# Applying Common Sense in the Oil Patch

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Years ago a friend told me..."Common sense is the least common of the senses." Time proved he was right.

In many instances, we assume that things are as they are, without looking into how they got that way. Starting at this point, I asked myself this very question with regard to wells; specifically, "How were the present oil and gas well diameters determined?" It seems that a hundred years ago, bit size and whatever powered the drill presented problems that held the answer.

We know that at the early stage of oil and gas drilling the percussion method was applied. This method involved installing a "shovel" (fish tail) at the bottom of a heavy weight bar which was attached to a cable that ran from the surface to the well's bottom. This cable was attached to a beam apparatus similar to a pumping unit that moved the BHA up and down while the "shovel" dug the hole. Every so often, the BHA was removed and replaced by a bailer (similar to a sand pump) to bring the cuttings to the surface.

This procedure served as the drilling method in the late 19th and early 20th century until Howard Hughes, Sr. developed his rotary method by which a bit was rotated from the surface by means of a tubular drill string.

If we assume that in those years, the drilling industry operated while reacting to what was available, we can also assume that well diameters and casing responded for the same reason. At this point, well diameters conformed to the availability and diameter of pipe produced. By the mid-20th century, drill pipe, as it is known today, was born. Without questioning the efficacy of a particular diameter size, well diameters continue to this day to yield to drill pipe size, just as happened a century ago. The same situation applies to casing diameters.

The size and capacity of drilling rigs is also dictated by well depth and pipe diameters. If today we want to change the size of drilling rigs, we will be confronted with changing these other two factors. Common sense asks, "Is it necessary to continue the practice of drilling according to the usual diameters, or are there alternatives to reducing the cost of making a new well by reducing diameters, as well as the size of a drilling rig?"

These questions provoke another: if well diameters are reduced, is artificial lift (as we know it today) still possible? The answer to this question requires an analysis of a diameter's impact on production. If today, a production engineer is asked to start a well design from scratch, the first thing that he will have to consider is the size of the last string to be run in the hole. The option of reducing well diameters now requires a study of its compatibility with this last string. For example, regarding a drilled and completed well that needs sucker rods and a pump to lift fluids to surface, sucker rods and the diameter of couplings will determine the well size. Rod pumping consists of running a string of rods with small diameters near the bottom and larger diameters near the surface. (Fig. 1 below shows the various rod sizes and coupling diameters recommended by the API.)

If 1" rods are needed, the slim hole coupling will have 2" OD, which dictates that the ID of production tubing will have to be larger than 2", not only to accommodate couplings, but also to allow the passage of fluid around it.

Checking Fig 2 for sizes of production tubing, we can see that in order to\ accommodate a 2" sucker rod coupling, we need at least an API 2.7/8" tubing with an ID of 2.4 inches. In the same table, we can see that the coupling that connects tubing with tubing is 3.5" OD, which will dictate the diameter of well casing. Fig 3 illustrates that 5.1/2"casing will accommodate 2.7/8" production tubing. Casing coupling OD will dictate the hole's diameter.

From this analysis, we can see that in order to accommodate the well casing we need to drill a hole of at least 7". And that's not all. It is also known that to control drilling from the start we need to drill a surface hole, case it, and install a BOP. In addition, this hole will have to be of such diameter size that after the hole is cased, the diameter will be sufficiently large enough for the bit to reach T.D.

To verify the accuracy of our analysis, our drilling engineers designed a well with the last string to be run in it. The design resulted in a hole of 12" on the? surface. This same result would not necessarily be the same with regard to some slim-hole gas wells cased with 2.7/8" or 3.1/2" because reservoir energy causes gas flow to surface. However, it is necessary to note that once the energy diminishes and water starts to enter the borehole, these slim-hole wells also need some kind of artificial lift to remove fluids (de-watering).

In view of all these considerations, the question remains: Is it possible to reduce the cost of oil wells by reducing well diameters. History tells us that in the 1950's the industry tried small diameter tubing (macaroni tubing) to drill, and also to produce through slim holes. With very few exceptions this method failed, and did so primarily due to weak pipe connections. These connections (or "threads"), simple as they look, involve complex engineering, particularly in those cases in which the pipe's wall thickness does not allow the machining of a strong thread.

The pipe design engineer is confronted with one or more of the following thread design challenges:

1) the lack of the pipe's wall thickness to machine a strong connection
2) the possible necessity of reducing the pipe size
3) the increase of pipe wall thickness, which in turn reduces the capacity to go deeper in the hole.

This geometric compromise forces the design engineer to move within narrow margins, resulting in limiting the thread capacity. Because the machining of threads requires wall thickness, at least at both ends of the pipe (i.e. upsets/Tool Joints), if the pipe diameter is increased, the diameter of upset or tool joints will have to increase as well. Once more, we can see how these variables affect the well diameter.

With regard to rotary drilling (and assuming that slim drill tubing or macaroni tubing is reliable), another roadblock appears, this time related to hydraulics. In order to drill efficiently, normal drilling practices induce pressure losses due to the circulation of drilling fluid inside drill pipe to maximize hydraulics at the bit. At the same time, the need to maintain a good annular velocity to remove cuttings runs contrary to the principle underlying the use of  small diameter pipe.

Today most wells are drilled with 4.1/2" drill pipe, between a 7" to 9" diameter hole, and are cased with either a 4.1/2" or 5.1/2" pipe. All other casing diameters, such as surface or intermediate casings, are related. Drilling engineering and infrastructure, as well as materials, are designed in accordance with these diameters and constrains.

Once more, common sense forces us to look for alternatives to optimize drilling and production. The questions remain: must we settle for the inefficiency of archaic, present practices? Or, should we capitalize on the innovation of alternative, proven ways of doing business?

If we see that "business as usual" is the response, despite innovation regarding sucker rod dimensions and despite improvements in materials and thread design, we are stranded with little choice. These strings, one for production and the other for drilling, dictate not only well diameters but also the type of rigs used on the surface.

The quest for options or alternatives is met today with “continuous tubing”, a product originally designed for servicing wells. It is commonly referred to as “Coiled Tubing” or “CT” in that it is wound on a drum or reel.

Another question that begs an answer, is, “Can we drill slim holes or even regular wells with CT?” The answer is a resounding, “Yes”. CT in reels is available in diameters up to 3.1/2”. Depending on pipe diameter, the length of pipe on a reel length allows for a well depth of up to 4000 to 5000 feet.

While CT drilling is not for massive applications, it is an excellent option to drill slim, shallow wells. In using CT to produce fluids, its application exceeds expectations. Since 1994, we are working to adapt CT to innovative production methods, with a product that is still used exclusively to service wells. Our testing and experience has proven our ability to replace sucker rods by CT strings in rod pumping wells. Advantages to the industry are numerous. Not only will sucker rod and production tubing replacement eliminate unnecessary geometries and connections, but it will also lead to energy savings. Such savings are possible because CT string is lighter than that of sucker rods. Also, sucker rods and production tubing can be replaced with only one product.

Another advantage of CT artificial lift is that while larger well diameters today are necessary to accommodate iron, typical production rates of an artificial lift well can be brought to surface through an area no bigger than 1.2 square inches.

Regarding safety and environment, the advantages of CT surpass current practices using sucker rods, in that no pipe connections are necessary, thus reducing the possibility of leakage, breakage and “fishing” jobs.

**Summary:**

Below are listed the major drilling advantages to using Coil Tubing:

- the ability to drill not only medium-to-shallow wells, but also to produce normal-to-slim hole wells.
- the ability to innovate drilling, using CT to depths of approximately 4,000 ft.
- the ability to replace all sucker rods to a depth of 6,000 ft. with steel CT.

Further testing and improvement in materials will lead to additional applications. On the horizon is testing for our new composite CT to be used as a sucker rod string that can bring additional advantages to the industry, such as corrosion resistance and a lighter, more efficient pumping string.

CT manufacturers are devoting continuous R&D efforts to improve product and to expand the range of coil tubing applications. This is the challenge for the coil tubing industry in the 21st century.

**Graphics:**

**Fig. 1 Sucker Rod Sizes**
**Fig. 2 Tubing Sizes**
**Fig. 3 Casing Size**