Drilling Bits II

Outline

- Bit classification
- Rock failure mechanisms and drilling mechanisms
- Roller cone bits
- IADC Classification for Roller Cone Bits

Covered Last Lecture

- PDC Bits
- IADC Classification for PDC
- Natural diamond bits
- IADC bit wear

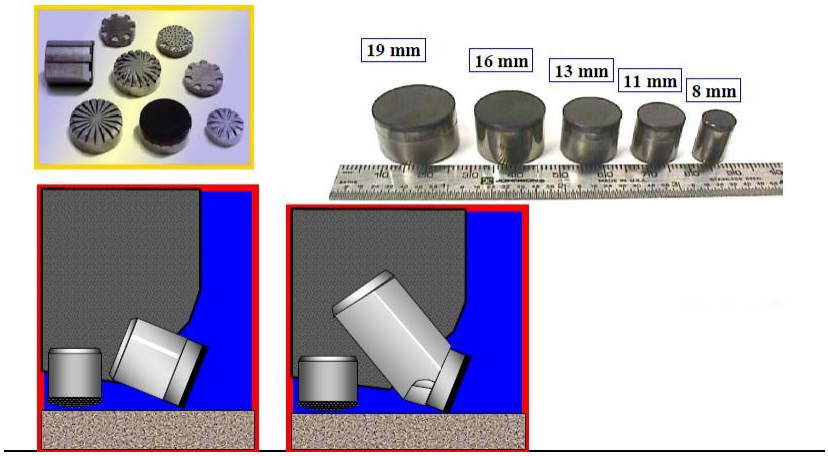
Will be Covered Today

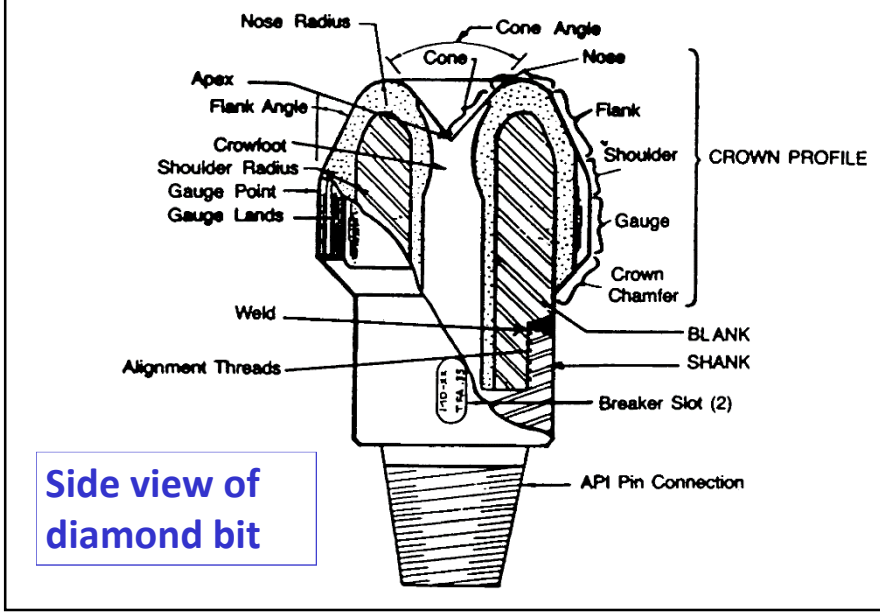
PDC bits or Fixed Cutters

PDC Bits applications

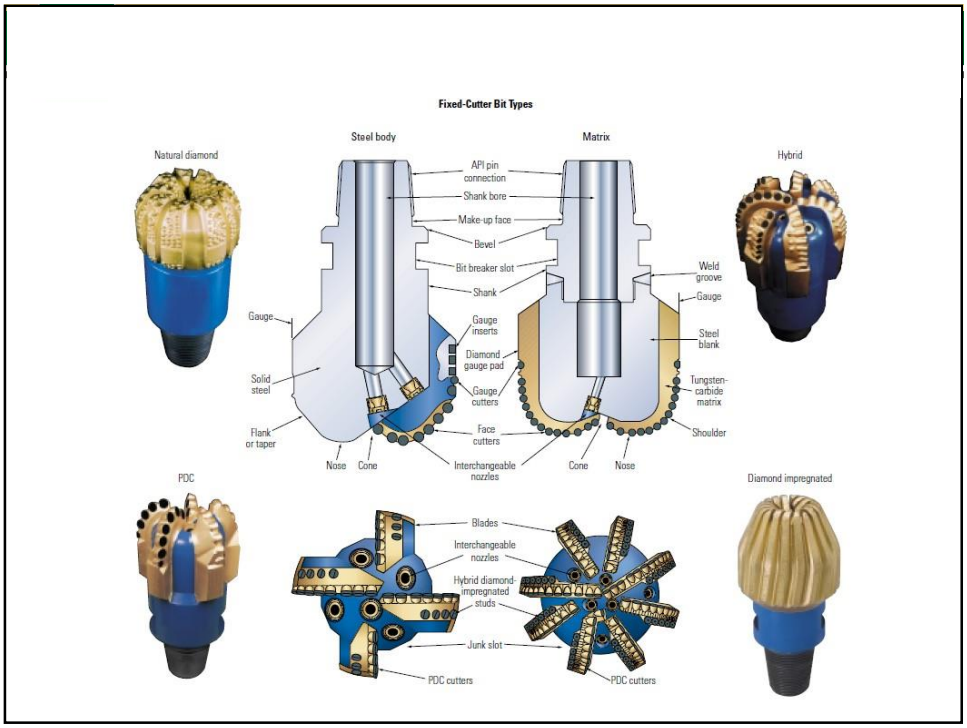
- PDC bits are used primarily in deep and/or expensive wells
- Soft-medium hard formations
- Advances in metallurgy, hydraulics and cutter geometry
  - Have increased cost of individual bits
  - Have allowed PDC bits to drill longer and more effectively
  - Allowed bits to withstand harder formations
- PDC bits advantageous for high rotational speed drilling and in deviated hole section drillings
- Most effective: weak, brittle formations (sands, silty claystone, siliceous shales)
- Least effective: cemented abrasive sandstone, granites

Cutters





Side view of diamond bit



PDC IADC code

	Body Material	Total PDC	Cutter Size	Profile Type
Bit Data	Steel	108	19	Medium
IADC Code	S	4	2	3

PDC IADC code

1ST Character

Body Material

M	S	D
Matrix	Steel	Diamond

PDC IADC code

2nd Character

Cutter Density

13mm cutter equivalent

1	2	3	4
<30	30-40	40-50	>50

PDC IADC code

3rd Character

Cutter Size

Only use 1 to 4

1	2	3	4
>24mm	24-14	14-10	<10mm

PDC IADC code

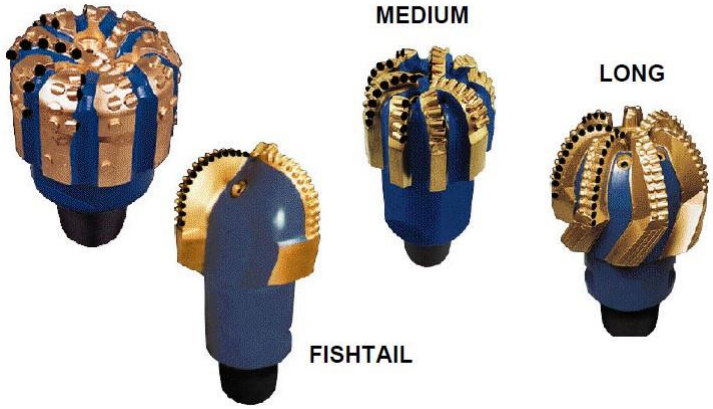
4th Character

Bit Profile

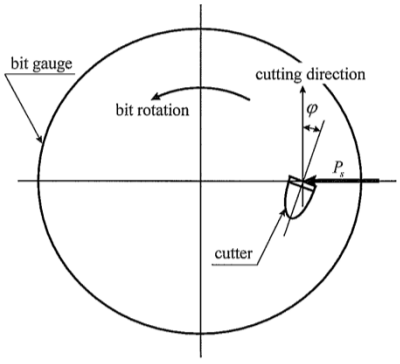
Simplified to 4 categories

1	2	3	4
Fishtail	Short	Medium	Long

PDC IADC code

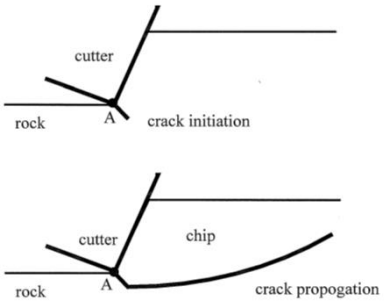


PDC bit cutting action

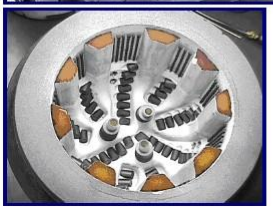


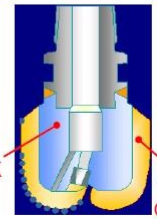
PDC cuttings development

Chip development



PDC matrix body





PDC Matrix Body

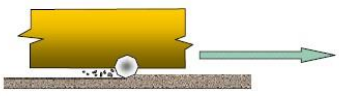
When to Consider Using a Natural Diamond Bit?

1. Penetration rate of rock bit < 10 ft/hr.
2. Hole diameter < 6 inches.
3. When it is important to keep the bit and pipe in the hole.
4. When bad weather precludes making trips.
5. When starting a side-tracked hole.
6. When coring.

* 7. When a lower cost/ft would result

Compressive and shear drilling mechanism

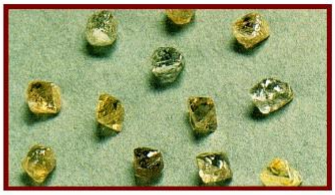
- Shear/Compressive Failure



Diamond Bit
CONTINUOUS
CRUSHING & ABRASION

Natural diamond

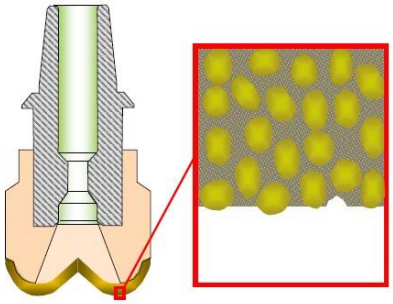
- Natural Diamonds
  - Size
  - Shape
  - Quality

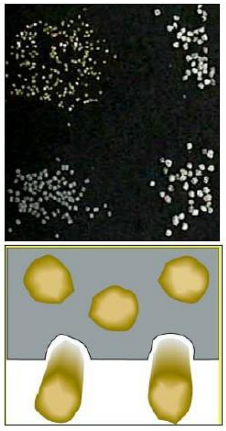


Impregnated diamond bits

Impregnated bits are a PDC bit type in which diamond cutting elements are fully imbedded within a PDC bit body matrix

- Impregnated Diamond Blades

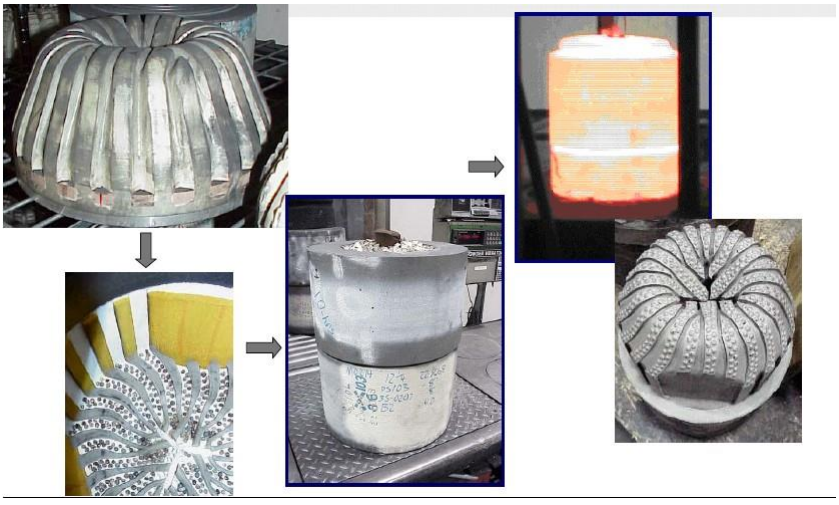


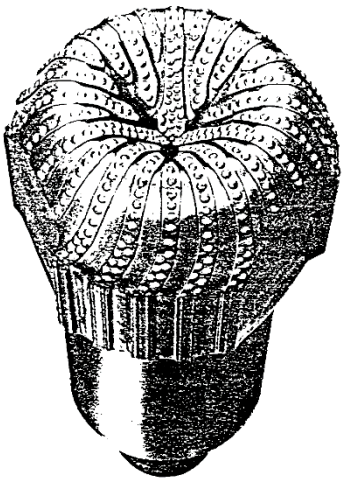


TSP

- TSP (Thermally Stable PDC)

Diamond matrix body



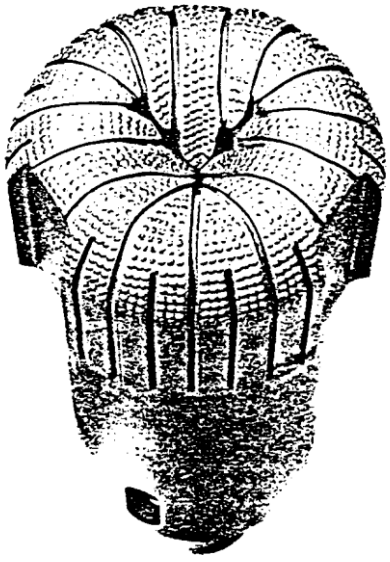


SOFT-FORMATION DIAMOND BIT

COURTESY OF NL HYCALOG

Soft Formation Diamond bit

- Larger diamonds
- Fewer diamonds
- Pointed nose



Hard Formation Diamond bit

- Smaller diamonds
- More diamonds
- Flatter nose

The purpose of bit dull grading

The Purpose of Dull Bit Grading

- Aid optimum bit selection
- Help avoid catastrophic failure
- Identify bits that are suitable for re-run
- Suggest optimum operating parameters
- Provide insights for improving bit design

Lower Cost per Foot

IADC system

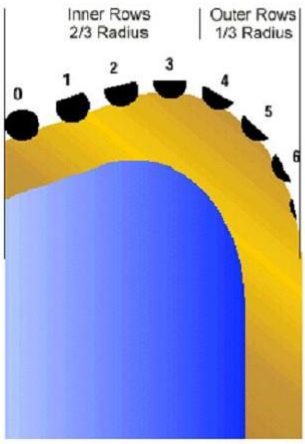
Cutting Structure

Inner Teeth	Outer Teeth	Major Dull	Location	Seals/ Bearing	Gauge	Other Dull	Reason Pulled
✓	✓						

Inner versus Outer Teeth - Inserts

Interlock row
Gauge row
Heel row
Gauge Guard row

Inner versus outer teeth – fixed cutter



- Not gauge cutters only
- Not divided at the nose
- Not 1/3 and 2/3 cutter count
- But ***radius***

Grading of Dull Roller cone bits

How do bits wear out?

- **Tooth wear or loss**
- **Worn bearings**
- **Gauge wear**

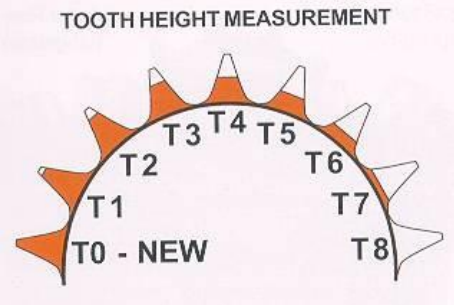
Cutting structure				**Bearing**	**Gauge**	**Remarks**	
Inner rows	Outer rows	Dull Char.	Location	Seal		Other dull	Reason pulled

Grading of Dull Roller cone bits

How do bits wear out?

- ***Steel teeth*** - graded in eights of original tooth height that has worn away

e.g. T3 means that 3/8 of the original tooth height is worn away



Grading uneven wear

Assign a tooth wear grading for the inner cutting structure only:
One number –
•Inner wear in 1/8ths
There are the same number of inserts in the outermost row of the inner rows, as in the other two inner rows combined. Consider only The single cone that is Wholly visible.

Location

Inner Teeth	Outer Teeth	Major Dull	Location	Seals/ Bearing	Gauge	Other Dull	Reason Pulled

Cutting Structure Only

Roller cone location

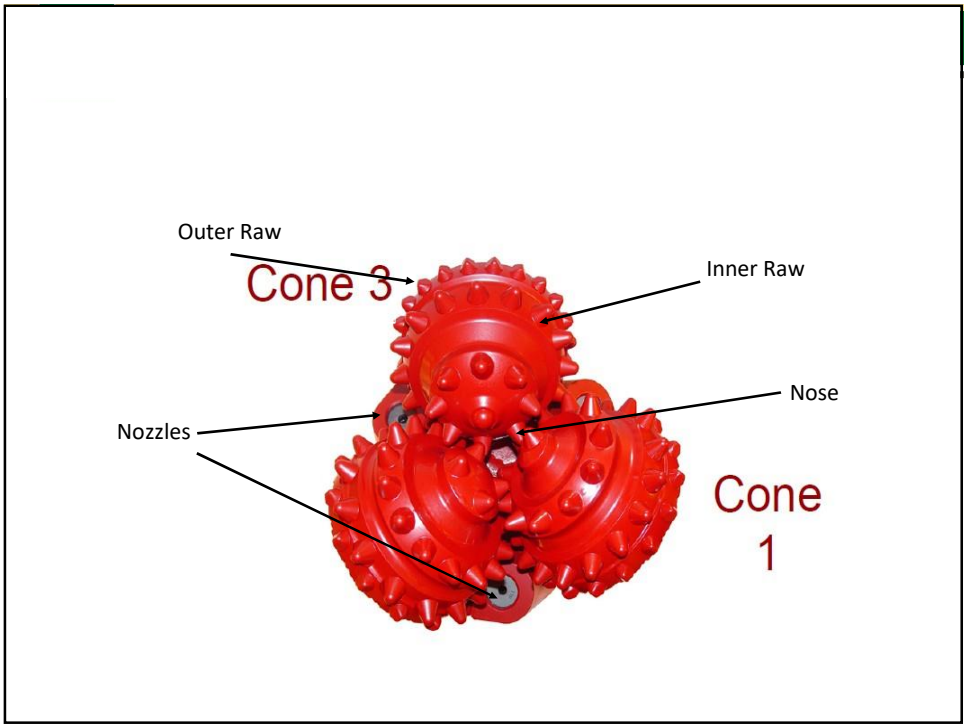
Use the slandered abbreviation:

N - Nose: The centermost cutting element(s) of the bit

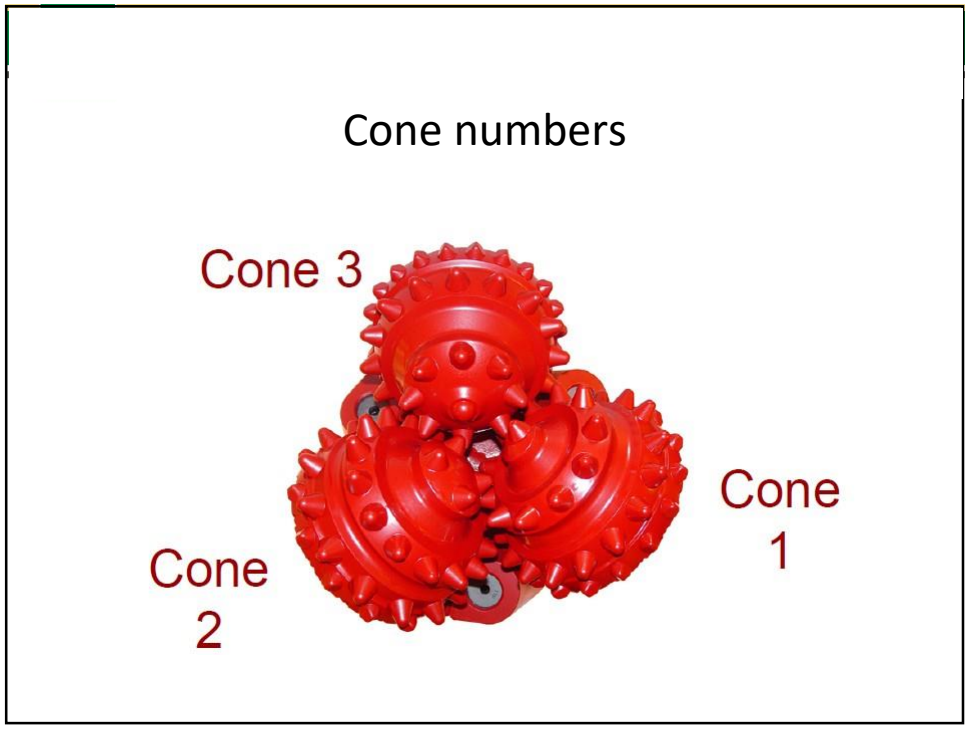
G- Gauge: Those cutting elements which touch the hole wall.

M- Middle: Cutting elements between the nose and the gauge.

A- All: All rows



Cone numbers



Seals and bearings

Inner Teeth	Outer Teeth	Major Dull	Location	Seals/ Bearing	Gauge	Other Dull	Reason Pulled
							

Seals and bearings

- X grading is not applicable – fixed cutter
- E Seals are effective
- F Seals have failed
- N Seals cannot be graded
- 0 to 8 - for unsealed bearings only

Gauge

Inner Teeth	Outer Teeth	Major Dull	Location	Seals/ Bearing	Gauge	Other Dull	Reason Pulled
					✓		

Measuring gauge

Locate the gauge ring Hard against two of the cones.

Measure the smallest gap.

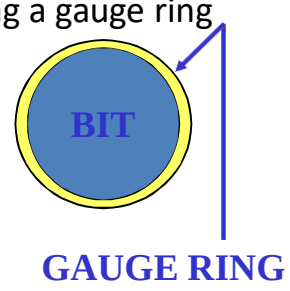
Take 2/3 of this value.

For fixed cutter bits Take the measured value.

Grading of Dull Roller cone bits

How do bits wear out?

- Gauge Wear:
  - Bit is either in-Gauge or out-of-Gauge
  - Measure wear on diameter (in inches), using a gauge ring



IADC system

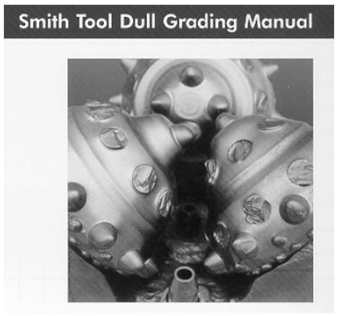
Inner Teeth	Outer Teeth	Major Dull	Location	Seals/ Bearing	Gauge	Other Dull	Reason Pulled
		✓				✓	

Cutting Structure Only

Grading of Dull Roller cone bits

How do bits wear out?

- ***Tungsten Carbide Insert bit***

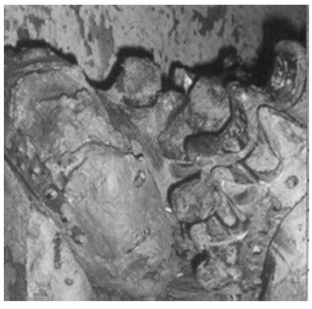


e.g. T3 means that 3/8 of the inserts are broken or lost

Grading of Dull Roller cone bits

How do bits wear out?

- ***Bearings:*** B3 means that an estimated 3/8 of the bearing life is gone



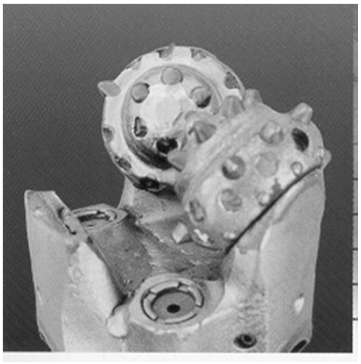
Balled up Bit

Cracked Cone

Grading of Dull Roller cone bits

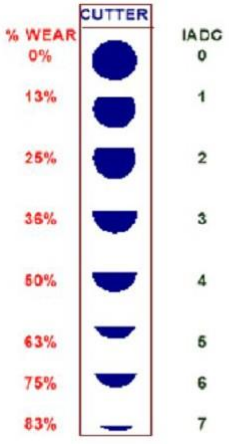
How do bits wear out?

Washed out Bit



Lost Cone

PDC cutter wear grading



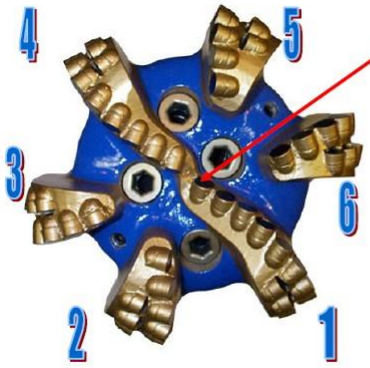
Example real PDC?

What if diamond layer has gone?
How do you grade it?

Cutter exposure – 200% wear.
Two events in the life of a PDC cutter

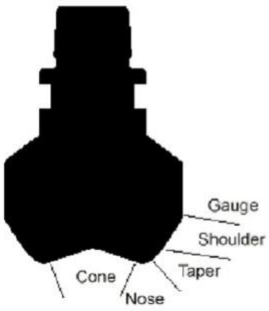
1. Wear flat develops
2. Blade/body contact begin

PDC blade number



Innermost cutter is on blade number 1

PDC locations

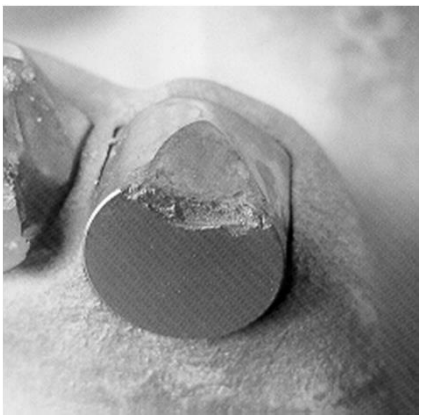


- C = Cone
- N = Nose
- T = Taper
- S = Shoulder
- G = Gauge

NO = No Dull

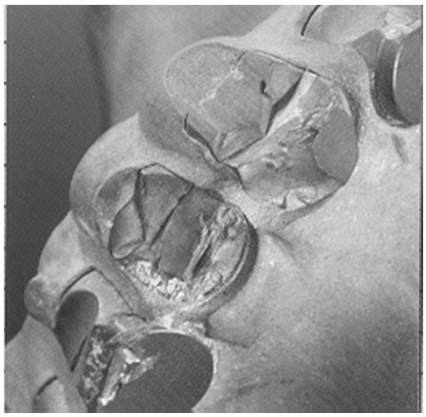
Worn teeth

Grading of Worn PDC Bits



CT - Chipped Cutter

Less than 1/3 of cutting element is gone



BT - Broken Cutter

More than 1/3 of cutting element is broken to the substrate

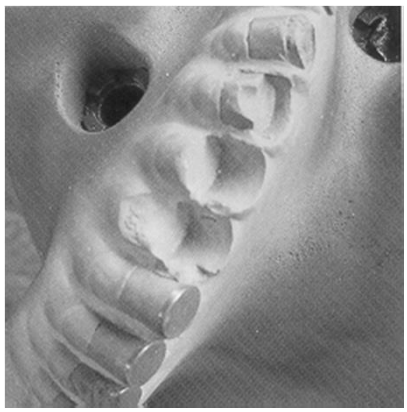
Heat checking

Heat checking matrix body

Heat checking to matrix body:

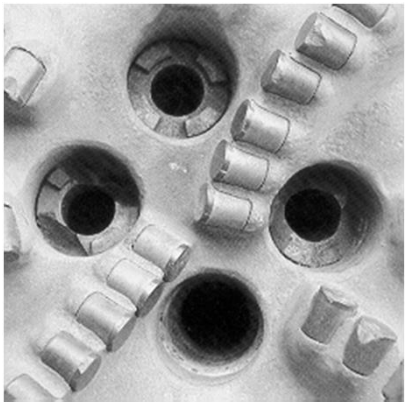
Stick slip

Grading of Worn PDC Bits – cont'd



LT - Lost Cutter

Bit is missing one or more cutters



LN - Lost Nozzle

Bit is missing one or more nozzles

Drilling bit types

Source: www.NOV.com

The Ideal Bit *

1. High drilling rate
2. Long life
3. Drill full-gauge, straight hole
4. Moderate cost

* **(Low cost per ft drilled)**