A New Look at Determining the Sensitivity Levels of Oilfield Shaped Charges

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Core Lab
RESERVOIR OPTIMIZATION

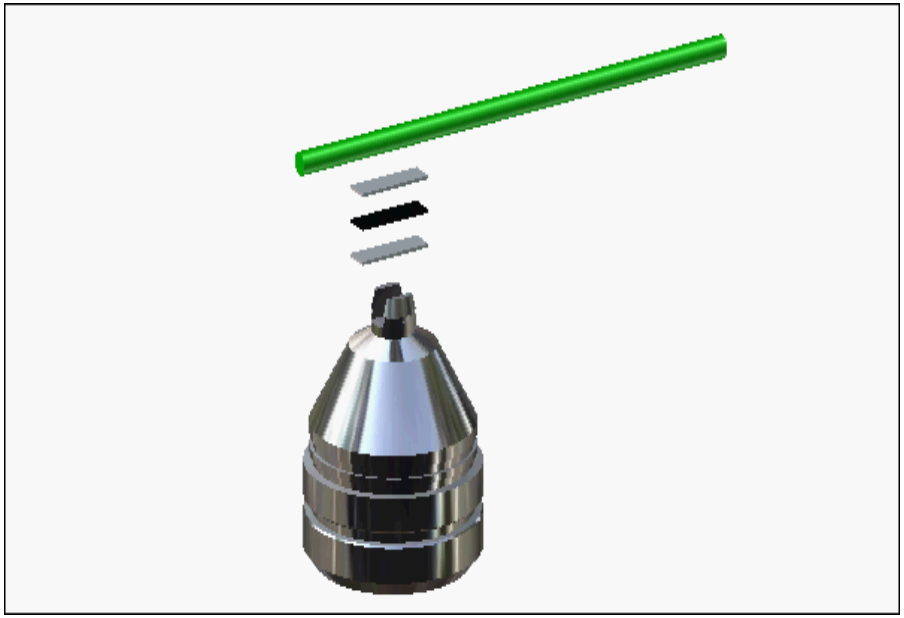
Owen Oil Tools

Abstract Summary

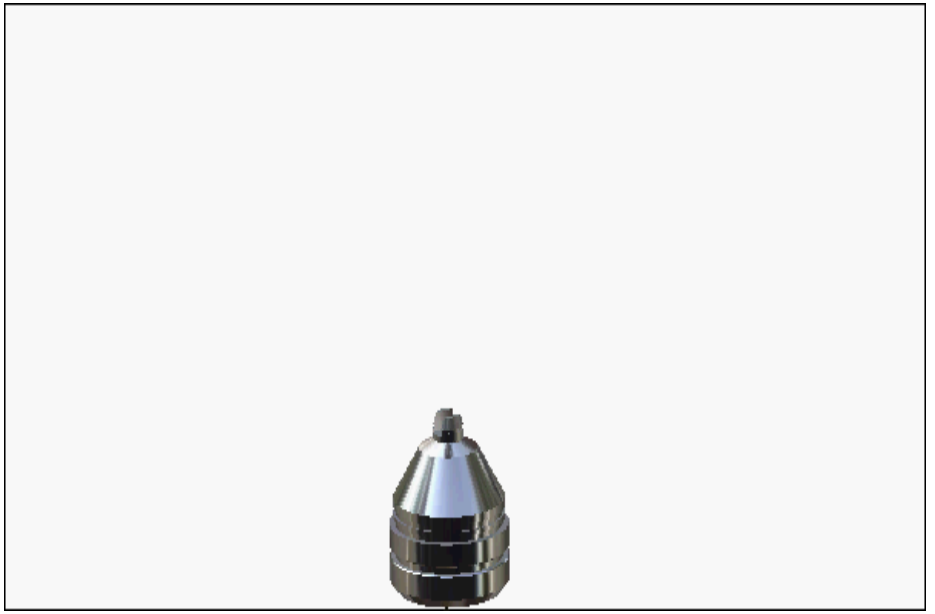
- The test series was prompted by multiple customer complaints received regarding misfired or low-ordered guns where the absence of detonating cord clips was determined to be the cause of the failure
- Research the effects on charge performance and sensitivity by moving the detonating cord away from the charge at differing distances
- The current method used by manufacturers is to add playing cards to the charge case ears and transfer from the detonating cord to the charge through the cards
- Compare the effects using the current method (playing cards) and the real world scenario (air gap)

Methods for Spacing

Playing Card Testing



Air Gap Testing

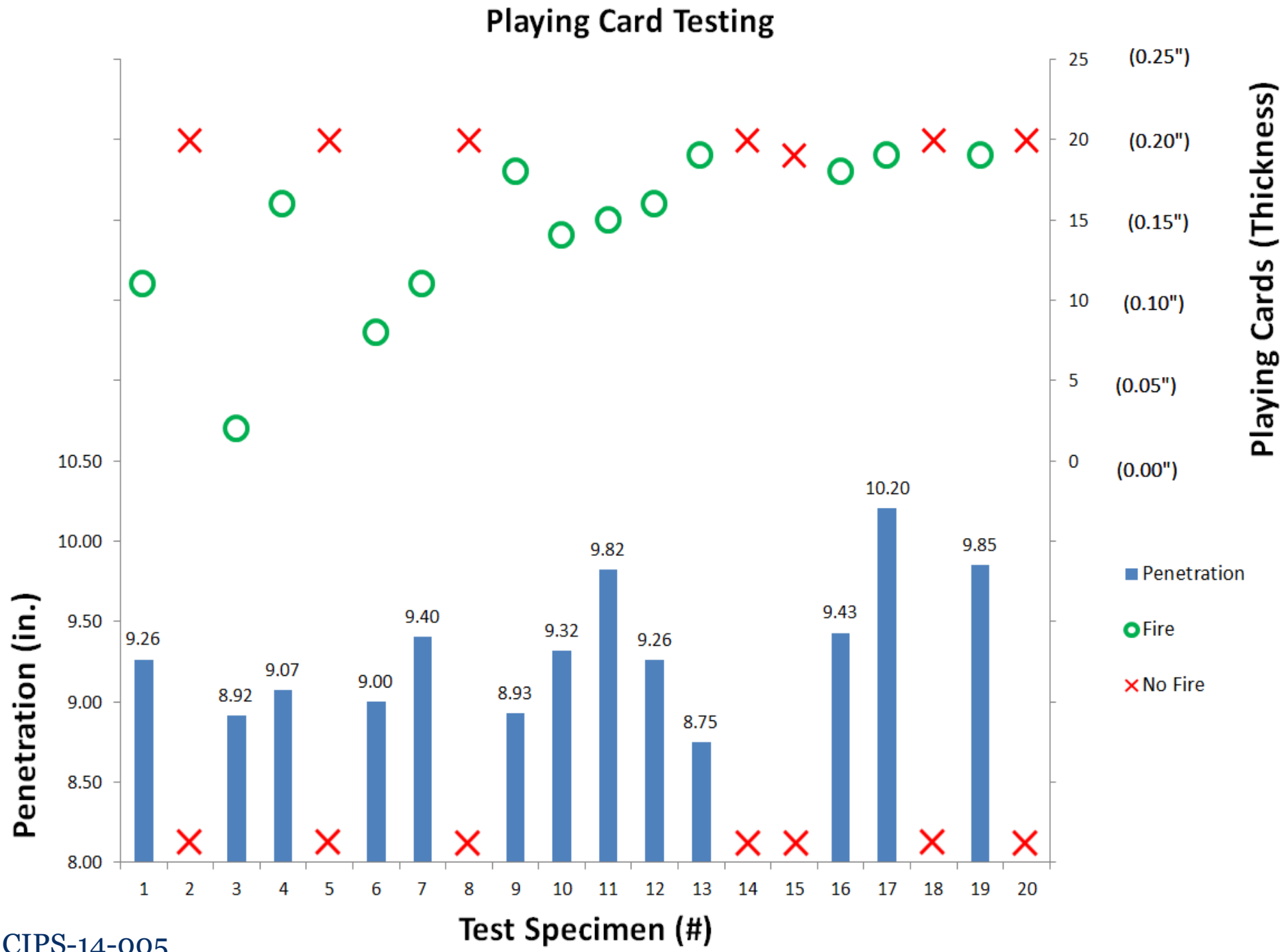


Test Series

- For the test series 80 grain RDX LS XHV cord was used
- One consistent charge used throughout testing
  - Average Standard deviation in QC concrete is
    - ~4.9% for penetration
    - ~5.4% for hole size
- Data Measurements
  - Aluminum bars were probed and measured with a depth gauge for total penetration
  - If full penetration could not be probed, bars were cut to retrieve jet

Test Method

- Data Analysis
  - Neyer SenTest software utilizes the Bruceton test method for a statistical analysis of the data
  - The Bruceton method uses a fire/no-fire criterion to determine a distance where a 50% success rate is achieved
- Test Considerations
  - Compressible cards with numerous laminations can have a negative effect in large gap testing
  - Shockwave dynamic theory is critical based upon the impedance of materials and interfaces
  - The air gap setup reduces user variability whereas the playing card testing has shown to be user dependent


Playing Card Testing
Penetration (in.)
10.50
10.00
9.50
9.00
8.50
8.00
9.26
8.92
9.07
9.00
9.40
8.93
9.32
9.82
9.26
8.75
9.43
10.20
9.85
25
20
15
10
5
0
(0.25")
(0.20")
(0.15")
(0.10")
(0.05")
(0.00")
Playing Cards (Thickness)
Penetration
Fire
No Fire
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Test Specimen (#)

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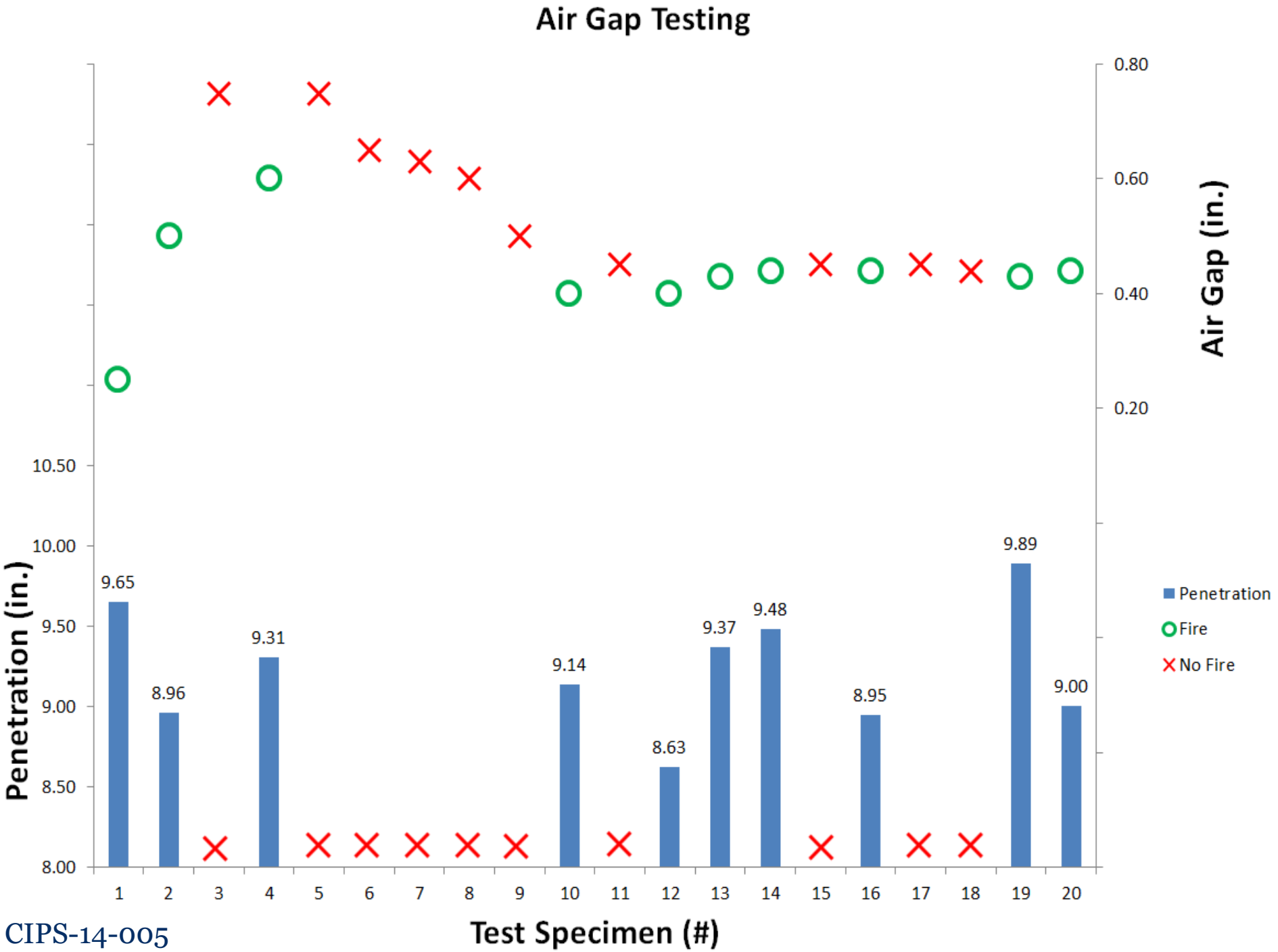
Air Gap Testing
Penetration (in.)
Air Gap (in.)
Test Specimen (#)
0.80
0.60
0.40
0.20
10.50
10.00
9.50
9.00
8.50
8.00
9.65
8.96
9.31
9.14
8.63
9.37
9.48
8.95
9.89
9.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Penetration
Fire
No Fire

Playing Card Test Results- Basic Analysis

- Performance Analysis
  - There was no statistical significance in the performance variations seen in hole size or penetration.
  - The standard variation for performance of this charge with no playing cards is comparable to the variation seen in the playing card testing.

- Sensitivity Analysis
  - Using the Neyer SenTest software it was determined with 99.9% confidence that at 19 playing cards (0.190”) you will successfully initiate 50% of the time.

Air Gap Test Results- Basic Analysis

- Performance Analysis
  - There was no statistical significance in the performance variations seen in hole size or penetration.
  - The standard variation for performance of this charge with no air gap is comparable to the variation seen in the air gap testing.

- Sensitivity Analysis
  - Using the Neyer SenTest software, finding a distance of 50% initiation could not be determined at 99.9% confidence when using an air gap.

Testing Conclusions

- After testing it was concluded that the maximum distance of initiation (cord distance from charge case) is further using an air gap than playing cards.

- However, the consistency of initiation and associated cord distance is difficult to determine in an air gap. Throughout the air gap testing a 99.9% confidence factor could not be achieved.

Recommendations

- The following recommendations are based on analysis of the data gathered during the test series:
  - When loading guns, always use manufacturers loading recommendations to attach detonating cord to charge. This will drastically improve the consistency of initiation.
  - More testing needs to be conducted to solidify the air gap testing method to provide a higher confidence factor amongst a variety of charges.
  - If a higher confidence factor and reliability level can be obtained, the industry standard (playing cards) may need to be re-evaluated to examine a real world sensitivity requirement.

Future Testing and Considerations

- Testing results have the potential to be charge type, explosive type, and detonating cord type specific
- Consider testing in a solid spacer material where laminations do not exist
- Testing of other explosive types to determine effects of, and comparison to, alternate explosive sensitivity testing methods
- Testing in full system scenarios (guns) to determine real world sensitivity levels