Unintended Ignition Switch Rotation

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[redacted]

Title: Key torque to turn

Project Leader: XXXX

Project Sponsor: XXXX

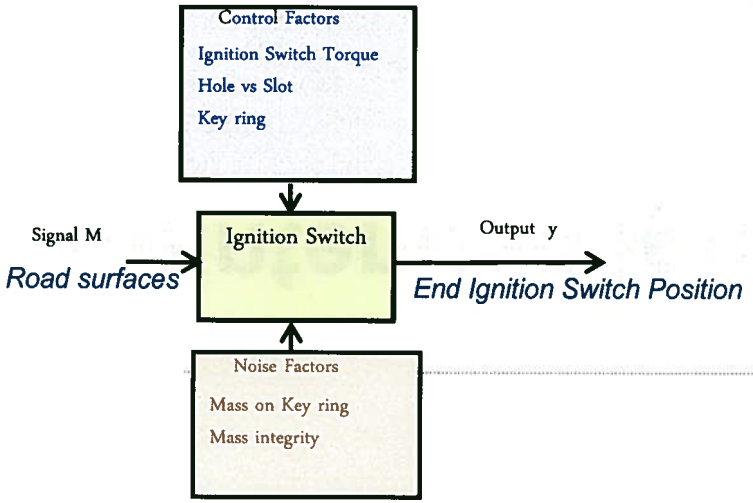
Project: # XXX

DFSS Coach: XXXXXX

Project Scope

- Determine objective test that causes ignition switch to unintentionally rotate away from run towards accessory

P-diagram



Findings / Learnings

- Determined 8 objective events that cause unintended key rotation
- Demonstrated proposed design performance as robust

Implementation

- Ensure ignition switch torque is 20N*cm +/-5
- Further increase robustness by changing key head to design to a hole from a slot.

Benefits

- Customer has system that is very robust to unintended key rotation

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Opportunity Statement / Expected Outcome

Opportunity Statement: A test has not been identified that causes ignition switch to transition from 'run' to 'accessory'.

What's in it for the customer? A robust ignition switch.

What's in it for GM? A robust ignition switch.

Expected Outcome (Specific Deliverables to the program): A test that will establish a condition that causes the ignition switch to move from 'run' to 'accessory'. The test will be used to assess the performance of the proposed ignition switch.

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Test Procedure

Controls:

Ignition Switch Torque to Turn

Hole vs Slot on key head

Key ring size / quantity

Signals:

Ride and Handling Loop @ Posted Speeds

Belgian Blocks Durability Schedule

Pothole #1 @ 25MPH

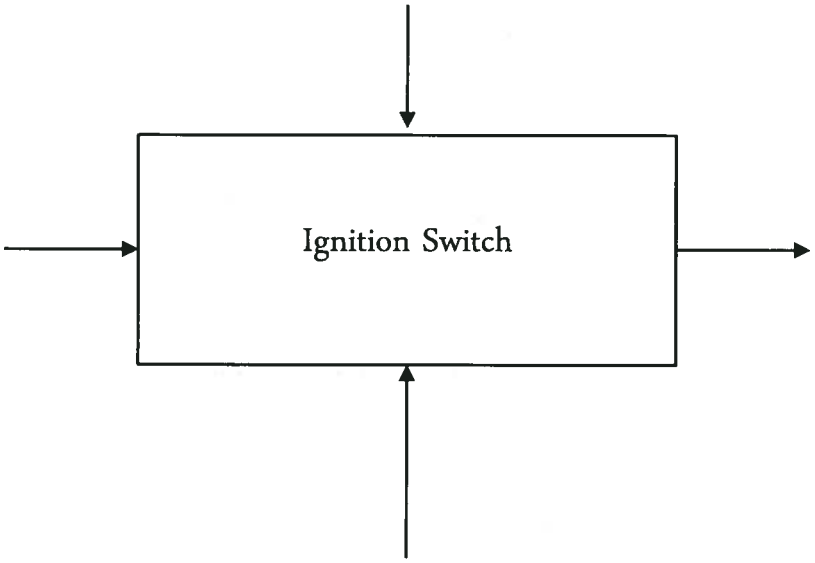
Pothole #2 @ 25MPH

Cubilete @ 10MPH

Panic Stop from 10MPH

R&H Chatter @ 45-55MPH

R&H Angled RR Crossing @ 70MPH



Response:

End Ignition Switch Position

- Run or Accessory

Noises:

Mass on Key Ring

Mass Integrity

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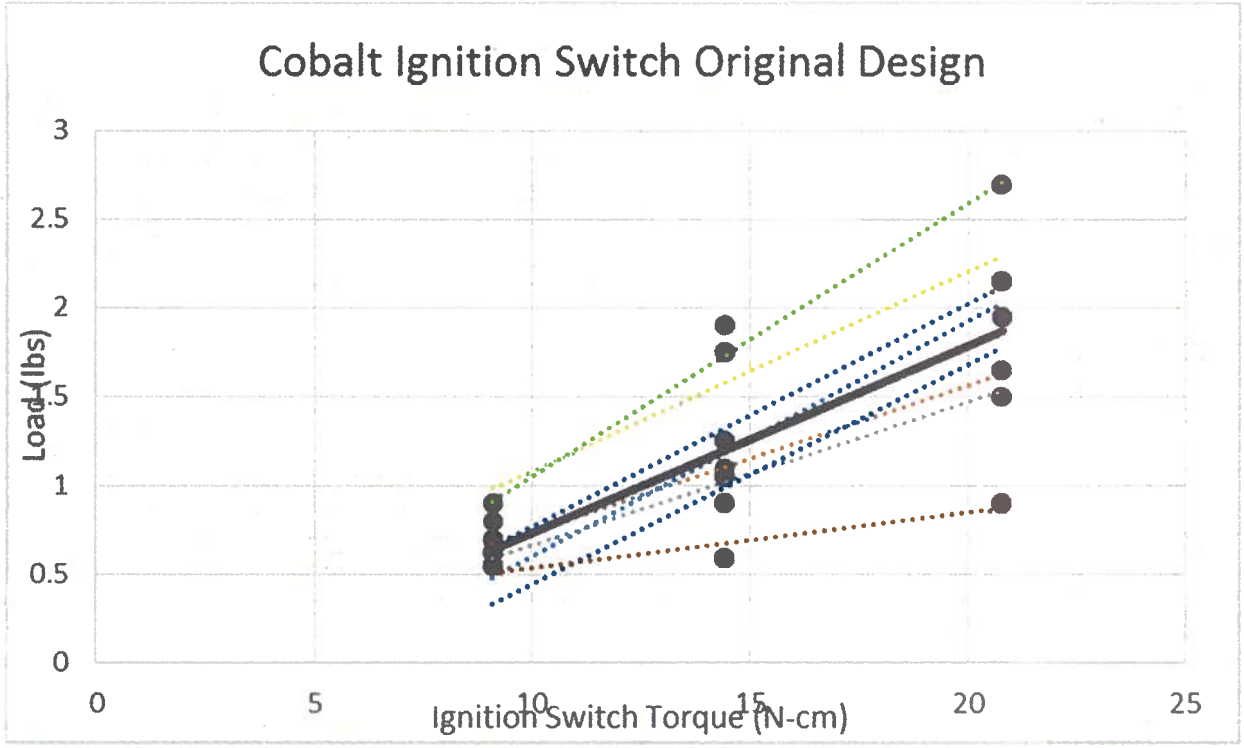
Test Results – Original Design

Data shows that increasing switch torque, increases robustness to inertial load



Microsoft Excel Worksheet

Plotted the maximum load for each test signal that ended with ignition switch in 'run' position. Bold line is average of all tests. Described as maximum load success line.

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GM Information

Effect of Switch Torque

Vehicle	Cobalt			
Key	Slot			
Switch		8.4 N*cm	12.9 N*cm	20.3 N*cm
Ride and Handling loop @ posted speeds	Minimum mass with unintended rotation (pounds)	0.7	1.0	2.4
Belgian Blocks durability schedule		0.8	1.2	2.2
Pothole #1 @25 MPH		0.7	1.2	1.7
Pothole #2 @ 25 MPH		0.9	1.3	2.4
Cubilete @ 10 MPH		0.8	1.4	2.4
Panic stop from 10 mph		1.0	1.9	3.0
R&H Chatter @ 45 - 55MPH Hz=MPH/3		0.6	0.7	2.2
R&H Angled RR crossing @ 70 mph		0.6	0.7	1.0

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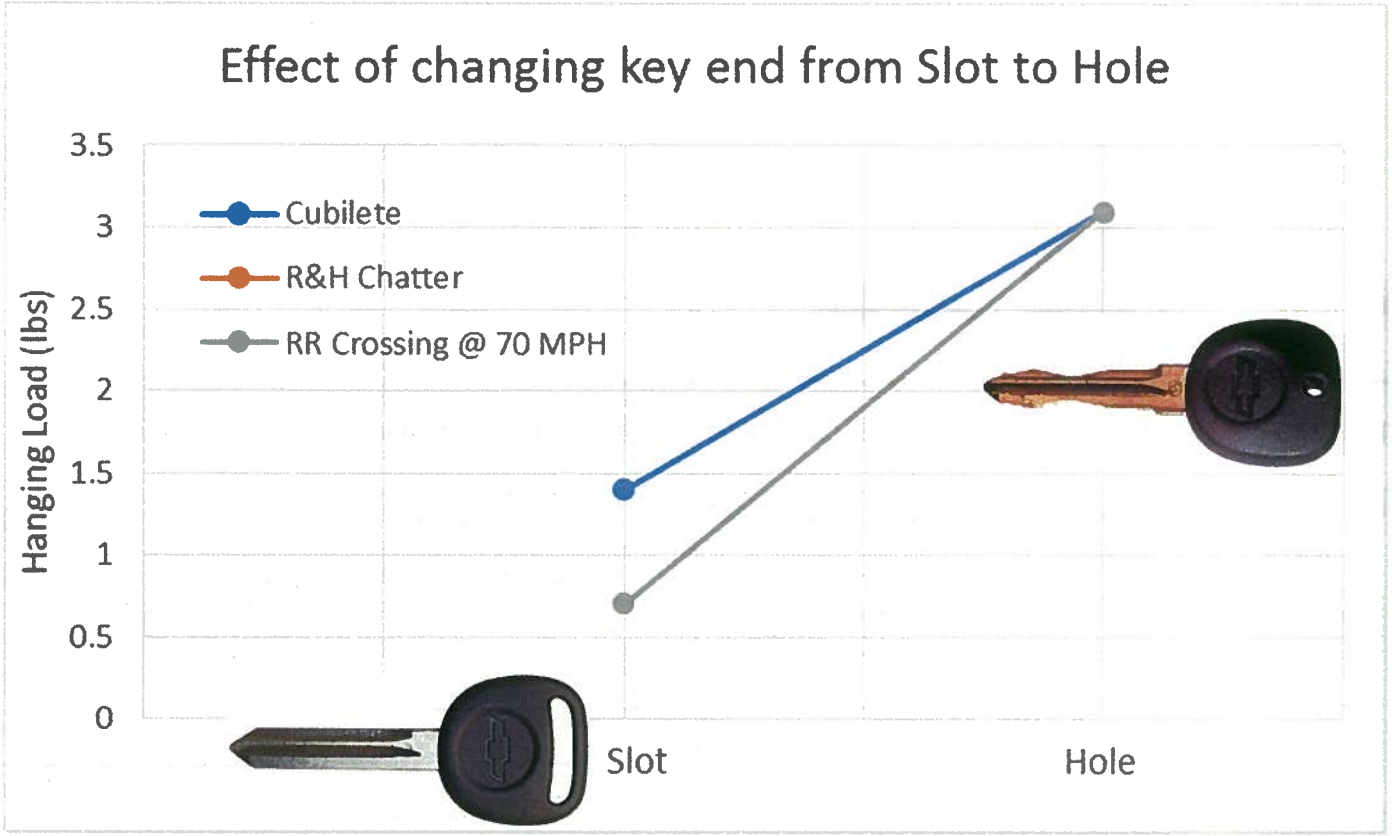
Test Results – Original Design



Plotted the minimum load for each test signal that ended with ignition switch in 'accessory' position with a 12.9N*cm switch.

Conditions with hole never experienced unintended rotation, and testing was stopped @ 3.1#

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GM Information

Effect of Hole vs. Slot

Vehicle	Cobalt			
Switch	12.9 N*cm		12.9 N*cm	
Key	Slot		Hole*	
Cubilete @ 10 MPH	Minimum mass	1.4	Max mass tested,	3.1
R&H Chatter @ 45 - 55MPH Hz=MPH/3	where rotation	0.7	rotation did not	3.1
R&H Angled RR crossing @ 70 mph	occurred. (pounds)	0.7	occur. (pounds)	3.1
*Configurations with hole & 13mm ring never experienced unintended rotation. Testing stopped at 3.1 #				

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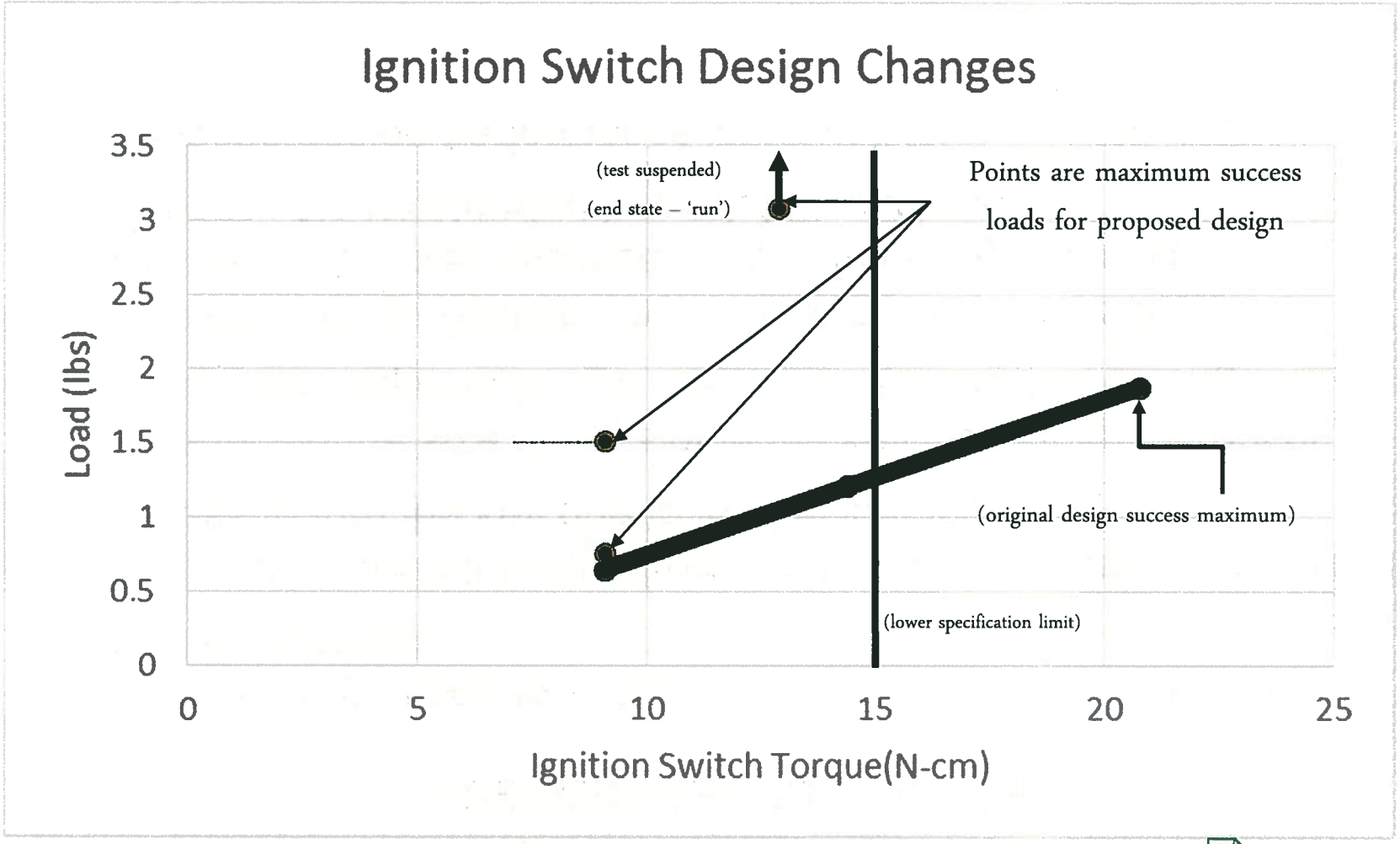
Test Results – Proposed Design



Microsoft Excel Worksheet

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Key Concept Phase Learnings/Decisions

- Original design used to establish drive schedules and key ring loading transition
  - Increasing switch torque from run to acc increases the required mass to turn the key due to inertial loading.
  - Reducing the size of the slot in the key (to a hole) increases the mass required to turn the key due to inertial loadings.
- Proposed design (switch torque 20 N*cm + / - 5 N*cm, and change key to hole) assessed using drive schedules and key loadings. No unintended key rotation occurred.
- Proposed design performance improved from original design

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Backup

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Physics

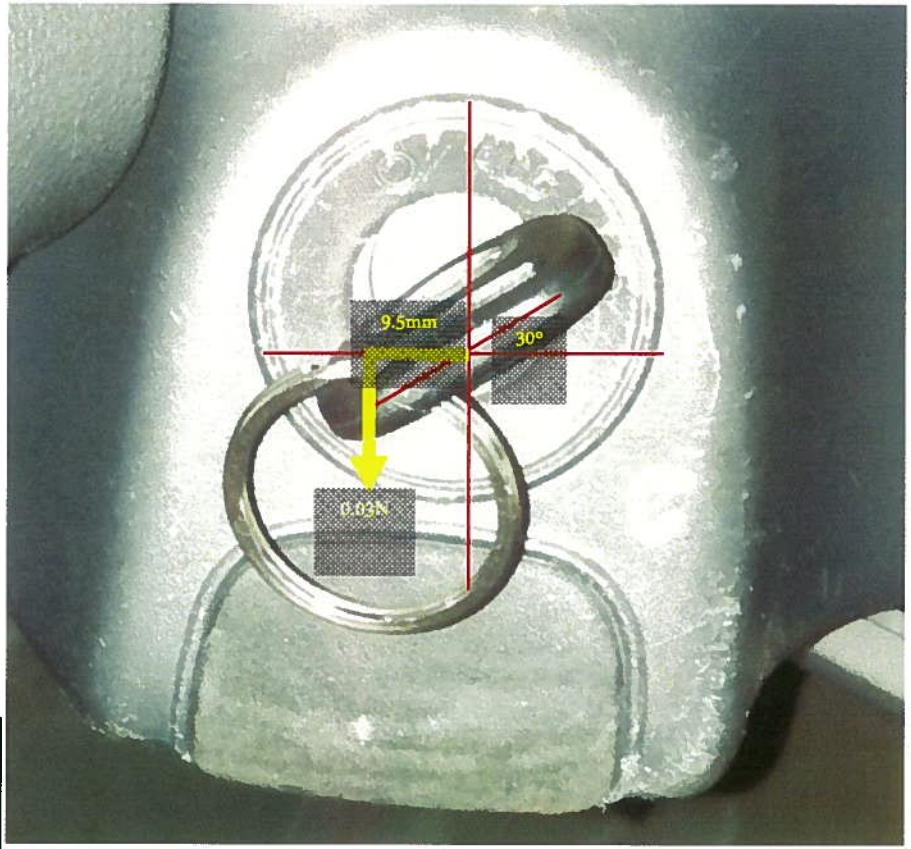
Ring weight = 0.031 Newtons (0.007lb)

Slot length in key head = 2.2 cm

Moment arm = ½ slot length * cos theta = 0.95 cm

Static Moment = 0.031 N * 0.95cm = 0.03 N*cm

Input moment due to inertial forces is negligible with key and ring only.



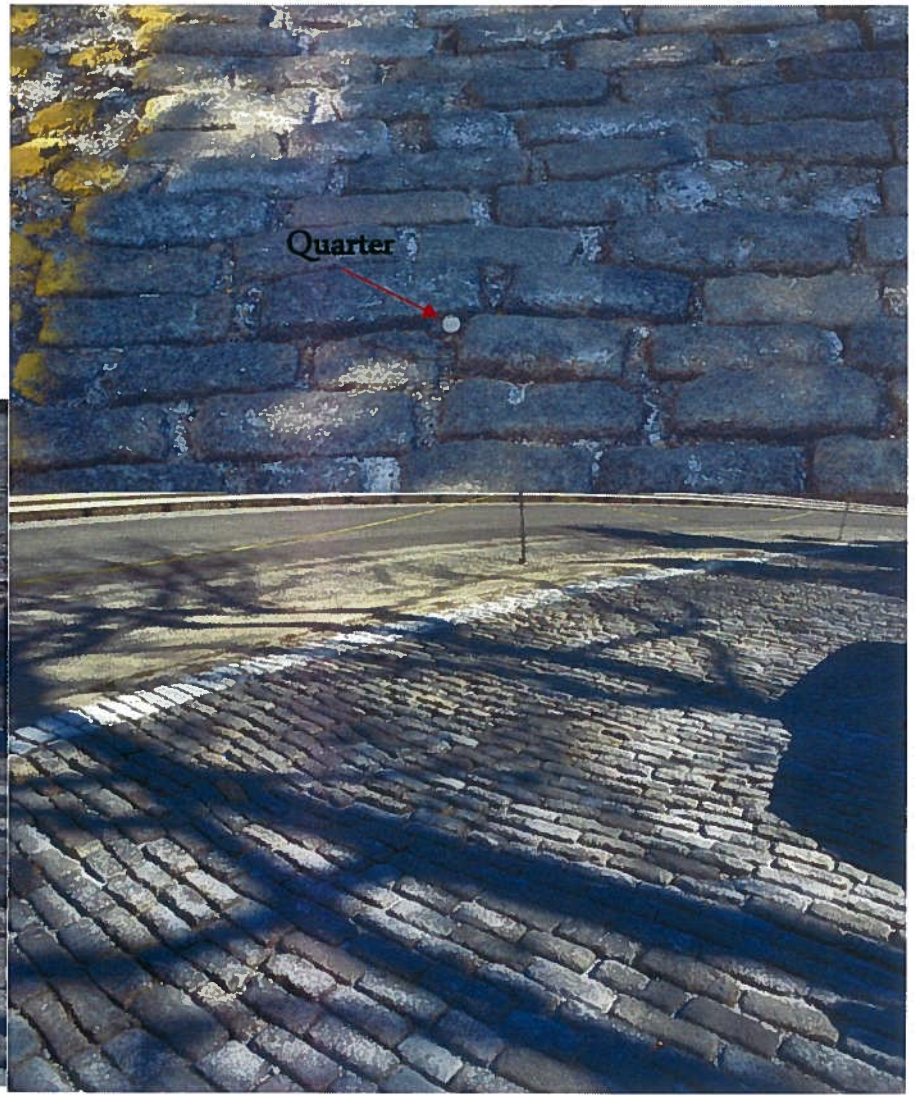
"g" level	N*cm of torque generated
33	1
67	2
133	4
267	8
533	16

Road system images

- **Road test descriptions:**
  - **Belgian Blocks durability schedule**
  - **Pothole #1 @25 MPH**
  - **Pothole #2 @ 25 MPH**
  - **Cubilete @ 10 MPH**
  - **Panic stop from 10 mph – self explanatory**
  - **Ride and Handling loop @ posted speeds**
  - **R&H Chatter @ 45 - 55MPH Hz=MPH/3**
  - **R&H Angled RR crossing @ 70 mph**
  - **Median crossing from 15 – 50 MPH**
  - **Median crossing w/ braking from 35 – 45 MPH**

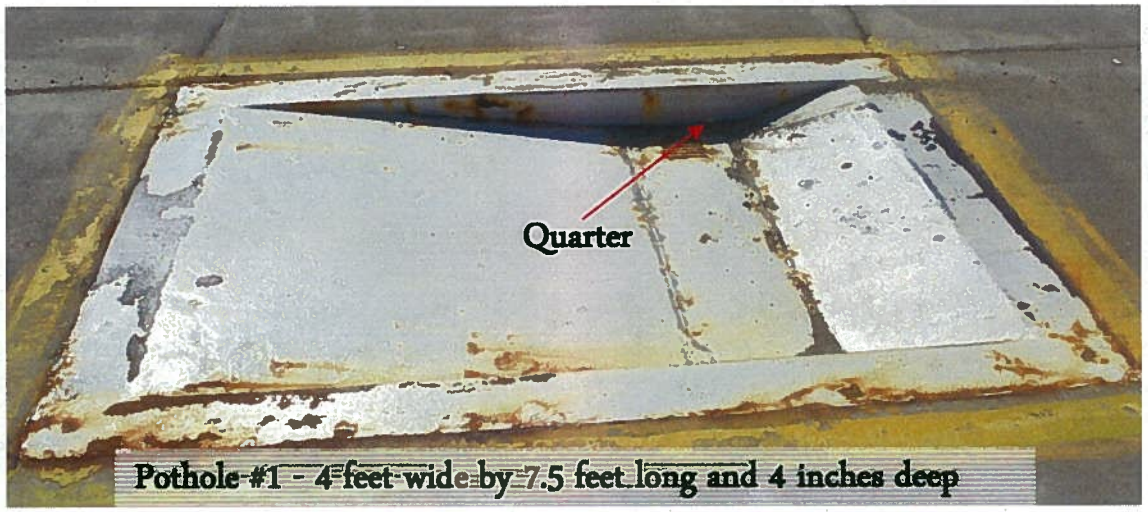
Belgian Blocks 25 - 35MPH

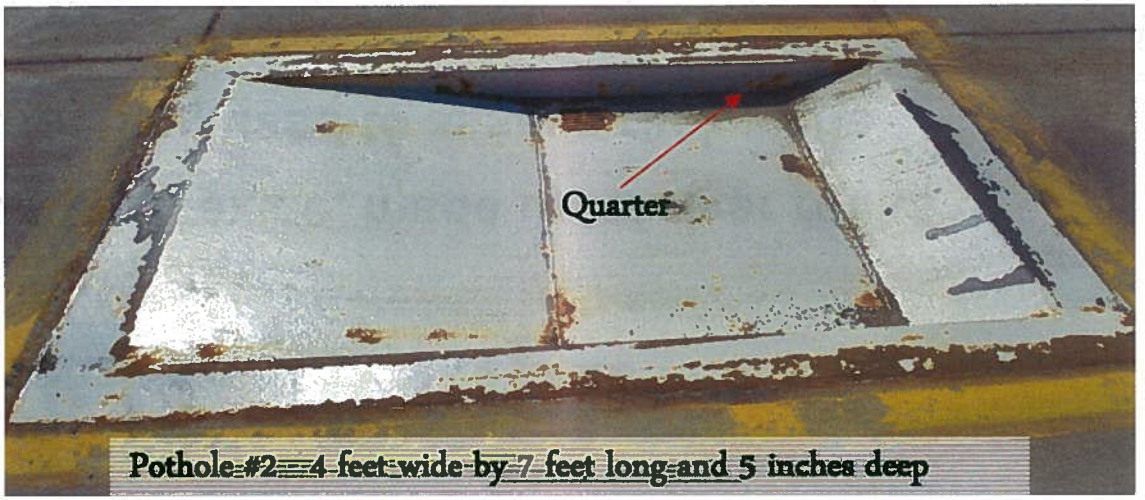
- A 1.7 mile replica of old Belgian granite block roads that are very rough, including dips and bumps to accelerate durability.



Potholes #1 & #2 @ 25 mph

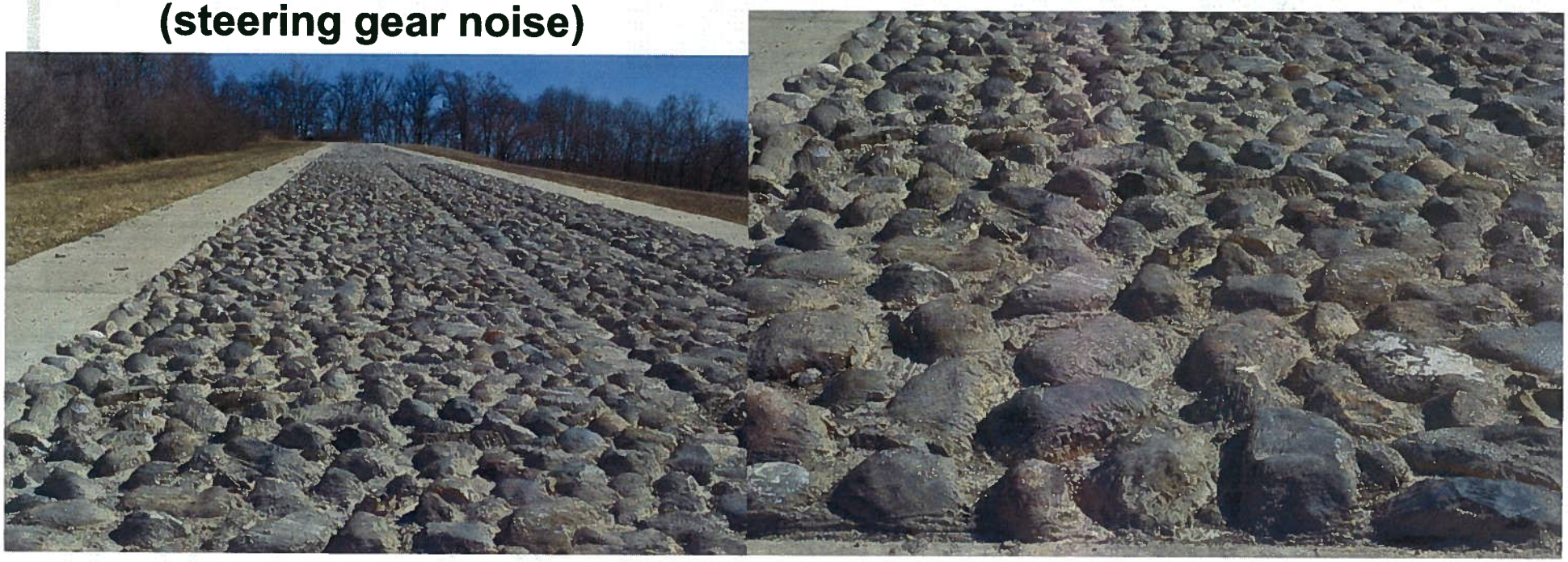
- Pothole #1 – a 50th percentile customer would see at least one of these vertical load events in a the vehicle's life.
- Pothole #2 – a 80th percentile customer



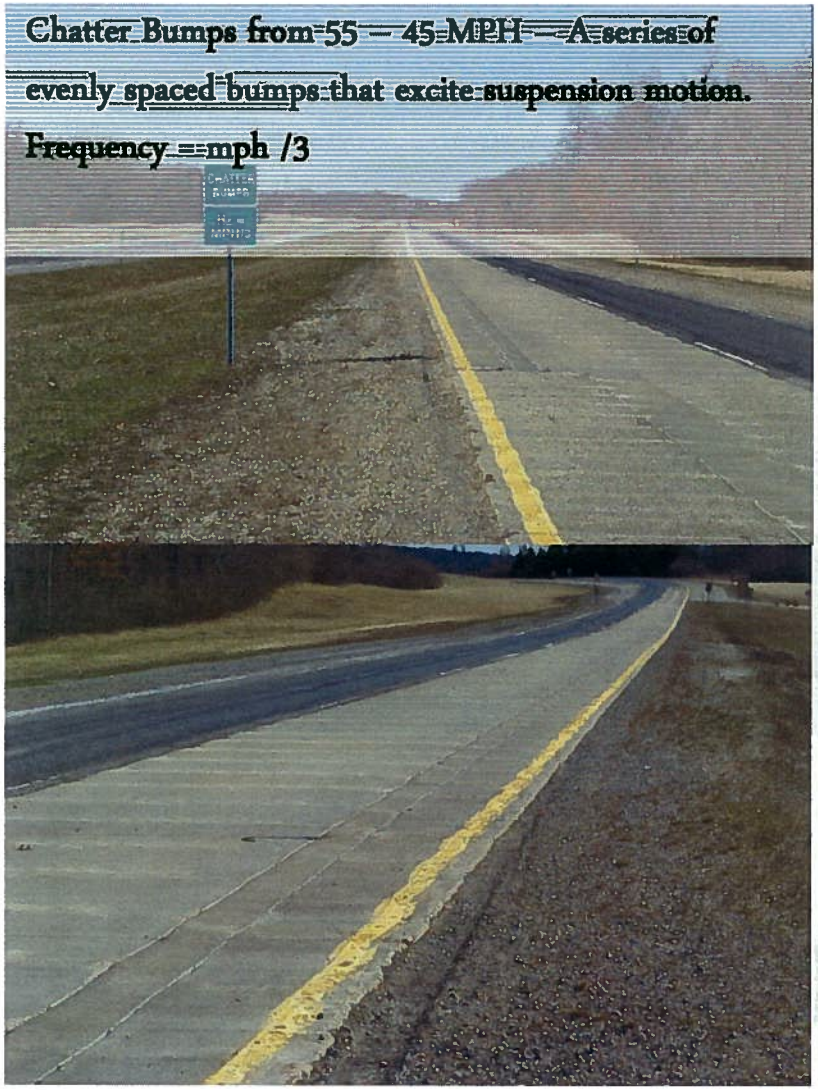


La Cubilete @ 10 mph

- A replica of a severe road in Mexico, made up of river rocks
- Not part of standard durability, used to assess rack rattle (steering gear noise)



Ride and Handling Loop



Ride & Handling Angled RR crossing @ 70 MPH - An elevated, railroad crossing that is at an angle to the road direction

Physics

Significantly reduced moment arm