Outline

- Objective
- Charter
- Progress Overview
- Advanced Dull Grading Process Map
- Grading Every Cutter – Training Examples
- Key Accomplishments
- Additional Considerations
- Next Steps
Objective

Re-write the IADC dull grading system to better support a workflow focused on continuous improvement and root cause analysis.

This section of the grading system shall focus on a qualitative classification scheme of **PDC cutters, drill bits, and tools with cutting elements**, with a second priority on quantitative analysis.
Charter Statement

Create a Forensics Evaluation Workflow(s) and Best Practice(s) Document to be published within IADC and SPE.

<table>
<thead>
<tr>
<th>Task</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collect the most common cutter damage examples, group and label them according to the workgroup consensus</td>
<td>X</td>
</tr>
<tr>
<td>Define a standard set of words and descriptions for each class</td>
<td>X</td>
</tr>
<tr>
<td>Gather, label and provide to the Case Study Workgroup a large set of case study photo examples for human training and machine learning</td>
<td></td>
</tr>
<tr>
<td>Document the frequency of occurrence of different degradation modes to use as a priority guide for training documents</td>
<td></td>
</tr>
<tr>
<td>Review and update all other bit related codes within the current IADC system to make sure they are; needed, unique, well understood, and up to date. (Broken blades, washouts, etc.)</td>
<td></td>
</tr>
<tr>
<td><strong>Concentrate on PDC drill bits</strong>, then make this compatible with, Roller Cones, Reamers and Under Reamers, and Hybrid bits</td>
<td>X</td>
</tr>
<tr>
<td><strong>Document the new proposed codes</strong> and resolve any conflicts with the other workgroups</td>
<td>X</td>
</tr>
<tr>
<td>Review the proposed codes, storage methods, and examples with industry experts for alignment</td>
<td></td>
</tr>
<tr>
<td>Conduct an end user field trial of the new system and update codes and instructions based on feedback Repeat if required</td>
<td></td>
</tr>
<tr>
<td>Create a final best practices document</td>
<td></td>
</tr>
</tbody>
</table>
Progress Overview

- SME forum established
- 17 Meetings to date
- Attendees 30-50/meeting
- Extensive polling
- Training document drafted
- Group effort
- 42 pages of content so far
- Training examples developed
Advanced Dull Grading Process Map

Dull Grading Processes

Human – Rig Grade
Visual evaluation by zone

Automated
ML Systems utilized to reduce variability and improve efficiency

Human – Shop Grade
Process driven advanced evaluation

IADC Rig Grade

IADC Shop Grade

Individual Cutter Data

Advanced Forensics

Real Time Rig Decisions
Grading Every Cutter

- Enabling consistent data rich dull grading is key to unlocking advanced bit forensics

1. Define process for how to grade a single cutter
2. Grade each cutter on the bit
3. Summarize the tabular data into a standard format
Key Accomplishments

- Universal damage classification scheme established

PDC Cutter Damage Categories:

- ND – No Damage
- CD – Chamfer Damage
- CC – Chipped Cutter
- WC – Worn Cutter
- SC – Spalled Cutter
- BM – Beach marks
- IS – Island Spall
- BC – Broken Cutter
- AB – Axial Break
- TB – Tangential Break
- DC – Delaminated Cutter
- FC – Face Crack
- ID – Indeterminate Damage
- LC – Lost Cutter

Advanced Cutter Damage Categories – Shop Grade

CD – Chamfer Damage
- No Major Damage w/ Rounded Chamfer

CC – Chipped Cutter
- Wear scar with angular and/or flaking cutting edge

BM – Beach Marks
- Spalling with indications of curved fractures on the face of the diamond

IS – Island Spall
- Spalled Cutter w/Diamond PullOut. Flaking of the cutter face does not extend to the carbide and some of the face remaining intact, whereas a portion of flaking is surrounding an intact cutter face

AB – Axial Break
- Diamond loss exposing a portion of the carbide substrate with at least a portion of the diamond fracture plane parallel to the cutter face, but with some cutter face intact

TB – Tangential Break
- Cutter sheared through diamond face through entirety of substrate

FC – Face Crack
- Diamond face has single or multiple cracks that were not propagated to failure
Key Accomplishments - Cont.

- Introduction and standardization of additional measurements
- Cutter substrate damage classes
- Severity measurement system
- Bit zones expanded

<table>
<thead>
<tr>
<th>Scale Type</th>
<th>Description</th>
<th>Images</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 8 Scale (Current)</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /> <img src="image3.png" alt="Image" /> <img src="image4.png" alt="Image" /> <img src="image5.png" alt="Image" /></td>
</tr>
<tr>
<td>Linear Measurement (mm)</td>
<td><img src="image6.png" alt="Image" /></td>
<td><img src="image7.png" alt="Image" /> <img src="image8.png" alt="Image" /> <img src="image9.png" alt="Image" /> <img src="image10.png" alt="Image" /></td>
</tr>
<tr>
<td>0 to 10 Scale</td>
<td><img src="image11.png" alt="Image" /></td>
<td><img src="image12.png" alt="Image" /> <img src="image13.png" alt="Image" /> <img src="image14.png" alt="Image" /> <img src="image15.png" alt="Image" /></td>
</tr>
<tr>
<td>% Loss</td>
<td><img src="image16.png" alt="Image" /></td>
<td><img src="image17.png" alt="Image" /> <img src="image18.png" alt="Image" /> <img src="image19.png" alt="Image" /> <img src="image20.png" alt="Image" /></td>
</tr>
</tbody>
</table>

Substrate Damage:
- NDS – No Damage to Substrate
- ERS – Eroded Substrate
- CRS – Corroded Substrate
- ECS – Eroded/Corroded Substrate
- HCS – Heat Checked Substrate
Bit Zones – expanded from Inner / Outer

- **Cone:** Cutters at the center of the drill bit, inside of the nose
- **Nose:** The cutter at the highest point of the blade arc (one cutter per blade)
- **Shoulder:** Cutters between the nose and gauge
- **Gauge:** The first cutter aligned with the top of the gauge pad
Additional Considerations - Subgroups

- Drill bit zone definition
- Shaped cutter compatibility
- Impreg/Hybrid bit compatibility
- Core head compatibility
- Roller cone compatibility
- Drill bit damage categories
- Reason pulled
  - (collaboration with BHA team)
Next Steps

- Finalize training examples
- Develop field test plan
- Refine coding, fix issues
- Revise paper/instructions
- Develop digital interface (DDR)
- Publish new standard
On to the BHA Group!

Paul Neil