Multilateral Wells

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In the mid-1990s, multilateral wells proliferated worldwide as innovative drilling and completion technologies made construction of laterals less costly and less technically challenging. *Multilateral* (ML) *wells* comprise more than one wellbore drilled from and connected to a single main bore. In certain reservoirs, operators can leverage this approach to improve reservoir production by accessing numerous production zones or by increasing the contact area between a wellbore and a formation with minimal increase in drilling and completion costs. These techniques also reduce the environmental footprint of drilling rigs and subsequent production trees, particularly for land operations.

Multilateral Configurations—TAML Levels

Operators have used rudimentary ML wells since the 1950s. However, by 1997, they were applying the strategy in an expanding variety of configurations, inspiring an industry group of operators and service companies to form a consortium—Technology Advancement of Multilaterals (TAML)—to develop a classification system for ML wells. The consortium chose to categorize the wells according to the type of junction used to join the main bore to the lateral, and produced standards that were designated TAML Levels 1 through 6. The ascending order of these levels reflects increasing mechanical and pressure capability of the junction (Figure 1). As a consequence, cost, complexity and risk also increase at the higher TAML levels.

The main bore, lateral and junction of a *TAML Level 1* well are uncased. This basic lateral is designed to enhance reservoir drainage from consolidated formations. It has the advantage of low drilling and completion costs, but the openhole junction makes reentry into the lateral wellbore and control of flow from the lateral impossible.

Wells that have cased and cemented main bores and openhole laterals are designated *TAML Level 2*. A cemented main bore significantly reduces the risk of wellbore collapse and provides isolation between laterals. By placing sliding sleeves and packers in the main bore, operators can produce the bores singly or commingle production.

Placing a liner in the lateral and mechanically connecting it to the cased and cemented main bore results in a *TAML Level 3* well. A *liner* is a string of casing that does not extend to the surface but is anchored or suspended inside a previously run casing string. This TAML Level 3 well includes a lateral that is cased but not cemented at the junction. It is a relatively low-cost option that includes reentry capabilities and a lateral that is better supported than that of Levels 1 and 2. Using sliding sleeves and packer plugs, operators can produce the bores singly or commingle production. A TAML Level 3 junction does not provide hydraulic isolation and its use is restricted to consolidated formations.

TAML Level 4 junctions are applicable in both consolidated and unconsolidated formations because both the lateral and the main bore are cased and cemented at the junction. The junction provides fullbore access to the lateral, and mechanical support is supplied by the tubulars and cement.

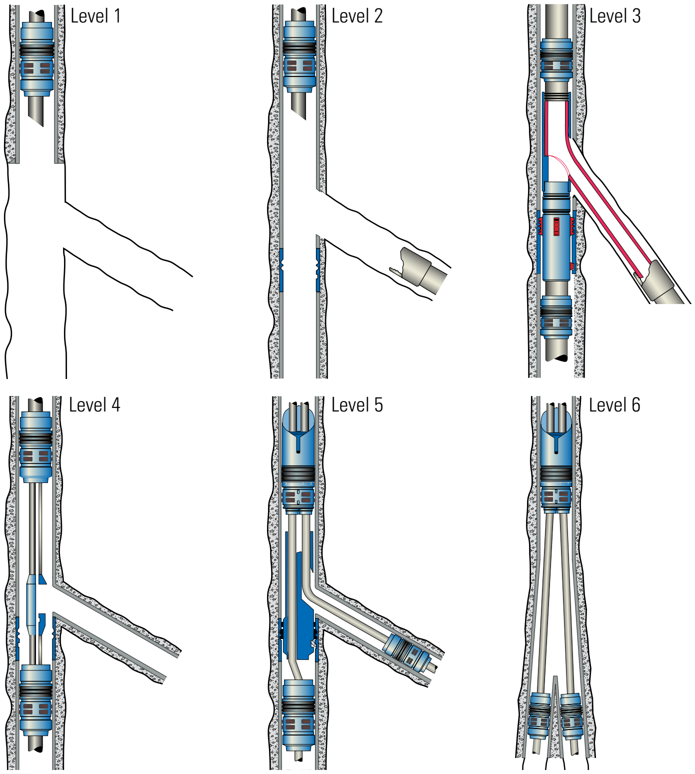

Figure 1. Multilateral wells are characterized according to definitions established in 1997 during the Technology Advancement of Multilaterals (TAML) Forum held in Aberdeen. These standards classify junctions as TAML Level 1, 2, 3, 4, 5 or 6 based on mechanical complexity, connectivity and hydraulic isolation.

However, because the cement can only withstand limited differential pressure, the junction does not provide hydraulic isolation.

TAML Level 5 wells do provide hydraulic isolation at the junction because pressure integrity is provided by the completion, which includes production tubing connecting a packer in the main wellbore above the junction and a packer in the lateral wellbore. Because hydraulic isolation and support are provided by the completion hardware, the junction may be a TAML Level 3 or 4 before the Level 5 completion is installed.

TAML Level 6 wells also provide hydraulic isolation at the junction. A well at this level differs from a TAML Level 5 well in that pressure integrity is provided by the main wellbore casing and a cemented or uncemented liner in the lateral. The cost and complexity of creating a single-metal-element dual-bore casing junction downhole has prevented TAML Level 6 wells from being developed. As of today, the category exists as a result of early experiments.

Choosing a Lateral Design

The geometry of an ML well is determined by the production targets, their relative depths and lateral extents. The laterals may be on the same horizontal plane at the same true vertical depth or they may be on the same vertical plane and follow the same direction but at different depths. Within these two main categories, a nearly infinite number of combinations can be created that may cover multiple zones or span out in various directions within a single reservoir (Figure 2).

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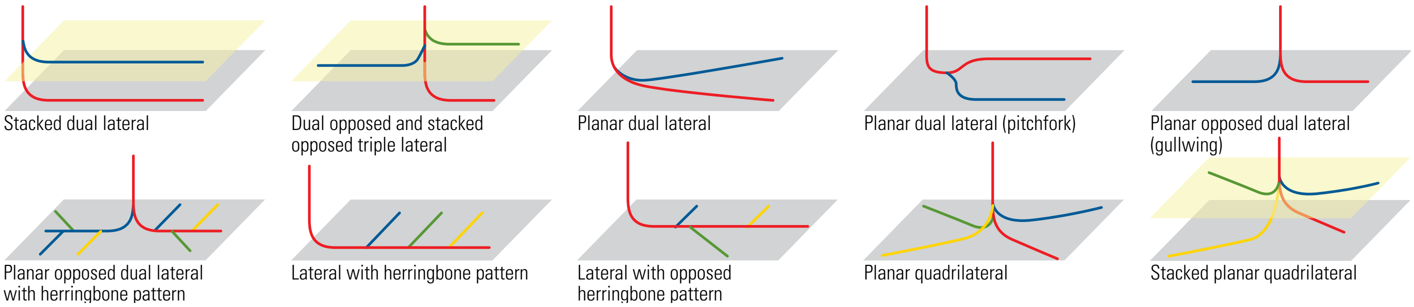

Figure 2. Stacked laterals are in the same vertical plane; opposed, or gullwing, laterals are in the same zone but run in opposite directions; and fishbone, herringbone or whalebone patterns are created by numerous laterals that extend outward from a single horizontal main bore to cover the zone.

Because ML wells that have higher TAML designations are more complex, they are more costly and their configurations are more flexible. As they do with ML geometry, engineers choose a TAML level junction based primarily on reservoir characteristics, costs and function.

Common Applications

The most frequent applications of ML wells are in reservoirs that require sand control and in heavy oil reservoirs. In the case of sand control, the reason is often slot management on offshore platforms. More reservoir can be accessed from a single casing string to surface. Relatively lower-cost sand control methods for multilaterals include slotted liners or stand-alone screens that act as filters to prevent formation sand entering the wellbore. These are typically Level 5 wells.

In heavy oil applications, the goal is to access more reservoir from a single parent bore. The amount of reservoir accessed from a single surface casing can approach 100,000 ft. These are typically Level 1, 2 or 3 wells.

Artificial Lift

Like many wells, multilaterals may require some form of artificial lift to supplement reservoir energy to bring produced fluids to the surface. Because most junctions do not contain pressure seals across the annulus, laterals are rarely good candidates for injection wells that operate at elevated pressures. Pump-type systems are applicable when formation fluid is produced naturally to a depth that is above the junction and shallow enough for a pump to lift economic volumes of liquids to the surface.

Offshore Drilling

Multilateral wells are suited to offshore and subsea operations. Offshore platforms are often slot limited; they are designed to accommodate a finite number of casing strings and wellheads at the surface. Should an operator discover the need for more wells than are allotted in the original platform design, installing laterals that branch from the existing main bore is significantly less expensive than acquiring another platform. In addition, the capital and operating expenses of offshore operations are such that the cost of MLs and junctions is small by comparison.

Commingled Production

In many areas, *commingled production*—in which formation fluids from separate zones are mixed downhole and allowed to flow as a single stream to the surface—is not allowed or is impossible because of pressure differences between zones. Only TAML Level 5 or Level 6 junctions provide the pressure integrity required to prevent commingling of flow from the lateral and the main bore; TAML Levels 2 through 6 junctions may be used if the well includes a dual upper completion to keep the flow streams separated.

Handling the Pressure

Junctions can fail as a consequence of high drawdown pressures, and engineers must understand the scale of those pressures when choosing a junction. Because drawdown pressures are exerted directly on the formation in TAML Levels 1, 2 and 3 junctions and on a cement sheath in TAML Level 4 junctions, these junctions should be used only in low-drawdown environments. TAML Levels 5 and 6 junctions are separated from the formation by casing and cement and able to withstand significant drawdown pressure.

Reentry

The ability to reenter the lateral for well intervention operations is another ML design consideration. Because it is a directionally drilled section that has no junction, the lower lateral is almost always easily accessed using standard intervention methods. Operators must make an economics-based decision during the well planning stage to include junctions that allow through-tubing access, junctions that can be adopted to allow access after installation or junctions through which no access is possible.

The decision to deploy lateral junctions that allow fullbore or restricted access is a function of the overall well design. Engineers usually opt for fullbore access if a packer is to be placed below the junction or if an artificial lift system must be located near the lower lateral. In addition, based on their knowledge of the reservoir, operators may require fullbore access to perform perforating, gravel packing, cleanout and other remedial operations. Fullbore access can be adapted to all TAML level junctions but must be specified before installation; some commercially available junctions allow no access or only restricted access to the lateral and cannot be adapted after installation.

Costs and Benefits

The decision to use an ML system and what type to use are the result of cost-benefit analyses. In general, the less complex junctions present operators with lower risks and costs. But risk mitigation and cost savings must be balanced against individual well and field development expectations. In low-value reservoirs, a simple openhole lateral that has no reentry capability may increase ultimate reserve recovery or accelerate production while having little impact on overall drilling and completion costs. In high-value deepwater plays, installing a hydraulically sealed TAML Level 5 or Level 6 junction can drive total well costs into millions of dollars and still be a good investment because it may save drilling another well or preserve a well slot on an existing production platform.