1. Applications of Directional Drilling

1.1 Definition of Directional Drilling
1.2 Directional Drilling Applications
1.3 Basic Terminology
Directional drilling is the process of directing a wellbore along a predetermined trajectory to intersect a designated subsurface target.
1.1 Types of Wells

1 Vertical Well – a wellbore with the wellhead and subsurface target located on a vertical line

2 Directional Well – a wellbore with subsurface target, typically located away from the surface location of the well

3 Horizontal well – a wellbore with the section of well path where the inclination is maintained at around 90°, usually with the intent to keep the hole in the pay zone in order to maximize exposure to a reservoir.
1.2 Directional Drilling Applications

Courtesy: French Oil & Gas Industry Association

- Subsea Drilling from Shore
- Drilling Under Populated Area
- Drilling Under Mountain
- Drilling Under Inhospitable Area from Offshore
1.2 Directional Drilling Applications Offshore Drilling

Courtesy: French Oil & Gas Industry Association

1.2 Directional Drilling Applications

Cluster Drilling

Courtesy: French Oil & Gas Industry Association

1.2 Directional Drilling Applications

Sidetracking

Well section abandoned and resumed by directional drilling.

Downhole failure

Courtesy: French Oil & Gas Industry Association
1.2 Directional Drilling Applications

Relief Well

Courtesy: French Oil & Gas Industry Association

Uncontrolled flow of oil and gas

Direction of prevailing winds

FLOATING DRILLING RIG

FLOWING WELL

RELIEF WELL

3,300 to 5,000 ft

Desirable Distance < 100 ft

1.2 Directional Drilling Applications
Horizontal Wells

Courtesy: French Oil & Gas Industry Association
1.2 Directional Drilling Applications
Multilateral Wells

Note: Cement is not a pressure seal.
1.2 Directional Wells Increase Coverage

Courtesy: Short. Directional & Horizontal Drilling

sqm = square miles
MD = 15,000 FT BELOW KOP
* = TVD BELOW KOP
1.3 Basic Terminology

**Well Path** – the trajectory of a directionally drilled well in three dimensions

**Measured Depth (MD)** – the length of the wellbore measured along the actual well path

**Total Depth (TD)** – the measured depth to which a well is drilled

**True Vertical Depth (TVD)** – the vertical distance from a point in the well (current or final depth) to the surface (rotary kelly bushing)

**Kick Off Point (KOP)** – the depth at which the well is deflected from the vertical

**Displacement** – horizontal distance from a well head to the well’s final depth

**Inclination** – angle between a tangent to the well path and a vertical line, measures the deviation from vertical at a certain point

**Azimuth** – angle between a tangent to the well path and North axis (true north or magnetic North) measured in horizontal plane, clockwise from North
1.3 Basic Terminology (cont’d)

- **Well Head**: the portion of the wellpath in which the inclination angle is close or equal to zero.
- **Vertical**: the portion of the wellpath in which the inclination angle is close or equal to zero.
- **Build Section**: the portion of the wellpath in which the inclination angle is increased.
- **Build Up Rate (BUR)**: the rate of change (deg/100ft or deg/30m) of the increasing angle in the hole.
- **Tangent or Hold Section**: the portion of the wellpath in which the inclination and azimuth is maintained the same throughout the section.
- **Drop Section**: the portion of the wellpath in which the inclination angle is decreased.
- **Drop Off Rate**: the rate of change (deg/100ft or deg/30m) of the decreasing angle in the hole.

*Oktay Mamedbekov. Directional Drilling. Applications.*
1.3 Basic Terminology (cont’d)

**Build rate** – inclination angle difference between two consecutive survey points, extrapolated to 100 feet or 30 meters measured in vertical plane (deg/100ft or deg/30m)

**Turn rate** – azimuth difference between two consecutive survey points, extrapolated to 100 feet or 30 meters, measured in horizontal plane (deg/100ft or deg/30m)

**Dogleg Severity (DLS)** – combination of build and turn rate; normalized measure of well bore curvature at a certain point (deg/100ft or deg/30m)

**Radius of curvature** – the reciprocal of build rate (ft or m)
1.3 Basic Terminology (cont’d)

**Build & Turn rate**

\[
\begin{align*}
\dot{i}_\alpha &= \frac{\alpha_i - \alpha_{i-1}}{S_i - S_{i-1}} \\
\dot{i}_\varphi &= \frac{\phi_i - \phi_{i-1}}{S_i - S_{i-1}}
\end{align*}
\]

**Radius of curvature**

\[
R = \frac{1}{i}
\]

\[
R \text{ [ft]} = \frac{57.3}{i \text{ [deg/ft]}} \text{ or } R \text{ [m]} = \frac{57.3}{i \text{ [deg/m]}}
\]

**Build rate**

\[
i \text{ [deg/ft]} = \frac{57.3}{R \text{ [ft]}} \text{ or } i \text{ [deg/m]} = \frac{57.3}{R \text{ [m]}}
\]

1.3 Basic Terminology (cont’d)

**Example 1**

\[ i = 6 \text{ deg/100 ft} = 0.06 \text{ deg/ft} \]
\[ R = 57.3 \text{ deg} / 0.06 \text{ deg/ft} = 955 \text{ ft} \]
\[ i = 6 \text{ deg/30 m} = 0.2 \text{ deg/m} \]
\[ R = 57.3 \text{ deg} / 0.2 \text{ deg/m} = 286.5 \text{ m} \]

**Example 2**

\[ R = 636 \text{ ft} \]
\[ i = 57.3 \text{ deg} / 636 \text{ ft} = 0.09 \text{ deg/ft} = 9 \text{ deg/100 ft} \]
\[ R = 191 \text{ m} \]
\[ i = 57.3 \text{ deg} / 191 \text{ m} = 0.3 \text{ deg/m} = 9 \text{ deg/30 m} \]