IPS 2024

2024-IPS-5.1

Casing Material – a Source of "Perforating Debris"?

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Agenda

Perforating debris

- What it is, why it’s important
- Potential sources
- How we quantify
- Casing debris – a closer look

Debris

Conventional definitions

Evaluation of Well Perforators

API RECOMMENDED PRACTICE 19B
THIRD EDITION, JULY 2021

American Petroleum Institute

4.5.1.2 Debris is defined as all solid materials that are blown out of the exit holes in the gun at the time of detonation or fall out of the exit holes during the trip out of the well.

https://petrowiki.spe.org/Glossary:Perforating_debris

Glossary:Perforating debris

Pieces of charge cases, loading tubes, and alignment equipment generated by firing the gun. They may or may not be left in the well.

Debris

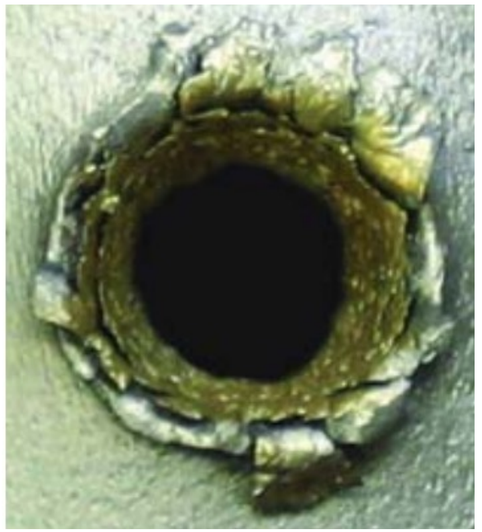
Broader view

- Material residue left in wellbore after perforating
- Typically metallic, typically magnetic
- Can interfere with subsequent activities
  - Completion
  - Production
  - Intervention

Debris

Potential sources

- Perforating system
  - Internal components
  - Carrier (exit hole) material
- Casing
  - Base material
  - Scale
- Cement, formation material
- Reaction products from combinations of the above (to include wellbore fluid)



Debris

Regardless of the source…

Mass is conserved

It either…

- goes where you don’t want it, or
- goes/stays where you don’t mind it

It doesn’t “disappear”

Debris

How we quantify

- API RP 19B Section V

4.5 Debris Collection Procedure for Perforating Guns (Section V Test)

4.5.1 Hollow Carrier Perforating Guns

4.5.1.1 Because of the complexity and variability of well conditions it is thought to be impossible to determine with any degree of accuracy, the amount of perforating debris that will be left in a well bore by conducting a surface test. Since a downhole test is neither practical nor affordable it was necessary to design a surface test whereby potential gun debris could be quantified specifically for comparing competing systems. This procedure does not address casing scale or debris from any other source but the perforating gun.

4.5.1.2 Debris is defined as all solid materials that are blown out of the exit holes in the gun at the time of detonation or fall out of the exit holes during the trip out of the well.

4.5.1.3 This test was designed to quantify the debris that comes out of a perforating gun upon detonation and identify and quantify any debris remaining in the gun that is small enough to potentially come out of the gun on the trip out of the well. It is designed for comparative purposes only and shall not be used to determine the amount of debris that will be left in any given well bore.

This is a Test…This is ONLY a Test

Debris

Potential sources

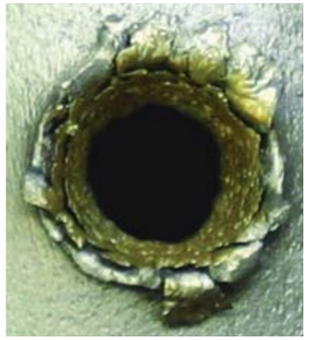
- Perforating system
  - Internal components
  - Carrier (exit hole) material
- Casing
  - Base material
  - Scale
- Cement, formation material
- Reaction products from combinations of the above (to include wellbore fluid)

API RP 19B Section V

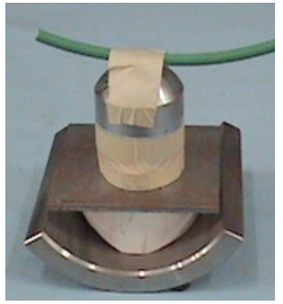
Debris

Casing debris – a closer look

- Does the “hole” represent mass removed from casing?
- Or does it all remain on casing (burr)?
- If it is mass removed, then
  - By definition it is potential debris
  - How much is there?

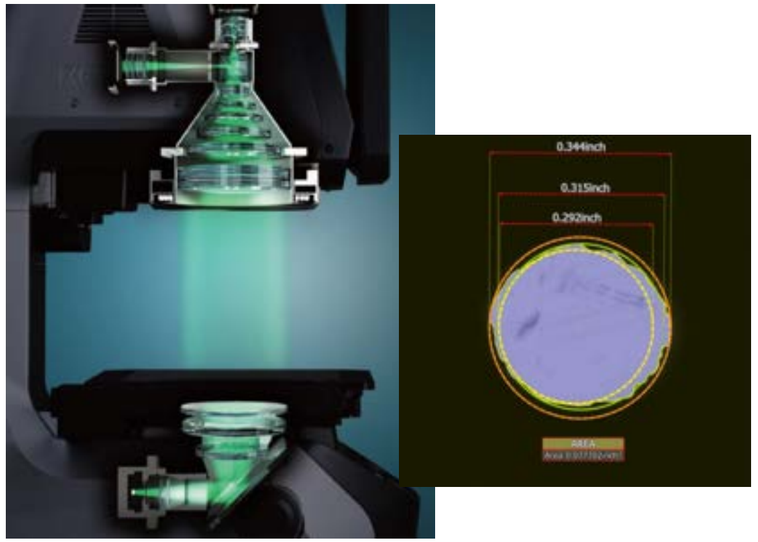


- Simple approach – weigh casing before and after perforating
  - Can be applied in principle to full casing (system test)
  - Easily applied to casing coupons (single shots)



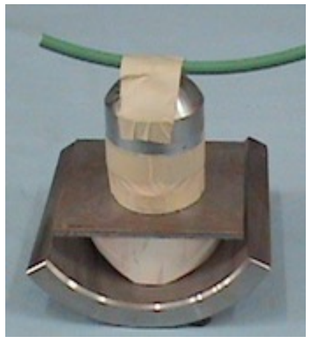
Debris

Casing debris – a closer look



Recent effort

- Simplest approach
- Single-shot bunker tests (casing coupons)
- Precisely measure through-hole diameters
- Precisely weigh each before and after perforating



Coupon test setup

Casing ID (entry)

Casing OD (exit)

Optical Comparator (4)

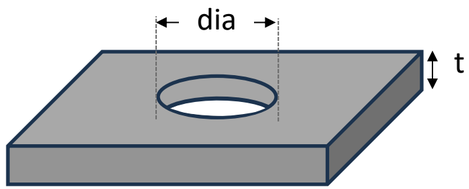
- Representative Diameters
  - Best fit * → $D_{bf} = f(x_n, y_n)$..... *least squares method*
  - Equivalent ** → $D_{eq} = \text{sqrt}(4A/\pi)$..... *assumes circle*
  - Hydraulic ** → $D_h = 4A/P$ *** ..... *takes into account perimeter*
- Circularity → $C = 4\pi A/P^2$ *** ..... $C \leq 1$

Debris

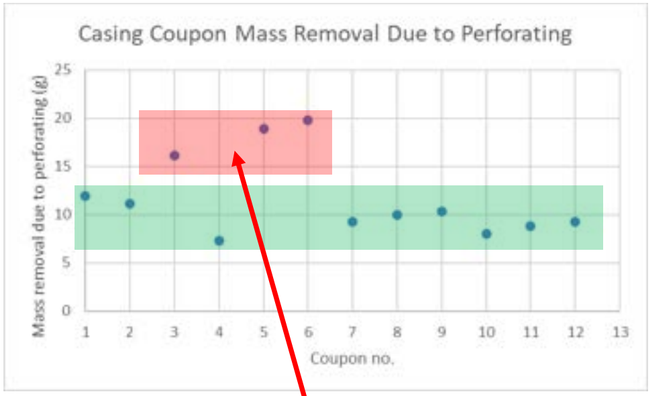
Casing debris – a closer look

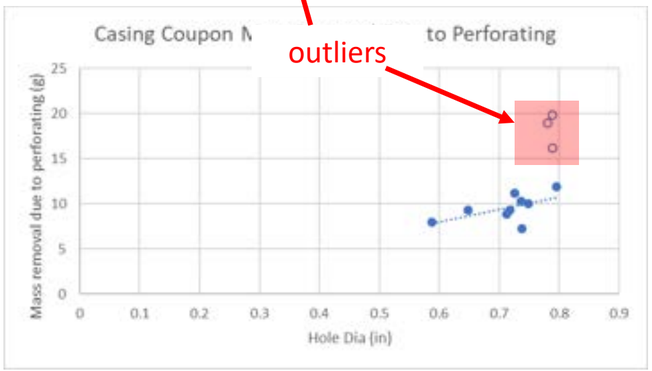
Results

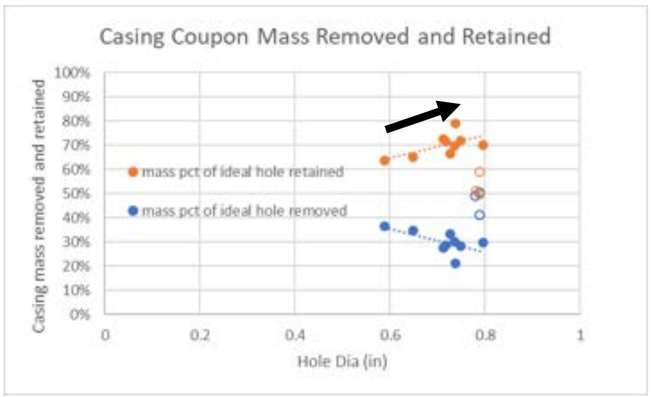
- 12 tests conducted
- Mass loss confirmed for all
- 9 “good” datapoints; 3 outliers
- Hole mass correlates with diameter



- Calculate theoretical mass if “hole punched”
- Actual mass ~30% of theoretical “hole punch” value
- ~70% of theoretical “hole punch” value retained (burr)
- Trend: larger holes → greater proportion *retained*







Casing debris – a closer look

Especially with ultra-low debris systems

Implications

- Casing material may be a source of “perforating debris” downhole
- Simple testing may be able to provide some insight

Caveat

- “simple testing” may miss important downhole factors, cannot tell the “whole story”

Thoughts

- Further testing w/ different charge/gun/casing configurations
- System testing (full casing, cement backed)
- Downhole conditions

QUESTIONS?

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