PARADIGM

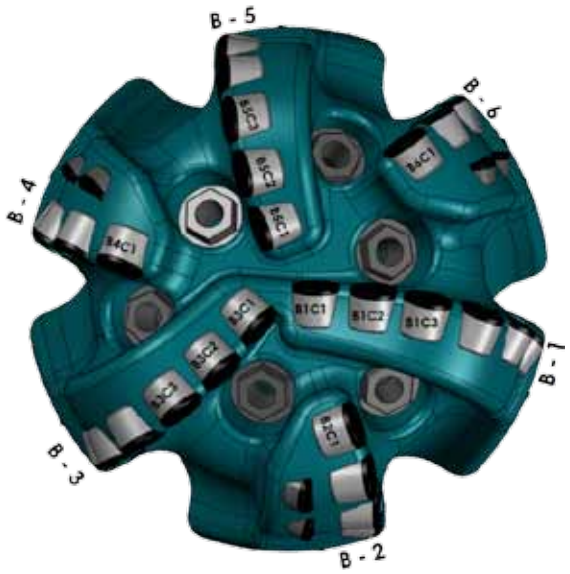
PDC Bit Basics: Two Views of Bit Design

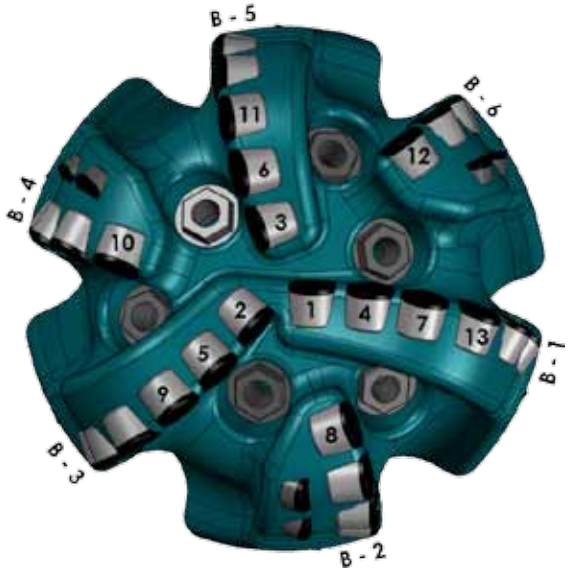
ULTERRA™

VIEW ONE: FACE VIEW

The face view (Figure 1-1) is the most descriptive image of a PDC drill bit. If pictures are worth large quantities of words, the face view is worth the most. With this view, a skilled individual can determine whether the cutter layout of the bit is plural set or single set, the direction of the spiral and even some general information about the back rake and side rake of a PDC cutter. On an even more fundamental level than that, the face view can tell a person much about why PDC bits are designed in a certain way. Before that, it is useful to go through some basics.

Figure 1-1: Face view image of the computer model for a PDC drill bit design.





BLADE NUMBERS

From a design perspective, Blade 1 is defined as the blade that supports the cutter nearest to the centerline of the bit. On design documents for PDC bits (e.g. drawings and spec sheets), Blade 1 is often at 3 o'clock in the face view–Blade 1 is shown at 3 o'clock for modern Ulterra bit designs. The remaining blades are numbered sequentially in a clockwise fashion (Figure 1-2). Identifying Blade 1 on a dull bit in the field can be tricky, and the best approach might be to compare the bit to a photo or to the face image on the spec sheet.

CUTTER NUMBERS

There are two systems used to number the PDC cutters in a bit. The field system assigns a number to the cutter according to the blade that supports it and then by the position of the cutter on that blade (Figure 1-2). The advantage of the field system is that it is straight forward and easily applied to any bit still in one piece.

The design system assigns a unique number to each cutter according to the distance from that cutter to the centerline of the bit (Figure 1-3). That distance is called the radial location of the cutter. The advantage of the design system is that it identifies each cutter with a simple, unique number that allows for easy tabulation. When the design cutter numbers are shown in the face view (Figure 1-3), information about the cutter layout is also revealed.

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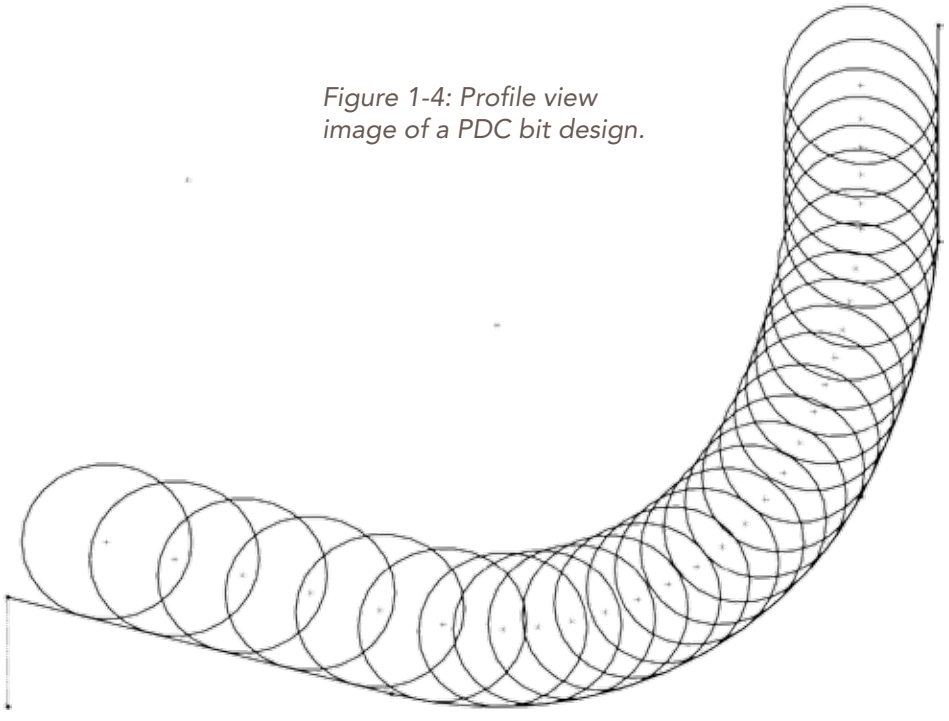

Figure 1-4: Profile view image of a PDC bit design.

BLADES TO CENTER

A blade is a primary blade if it extends to the center of the bit–A primary blade is a "blade to center". Primary blades can be connected in the center of the bit, but it is not required. In Figure 1-3, Blades 1, 3 & 5 are primary blades while Blades 2, 4 & 6 are secondary blades. For very large bits and/or bits with a large blade count, there can be another class of even shorter blades.

VIEW TWO: THE PROFILE VIEW

Also of great use to a bit designer is the profile view (Figure 1-4); but unlike the face view, the profile view is abstract in nature. In it, the cutters are represented as circles/ellipses placed along the cutter profile (the "J" shaped curve). While the face view (or any view showing the solid geometry of the bit model) illustrates real world geometric concerns like nozzle orientation and cutter clearances, it is the profile view that allows things like cutter density and cutter work to begin to come to light. In the profile view, the designer gets a good look at cutter spacing and it is a powerful weapon in the design arsenal.

CUTTER PLACEMENT–MORE HERE, LESS THERE

Generally speaking, a PDC bit is designed to have the highest cutter density near the outer diameter (or gauge) of the bit. This makes sense, considering that the cutters closest to gauge will be traveling the furthest with each revolution of the bit.

As previously stated, the radial location of a cutter is defined as the distance between the cutter and the centerline of the bit. In some design systems, the radial location is the distance from the center axis to the point where the cutter touches the cutter profile. Figure 1-5 shows cutters in profile with vertical lines passing through these tangent points. Going from bit axis (left) to gauge (right), the distance between lines are decreasing, illustrating the increasing cutter density.

The high cutter density near the gauge can be seen in the face view by the way the cutters appear to be stacked over one another. Near the center, the viewer can see the bit body between each cutter; but near the gauge, the cutters are arranged more perpendicularly to the viewer and the material can no longer be seen. This is a consequence of the cutter profile, as seen in the profile view.

LOOKING FORWARD

Good information is needed to start a PDC bit design (the better the information, the better the bit design). Critical components of that data are the parameters that define the cutter profile.
In the next Paradigm, the topic of cutter profiles will be covered in detail, including the single arc profile type, profile parameters and the relationship between the cutter profile and cutter density.

Figure 1-5: Cutters in profile with radial locations marked by vertical lines.