IADC DEC Tech Forum

Bit and BHA dull classification revamp

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The Leadership Team

- Paul Pastusek – Exxon Mobil
- Dustin Daechsel – Shell
- Robin Macmillan – Data Gumbo
- Robert van Kuilenburg – Noble

+120 other SME's across a wide variety of drilling disciplines

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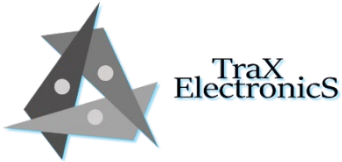
Participants and Sub Teams



The History

Background

- The current Fixed Cutter IADC dull grading codes were created in 1987 and revised in 1992 along with the roller cone codes. SPE papers have also made proposals for hole enlargement tools, though this is not widely known. The IADC codes are a compact, text based way to describe the bit condition, containing **limited** categorization and quantification information.

- The IADC drill bit dull grading system has held up quite well. However, with the introduction of large automated systems, machine learning, evolving drill bit and BHA products, and the requirement for more complete and detailed data, there is an obvious need to improve the system.

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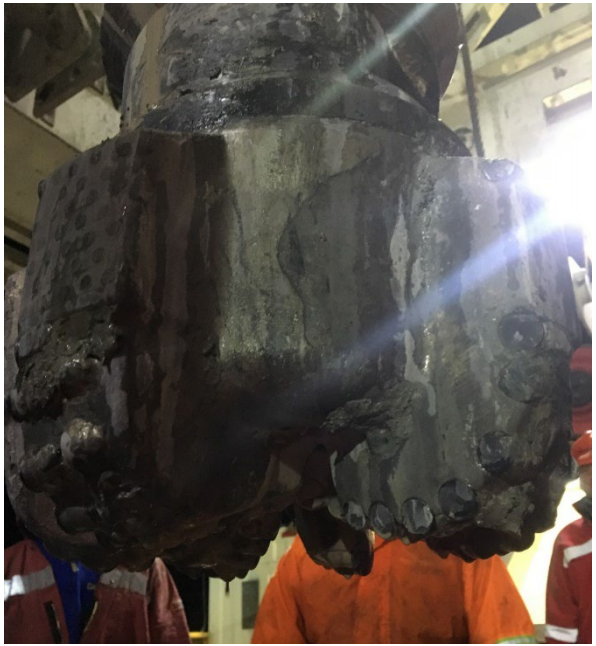
The Challenge

The Limits With the Current Code

IADC codes have some known limitations:

- The code set is focused on justification for pulling the bit, and describes basic wear, but does not capture details needed for forensic root cause analysis.
- Current codes require human expertise and are very subjective, photo verification is a must.
- They do not include common BHA element codes that are known to help with drilling diagnostics.
- There is no framework or best practice to include other data such as digital pictures, etc.
- The system has limited support for fully automated drilling system processes on the near horizon.



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Objectives

- Reduce subjectivity (clearer definitions and training)
- Support both human and automated grading systems
- Best practice for a digital storage & retrieval
- Framework to support realtime, rig and office based selection for the next bit/BHA and parameters
- Forensics for tool and system redesign

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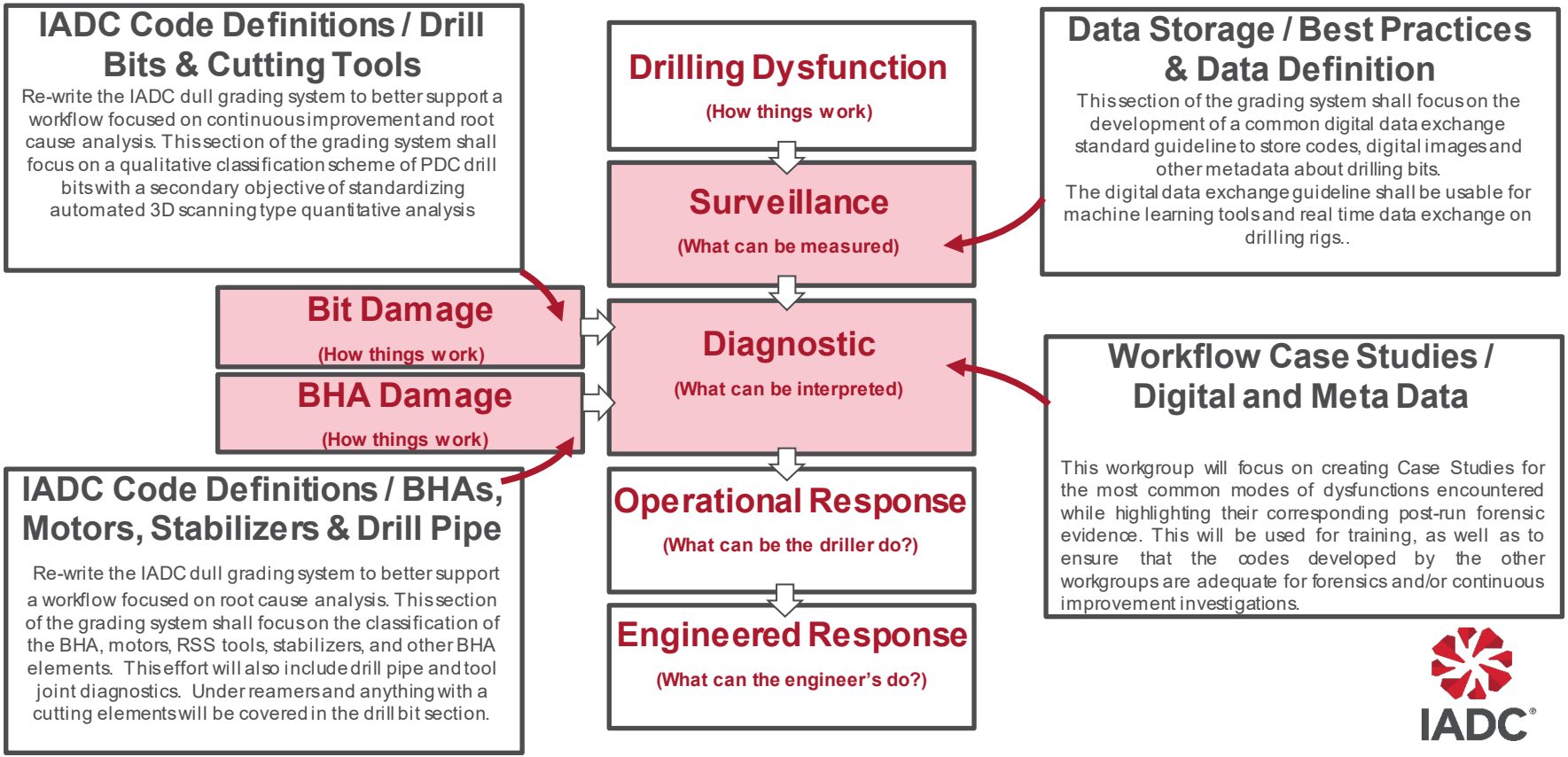
The IADC Code Upgrade Scope

Subgroup interaction workflow



Forensics Working Groups
BHA Update

Structure

Motors	Rotary Steerables	Data Acquisition	Performance Enhancing	Iron
PDM Turbine	Push Point	MWD LWD Dynamic Subs	Friction reduction Vibration Mitigation Reamers Jars	Stabs Collars Subs
Emmanuel Omojuwa 14 Members Roland	Hani Ibrahim 11 Members Paul / Tony	Suki Gill 12 Members Jim / Paul	9 Members Jim / Paul	11 Members Tony / Roland

Proposed Hierarchy of analysis

- **3 Level Structure**
- Level 1 – High level overview of complete BHA
    - Flags if there is an issue with a component
- Level 2 – Detailed grading/classification of each component
- Level 3 for shop (Secondary)
    - Root cause analysis and reporting structure
        - Standardize reporting and classification for investigations

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Proposed Consolidated Dull Grading Table

BHA								
Drill Bit	MWD	PDM	RSS	FE*	STB	Enhance**	DC/ HWDP	Reason Pulled
N	OK	RI	OK	N/A	OK	N/A	OK	DP

Main RP Only

Categories

- **N** - Not Used
- **OK** – No problem found
- **RI** – Requires Investigation
- *For bit – Rerunnable*
  - **Y**
  - **N**

* Formation Evaluation
**Performance Enhancement Components

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Forensics Working Groups
Data Standards

Data Best Practices

- Structured vs Unstructured
  - Text (IADC grading etc) lends itself well to being structured and will continue to be so and will reflect the new classification schemes
  - Images (photos) will need to be both structured and unstructured depending on usage
  - Metadata and security sections currently being worked by team

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Forensics Working Groups
Fixed Cutter Dull Codes

Fixed cutter update

Major updates to :

- Wear / Damage classification types
- Location descriptions (C/N/S/G)
- Shop grade format
- Severity determination still undecided (0-10) or (0-8)

Damage Categories

Rig Grade Format

The rig grade provides a simplified format to drive better real time decisions on the rig floor.

	PDC Cutter Damage				Drill Bit Characteristics		Additional Information		
	Cone	Nose	Shoulder	Gauge	Bit Char.	Gauge	Reason Pulled	Other Observations	Dull Grade Type
Cutter Damage Severity (rig)	0	2	8	4	RO, ER, BU	"1/16"	PR	SS, VIB, SP	RG
Primary Cutter Damage Char.	ND	WC	SC	BC					

- PDC Cutter Damage
  - **Cutter Damage Severity (rig)**
    - Visual estimation for each zone of the cutting structure
    - 0 to 8 severity scale
      - Most intuitive method to visually estimate
      - Precision = whole numbers
  - **Primary Cutter Damage Char.**
    - The rig side grader will assess each zone of the bit and provide a subjective evaluation of the primary damage mechanism
- Drill Bit Characteristics
  - **Bit Characteristics**
    - Captures system level damage like Erosion, ring out, core out, etc.
  - **Gauge**
    - Captures under gauge dimensions in 1/16” increments
- Additional Information
  - **Reason Pulled**
    - Contextual information for why the bit was pulled. (PR, BHA, etc)
  - **Other Observations**
    - Additional contextual information about the run that may not be captured in the reason pulled classification. (Stick Slip, Vibration, Stuck Pipe, etc)

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

Red Text indicates shop grade only categories

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ID – Indeterminate Damage (example)

Shop or Advanced (scanning grade)

	PDC Cutter Damage				Drill Bit Chracteristics		Additional Information		
	Inner CS		Outer CS		Bit Char.	Gauge	Reason Pulled	Other Observations	Dull Grade Type
	1.3		5.7						
	Cone	Nose	Shoulder	Gauge					
Cutter Damage Severity (shop)	0.3	2.2	7.5	3.8					
% Diamond Loss	5%	20%	27%	44%	CR, JD	I	PR	SS, VIB, SP	HF
Primary Cutter Damage Char.	ND	WC	SC	BC					
Secondary Cuttuer Damage Char.	ND	SC	BM	TB					
Substrate Damage Char.	NDS	NDS	ERS	ERS					

- PDC Cutter Damage
  - **Cutter Damage Severity (shop)**
    - Precise values captured for every cutter
      - Zones to be calculated as the average severity of all cutters in that zone
    - 0 to 8 severity scale
      - Provides consistency with rig grade
      - Precision = 0.1
  - **% Diamond Loss**
    - Additional measurement captured only in shop grade
    - % of PDC face lost relative to full cylinder dimensions
    - Precision = 1%
  - **Primary Cutter Damage Char.**
    - SME and/or ML algorithms to classify the primary damage mechanism for every cutter
      - Zone value determined by majority
      - Consistent categories for both Primary and Secondary fields
  - **Secondary Cutter Damage Char.**
    - SME and/or ML algorithms to classify the secondary damage mechanism for every cutter
      - Zone value determined by majority
      - Consistent categories for both Primary and Secondary fields
  - **Substrate Damage Char.**

Location Descriptions

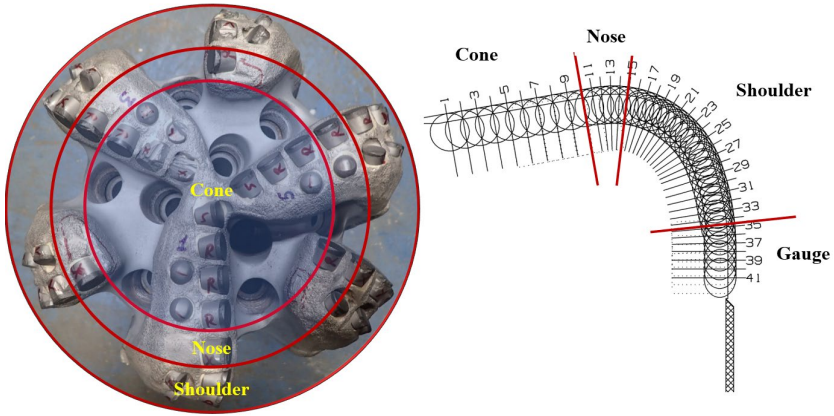


Fig. 1 – Face view showing cone, nose, shoulder regions (left) and cutter profile view showing regions (right)

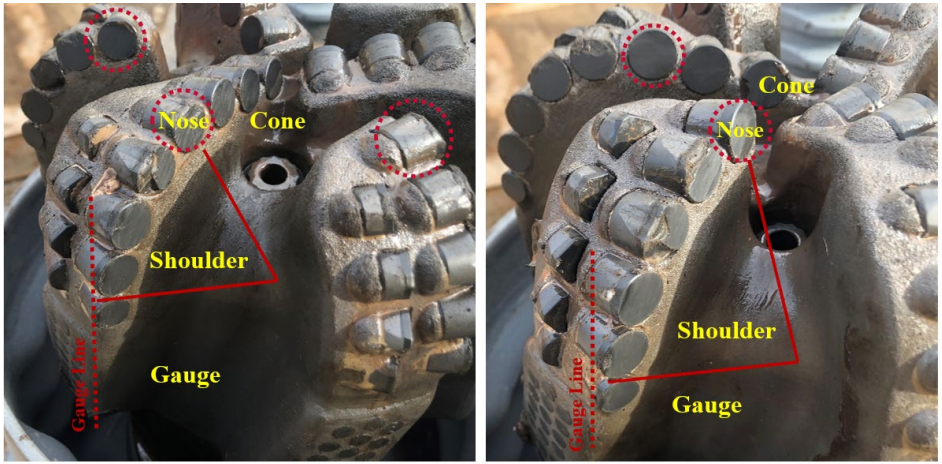


Fig. 2 – Blade view showing cone, nose, shoulder and gauge regions, as well as "gauge line"

Forensics Working Groups
Case Studies Forensic Workflow

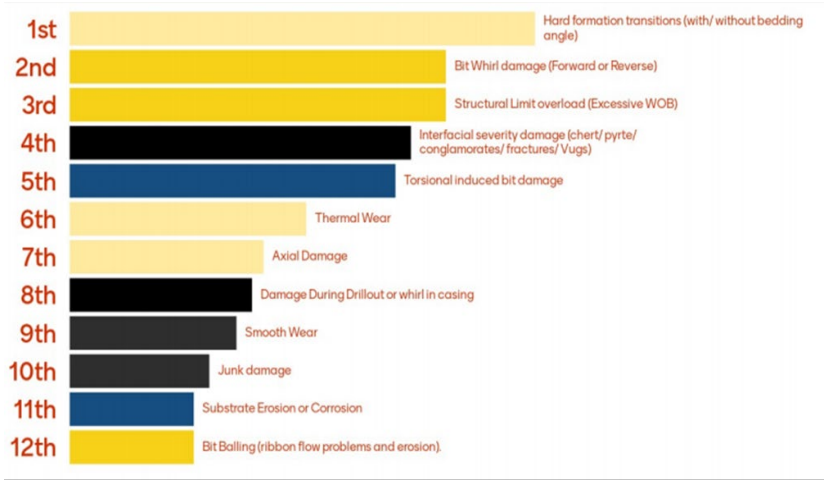
Case study update (starting from scratch)

Case studies are meant to compliment the PDC and BHA dull classification scheme, identify the most common failure modes.

The cases will serve as guide as to what the potential causes of the observable damages could be, what digital information may increase the certainty of the forensics and what potential remedial actions

Drill Bit Case Studies

Bit Damage Causes

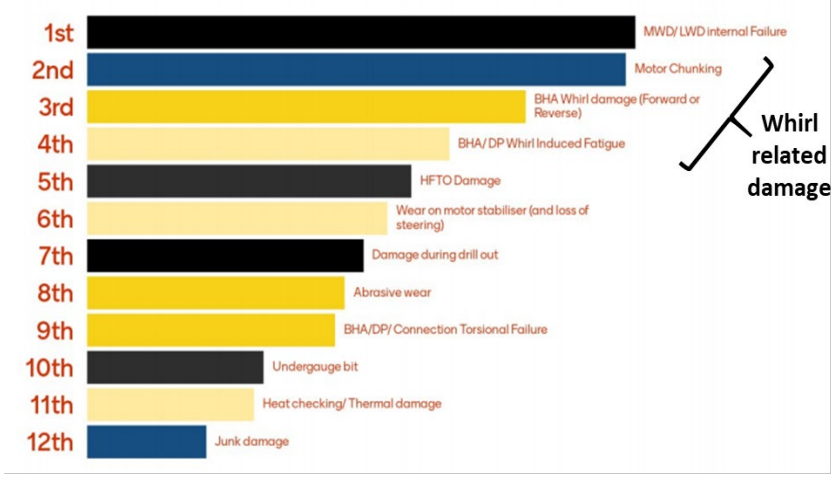


Further Causes Identified

high frequency torsional oscillations	damages on bit due to hole opener and viceversa	Damage to second bit run due to previous RO bit run
improper bit break-in procedures - damage from previous bit	Motor stalling	Bit stalling
Loss of tool face control	reaming in hole	Slide-Rotate Bend Stress

BHA Damage Case Studies

BHA Damage Causes



Further Causes Identified

Motor stalling	Inability to steer	BHA damage due to surface control system dysfunction (e.g. WOB oscillation from the surface system)
Stabilizer hanging	washouts	Excessive shocks and vibrations off bottom while circulating bottoms up at TD and rotating BHA at high surface RPM
Broken shaft in RSS	Torque limiter induced stick slip	high torque on surface

Additional SPE Paper Submittals

299: IADC Dull Code Upgrade: Objectives And Organization

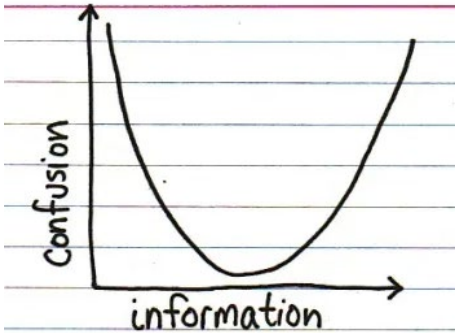
(P.E. Pastusek, ExxonMobil Upstream Integrated Solutions Co; D. Daechsel, Shell; R.A. Macmillan, Robin Macmillan LLC; R. van Kuilenburg, Noble Services Company; C.R. Vempati, Baker Hughes; C. Propes, Halliburton; D. Shackleton, Independent Data Services PVE LTD; D. Lyles, Taurex Drill Bits; J. Oberkircher, IADD; J. Sharples, Peloton; P. Neil, National Oilwell Varco; R. Illerhaus, Operations Efficiency Consulting; T.S. Roberts, NOV ReedHycalog; W. Watson, Shell)

251: IADC Code Upgrade: Data Collection And Workflow Required To Conduct Bit Forensics And Create Effective Changes In Practices Or Design

(W. Watson, Shell; P.E. Pastusek, ExxonMobil; F. Dupriest, Texas A&M University; Y. Witt-Doerring, University of Texas; J. Sugiura, Sanvean Technologies; D. Daechsel, Shell; R. Abbas, Chevron; R. Procter, RP Group)

253: IADC Code Upgrade: Bit And BHA Forensics Using Rig-based Photographic Documentation Practices

(W. Watson, Shell; P.E. Pastusek, ExxonMobil Upstream Integrated Solutions Co; F. Dupriest, Texas A&M; Y. Witt-Doerring, University of Texas; D. Daechsel, Shell; J. Sugiura, Sanvean Technologies; R. Abbas, Chevron; D. Shackleton, Independent Data Services)



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