IPS 24 – 1.3

Development of Shaped Charges for Uniform Casing Hole

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Outline

- Introduction
- Technical approach: Modeling & Simulation
- Designs validated in engineering and API 19B testing
- Summary

Introduction: Challenges in Charge Development

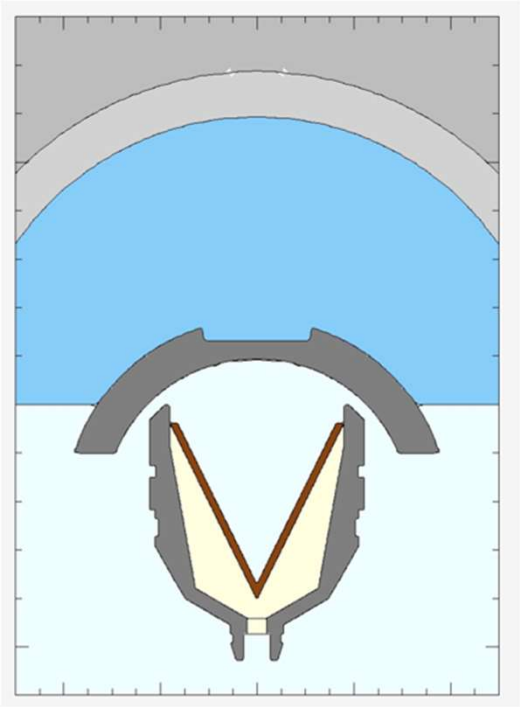
- Unconventional perforating operations demand uniform casing hole (UCH) charge.
- Such demands are seen in various operations such as Perf & Plug, PWC, and P&A.
- In limited entry fracturing, even distribution of treatment fluid requires UCH within a stage for the perf-holes at different phases.

  ❖ Challenge 1: Design charges to create UCH under different water clearances.

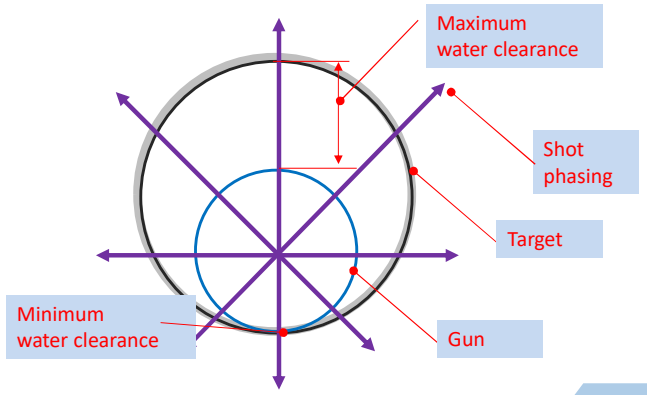
- Many charges to produce different UCH are required.

  ❖ Challenge 2: traditional "trial-and-error" based design takes too long

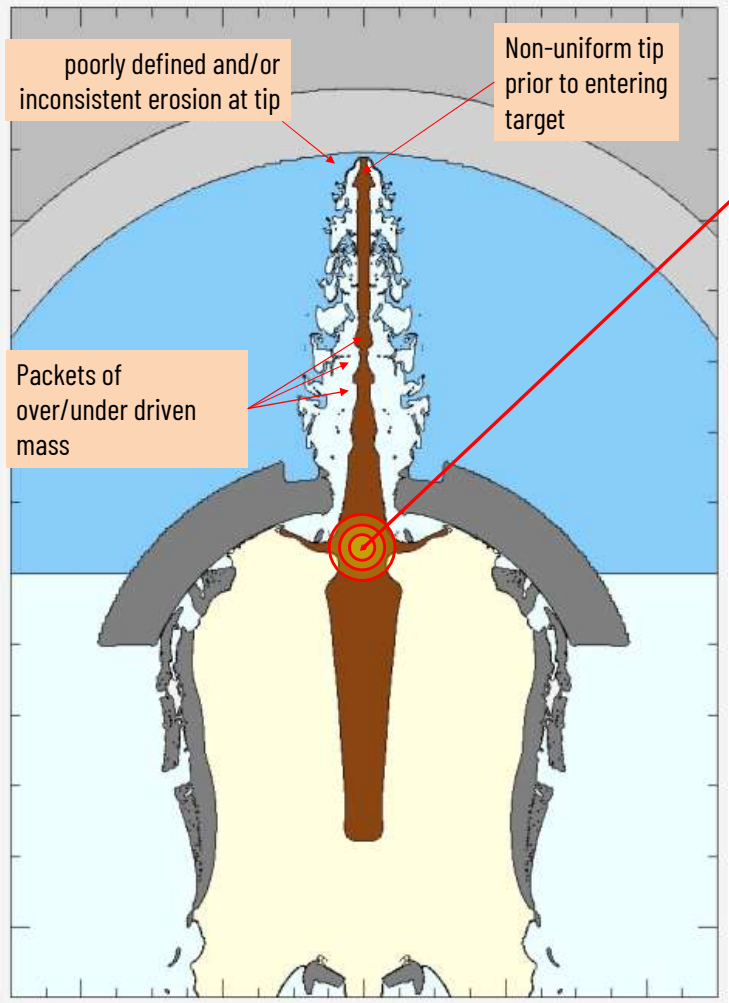
Technical Approach: Modeling & Simulations

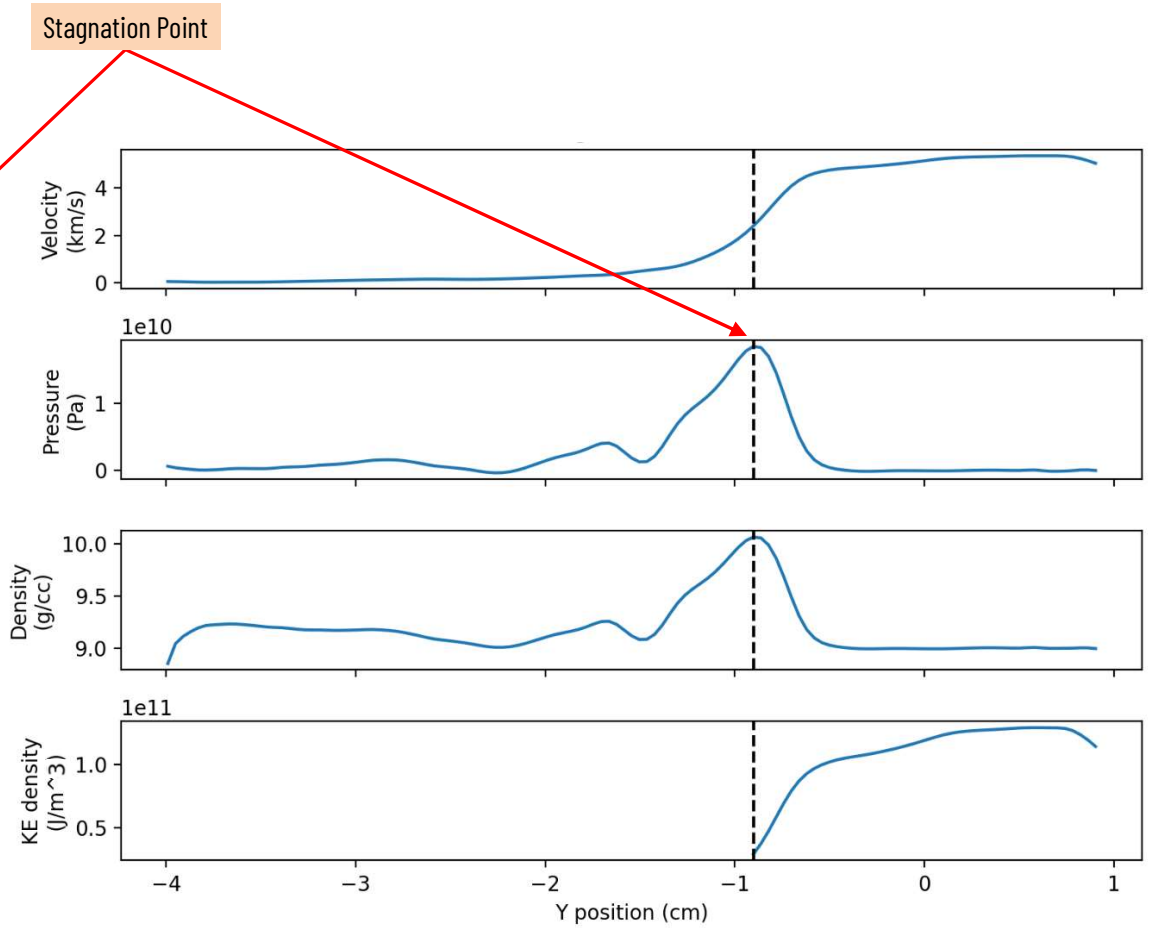


- Modeling and Simulation (M&S) is chosen to address the engineering challenges
- Search and find the design that produces consistent UCH (~5%)
- Long water clearance simulations prove more difficult to achieve good agreement with observed shot data.
- Good fit is typically observed in the medium clearance.

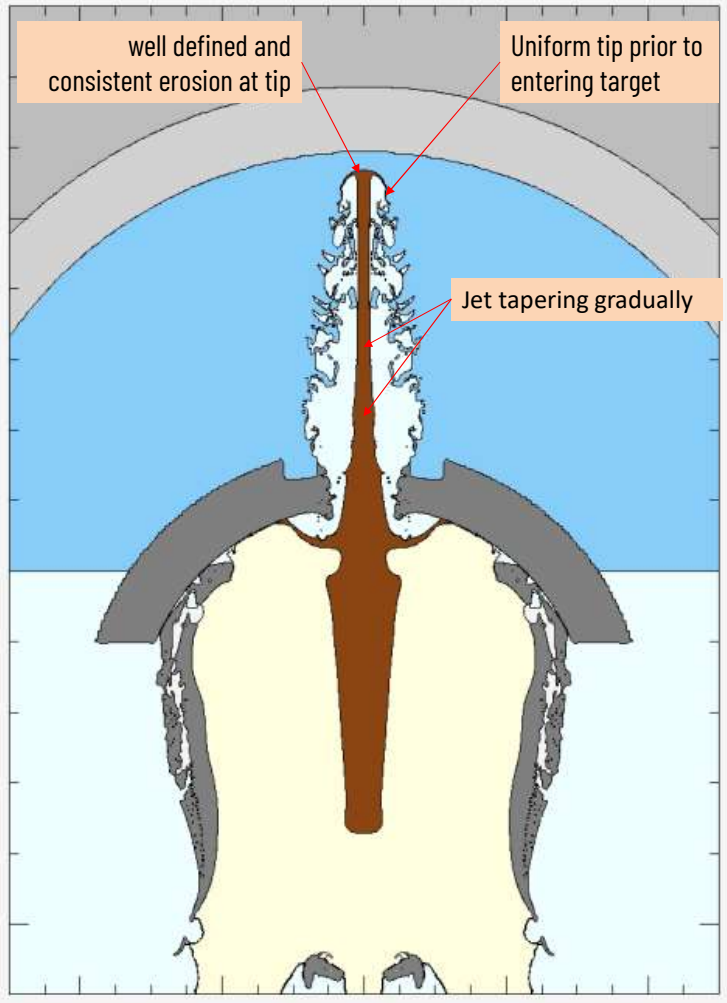


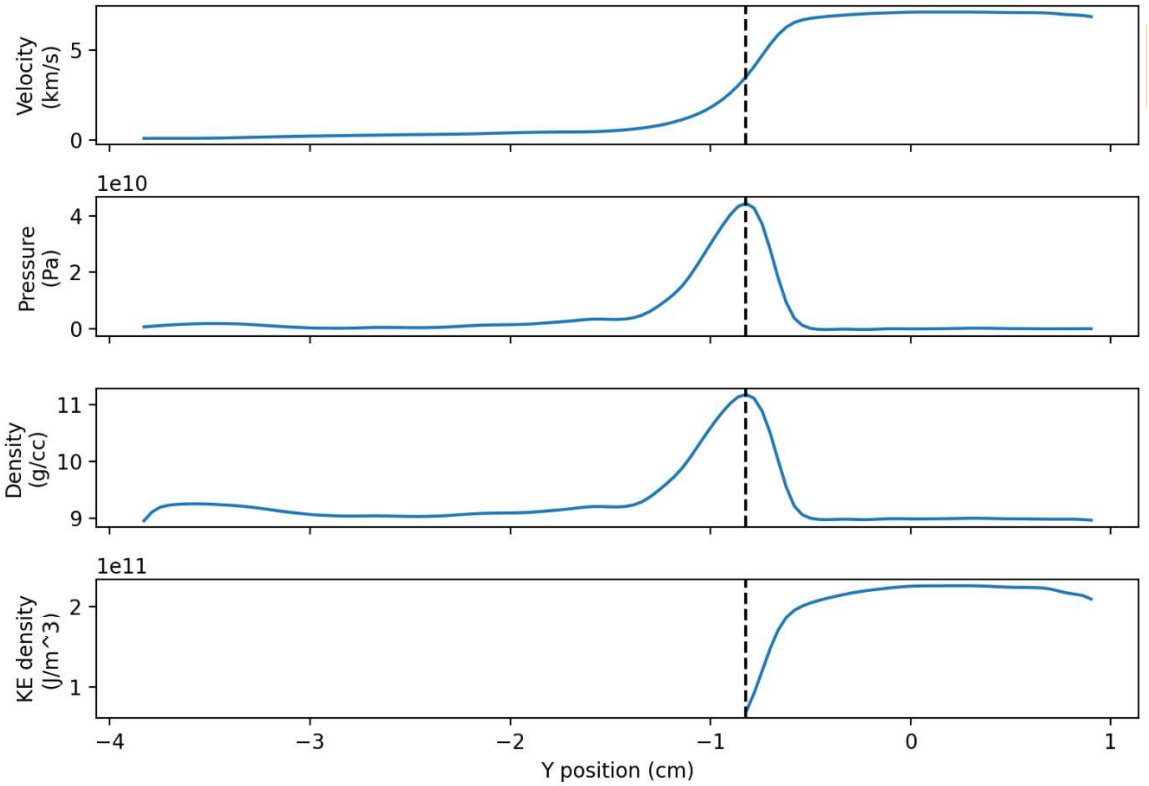
Jet Physics in the Designs of 10% Stdev UCH





Jet Physics in the Designs of 5% Stdev UCH





Charge Designs Validation in API System Tests

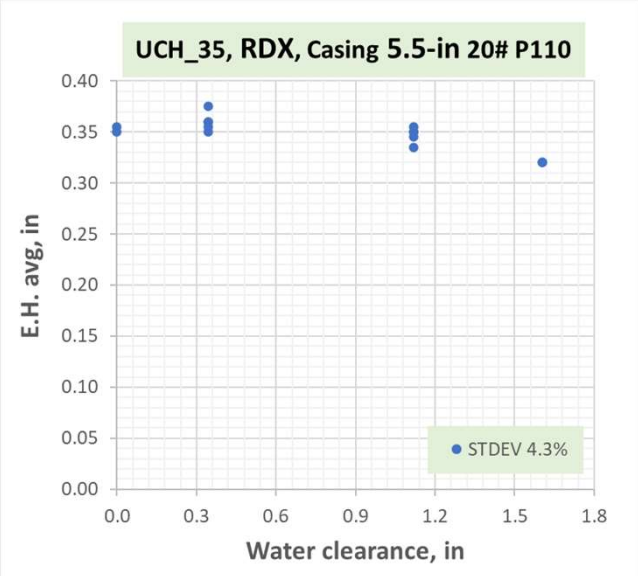
API 19B Section 1 testing results of uniform casing hole charges

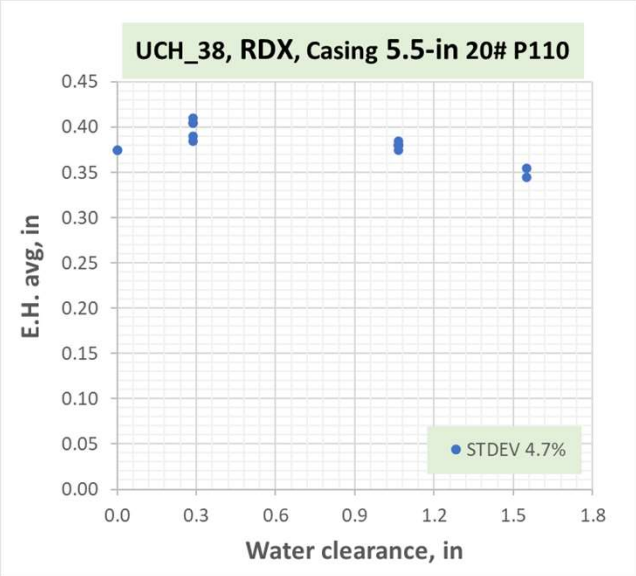
Uniform Casing Hole (UCH) Charge	Water clearance, in	Penetration, in	Casing Exit Hole, in	Standard deviation (Stdev), in	STDEV %
UCH_35	0.0~1.60"	18.6	0.35	0.015	4.3%
UCH_38	0.0~1.60"	19.7	0.38	0.018	4.7%
UCH_40a	0.0~1.60"	22.1	0.40	0.017	4.3%
UCH_40b	0.0~1.60"	21.4	0.40	0.017	4.4%
UCH_42	0.0~1.60"	21.5	0.42	0.018	4.2%
UCH_45	0.0~1.60"	20.0	0.45	0.021	4.7%

- API testing charges manufactured after Specs met in engineering QC shots

API 19B S1 cement target:
OD=72-in, >=28 days
Gun size: 3.12-in.
Casing: 5.5-in, 20# P110

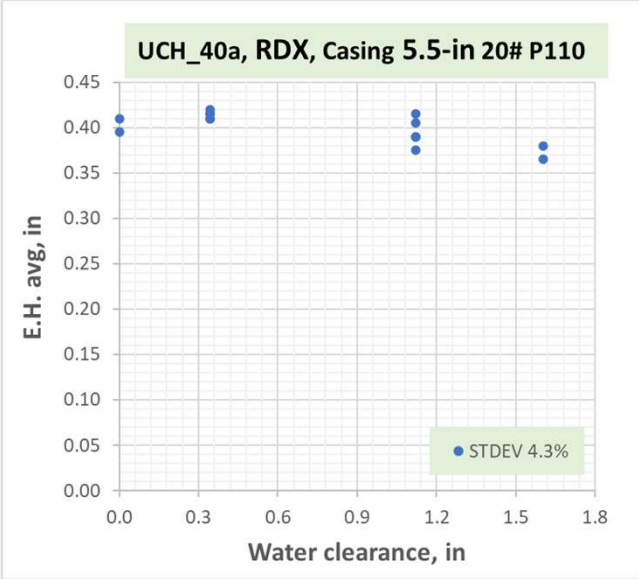
API 19B S1 Test Results for UCH_35 and UCH_38

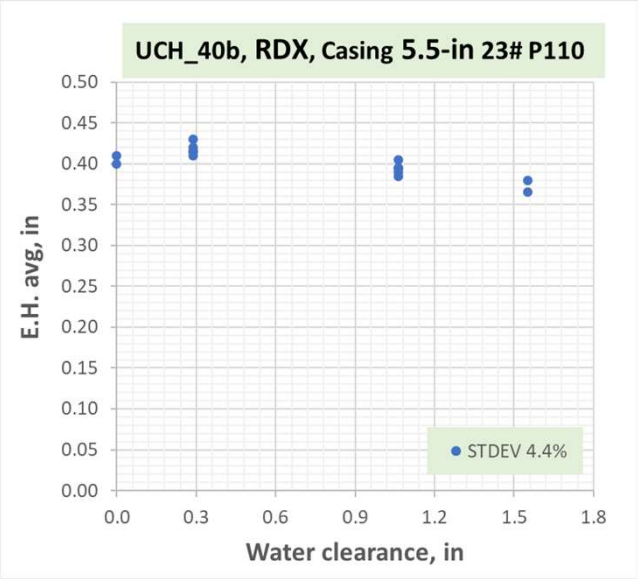




- E.H. presents similar trend, decrease with water clearance, but at very low rate.

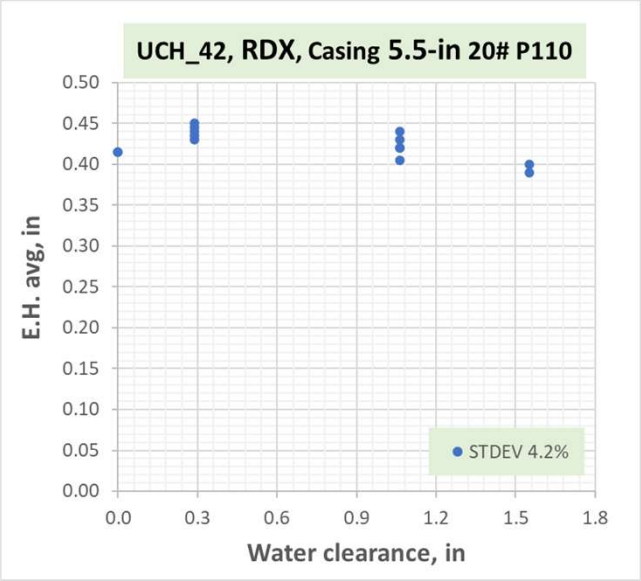
API 19B S1 Test Results for: UCH_40

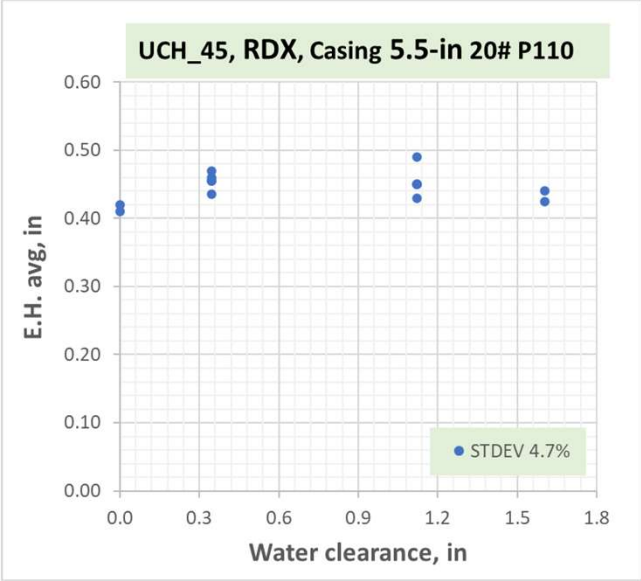




- UCH_40 tested for 2 casing weight, the results EH and stdev are almost the same, though casing wall 0.05" difference.

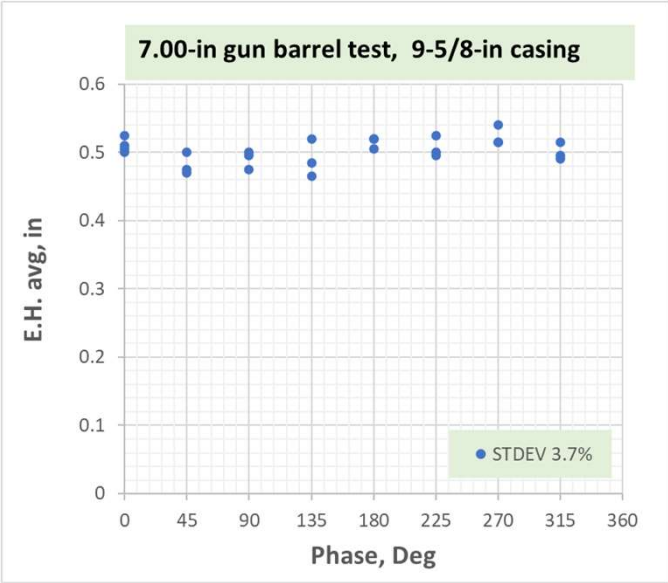
API 19B S1 Test Results for: UCH_42 and UCH_45

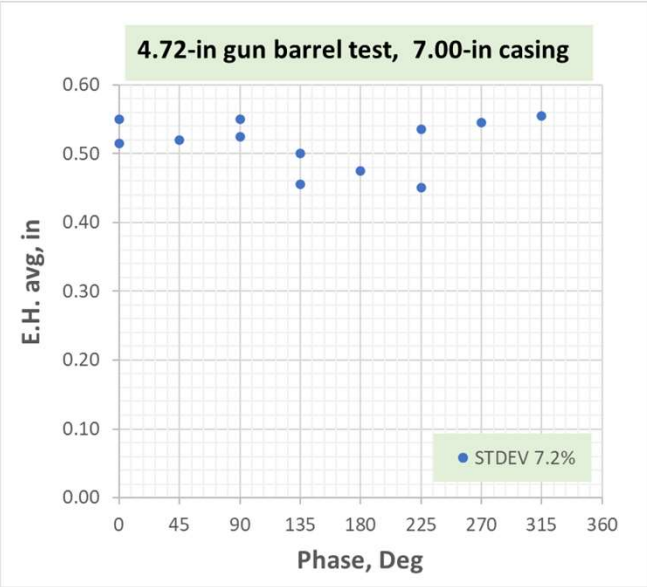


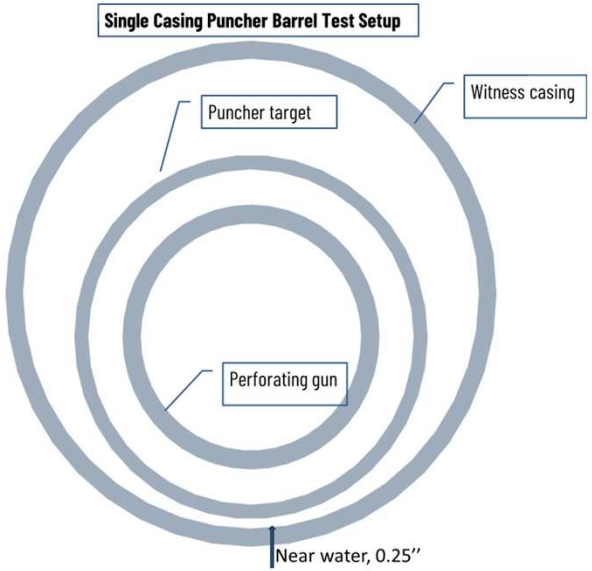


- UCH_42 shows EH consistent except at long water.
- UCH_45 presents different trend, no visible drop at long water

Barrel Test Results for Punchers







Puncher for gun	Target casing	Witness casing	Avg. casing hole, in	STDEV	Pene. on witness, in
4.72-in	7.0 26# L80	9-5/8 47# L80	0.51	7.2%	<0.1
7.00-in	9-5/8 47# L80	13-3/8 68# L80	0.50	3.7%	<0.03

Barrel test setup:

- Centralized gun in target casing
- The target casing sets 0.25" near witness casing
- Casing filled with water

Summary

- The M&S approach enables efficient engineering design and testing
- Successfully developed five UCH charges and two casing punchers within relatively short time.
- The future work will apply the similar method to develop deep penetration charges.

QUESTIONS?

MAY 13-15 IPS 2024

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