



Tough-Drill[™] SERIES

STRENGTH YOU CAN COUNT ON



BUILT FOR HARD AND
ABRASIVE FORMATIONS



VAREL
INTERNATIONAL

Overview

Tough-Drill™ PDC Bits

Varel's Tough-Drill PDC bits were specifically developed for tough drilling applications. Due to their improved stabilization characteristics, these bits address the ROP and durability challenges of hard and/or abrasive formations.

Continuous discussions with our growing customer base, coupled with extensive engineering and research focus, contributed to the development of Tough-Drill bits. These bits continue to improve drilling performance in hard and abrasive formations with compressive strengths in excess of 25,000 PSI.

To ensure ROP and durability improvements in tough drilling applications, Tough-Drill bits combine the following technologies to drastically minimize cutter wear:

- › **Advanced cutting structure (cutter layouts)**
- › **High performance PDC cutters**
- › **Superior hydraulic configurations**

With reduced PDC cutter wear, Tough-Drill bits are able to sustain higher penetration rates (ROP) for longer periods of time, thus drilling faster and longer.



Tough-Drill PDC Bit

- › As our valued customer, you wanted ROP and durability improvements in hard and abrasive rock applications ... we listened and delivered with our innovative Tough-Drill™ products.

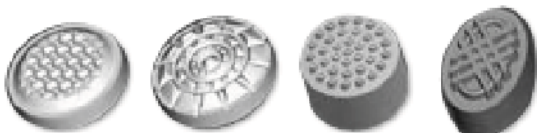


SPOT™ Models Bit Behavior

Advanced Cutting Structures

Tough-Drill™ bits are designed with Varel's proprietary SPOT™ design software. This tool, developed after extensive single-cutter and full-scale bit tests in laboratory and field conditions, ensures cutting structure optimization for specific applications.

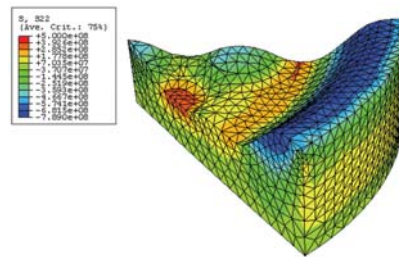
SPOT models complete bit behavior in different rock types during the drilling process. In addition, it evaluates cutter failure as a result of friction and heat transfer. Using appropriate rock geologic and mechanical properties, SPOT also performs sensitivity analysis for various drilling parameters (WOB and RPM) to evaluate their effects on ROP, bit wear, vibrations and footage. This process improves the ROP and run length of Tough-Drill bits.



Carbide Interface Geometries (CIG)

High Performance PDC Cutters

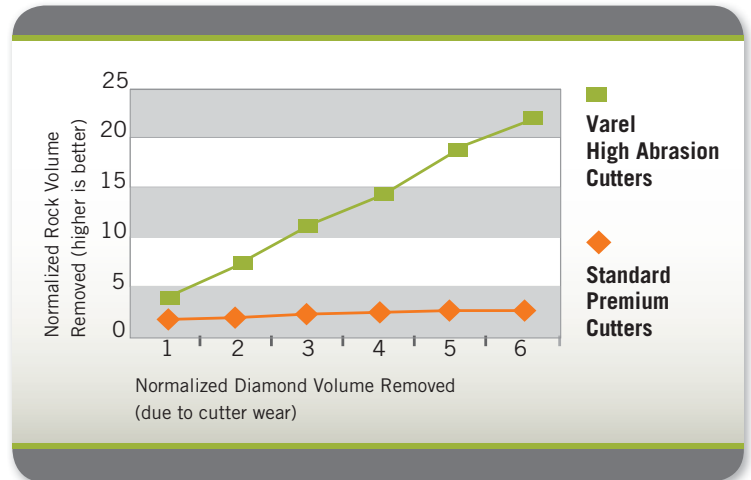
Application-specific PDC cutters, which incorporate advanced carbide interface geometries (CIG™) and materials science technologies, are used in Tough-Drill bits. The carbide interface geometries are modeled using finite element analysis (FEA) to minimize damaging residual stresses (axial, hoop and radial). This process dramatically improves the impact resistance of the PDC cutters.



Finite Element Analysis (FEA)

Comparison of Abrasion Resistance

Diamond grades are selected, analyzed and prepared to maximize abrasion resistance (see chart below).



Abrasion resistance comparison, at identical test conditions, between standard premium cutters and specialized Varel high abrasion resistance cutters

Tough-Drill™ PDC BIT

› Advanced Cutting Structure (Cutter Layout)

› Superior Hydraulic Configurations

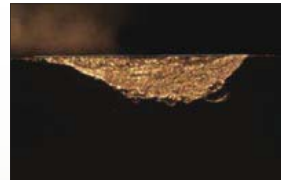
› High Performance PDC Cutters



Shown: 7 7/8" VTD616PDG

Wear Flat Comparison

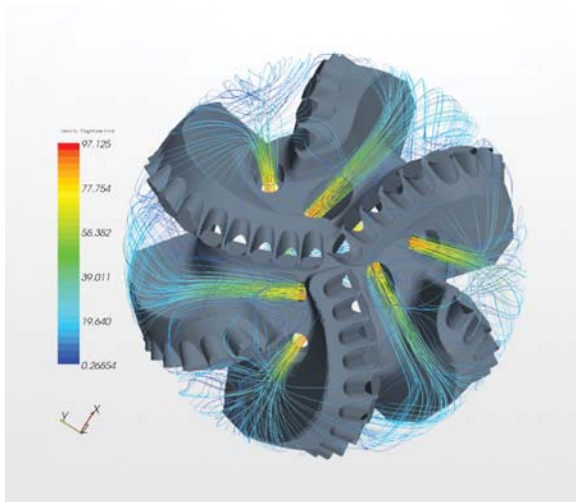
Wear flat comparison between standard premium cutter and specialized Tough-Drill high abrasion resistance cutter under identical conditions.



Standard Premium Bit



Tough-Drill



Computational Fluid Dynamics (CFD) study of a double row bit showing fluid and cutting trajectories. This evaluation improves bit cleaning and cutter cooling, thus enhancing ROP and durability.

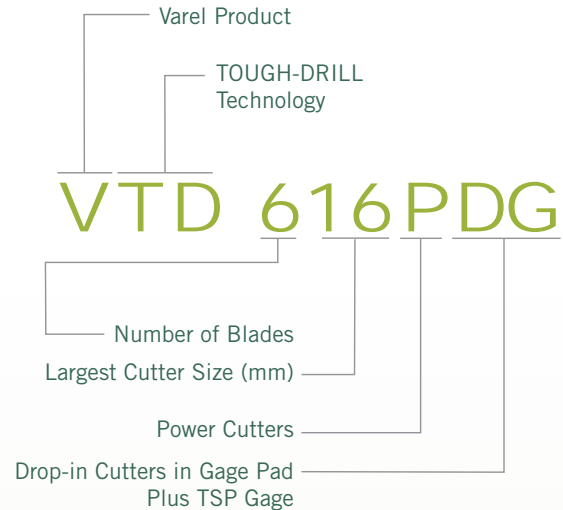
The Benefits

Through their comprehensive engineering and development process, Tough-Drill™ bits have superior stabilization characteristics, reduced impact damage, improved cleaning and cutter cooling efficiencies. The high abrasion resistance cutters used in Tough-Drill bits dramatically minimize cutter wear, thus improving ROP and footage drilled. Our performances continue to validate our claims.

Superior Hydraulic Configurations

As part of the product development process, Tough-Drill bits go through elaborate CFD. Re-grinding and re-circulation of drilled cuttings, a common occurrence in hard and abrasive applications, are eliminated in this process. In addition, possible stagnation zones are identified and eliminated. This sophisticated process improves cleaning efficiency, cutter cooling and ROP.

> Bit Nomenclature



Additional Features:

- S - Steel Body
- B - Box Connection
- T - Sleeve
- P - Power Cutters
- D - Drop-in Cutters in Gage Pad
- G - TSP Gage
- DG - Drop-in Cutters in Gage Pad Plus TSP Gage
- L - Lateral Jets
- N - Nozzle Pattern Less Than One Nozzle per Blade
- H - Nozzle Pattern in Excess of One Nozzle per Blade
- W - Crown TSP
- U - Up-drill/Backream
- X - Shock Studs

**All Western Hemisphere Tough-Drill bits have PDC, TSP and TCI gage pad features as standard.*



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SERIES



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