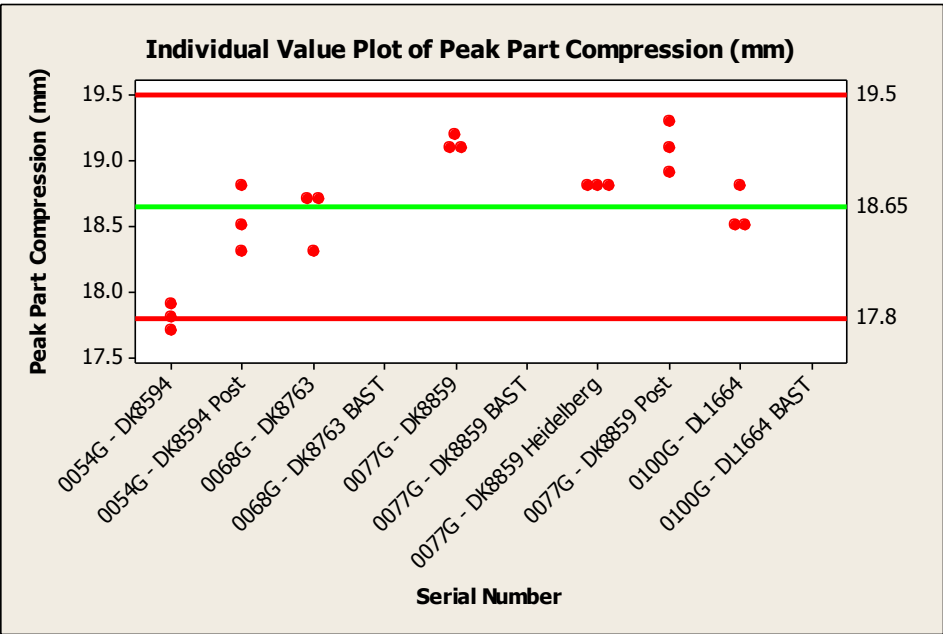
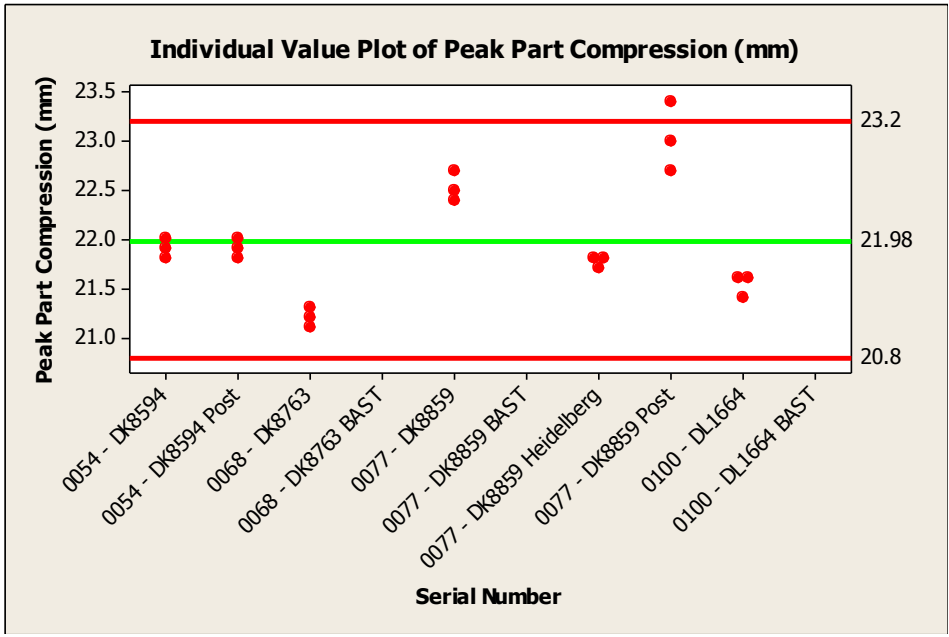
BioRID Test Corridor

Peak Pelvis Compression

Pelvis Bottom



Pelvis Back



* BAST data not included in analysis

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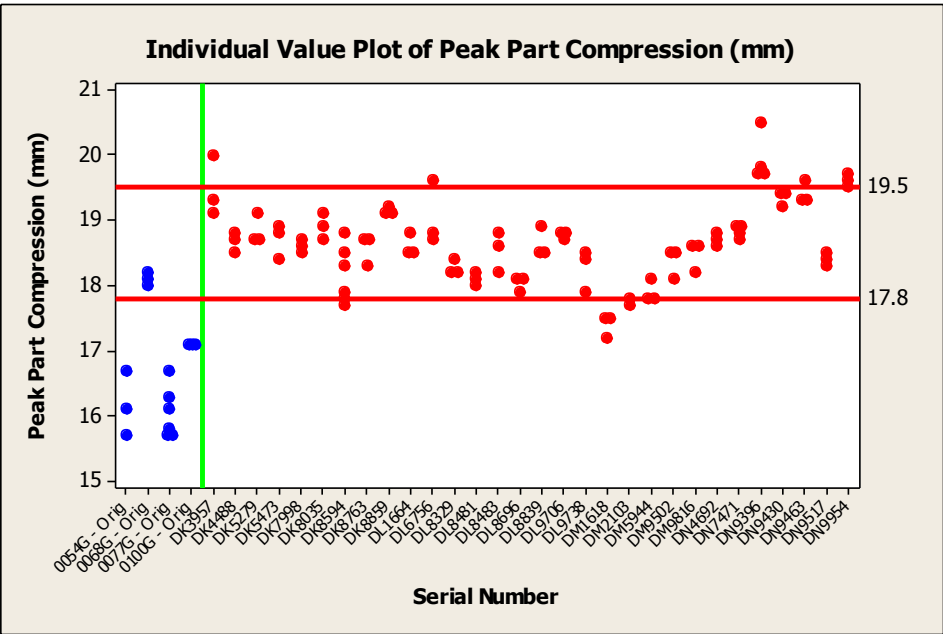
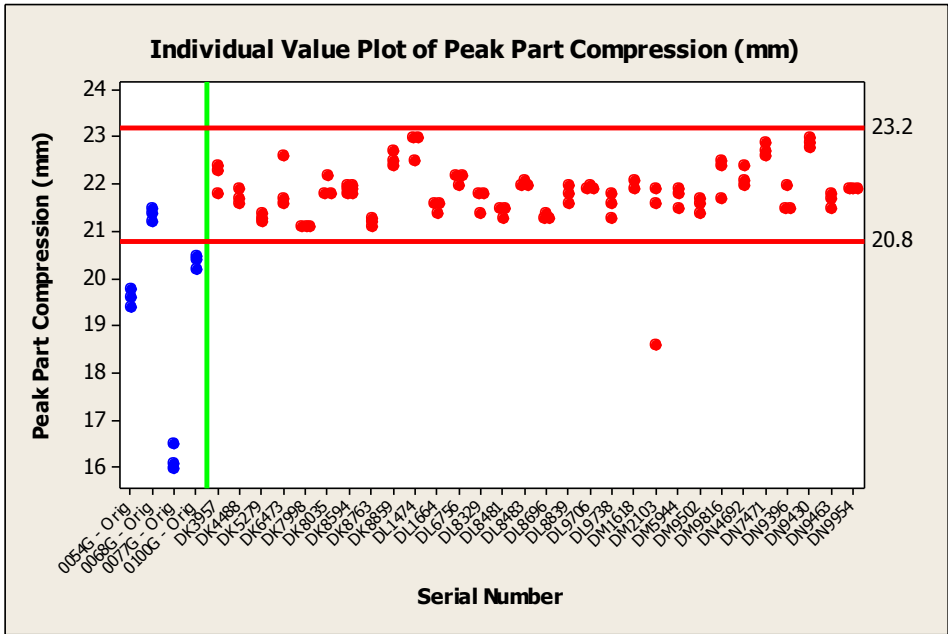
BioRID Test Corridor

Peak Pelvis Compression

Pelvis Bottom Population



Pelvis Back Population



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BioRID Test Lab Comparison

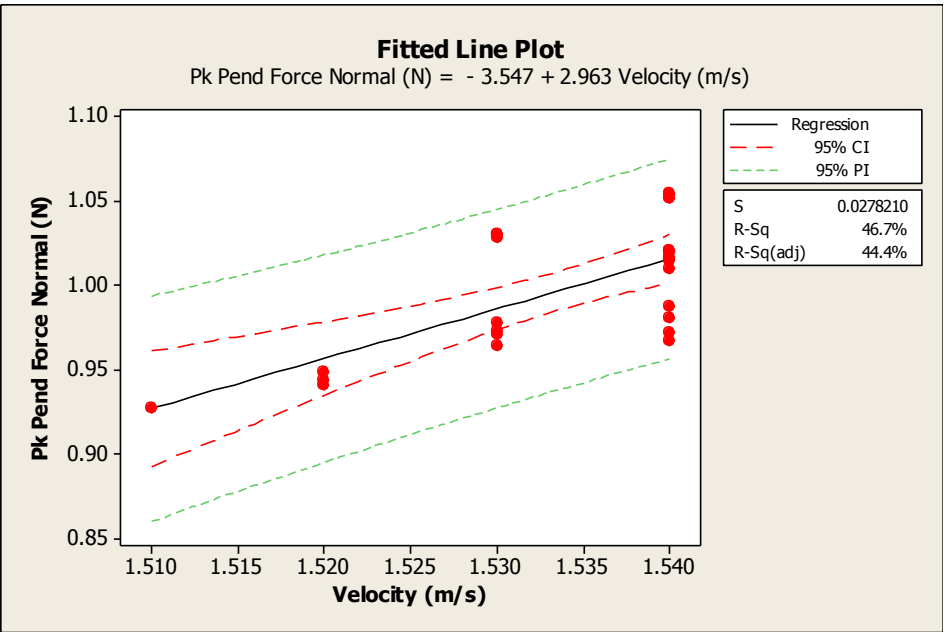
- Normalized test data to remove influence of parts with different means.
  - n divided by the average of all n's in all labs

    n = values for one discrete part (same serial number)
- Look for influence from input velocity and corrected for statistically significant regressions.
- Perform statistical analysis on the normalized ratios

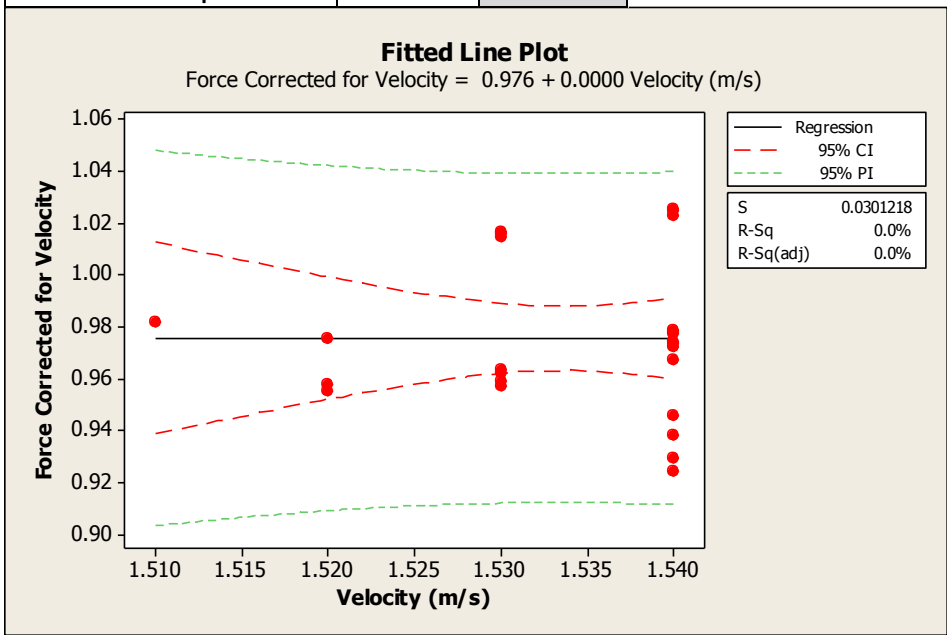
BioRID Test Lab Comparison

Pelvis Back (Pendulum Force vs Velocity)

Regression Analysis and Correction



Regression Summary (Test Parameter vs	P-Value	R-sq(adj)
Pk Pendulum Force	0.000	44.4%
Pk Sled Acceleration	0.971	
Pk Sled Velocity	0.231	
Pk Part Compression	0.502	



Pendulum Force was statistically significant for influence of test velocity in Pelvis Back Impacts

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BioRID Test Lab Comparison

Pelvis Back

2 Sample T-Test

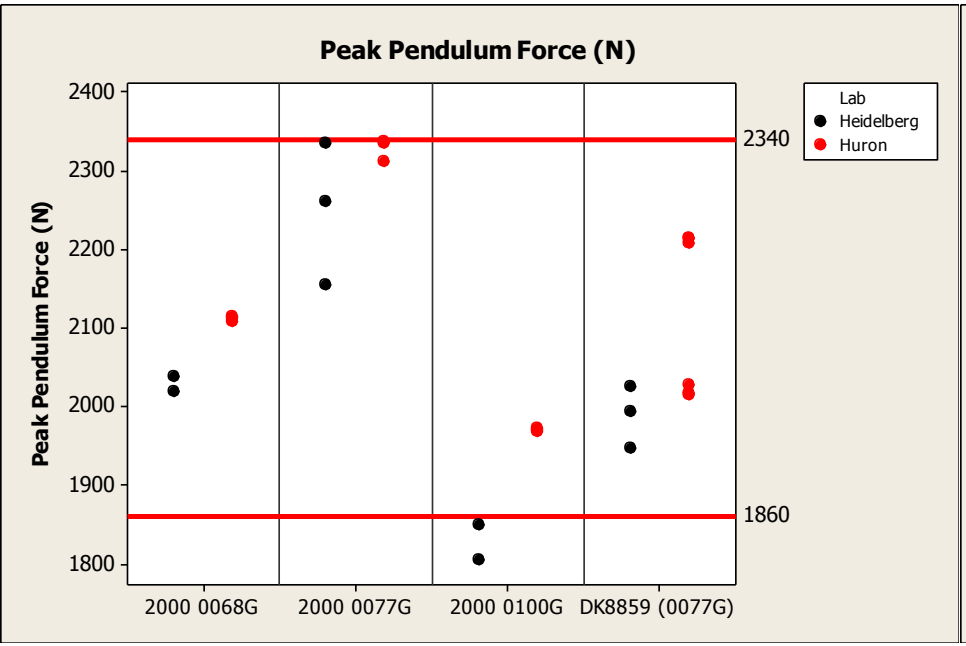
- Analysis indicates a less than 5% of mean difference between labs.

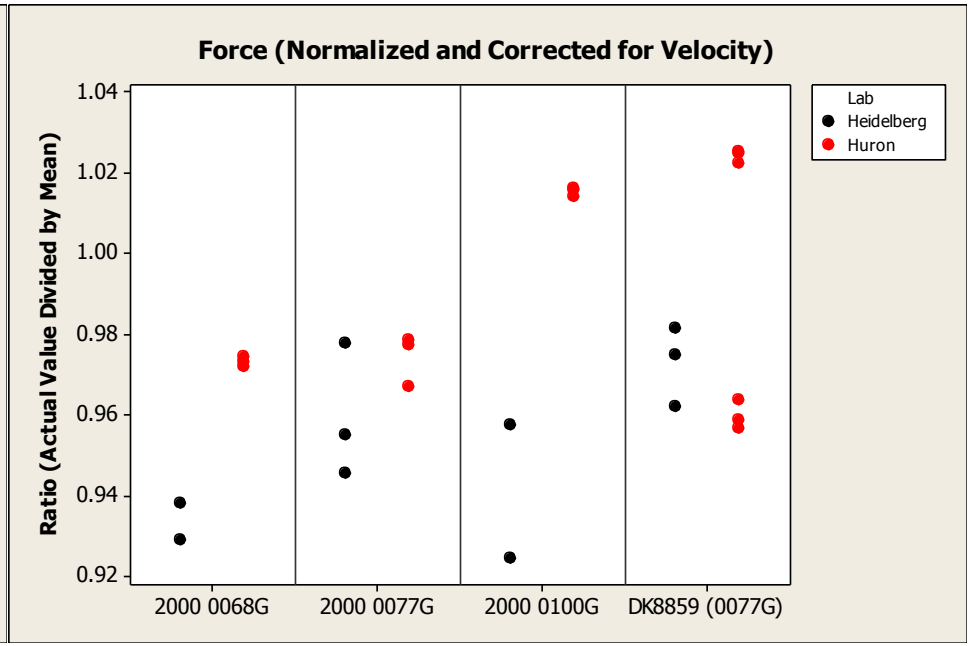
2-Sample T-Test	Mean*		Est of Difference	P-Value	% of Mean
	Heidelberg	Huron			
Pendulum Force	0.9548	0.9896	-0.0348	0.001	-3.64
Sled Acceleration	1.0001	0.9941		0.822	
Sled Velocity	1.0081	0.9933		0.597	
Part Compression	0.9897	1.0121	-0.0224	0.025	-2.26
*Mean is the ratio of the value devided by the average of values for one discrete part					

BioRID Test Lab Comparison

Pelvis Back (Pendulum Force)

Actual and Normalized





Pendulum Force differences is small between Heidelberg and Humanetics Huron test labs for the Pelvis Back impact tests.

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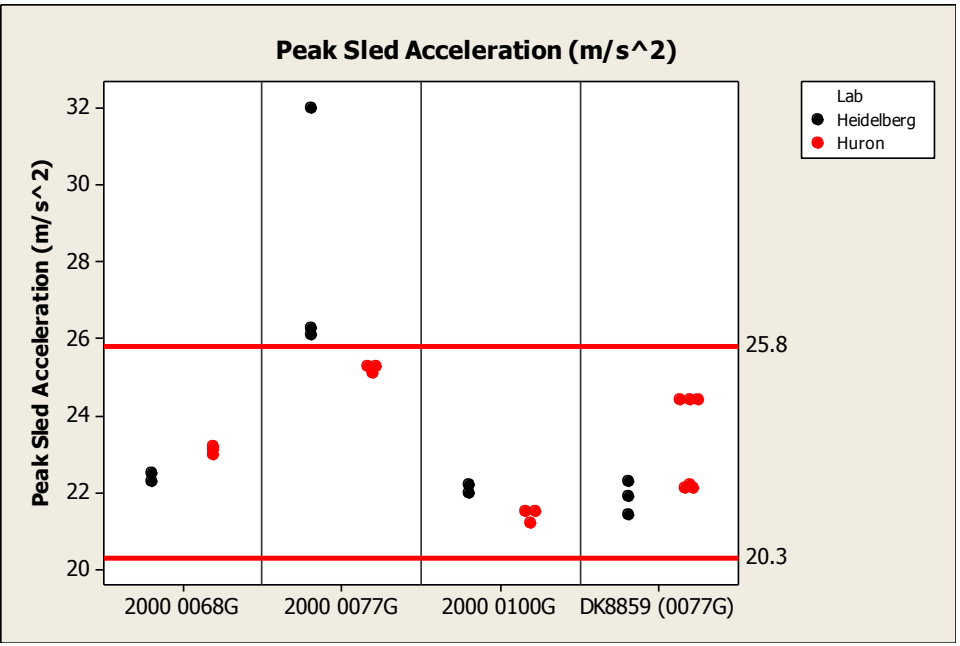
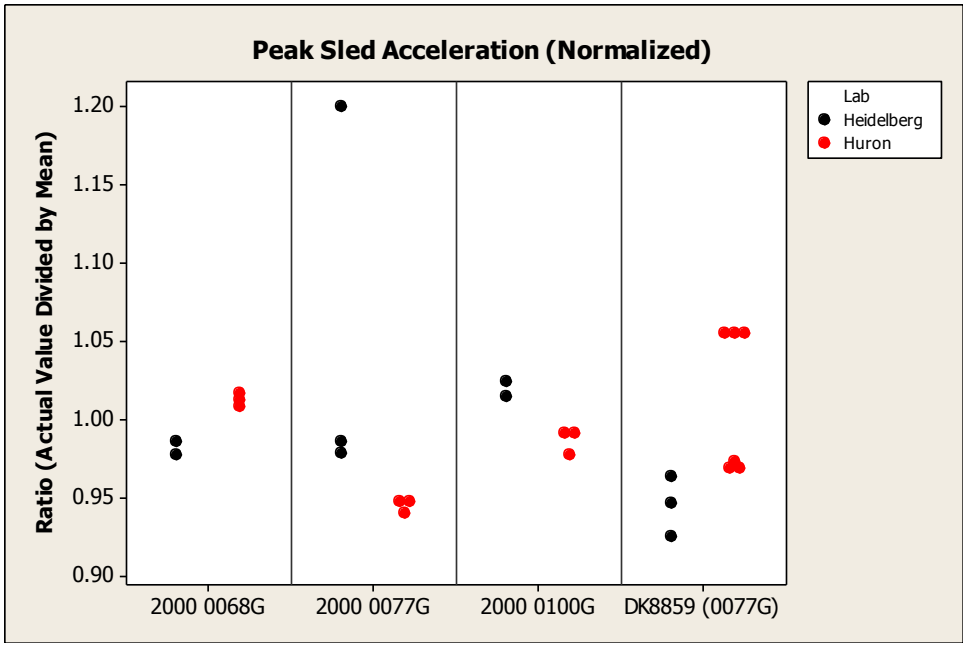
BioRID Test Lab Comparison

Pelvis Back (Sled Acceleration)

Actual and Normalized





There was no statistical difference in Sled Acceleration between Heidelberg and Humanetics Huron test labs in the Pelvis Back Impact tests.

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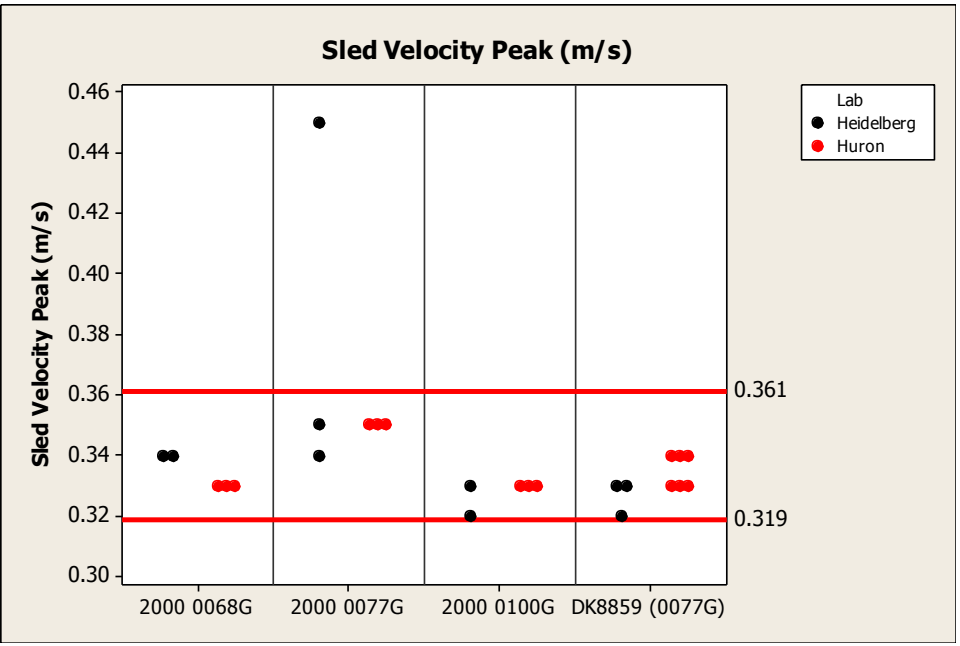
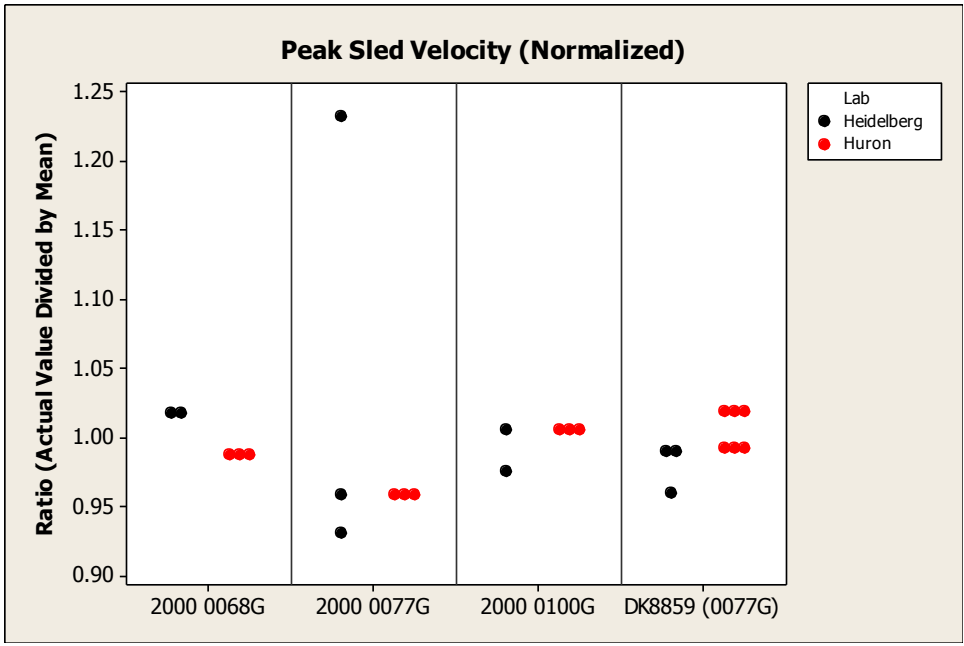
BioRID Test Lab Comparison

Pelvis Back (Sled Velocity)

Actual and Normalized





There was no statistical difference in Sled Velocity between Heidelberg and Humanetics Huron test labs in the Pelvis Back Impact tests.

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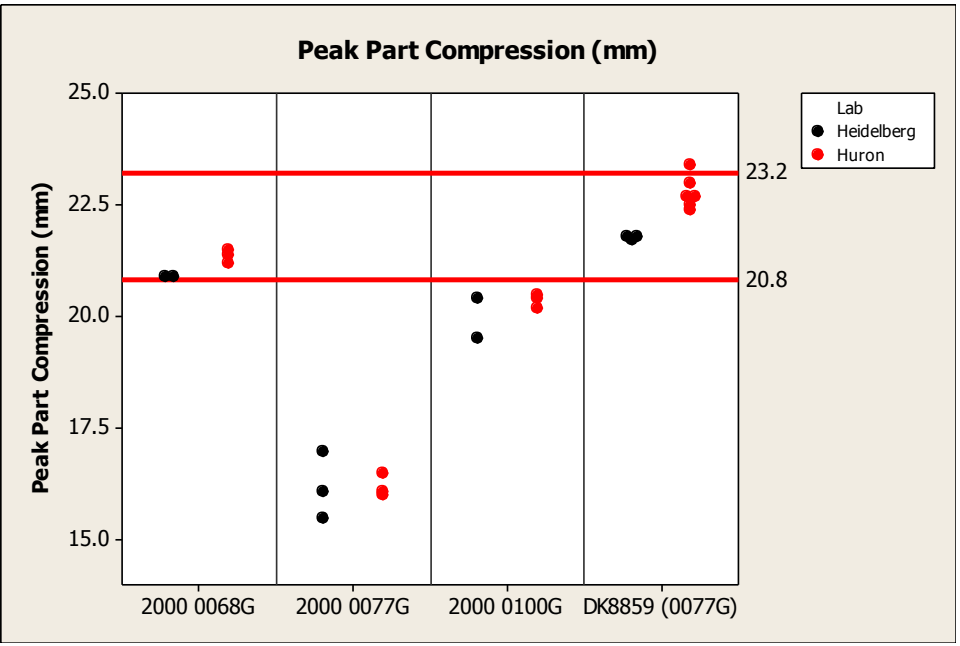
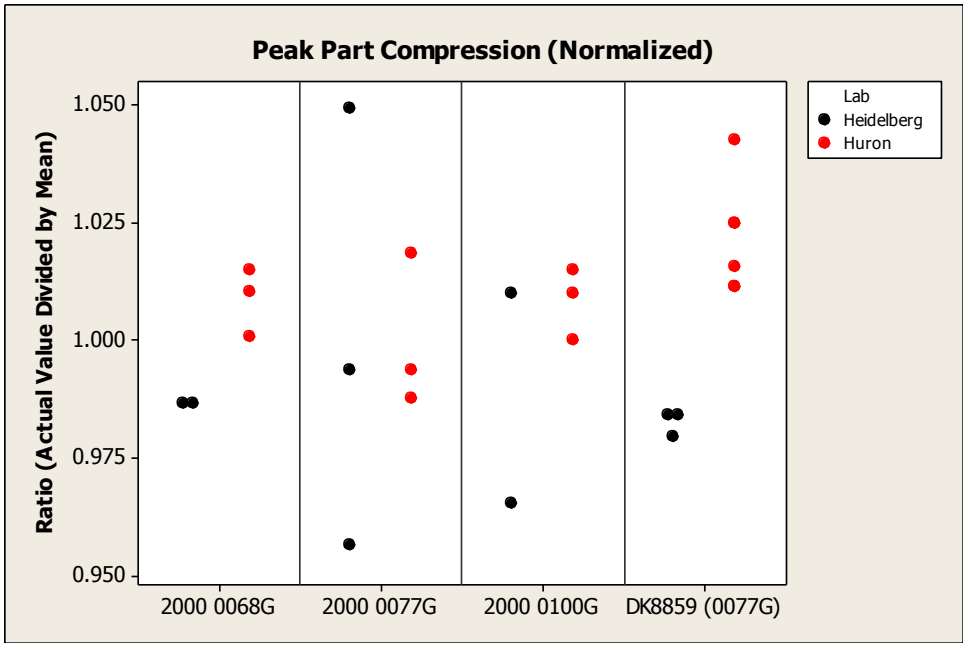
BioRID Test Lab Comparison

Pelvis Back (Part Compression)

Actual and Normalized





There is a small statistical difference in Peak Part Compression between Heidelberg and Humanetics Huron test labs for the Pelvis Back impact tests.

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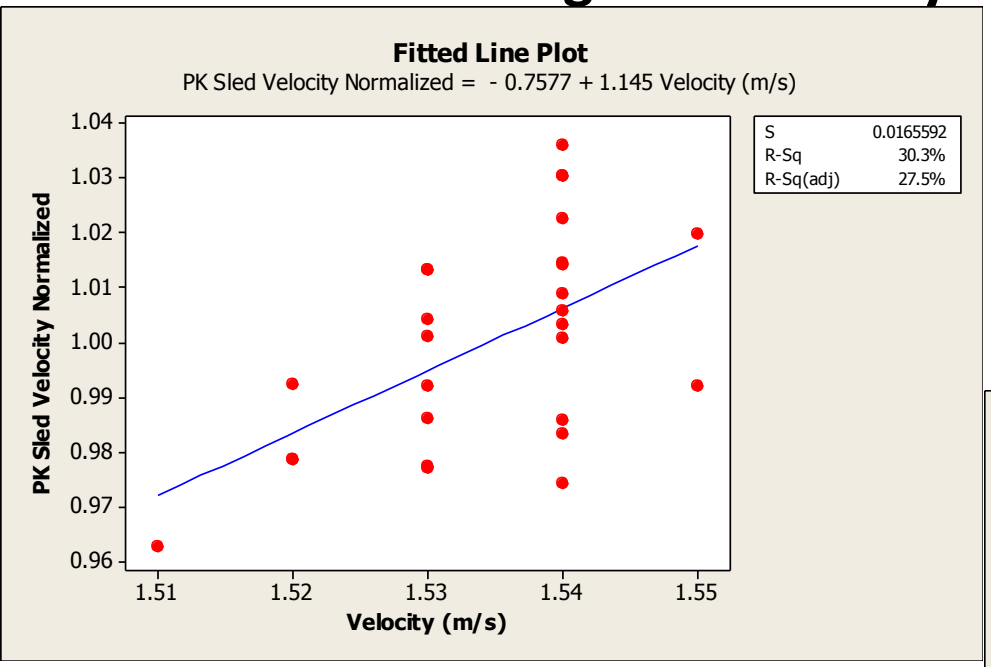
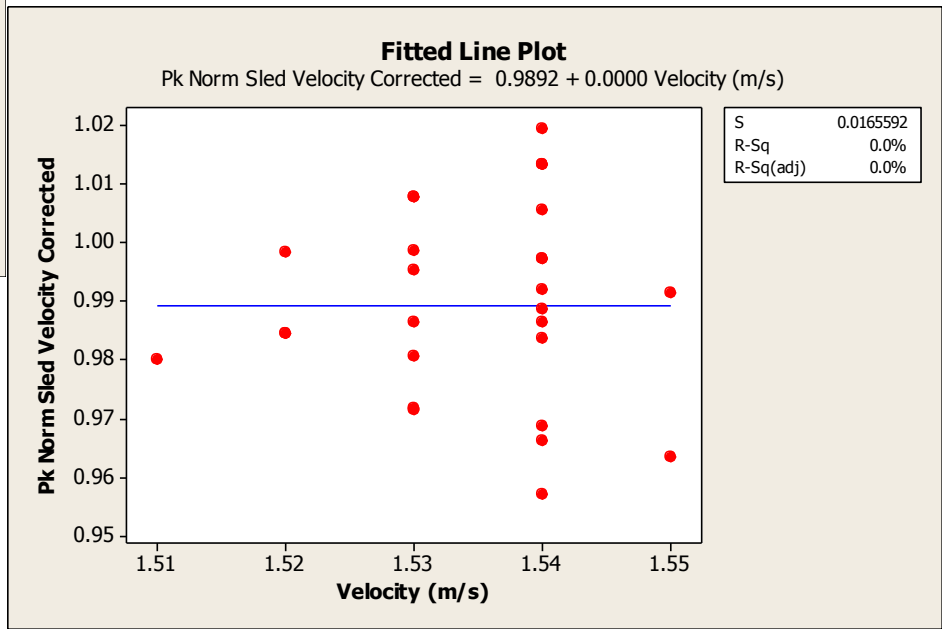
BioRID Test Lab Comparison

Pelvis Bottom (Sled Velocity vs Input Velocity)

Regression Analysis and Correction



Regression Summary (Test Parameter vs	P-Value	R-sq(adj)
Pk Pendulum Force	0.805	
Pk Sled Acceleration	0.994	
Pk Sled Velocity	0.003	27.5%
Pk Part Compression	0.433	



Sled Velocity was statistically significant for influence of test velocity for Pelvis Bottom Impacts

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BioRID Test Lab Comparison

Pelvis Bottom

2 Sample T-Test

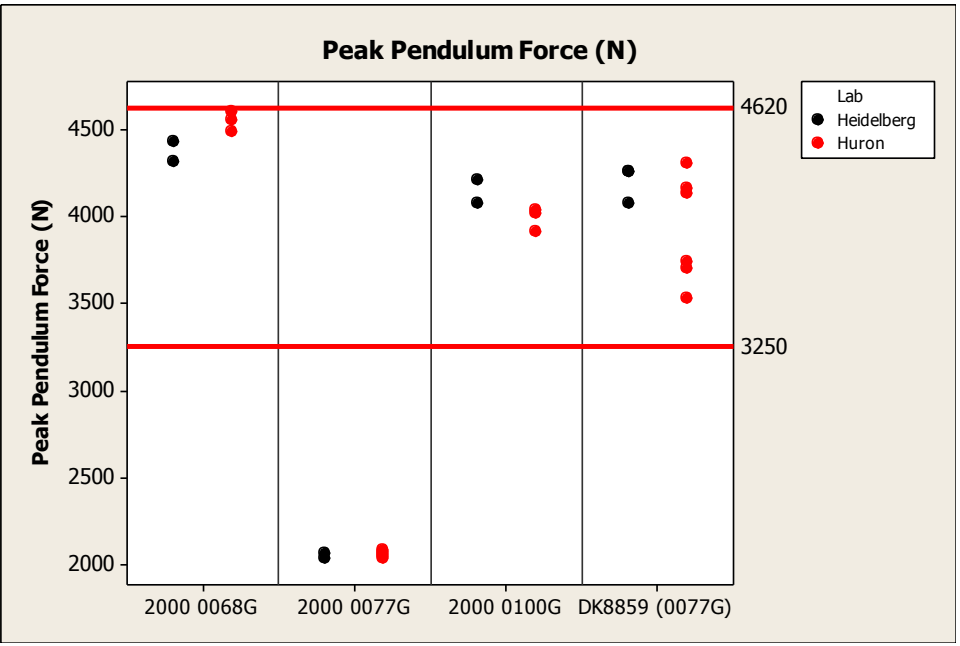
- Analysis indicates a less than 7.5% of mean between labs.
  - Less than 2.3% for any other channel

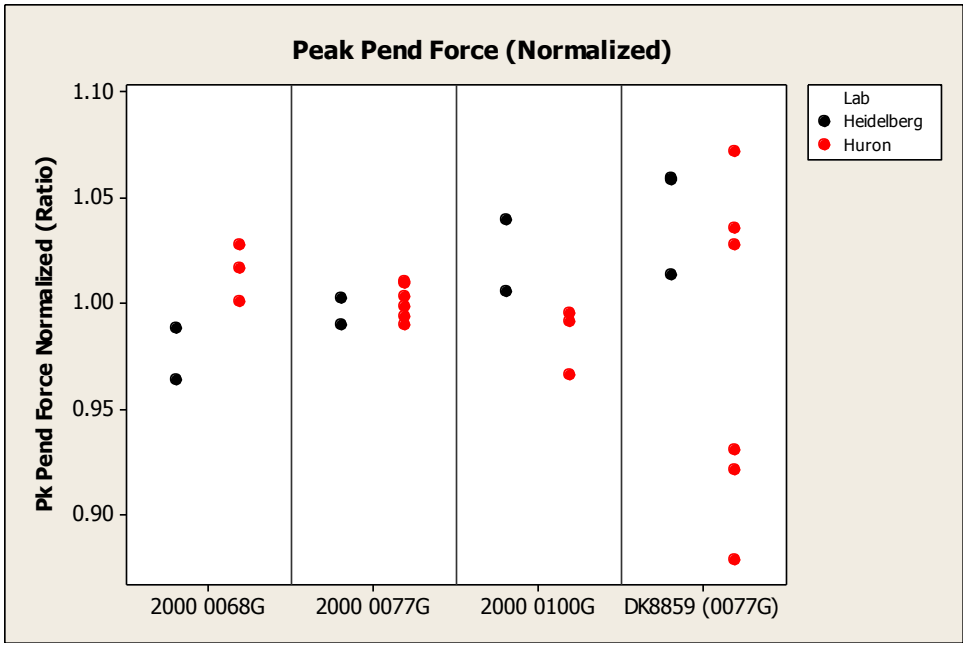
2-Sample T-Test	Mean*		Est of Difference	P-Value	% of Mean
	Heidelberg	Huron			
Pendulum Force	1.0139	0.9931		0.189	
Sled Acceleration	1.0481	0.976	0.0721	0.001	7.39
Sled Velocity	0.9746	0.9965	-0.0219	0.000	-2.25
Part Compression	0.9939	1.0032		0.274	
*Mean is the ratio of the value devided by the average of values for one discrete part					

BioRID Test Lab Comparison

Pelvis Bottom (Pendulum Force)

Actual and Normalized





There was no statistical difference in Pendulum Force between Heidelberg and Humanetics Huron test labs in the Pelvis Bottom Impact tests.

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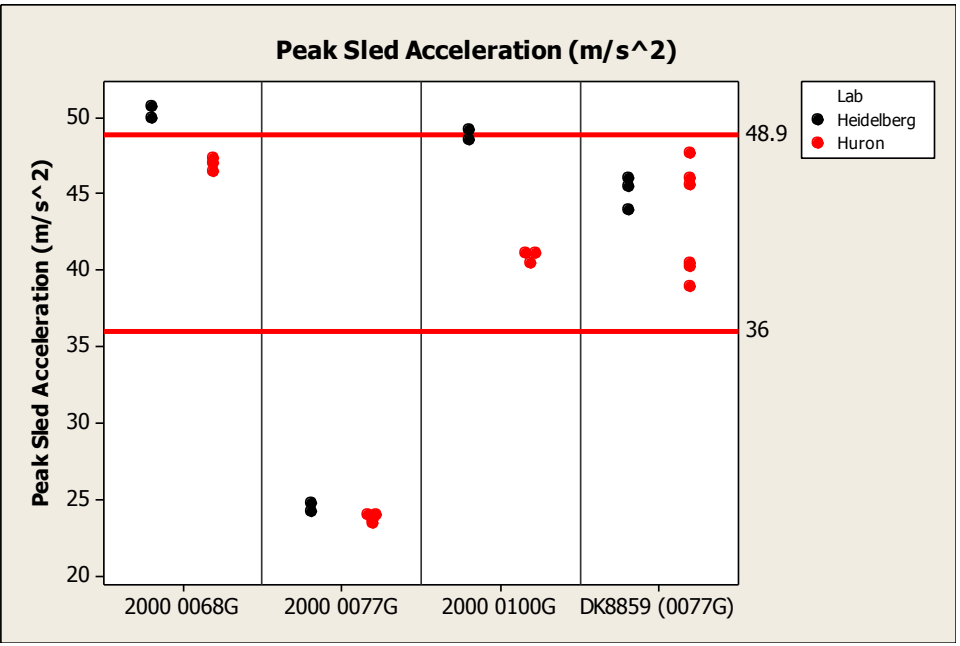
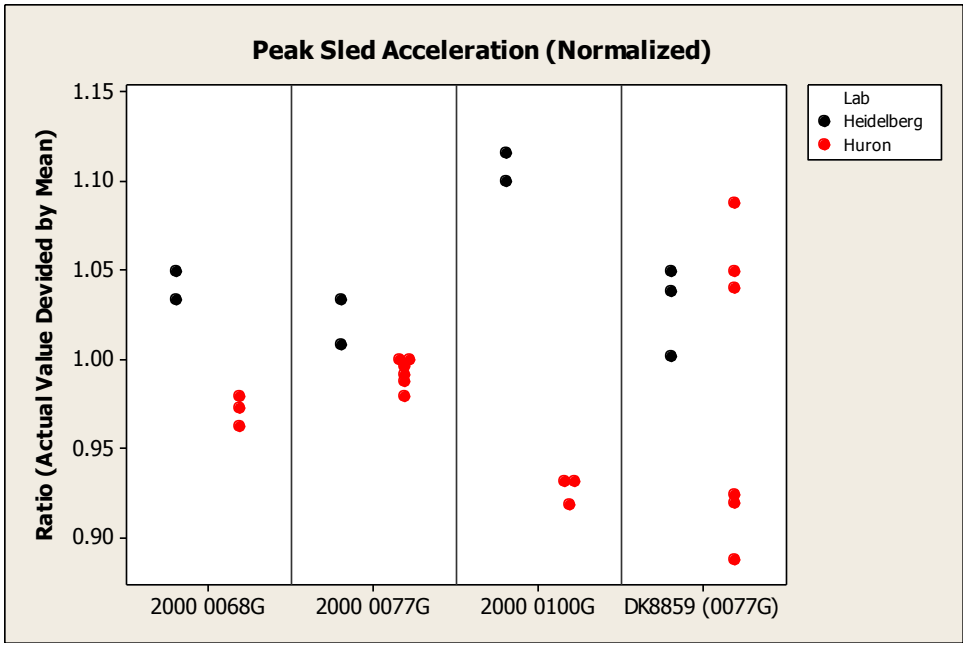
BioRID Test Lab Comparison

Pelvis Bottom (Sled Acceleration)

Actual and Normalized





There is a small statistical difference in Peak Sled Acceleration between Heidelberg and Humanetics Huron test labs for the Pelvis Bottom impact tests.

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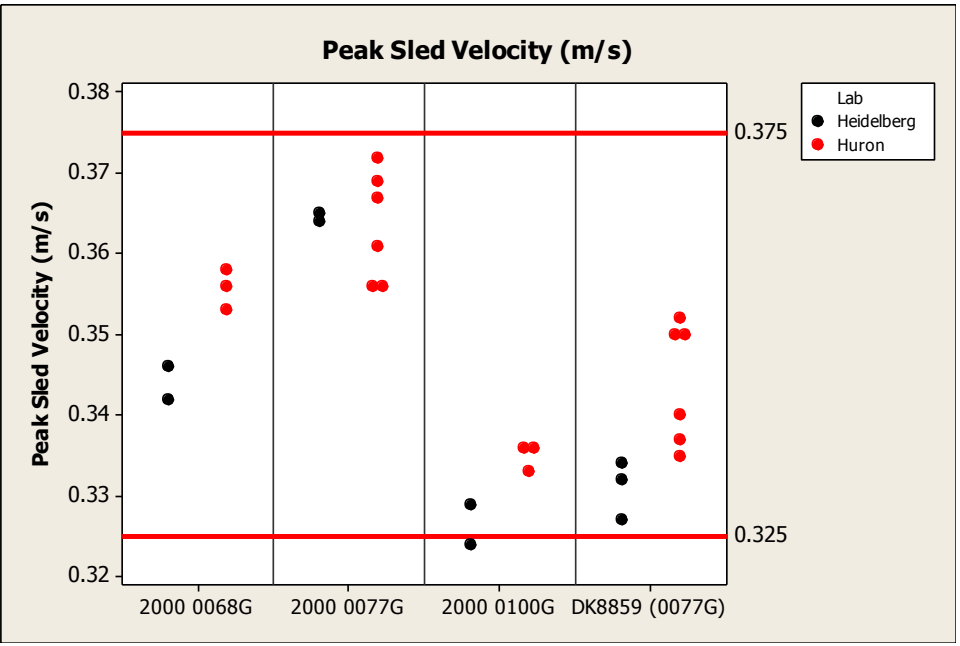
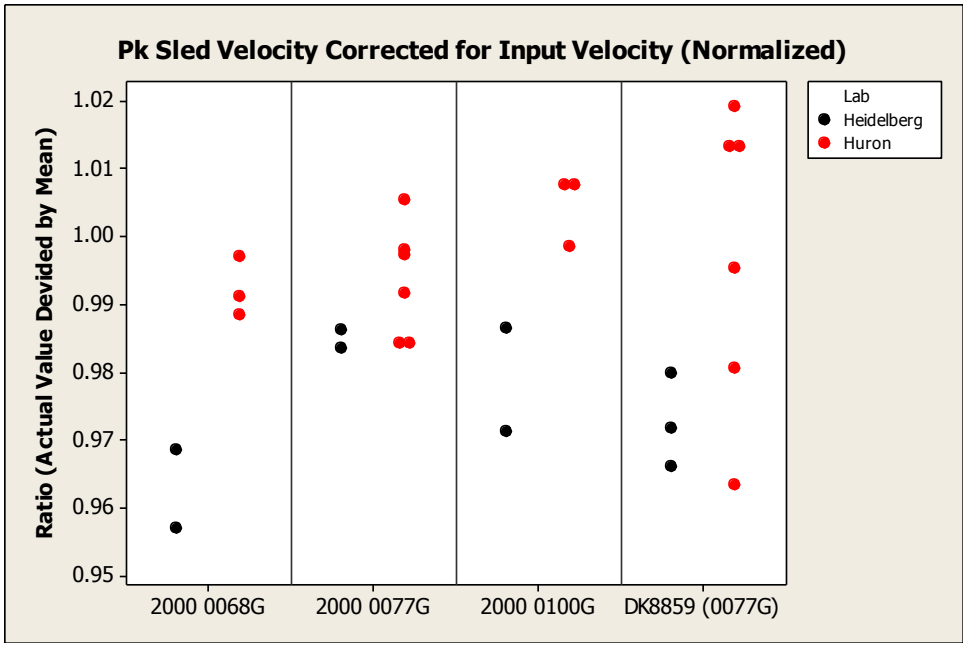
BioRID Test Lab Comparison

Pelvis Bottom (Sled Velocity)

Actual and Normalized





There is a small statistical difference in Peak Sled Velocity between Heidelberg and Humanetics Huron test labs for the Pelvis Bottom impact tests.

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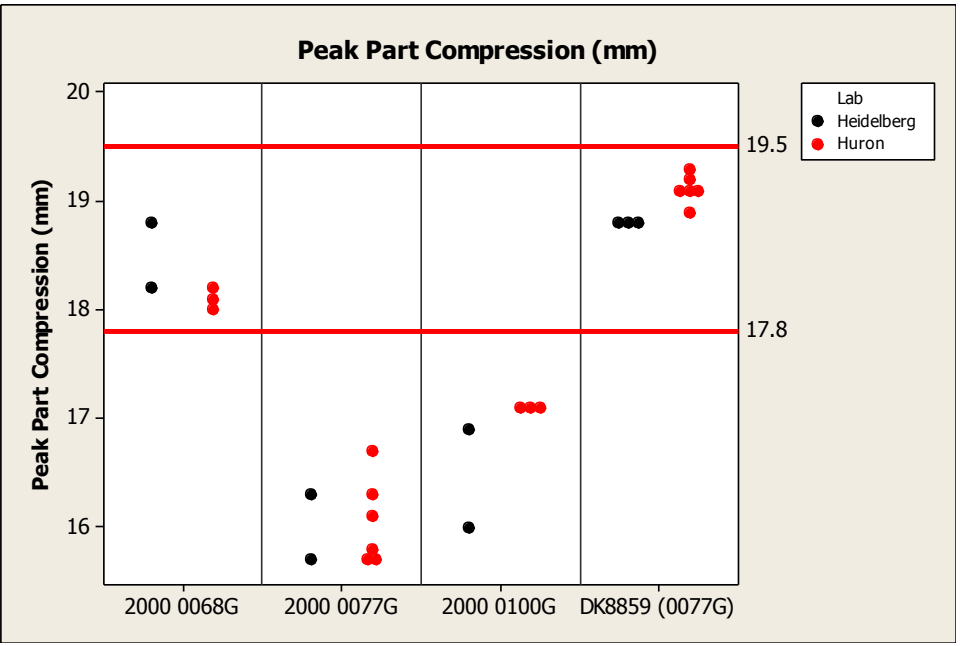
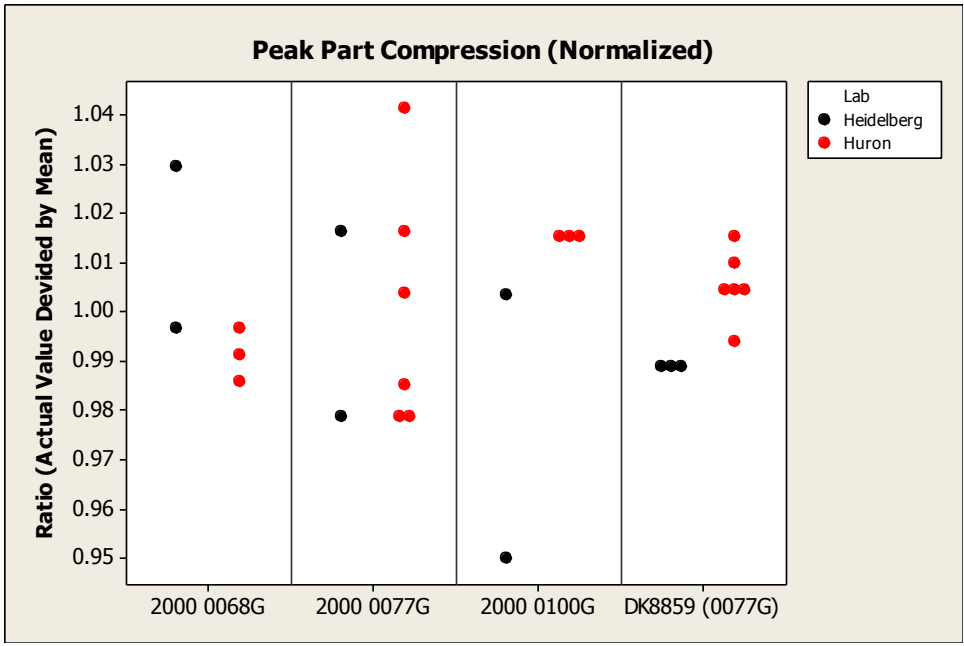
BioRID Test Lab Comparison

Pelvis Bottom (Part Compression)

Actual and Normalized





There was no statistical difference in Part Compression between Heidelberg and Humanetics Huron test labs in the Pelvis Bottom Impact tests.

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BioRID Pelvis Conclusions

- Conclusion
  - Proposed Corridors Complete (based off 4 R&R pelvis)
  - Current production population fit the proposed corridors.
  - All but one of the original (4) dummy pelvis' would have failed the proposed corridor
  - Others studies show sled accel & pendulum force are highly correlated. This study as well shows no need for bother, so eliminate sled accel parameter

Conclusions

- Conclusion
  - Lab to Lab
    - All lab to lab variation was less than 7.5% of mean.
      - Less than 2.3% if we don't use sled accel.
    - Repeatability should be worked on to reduce the within lab variation.
      - Reduce velocity corridor
      - Make sure wait times are followed
    - Repeat Lab to Lab when larger population of labs exists.
- No need for both back and bottom to control pelvis
  - Only use bottom impact

Jacket Only Impact

BioRID Jacket Test Corridor

- Create a test corridor around the (4) R&R jackets
- Test each jacket on the BioRID sled impacting it with a 14kg impact probe (H-III5F)
- Will these corridors indicate any differences in the original jackets replaced?
- Compare the corridor to current production

BioRID Jacket Test Corridor

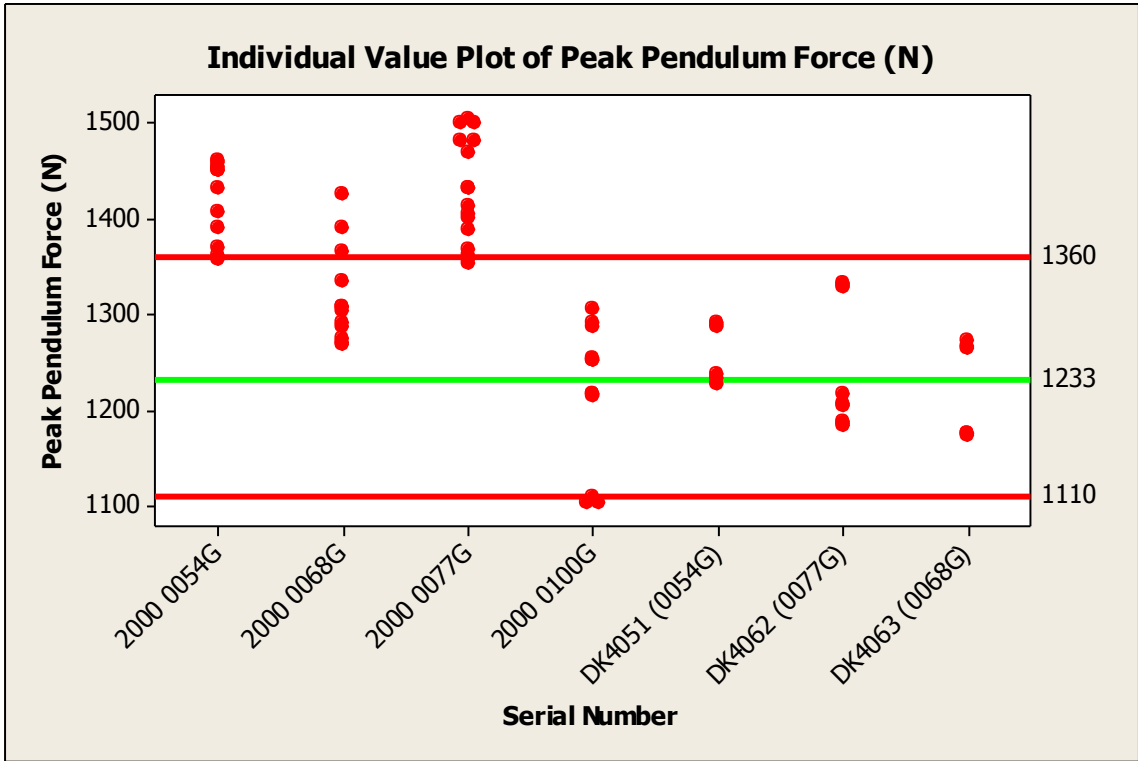
- Collected data from Humanetics Huron prior to shipping to BAST, repeat tests from BAST, post tests from Humanetics Heidelberg and post tests from Humanetics Huron.
- All data from all labs on these (4) jackets was used to determine the corridor
  - A Total of 33 tests was conducted
    - Data was reduced to 24 for part compression due to no data provided from one lab.

BioRID Jacket Test Corridor

- Statistical analysis was conducted on the each of the parameters collected
- The mean +/- 2 standard deviations was used to create the proposed test corridor.
- Rounded to 3 significant digits

BioRID Jacket Test Corridor

- Peak Pendulum Force
  - Mean = 1233 N
  - Std Dev = 62
  - (10.1% of mean)
- Proposed Corridor
  - 1110N - 1360N



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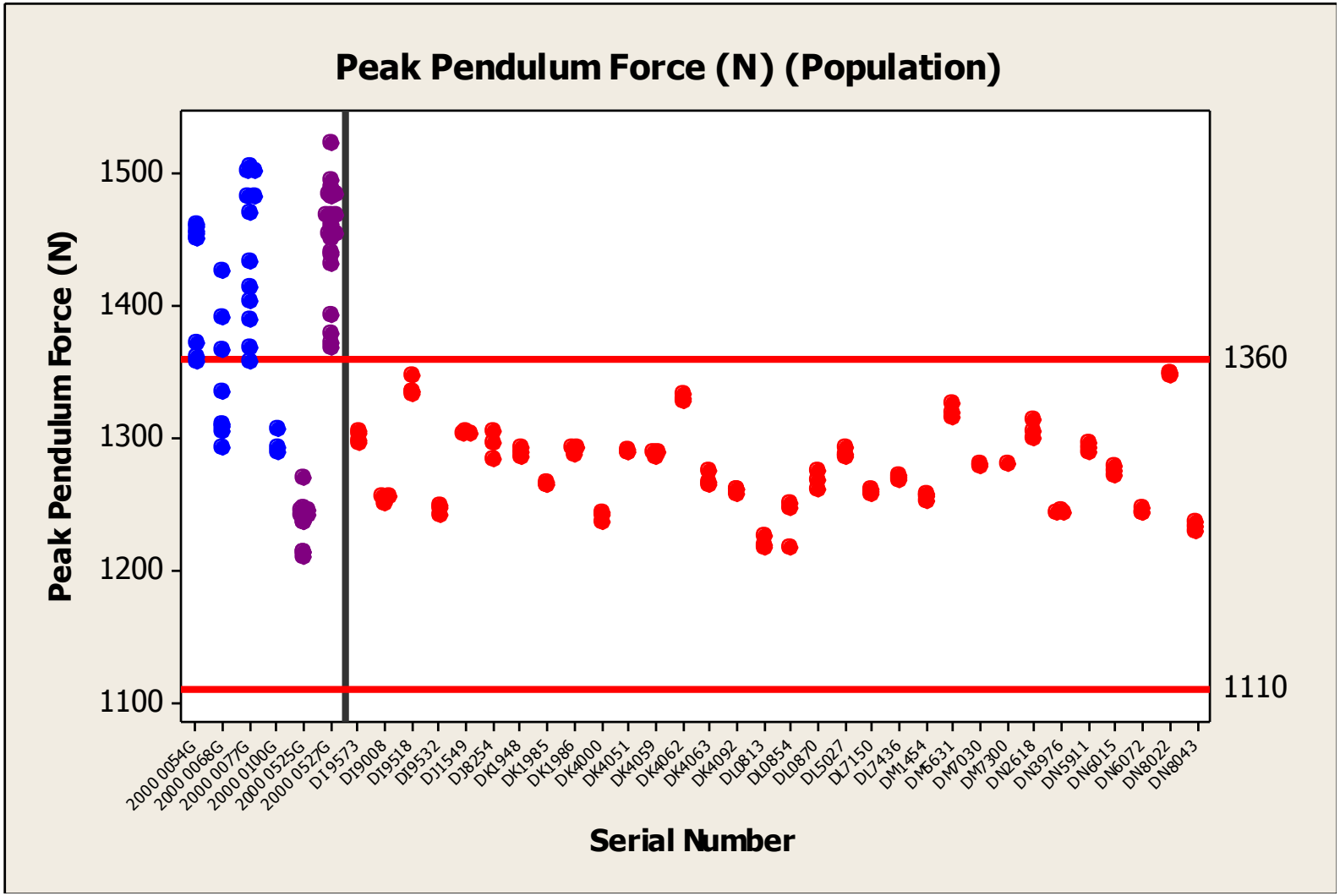
BioRID Jacket Test Corridor



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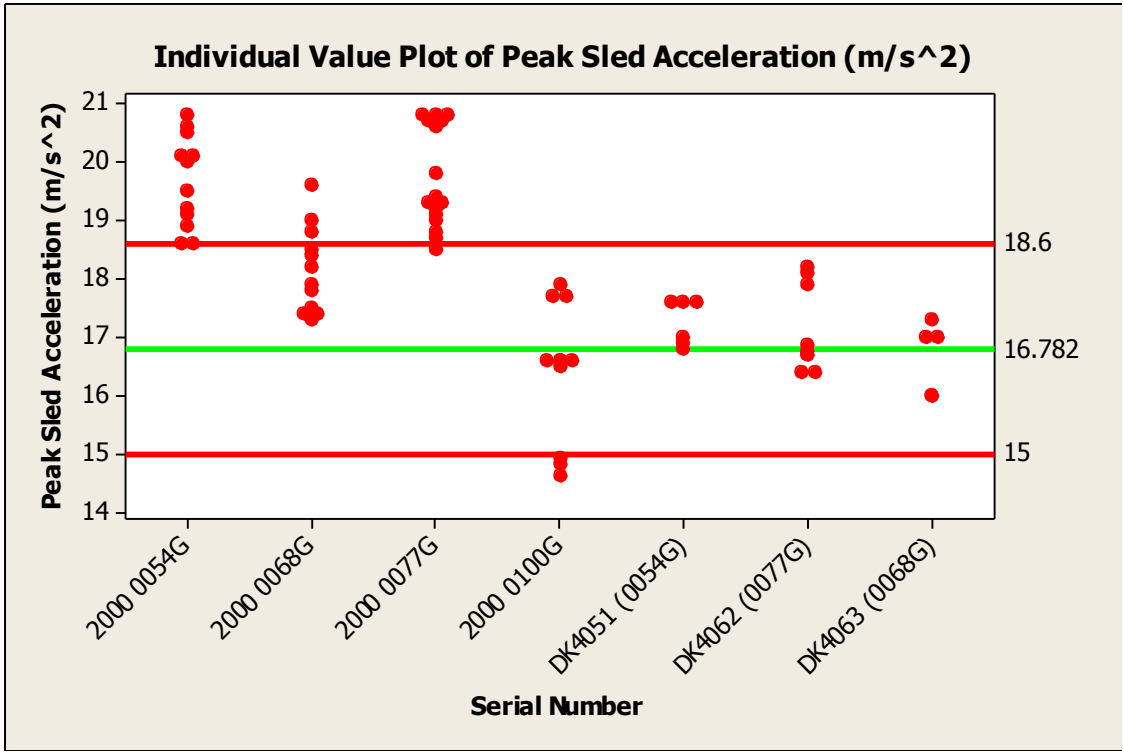
BioRID Jacket Test Corridor

- Peak Sled Acceleration
  - Mean = 16.782 m/s^2
  - Std Deviation = 0.886 m/s^2
  - (10.3% of mean)

- Proposed Corridor
  - 15.0m/s^2 – 18.6m/s^2



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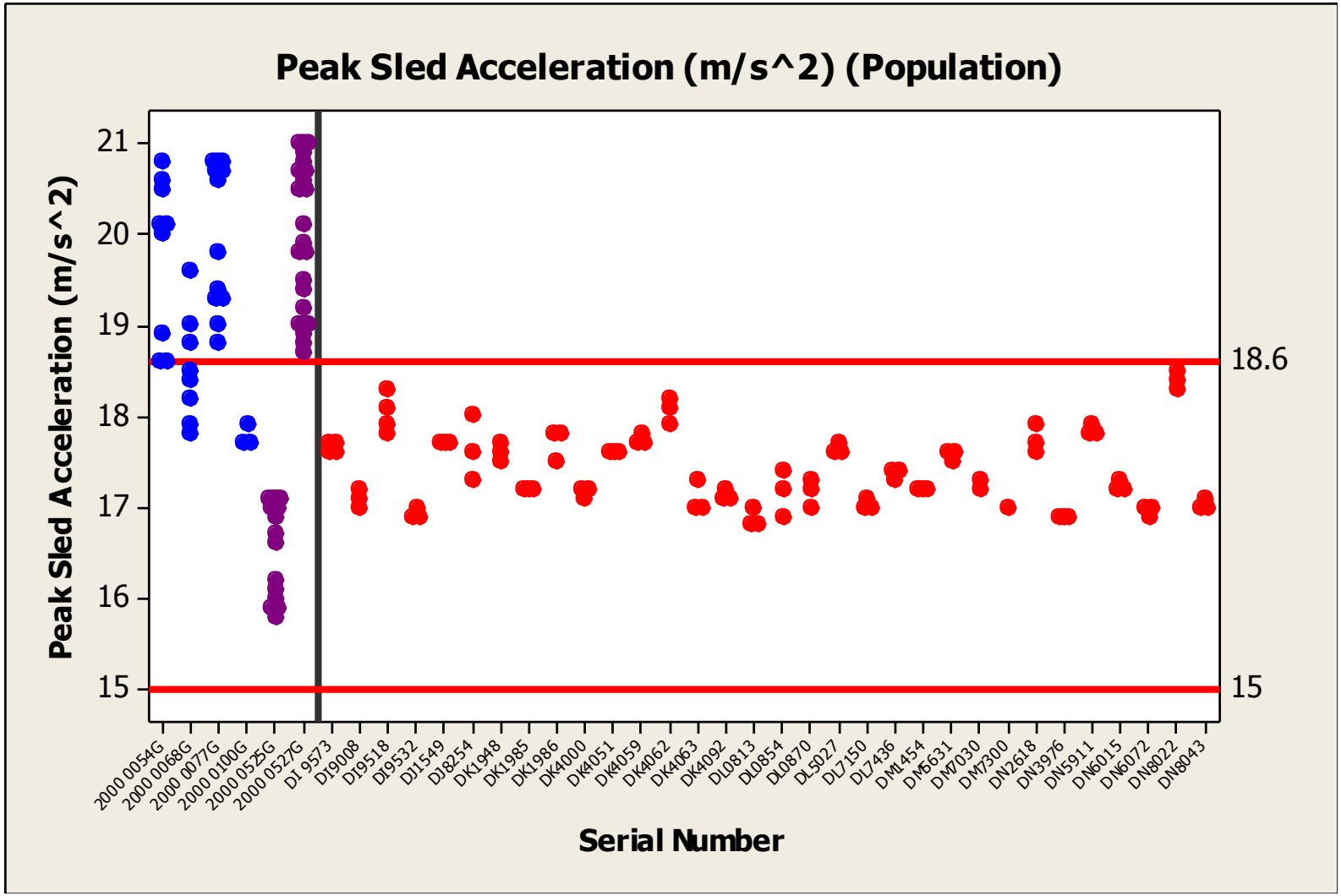
BioRID Jacket Test Corridor



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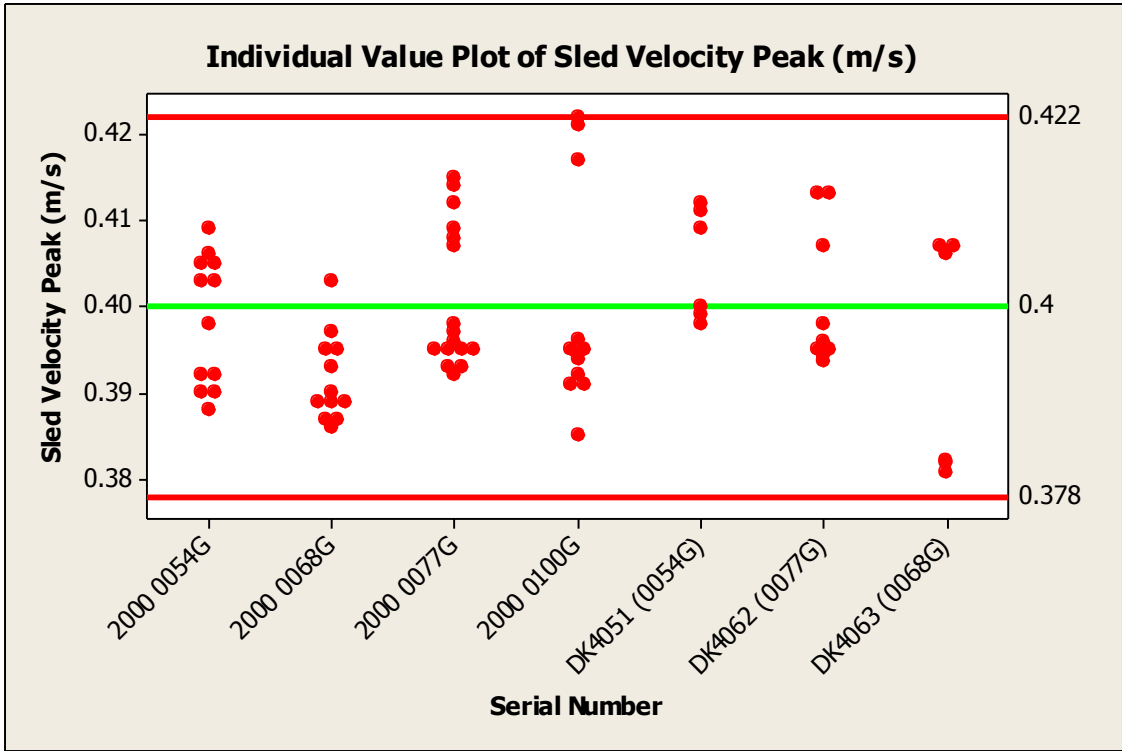
BioRID Jacket Test Corridor

- Peak Sled Velocity
  - Mean = 0.400 m/s
  - Std Deviation = 0.0109 m/s
  - (5.5% of Mean)

- Proposed Corridor
  - 0.378m/s – 0.422m/s



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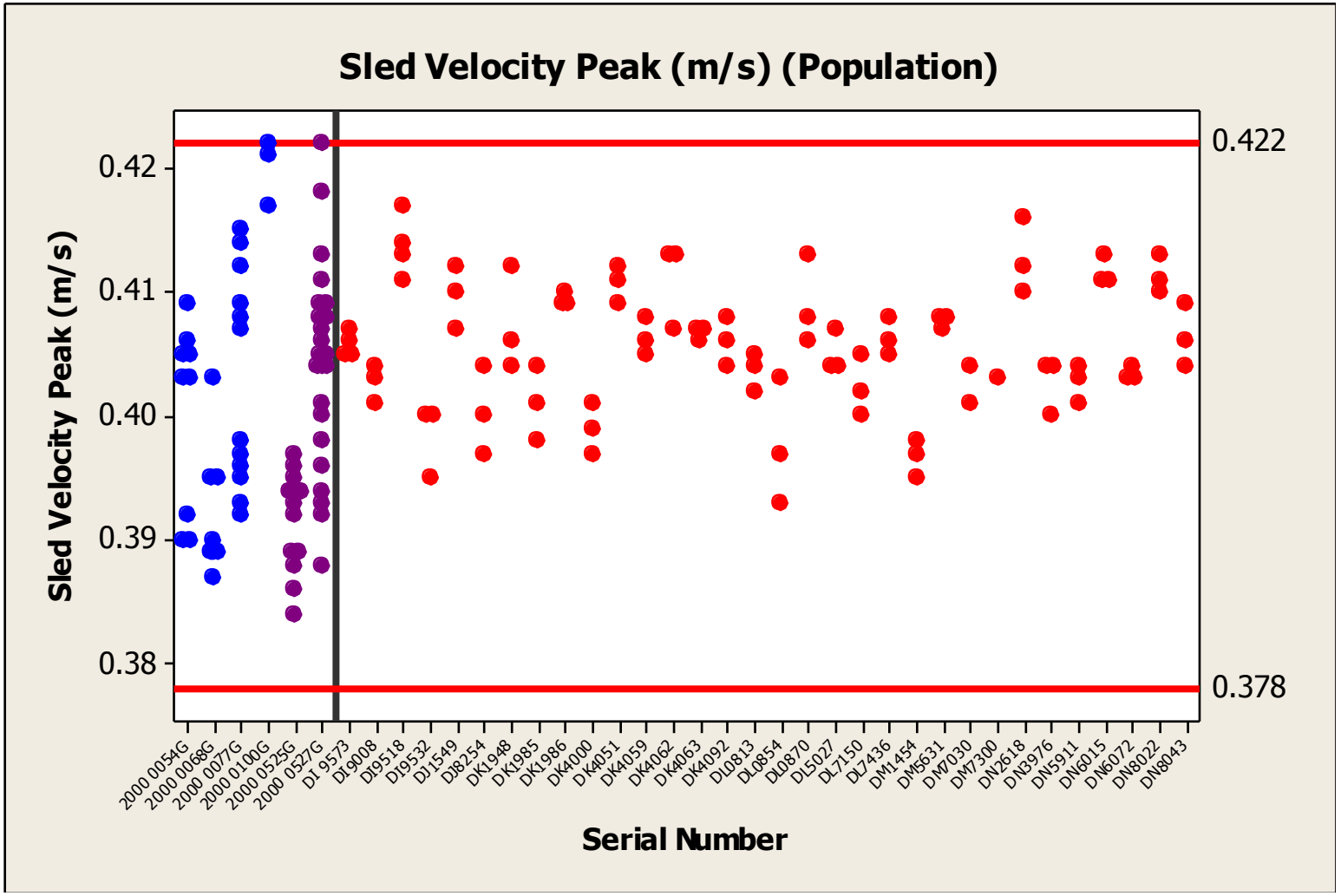
BioRID Jacket Test Corridor



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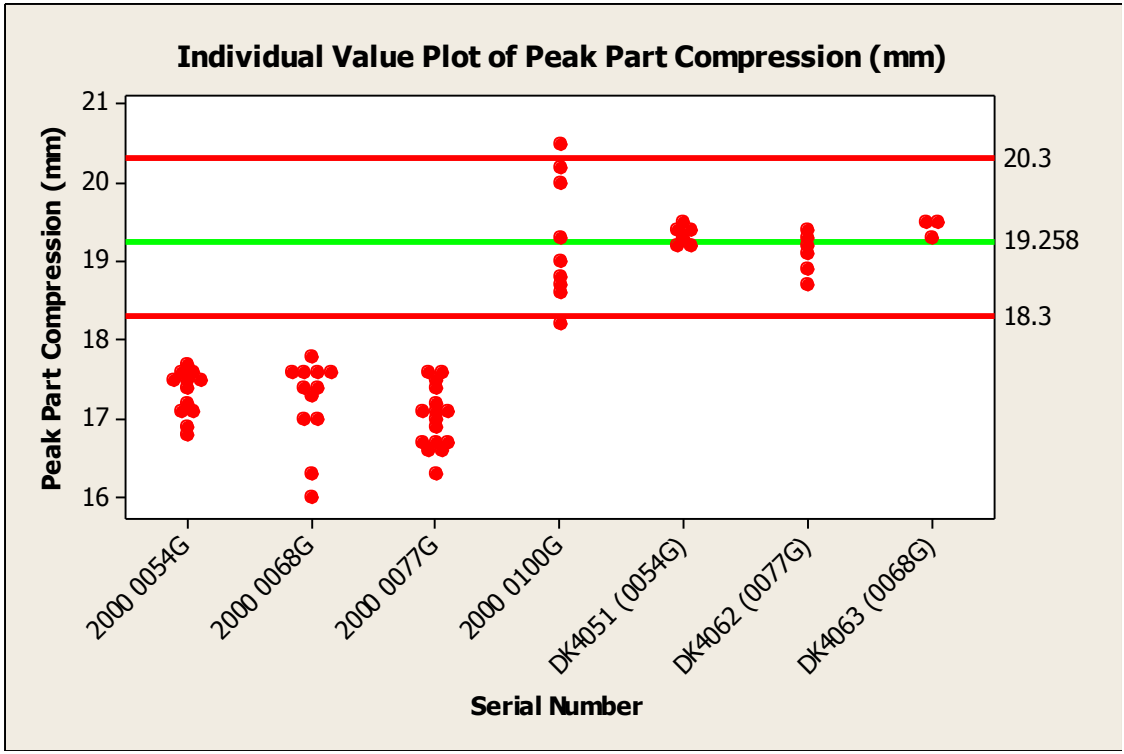
BioRID Jacket Test Corridor

- Peak Part Compression
  - Mean = 19.258mm
  - Std Deviation = 0.504mm
  - (5.2% of mean)
- Proposed Corridor
  - 18.3mm – 20.3mm



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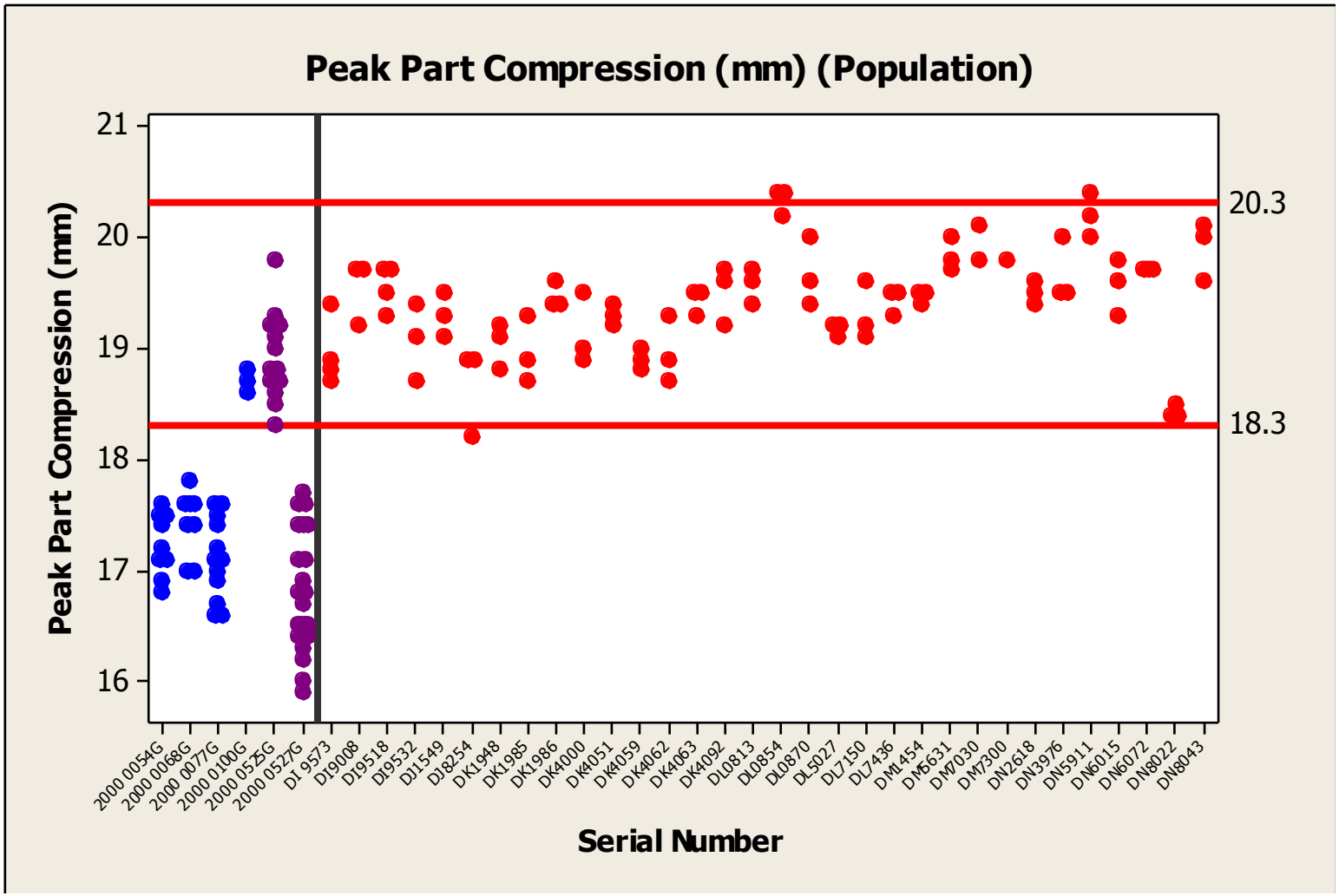
BioRID Jacket Test Corridor



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BioRID Jacket Test Lab Comparison

- Normalized test data to remove influence of parts with different means.
  - n divided by the average of all n's in all labs

    n = values for one discrete part (same serial number)
- Look for influence from input velocity and corrected for statistically significant regressions.
- Perform statistical analysis on the normalized ratios

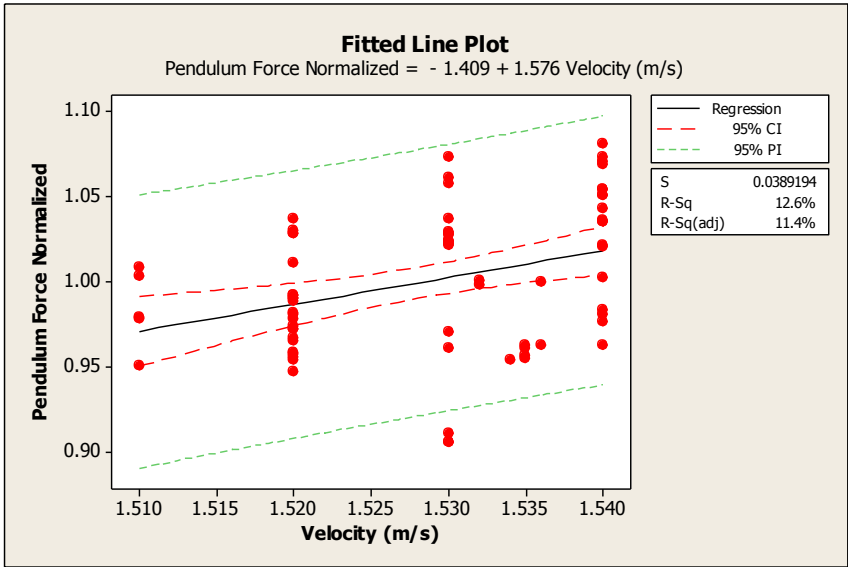
BioRID Jacket Test Lab Comparison

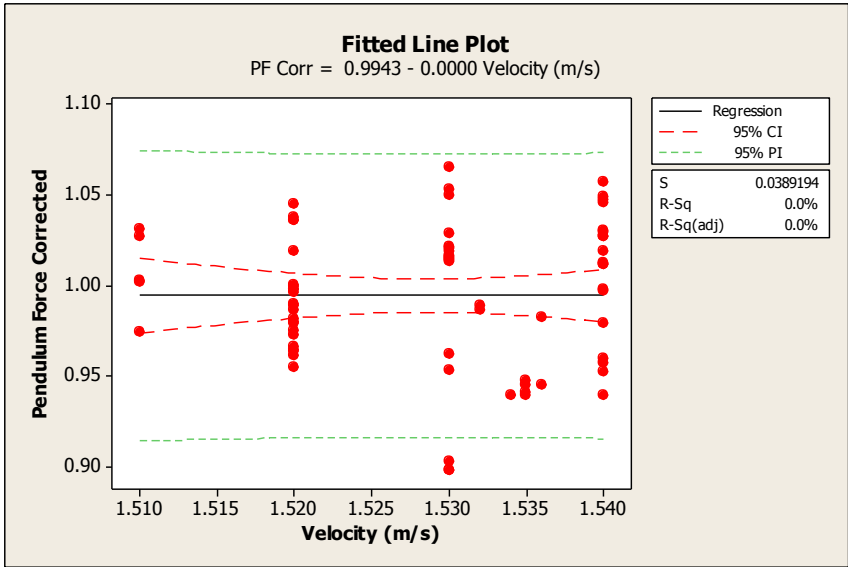
- All Normalized Test Parameters are statistically significant velocity sensitivity.
- Normalized data was corrected for regressions

Regression Summary (Normalized Test Parameter vs Input Velocity)	P-Value	R-sq(adj)
Peak Pendulum Force	0.002	11.40%
Peak Sled Acceleration	0.006	8.80%
Peak Sled Velocity	0.000	16.60%
Peak Part Compression	0.005	10.80%

BioRID Jacket Test Lab Comparison

Pendulum Force





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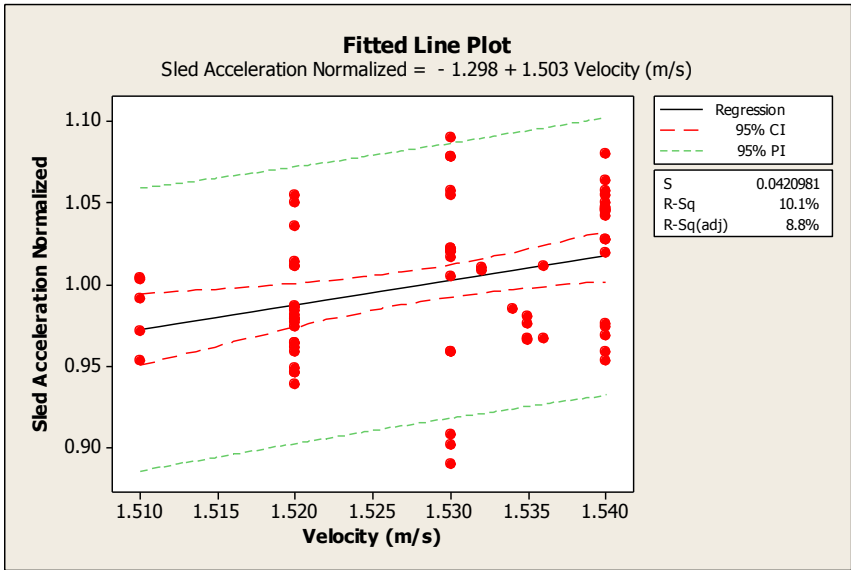
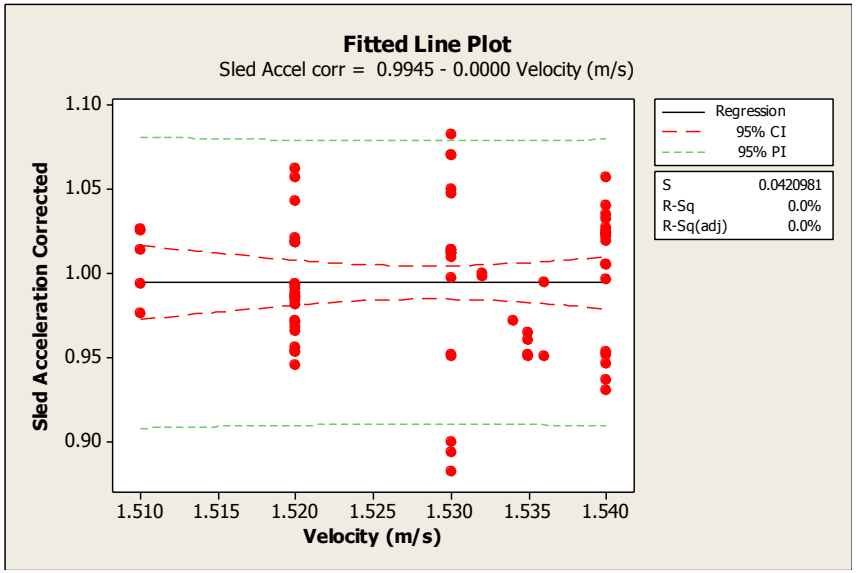
BioRID Jacket Test Lab Comparison

Sled Acceleration





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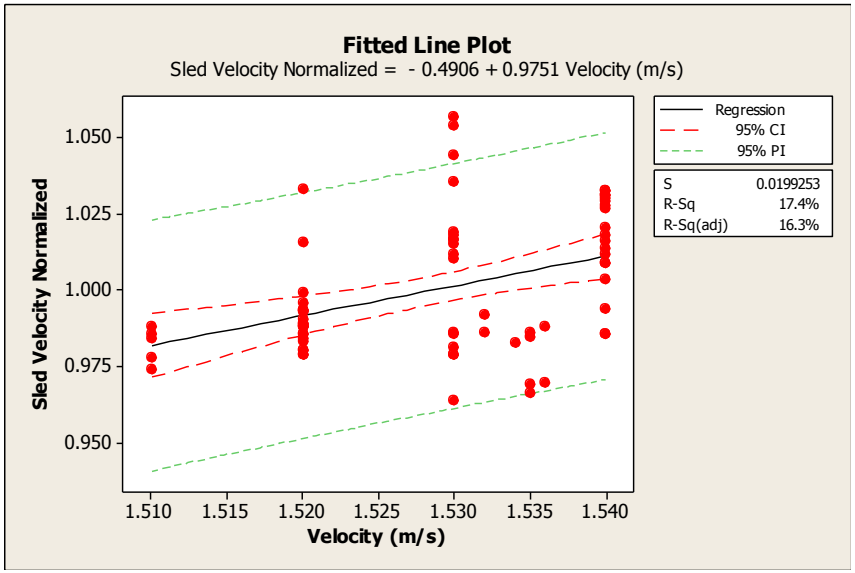
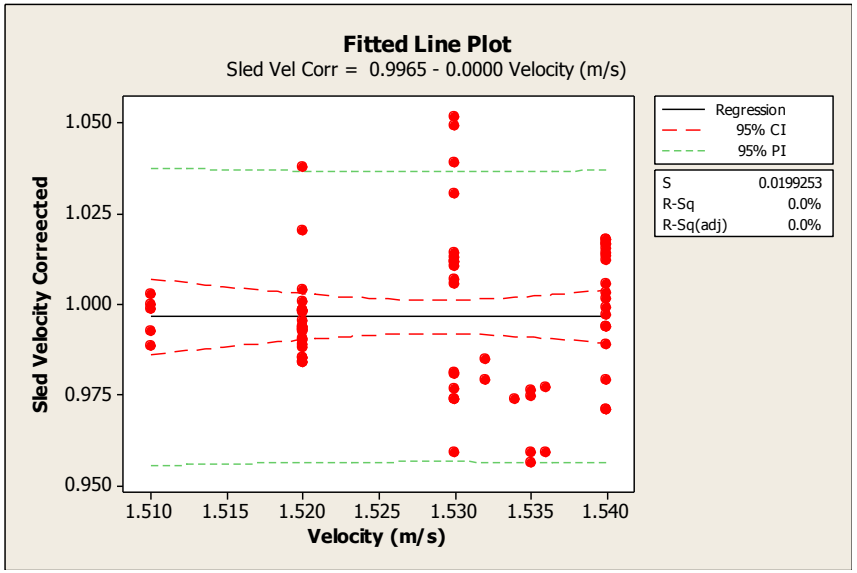
BioRID Jacket Test Lab Comparison

Sled Velocity





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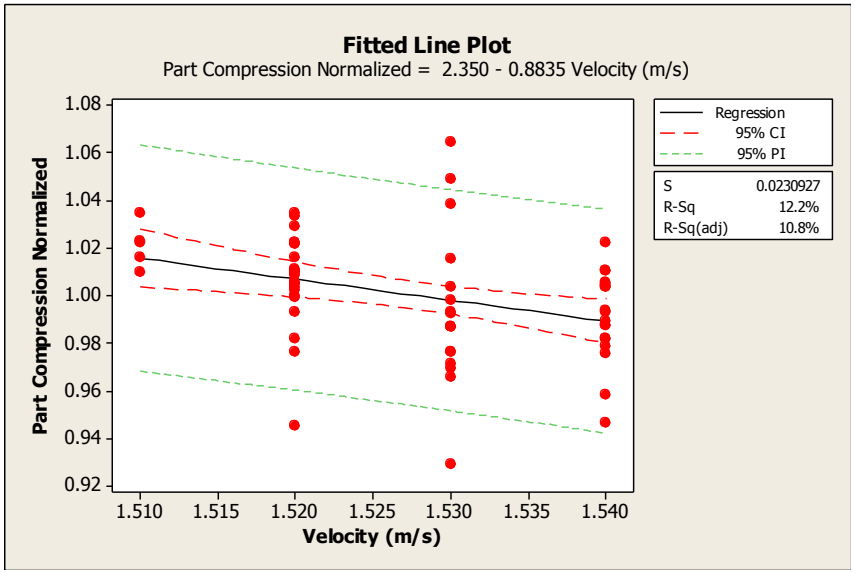
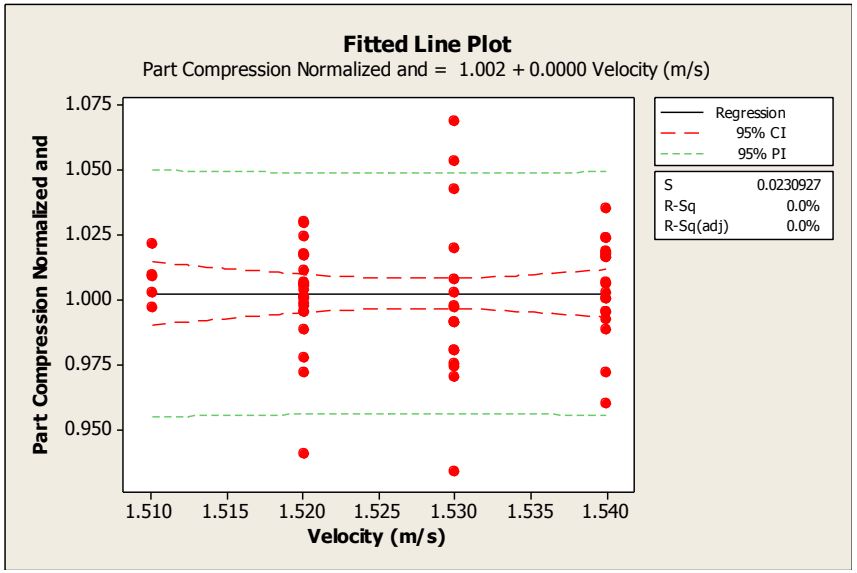
BioRID Jacket Test Lab Comparison

Part Compression





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BioRID Jacket Test Lab Comparison

ANOVA Analysis	P-Value	Lab Means		
		BAST	Heidelberg	Huron
Pendulum Force	0.000	0.9572	0.9628	1.0128
Sled Acceleration	0.000	0.9712	0.951	1.0147
Sled Velocity	0.000	0.9712	0.9825	1.0063
Part Compression	0.648	*		
* No Compression data available				

- ANOVA analysis indicates a statistical difference between labs after normalizing (removing any differences associated with part).
- The Huron test lab had a higher means than either BAST or Heidelberg for Pendulum Force, Sled Acceleration, and Sled Velocity
- There was no difference between labs for part compression

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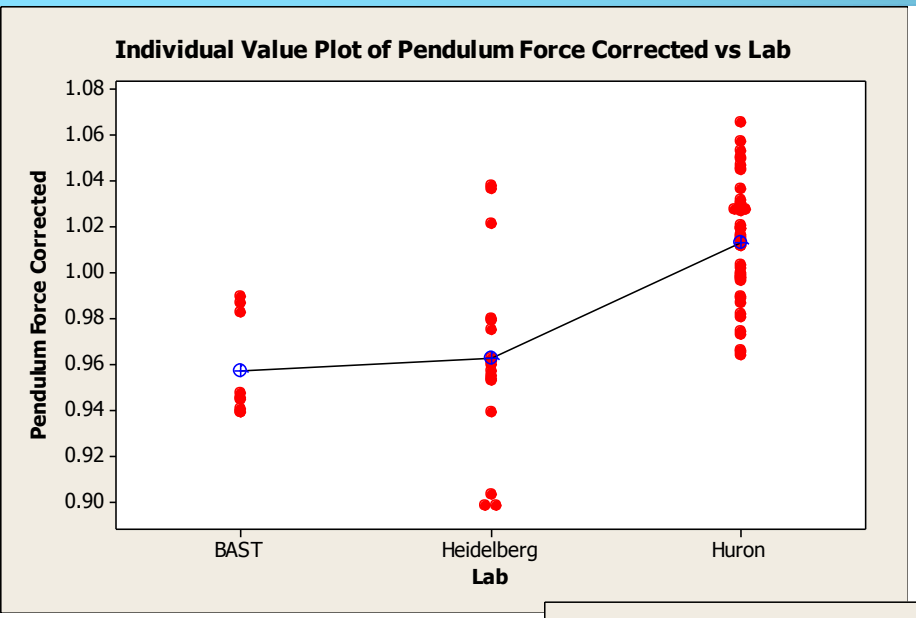
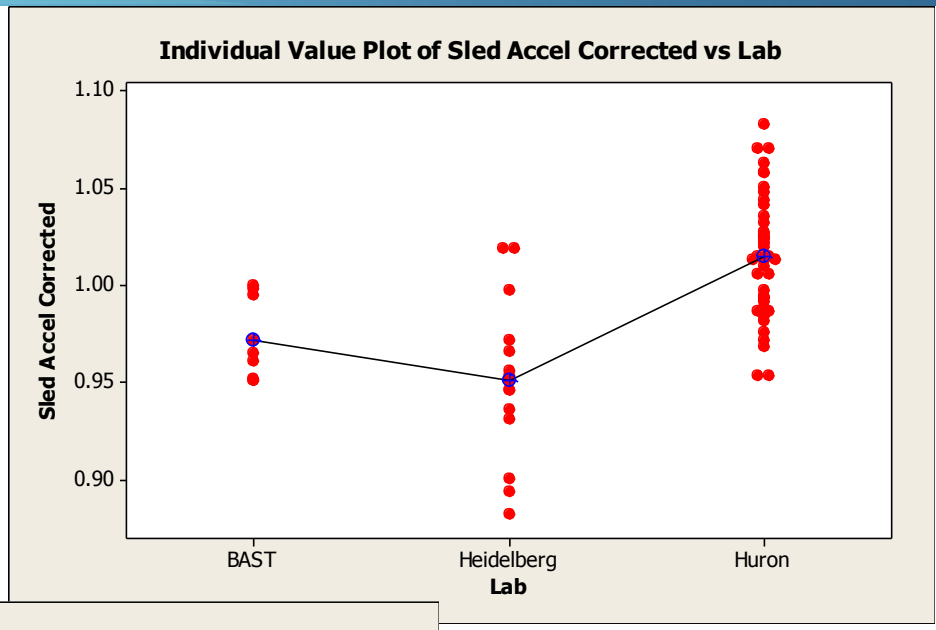
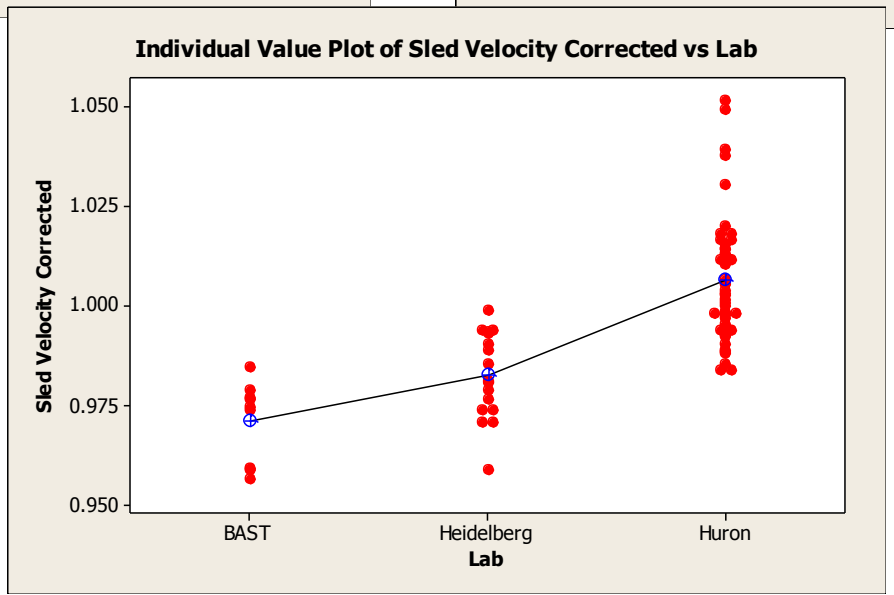
BioRID Jacket Lab Comparison







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BioRID Jacket Conclusions

- Conclusion
  - Proposed Corridors Complete (based off 4 R&R Jackets)
  - Current production population fits the proposed corridors.
  - All but one of the original (4) dummy jackets would fail the proposed corridors
  - Others studies show sled accel & pendulum force are highly correlated. This study as well shows no need for bother, so eliminate sled accel parameter

Conclusions

- Conclusion
  - Lab to Lab
    - Largest lab to lab variation was about 6% of mean, which is a large portion of the corridors
    - Lab differences should be investigated
    - Repeat Lab to Lab when larger population of labs exists.
  - Repeatability should be worked on to reduce the within lab variation.
    - Reduce velocity corridor
    - Make sure wait times are followed