

SPE/IADC 23939

"First Revision to the IADC Fixed Cutter Dull Grading System" ~ 1992

Version 2.4

How is Dull Grading Useful?



- Quick and simple way to describe the dull condition in an internationally recognized format
- A picture is worth a 1,000 words
 - However, no bit photos are in the daily drilling report
- Identifies issues and improves future bit selection
 - Bit balling
 - Abrasive formation
 - Cutter impact and vibrations
 - Lighter or heavier set drill bit
 - PDC vs Roller Cone

IADC Dull Grading – 8 Boxes



Eight boxes capture the dull bit condition and reason pulled:

	Cutting	Structure	Bearing	Gauge	Remar	`ks	
Inner Rows - Average Cutter Wear	Outer Rows - Average Cutter Wear	Primary Dull Characteristic	Location of Primary Dull Characteristic	Bearing & Seals	Undersize 16 th 's inch	Other Dull Characteristic	Reason Pulled

The SPE/IADC Fixed cutter dull grading document was last updated in 1992. Since then, the industry has adapted new, unofficial codes to overcome some the short falls in the document.

The SPE/IADC 1992 Roller cone & Fix cutter IADC dull grade documents use the same format and codes.

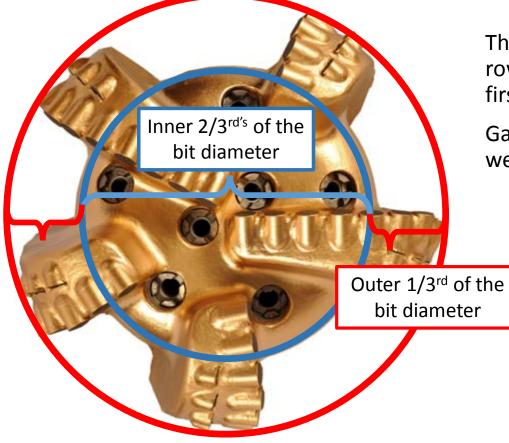
Dull Grade Summary



	Cuttin	g Stri	ıcture			Bearing	Gauge		Remarks			
Inner Rows - Average Cutter Wear	Outer Rows – Average Cutter Wear	Primary Dull Characteristic		· Drimary Dull		Bearing & Seals	Undersize (16 th 's inch)		Other Dull Characteristic	Reason Pulled		
Average wear on inner $2/3^{rd's}$ of the diameter Value: 0-8 0: 0% Wear 1: 1/8 Wear 2: 2/8 Wear 3: 3/8 Wear 4: 4/8 Wear 5: 5/8 Wear 6: 6/8 Wear 7: 7/8 Wear 8: 100% Wear 4 = 4/8 = 1/2 of the cutter diameter = 50% wear	Average wear on outer $1/3^{rd}$ of the diameter Value: 0-8 0: 0% Wear 1: 1/8 Wear 2: 2/8 Wear 3: 3/8 Wear 4: 4/8 Wear 5: 5/8 Wear 6: 6/8 Wear 7: 7/8 Wear 8: 100% Wear 2 = 2/8 = 1/4 of the cutter diameter = 25% wear	BF BT CT ER FC HC LT NO RG WT	Bond Failure Broken Cutter Chipped Cutter Erosion Flat Crested Wear Heat Checking Lost Cutter No Characteristics Rounded Gauge Worn Cutters	C N S T G	Cone Nose Shoulder Taper Gauge	X – Used for all fixed cutter bits	I = In-Gauge 1 = 1/16" 2 = 2/16" 3 = 3/16" 16 = 16/16" "I" can be mistaken for "1". "O" and "IN" are unofficially used.	Cha for BC - CC - CD - CI - LC -	Balled Up Cored Junk Damage Lost Nozzle Not Rerunnable Plugged Nozzle Ring Out Rerunnable Wash out See also: "Primary Dull Characteristics" nary & Other racteristics used Roller Cone bits: Broken Cone Cracked Cone Cone Interference Lost Cone	DMF DSF DST DTF LOG RIG CM CP DP FM HP PP PR TD TQ TW WC	Changed Bottom Hole Assembly Downhole Motor Failure Drill String Failure Drill Stem Test Downhole Tool Failure Run Logs Rig Repair Condition Mud Core Point Drill Plug Formation Change Hole Problems Pump Pressure Penetration Rate Total Depth Torque Twist-Off Weather Conditions Washout Drill String	
	*Gauge Cutters are pre-ground during the manufacturing process.		*Box is only used for cutter dull characteristic		e than one on can be		Measured with a "No- Go" PDC Gauge Ring	OC - Off Center Wear PB - Pinched Bit SD - Shirttail damage SS - Self Sharpening Wear TR - Tracking				

Inner & Outer Row: Location

	Cutting St	tructure		Bearing	Gauge	Re	emarks
Inner Rows (Inner 2/3 ^{rd's})	Outer Rows Primary Dull Outer 1/3 rd Characteristic Primary D		Location of Primary Dull Characteristic	Bearing Seals	Undersize (16 th 's inch)	Other Dull Characteristic	Reason Pulled
Average Cutter Wear (0-8)	Average Cutter Wear (0-8)						



The average wear in the inner & outer rows are calculated and recorded in the first two boxes.

BESTE

BEST

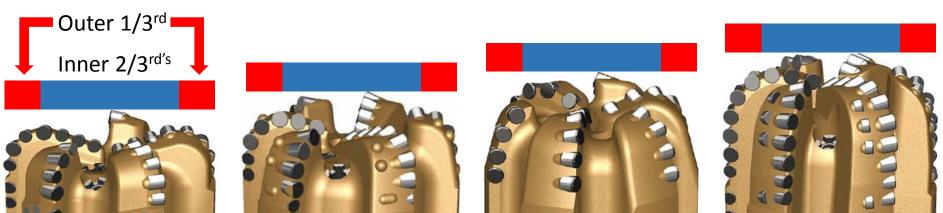
Gauge cutters are excluded from the wear in the outer rows

Tip: Inner & Outer Row: Location



The highest cutter on each blade is the approximate transition between the Inner 2/3^{rd's} & Outer 1/3rd



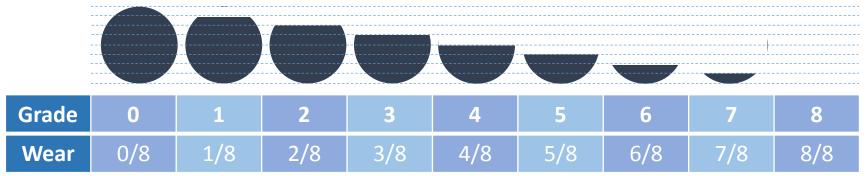


Inner & Outer: Cutter Wear (0-8)



	Cutting St	tructure		Bearing	Gauge	Remarks		
Inner Rows (Inner 2/3 ^{rd'} s)	Outer Rows (Outer 1/3 rd)	Primary Dull Characteristic	Location of Primary Dull Characteristic	Bearing Seals	Undersize (16 th 's inch)	Other Dull Characteristic	Reason Pulled	
Average Cutter Wear Grade: 0-8	Average Cutter Wear Grade: 0-8							

A grading scale between 0-8 is used to note the amount of wear in the Inner & Outer rows





Inner & Outer: Cutter Wear (0-8)

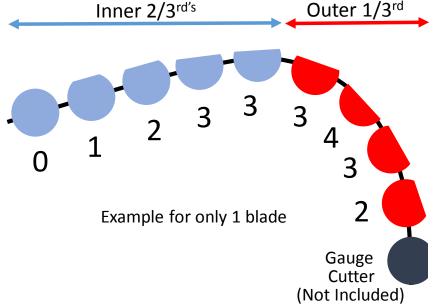


	Cutting St	tructure		Bearing	Gauge	Remarks		
Inner Rows (Inner 2/3 ^{rd's})	Outer Rows (Outer 1/3 rd)	Primary Du		Bearing Seals	Undersize (16 th 's inch)	Other Dull Characteristic	Reason Pulled	
2	3							



Calculating Average Cutter Wear for Inner & Outer Rows

- 1) Grade each cutter with a 0 to 8
- 2) Add up the values
- 3) Divide by the number of cutters
- 4) Round to the nearest number



Example for only one Blade

<u>Inner 2/3^{rd's} Row</u> 0 + 1 + 2 + 3 + 3 = 9 9 / 5 = 1.8 (round up) Inner 2/3^{rd's} Wear = "2"

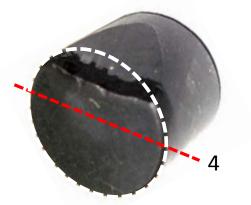
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Outer 1/3^{rd} Row

3 + 4 + 3 + 2 = 12

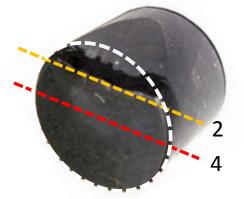
12 / 4 = 3

Outer 1/3^{rd} Wear = "3"
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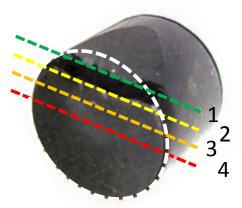
- The wear value (0-8) is the average wear condition, not the maximum amount of wear on one cutter.
- What is the minimum and maximum cutter wear?
 - The average will be between the minimum and maximum values
 - Is it closer to the minimum or maximum value?
- Establish the "4" cutter center line, 50% wear condition. Then estimate "2", 25% wear condition. Does the cutter wear look closer to "1", "2" or "3". (See below)



Step 1) Establish the center line, "4"



Step 2) Estimate "2", 50% from center line to cutter tip



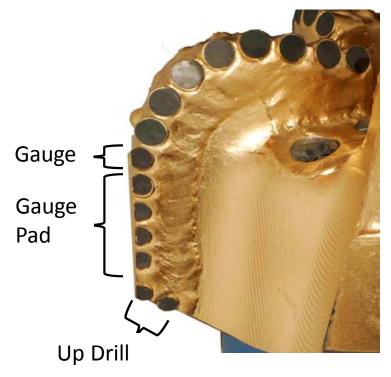
Step 3) Is the wear closer to "1", "2" or "3"?



- Cutters with no wear are often incorrectly graded 1-1 to indicate the bit is used.
 - 0-0 is the correct grading

 Gauge, Gauge Pad & Up Drill cutters are not included in the Outer Row cutter wear calculation.

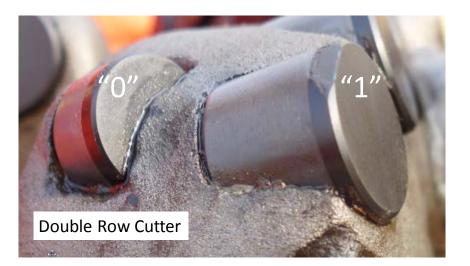






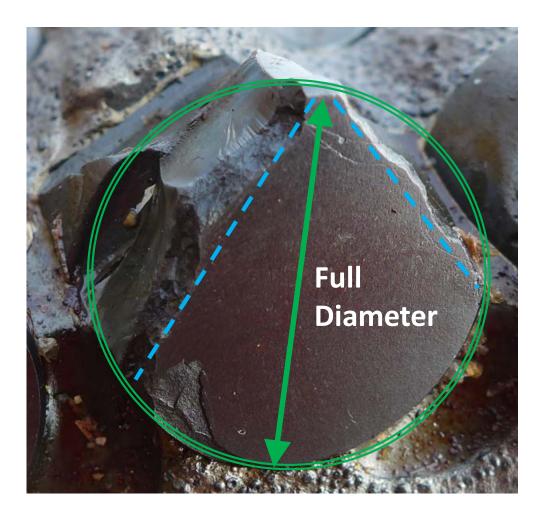
 Secondary row cutters are included in the Average Cutter Wear calculation.

 Cutter wear is measured across the diamond table and not the carbide substrate. If the diamond is missing and the carbide is intact, the cutter is graded as an "8".









When the cutter is irregularly broken, estimate the amount of diamond remaining

Grade: "3"



	Cutting	Structure		Bearing	Gauge	Remarks		
Inner Rows - Average Cutter Wear	Outer Rows – Average Cutter Wear	Primary Dull Characteristic	Location of Primary Dull Characteristic	Bearing & Seals	Undersize (16 th 's inch)	Other Dull Characteristic	Reason Pulled	
		What is the most notable cutter condition?						

Cutter

- BF Bond Failure
- BT Broken Cutter
- CT Chipped Cutter
- ER Erosion
- FC Flat Crested Wear
- HC Heat Checking
- LT Lost Cutter
- NO No Characteristic
- RG Rounded Gauge
- WT Worn Cutters

Unofficial:

- DL Delamination
- SP Spalled cutter

SPE 23939 – Dull Characteristics – "The most prominent or "primary" physical change from new condition of the cutter is recorded in the 3rd box.

"Other" dull characteristics of the bit are noted in the 7th box. The difference being that 3rd box describes cutter wear, while the 7th box may concern other wear characteristics of the bit as a whole."



Cutter

Cutters are in new condition with no notable dull characteristics

No No Characteristic





Erosion of the carbide substrate

ER Erosion

Cutter

















Cutter

Flat Crested Wear

FC

Smooth, flat wear across the diamond and possibly the carbide substrate



FC – Flat Crested Wear can be classified as WT – Worn Cutter. However, FC - Flat Crested Wear is suggested when wear is smooth and flat.

Gauge cutters are manufactured with cutter grind and should not be graded FC – Flat Crested Wear



Gauge Cutter, as per manufactured

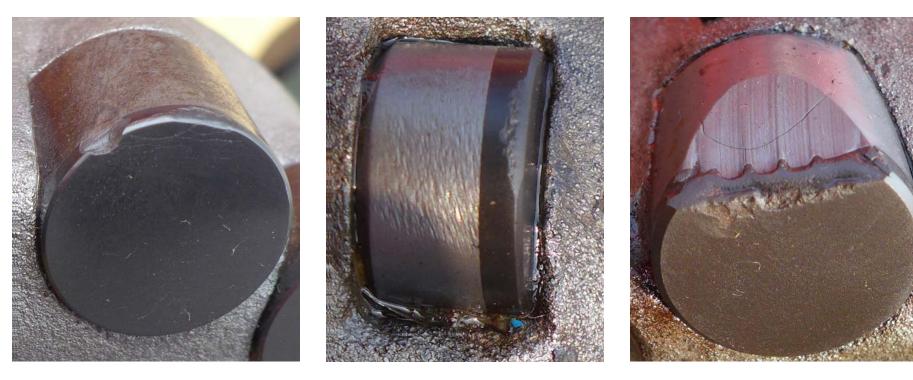


Cutter

Chipped Cutter

CT

Chipping on the diamond edge Chipping does do not extend into the carbide substrate (Non-IADC)



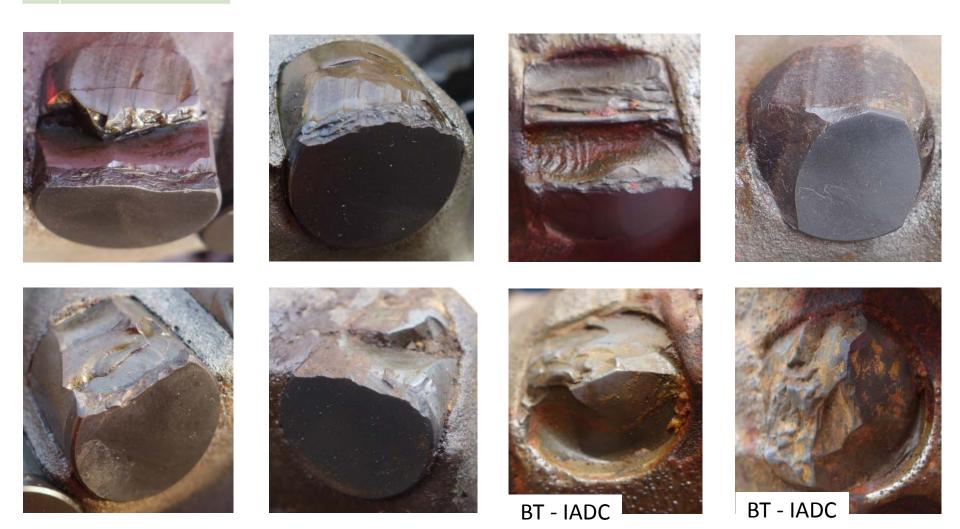


Cutter

Broken Cutter

BT

Fracture damage through the diamond table and into the carbide substrate.





Cutter

WT Worn Cutters

WT – Worn Cutters is non-planar wear or the combination of the following:

- CT Chipped Cutter
- BT Broken Cutter
- ER Erosion
- FC Flat Crested Wear





Non-planer wear flat



Non-planer wear flat



Cutter

CT – Chipped Cutter

Diamond Edge Chipping





Cutter

BT – Broken Cutter

Fracture through the carbide substrate







Cutter

FC – Flat Crested Wear

Flat, Smooth Wear



Cutter

WT – Worn Cutter

Non Planar Wear or a combination of CT, BT, FC, ER







Cutter

HC Heat Checking

Cracks on the carbide substrate

- Cylindrical body
- Wear flat











LT Lost Cutter

Missing cutter











Cutter

Bond Failure

BF

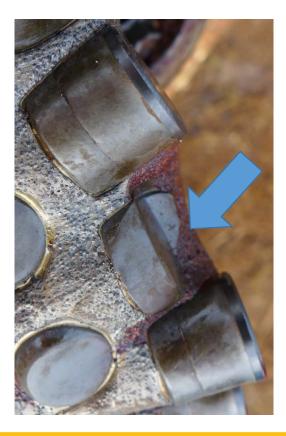
Separation between two carbide substrate pieces.

BF – Bond Failure can also be used to describe

- SP Spalling (Non-IADC)
- DL Delamination (Non-IADC)

LC – Lost Cutter: 100% loss of the carbide substrate and diamond







Cutter

BF - Bond Failure (IADC)

Separation between Substrate & Substrate



Cutter

SP - Spalling (Non IADC)

Separation between Diamond & Diamond





Cutter

DL - Delamination (Non IADC)

Separation between Diamond & Substrate



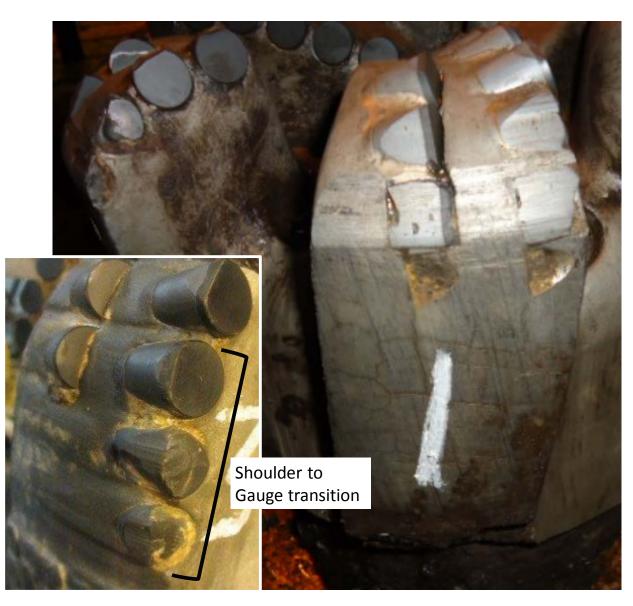


Cutter

RG Rounded Gauge

High amount of diamond loss in the upper shoulder to gauge transition.

The bit can be in-gauge or significantly under-gauge.



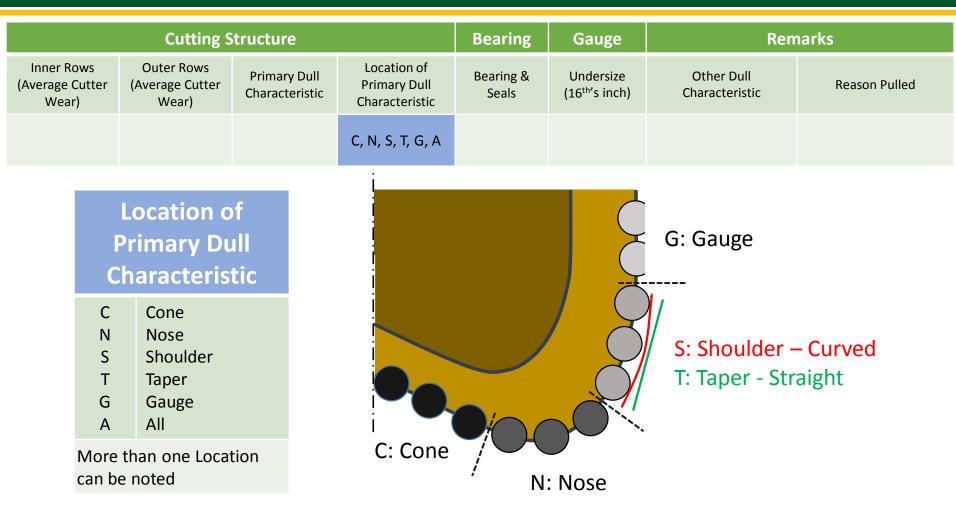
Tip: Dull Characteristic

BESTE BIT

- Box 3 is dedicated for "Cutter" information.
 - If there are no cutter dull characteristic, then indicate "NO".
- If there are many notable characteristics on the bit, pick the one that hindered performance or caused the bit to be pulled out of hole.
 - For example: WT and not HC
 - Only one cutter characteristic code in Box 3
- Non-IADC practices:
 - Multiple codes in one box. Ie. BT/HC
 - DL Cutter Delamination, separation at the diamond-carbide substrate interface.
 - SP Cutter Spalling, thin layers of diamond separated from the cutter face.

Location of Primary Dull Characteristic

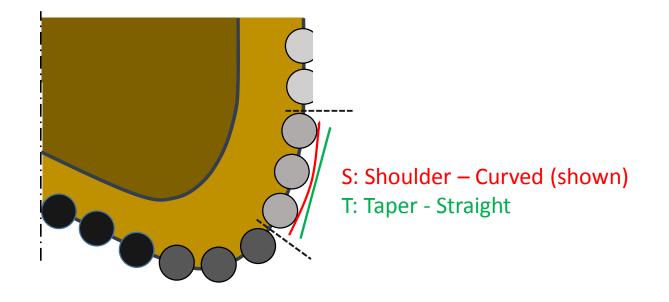




SPE 23939 – Location – "Used to indicate the location of the primary dull characteristic, 3rd box. One or more of these codes may be used to indicate the location."

Tip: Location of Primary Dull

- BESTEBIT
- "S" Shoulder Rounded shoulder profiles are commonly used on PDC bits.
- "T" Taper Flat taper profiles are not commonly used on PDC bits.
- Shoulder & Taper The combination of a curved shoulder and flat taper profile is extremely uncommon on PDC bits. Historically used on natural diamond and TSP products with long profiles.



Bearing & Seals



	Cutting S	tructure		Bearing	Gauge	Remarks		
Inner Rows (Average Cutter Wear)	Outer Rows (Average Cutter Wear)	Primary Dull Characteristic	Location of Primary Dull Characteristic	Bearing & Seals	Undersize (16 th 's inch)	Other Dull Characteristic	Reason Pulled	
				Х				

Fixed Cutter BitRoller Cone BitImage: Strain Strai

SPE 23939 – Bearing– "This box is used only for roller cone bits. It will always be marked "X" for fixed cutter bits

Gauge Undersize



	Cutting S	Structure		Bearing	Gauge	Rem	arks
Inner Rows (Average Cutter Wear)	Outer Rows (Average Cutter Wear)	Primary Dull Characteristic	Location of Primary Dull Characteristic	Bearing & Seals	Gauge Undersize	Other Dull Characteristic	Reason Pulled
					# 16 th Inch		

Gauge Undersize

I In Gauge

...

- 1 1/16th undersize
- 2 2/16th undersize
- 3 3/16th undersize
- 4 4/16th undersize
- 8 8/16th undersize

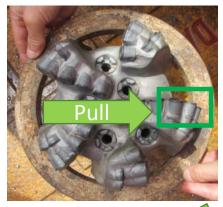


 $1 \frac{1}{2}$ " = 24/16" = "24"

Procedure:

- 1) Use a "No-Go PDC" gauge ring
- Place the gauge ring over the largest diameter: PDC cutter or Gauge Pad
- 3) Pull the ring tight to one side
- 4) Measure the opposing size
- 5) Record the distance to the
 - nearest 1/16th of an inch

SPE 23939 – Gauge – "6th Box is used to record the condition of the bit gauge. "I" is used for the bit still in gauge. Otherwise, the amount the bit is under gauge is recorded to the nearest 1/16th of an inch"



Procedure:

No-Go PDC Gauge Ring

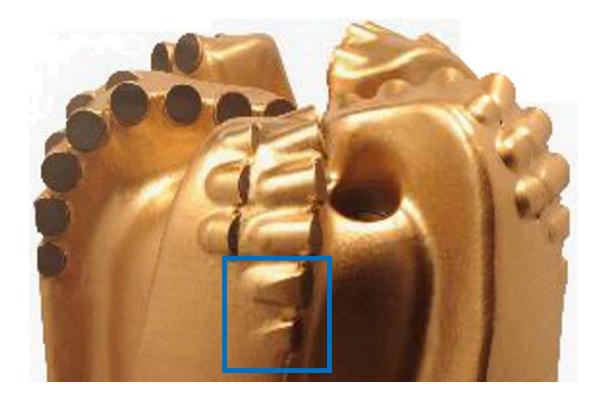
2/16" = "2"



Tip: Gauge Undersize



Gauge cutters are pre-ground during the manufacturing process. The amount of gauge cutter grind can vary by company and product line.



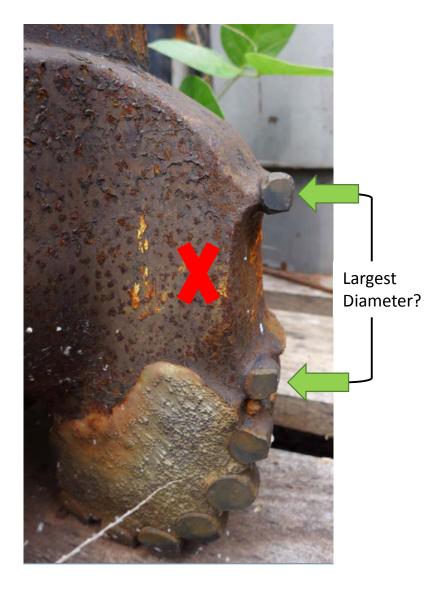


Tip: Gauge Undersize



The gauge pad might be tapered or stepped. Thus, measure the largest diameter, typically the gauge cutters.





Tip: Gauge Undersize

- "I" In-Gauge is commonly mistaken as "1", 1/16th.
 - Unofficially, "0" or "IN" are used in place of "I".
- Use a "No-Go" gauge ring when dull grading PDC & Roller cones bits.

BESTE

- "No-Go" gauge ring: Measures minimum OD tolerance.
- "Go" gauge ring: Measures maximum OD tolerance.
- PDC and Roller cone bits use different gauge rings.
 It is not suggested to use PDC & Roller cone rings interchangeably.
 - PDC Bit tolerance: +0.000" to slightly undersized.
 - Roller Cone Bit tolerance: -0.000" to slightly oversized.

PDC & Fix Cutter Bit Diameter Range	Diameter Tolerance (mm)	Diameter Tolerance (inch)			
Up to and including 6 ¾"	+0.00 / -0.38	+0.000 / -0.015			
>6 ¾" and <= 9"	+0.00 / -0.51	+0.000 / -0.020			
>9" and <= 13 ³ ⁄ ₄ "	+0.00 / -0.76	+0.000 / 0.030			
>13 ¾" and <= 17 ½"	+0.00 / -1.14	+0.000 / 0.045			
> 17 ½"	+0.00 / -1.60	+0.000 / 0.063			

Dull Characteristic: Other



a whole, such as "erosion." Many times this

the dull characteristic noted in the 3rd Box."

"secondary" dull grade identifies the cause of

		Cutting	Stru	ucture	9		Bea	ring	Gauge			Rema	rks	
(Avera	er Row age Cut Vear)	utter (Average Cutter Cha			ry Dull cteristic	Location of Primary Dull Characteristic		ring & eals	Undersize (16 th 's inch)	Other Dull Characteristic			Reason Pul	lled
				•	cutter dull lition)						most n condi			
	Other Dull (ristic					
	Cutter				Bit Body			Hydraulic				Gene	ral	
	BF BT CT	Bond Failure Broken Cutter Chipped Cutter		CR ER HC	Cored Erosion Heat Che	cking	BU LN PN	Lost	ed Up Nozzle ged Nozzle		NR RR NO	Not Reru Rerunnat No Chara	ble	
	ER FC HC LT NO RG	Erosion Flat Crested Wear Heat Checking Lost Cutter No Characteristic Rounded Gauge		JD RO WO BB	Junk Dam Ring Out Wash Ou Unofficia Broken B	nage t	SPE 23939 – Dull Characteristics – "Secondary evidence of bit wear is noted. Such evidence may relate specifically to cutting structure wear, as recorded in the 3 rd					1		
	WТ	Worn Cutters					box, or may be identifiable wear of the bit as							5

Unofficial:

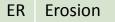
- DL Delamination
- SP Spalled cutter

Dull Characteristic: Other



Bit Body

Loss of bit body material: matrix, steel or hard facing











Dull Characteristic: Other



Bit Body

HC Heat Checking

Surface cracks on the bit body



Bit Body

Cored

CR



Loss of diamond in the center of the bit





Bit Body

RO Ring Out

Loss of diamond over a radial location, creating a "Ring" in the body.

Note: CR – Coring is cutter loss in the center of the bit







Bit Body

Irregular marks on the bit body, created by junk downhole

JD Junk Damage







Bit Body

Loss of bit body material from the drilling fluid.

WO Wash Out



Dull Characteristic: Primary & Other



Bit Body

BB Broken Blade (Non-IADC)

Partial or complete loss of a blade





	Cutting	Structure		Bearing	Gauge Remarks		
Inner Rows (Average Cutter Wear)	Outer Rows (Average Cutter Wear)	Primary Dull Characteristic	Location of Primary Dull Characteristic	Bearing & Seals	Undersize (16 th 's inch)	Other Dull Characteristic	Reason Pulled
						What is the second most notable condition?	

		Pr	imary & Other I	Dull	Characteristic		
	Cutter		Bit Body		Hydraulic		General
BF	Bond Failure	CR	Cored	BU	Balled Up	NR	Not Rerunnable
BT	Broken Cutter	ER	Erosion	LN	Lost Nozzle	RR	Rerunnable
СТ	Chipped Cutter	HC	Heat Checking	PN	Plugged Nozzle	NO	No Characteristics
ER	Erosion	JD	Junk Damage				
FC	Flat Crested Wear	RO	Ring Out				
HC	Heat Checking	WO	Wash Out				
LT	Lost Cutter						
NO	No Characteristic		Unofficial				
RG	Rounded Gauge	BB	Broken Blade				
WT	Worn Cutters						

Unofficial:

- DL Delamination
- SP Spalled cutter



Hydraulic

Formation attached to the bit body

BU Balled Up





Hydraulic

Missing nozzle from the bit body

LN Lost Nozzle







Hydraulic

Plugged Nozzle

ΡN

Blocked nozzle from:

- Motor stator debris
- Formation
- Junk dropped down the drill pipe







Dull Characteristic: Primary & Other



	Cutting	Structure		Bearing	ng Gauge Remarks			
Inner Rows (Average Cutter Wear)	Outer Rows (Average Cutter Wear)	Primary Dull Characteristic	Location of Primary Dull Characteristic	Bearing & Seals	Undersize (16 th 's inch)	Other Dull Characteristic	Reason Pulled	
						What is the second most notable condition?		

		Ρι	rimary & Other	Dull	Characteristic		
	Cutter		Bit Body		Hydraulic		General
BF	Bond Failure	CR	Cored	BU	Balled Up	NR	Not Rerunnable
BT	Broken Cutter	ER	Erosion	LN	Lost Nozzle	RR	Rerunnable
СТ	Chipped Cutter	HC	Heat Checking	PN	Plugged Nozzle	NO	No Characteristics
ER	Erosion	JD	Junk Damage				
FC	Flat Crested Wear	RO	Ring Out				
HC	Heat Checking	WO	Wash Out				
LT	Lost Cutter						
NO	No Characteristic		Unofficial				
RG	Rounded Gauge	BB	Broken Blade				
WT	Worn Cutters						

Unofficial:

- DL Delamination
- SP Spalled cutter

Dull Characteristic: Primary & Other



General

- NR Not Rerunnable
- RR Rerunnable
- NO No Characteristics

NR - Not Rerunnable

- Bit is in poor condition, due to:
 - Cutter wear or damage
 - Under gauge
 - Damage to the bit body

<u> RR - Rerunnable</u>

• Bit is suitable for additional runs with minor cutter wear

NO - No Characteristics

• No notable wear or damage to the bit, suitable for Re-Run



- If there are many notable characteristics on the bit, pick the one that hindered performance or caused the bit to be pulled out of hole.
 - For example: WT and not HC
 - Use only one code in Box 7
- Non-IADC practices:
 - Multiple codes in one box.
 - DL Cutter Delamination, separation at the diamond-carbide substrate interface.
 - SP Cutter Spalling, thin layers of diamond separated from the cutter face.
 - BC Broken Cone used in place of BB Broken Blade (Non-IADC)

Dull Grade Summary



Cutting Structure				Bearing	Gauge	Rer	marks
Inner Rows (Average Cutter Wear)	Outer Rows (Average Cutter Wear)	Primary Dull Characteristic	Location of Primary Dull Characteristic	Bearing Seals	Undersize (16 th 's inch)	Other Dull Characteristic	Reason Pulled

	Reason Pulled
BHA	Changed Bottom Hole Assembly
DMF	Downhole Motor Failure
DSF	Drill String Failure
DST	Drill Stem Test
DTF	Downhole Tool Failure
LOG	Run Logs
RIG	Rig Repair
CM	Condition Mud
СР	Core Point
DP	Drill Plug
FM	Formation Change
HP	Hole Problems
PP	Pump Pressure
PR	Penetration Rate
TD	Total Depth
TQ	Torque
TW	Twist-Off
WC	Weather Conditions
WO	Washout – Drill String

Dull Grade Example #1





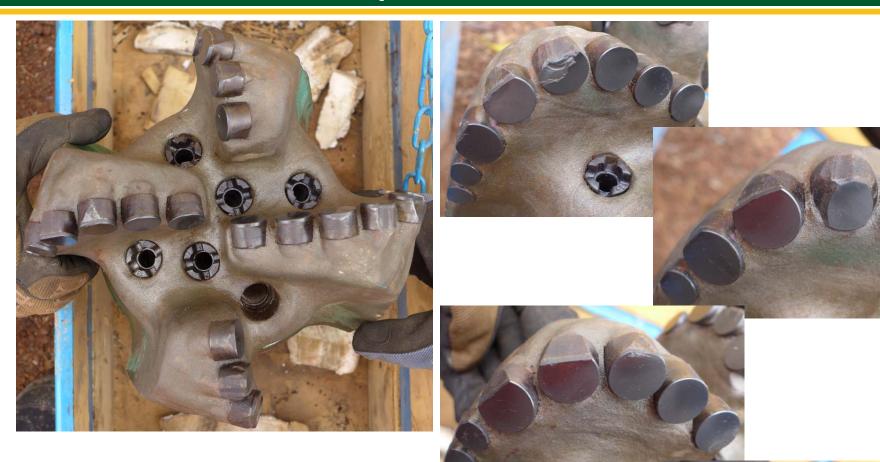
0-0-ER-C/N-X-I-ER-TD

1st ER – Cutter characteristic 2nd ER – Matrix body characteristic



Dull Grade Example #2





0-2-WT-N/S-X-I-LN-TD



Dull Grade Example #3







BESTE

BESTE



0-5-BT-S/G-X-I-ER-TD