

Reviewing the Basics of American Petroleum Institute Recommended Practice 19B Section 2 Laboratory Testing

Evaluating Perforators Under Stress Conditions, Berea Targets

Introduction/Berea Sandstone Target 2.1/2.2

Measuring Perforator Performance in stressed Berea sandstone with wellbore pressure applied.

Measuring Perforator Performance in stressed Berea sandstone or other natural rock with desired properties with specific lithostatic pressure applied.

Preparation of Berea Targets 2.3

Specified Porosity: 19-21%

Verify Permeability consistency sample to sample since there are a variety of Berea sandstone types (Buff, Grey, etc).

Core sizes: 4-inch diameter for 15g explosive or less and 7-inch diameter for >15g charges



Figure 1- Effect of shooting 25g DP in 4-inch core.

Valid Penetration Rules

3-inches must remain below deepest penetration to be considered a valid test.

Core cutting by lathe or core barrel –want close to a perfect cylinder

Core Drying – 24 hours at 200°F or time to achieve constant weight. An oven with circulation will accomplish this on a 7” diameter Berea core.

Vacuum Saturating – needs to be slow enough to prevent gas trapping, can be accomplished visibly in a clear polycarbonate chamber. Success can be verified by calculations.

Porosity – calculated gravimetrically with either 3% NaCl brine or Kerosene. Need about a 60 Kg scale accurate to 1 gram and calipers large enough for accurate diameter and length measurements.

Kerosene or similar solvent is preferred since brine may react with rock clay minerals.

Storage of Cores – requires a sizeable bath of material suitable for fluids used, non-corrosive and stand up to solvents such as odorless mineral spirits.

Test Apparatus 2.4

Rubber Sleeve

Need rubber sleeve to snugly fit core diameter and target end fixturing for length. Composition can be Nitrile (Buna-N) or viton when kerosene or other solvents are used. Thicker, lower durometer (70) sleeves less prone to cut and fail are preferred.

Target End Fixtures

A 0.38 inch thick mild steel faceplate from ASTM A-36 grade steel with 0.75 inch spacer of Hydrostone to represent cement sheath for the shooting end and an adequate-sized vent tube (recommended 1-inch OD by 0.25 inch ID on the non-shooting end (top). Using Type-A cement is easier to handle and very similar to downhole cement.

Pressure Vessel and Gauges

Pressure vessel must have at least 12 inches ID, and bi-annually calibrated equipment capable of obtaining a permanent pressure profile recording of each test. Fast gauges are available for recording instantaneous surge in wellbore.

Core Target Mounting

Gun should be securely fastened with correct clearance and alignment to the core target. The end fixtures need to be free to travel in the direction of the core to transmit stress uniformly. Uniform stress is good unless simulating a field with preferential stress orientation.

Perforating Tool (Simulated Gun)

Represents a single-shot gun that must be a duplicate of the field gun.

A flat plate of matching thickness attached to a re-usable gun is preferred to actual gun material, caution is to ensure hardness of material matches field gun.

Test Apparatus 2.5

Chamber fluid

Water at ambient conditions.

Water is less hazardous than laboratory oil and better with a solvent-based pore fluid.

Clearance

0.5 inches *or at specific well conditions*. Specific well conditions when known, what would be done in a RP API Section 4 test.

Charge Selection and Aging

Minimum production runs of 1000 for RDX-type or 300 for high temperature PETN-type charges. These charges need to be aged 4 weeks packaged in a standard shipping container. This mindset can only help manufacturers improve its products.

Number of Shots

A minimum of 3 per setup to represent average performance expected from a production run. This has proven to be very useful with the number of variables to consider.

Firing Pressure

The pressure vessel is pressured up to 3,000 psi and held for 5 minutes to ensure seal, the compressed core allowed to relieve saturation fluid out vent. Vent valve is closed to protect gauges and pumps from shock caused by firing event. Closing the vessel in may be damaging when shooting high gram loads with water as the confining fluid and brine in the pore space. It is recommended to use a bladder or gas-cap accumulator to diffuse the shock of detonation.

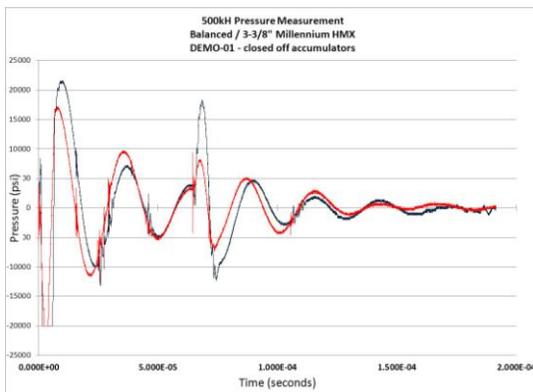
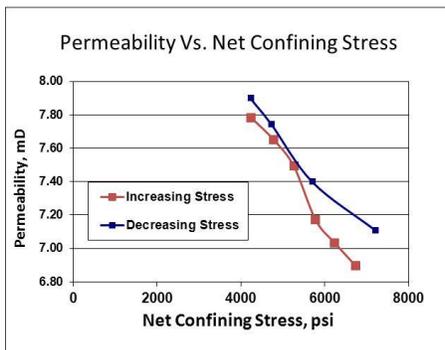


Figure 2- High pressures may damage confinement vessel with closed system.

If higher pressures are desired to mimic a bottomhole condition, it is best to go to an API RP 19B section 4 test since dynamic underbalance effects tend to dominate tunnel geometry. The rock can be changed to match field rock properties, fluids in both the wellbore and pore space can be matched, internal gun air volume can better match downhole dynamic under-balance.



Determining Depth of Penetration

The maximum depth from the exterior steel face plate to the end of the perforation tunnel, determined by probing for weakened rock beyond the perforation tip. Consistency in technique is the recommended approach this since most testing is comparative and not absolute.

Faceplate Hole Diameter

Hole diameter measured along short and long elliptical axes and reported along with the average of the two measurements. The measurements are to be made outside the faceplate with a caliper whose arms pass through the perforation and at an accuracy of 0.01 inches. Once again, consistency in technique is the recommended approach.

Control of Perforation End Position in the Target

In 4-inch diameter cores, the perforation tip must be within 1.25 inches of centerline axis, and within 2.0 inches in a 7-inch diameter core.

Recording of Data

Reported data is not to be listed as API registered. Interested clients may lobby for this, however testing cost would rise.

Conclusions/Inferences

The data gained from the above RP may be too narrow for its effort. Casing entrance hole size can be gained from QC shots and penetration depth into a 3,000 psi stressed Berea sandstone has limited value.

It has been more than the recommend time for an RP to be reviewed, 5 years, and this one is ready to be updated .