Simple Mandrel Spacing

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Mandrel spacing is different from the careful valve designs that you should make for your wells:

- The mandrel design must work over the life of the completion.
- Well performance will change over time.
- Prediction of how these conditions will change is error-prone.

Thus, there is no such thing as a perfect mandrel spacing.

In order to avoid a bad spacing make sure that you have mandrels where they are needed. Use these 4 checks on any mandrel spacing:

1) **Can unload by u-tubing completion brine back to surface.**
2) **Can unload to the operating depth expected initially.**
3) **Mandrels are spaced correctly in the operating range, never so far apart that significant revenue is lost or deferred.**
4) **Mandrels are spaced deep enough, so that later in life you can still lift as deep as possible. Usually this is two joints above the packer (for ease of fishing the packer).**

This is a graphical technique.

This is not difficult. It can be done in 10 minutes with a pencil and paper.

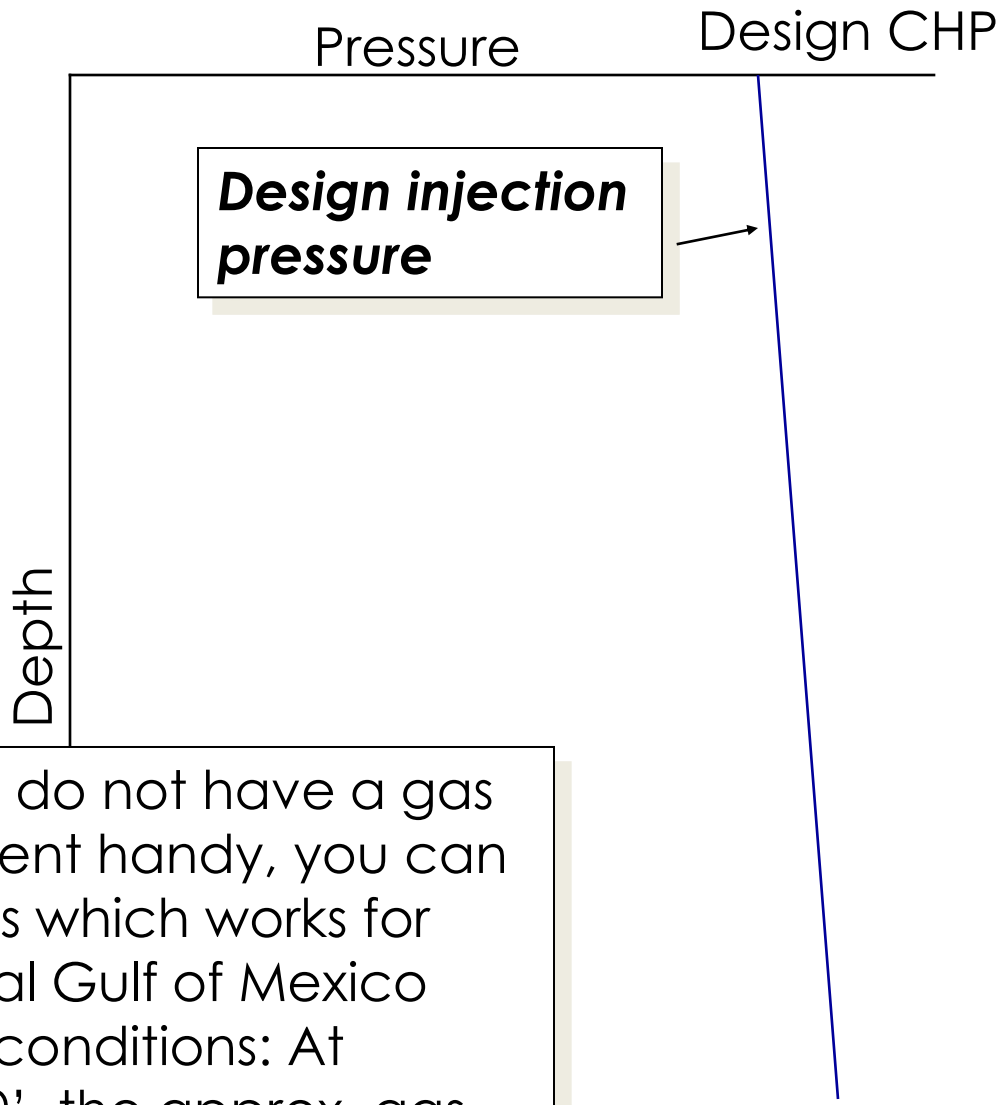
The resulting mandrel depths are going to be in TVD. Convert them to MD before sending to the rig!

This spacing works for both IPO and PPO valves.

Some people will think that there are too many mandrels. It is important to discuss how many additional barrels of production each mandrel costs. Having a mandrel in the right place at the right time will be worth more at least 10 bopd at some point in time (probably at many points in the well life). It could be worth considerably more than this.

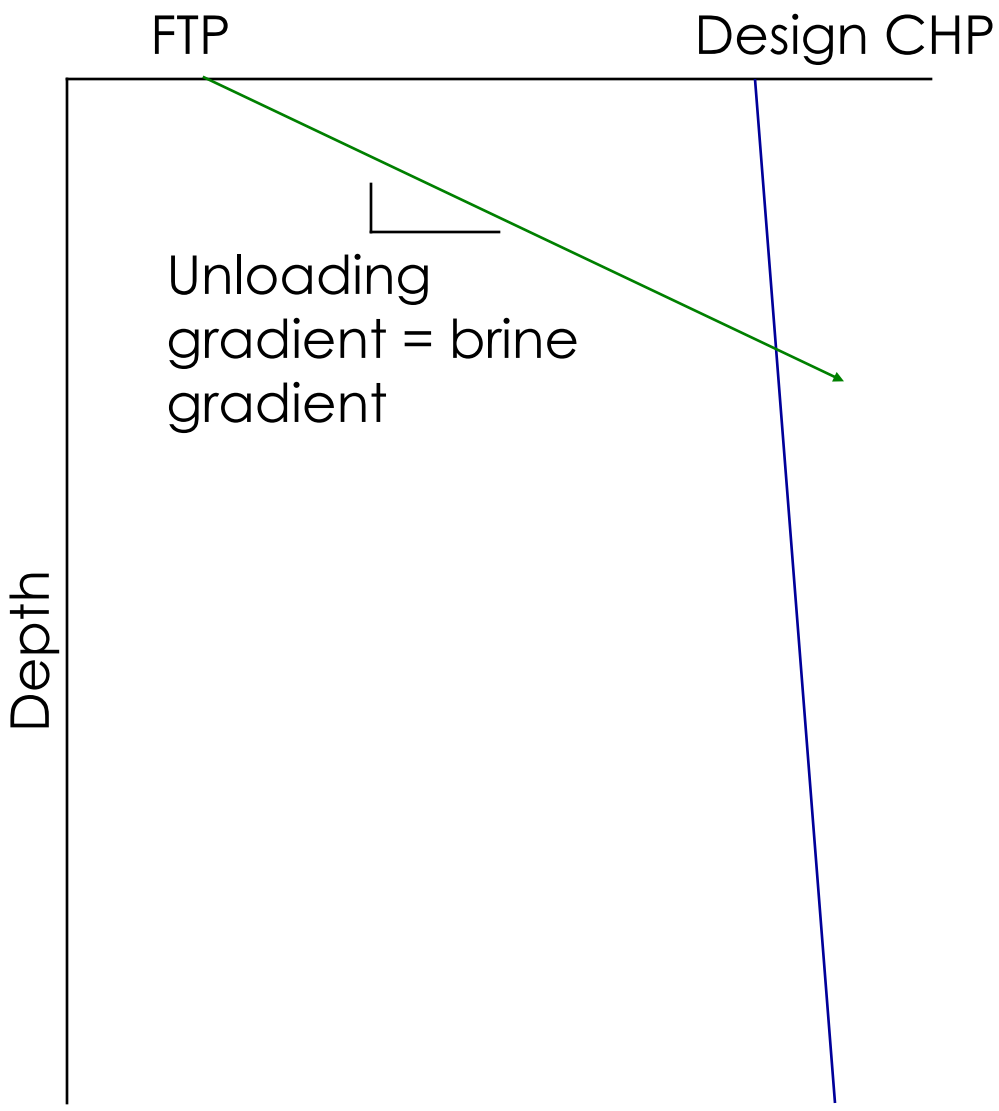
And that much production is worth more than all the mandrels in the well.

First, draw in the injection pressure gradient starting with the design injection pressure 50 psi less than the available injection pressure at the wellhead.

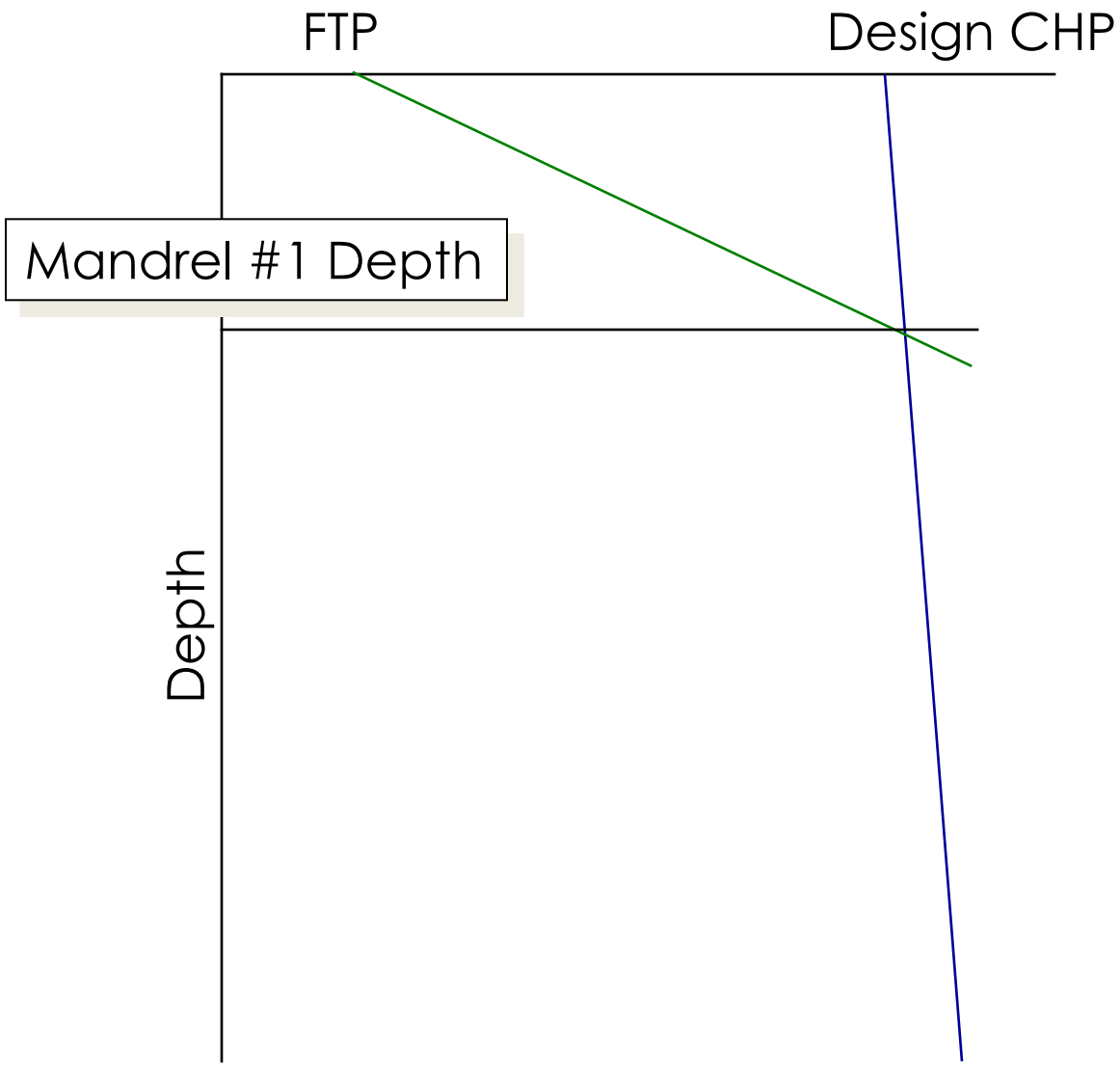


If you do not have a gas gradient handy, you can try this which works for typical Gulf of Mexico shelf conditions: At 10000', the approx. gas pressure (psi)= (1.28*CHP) - 52

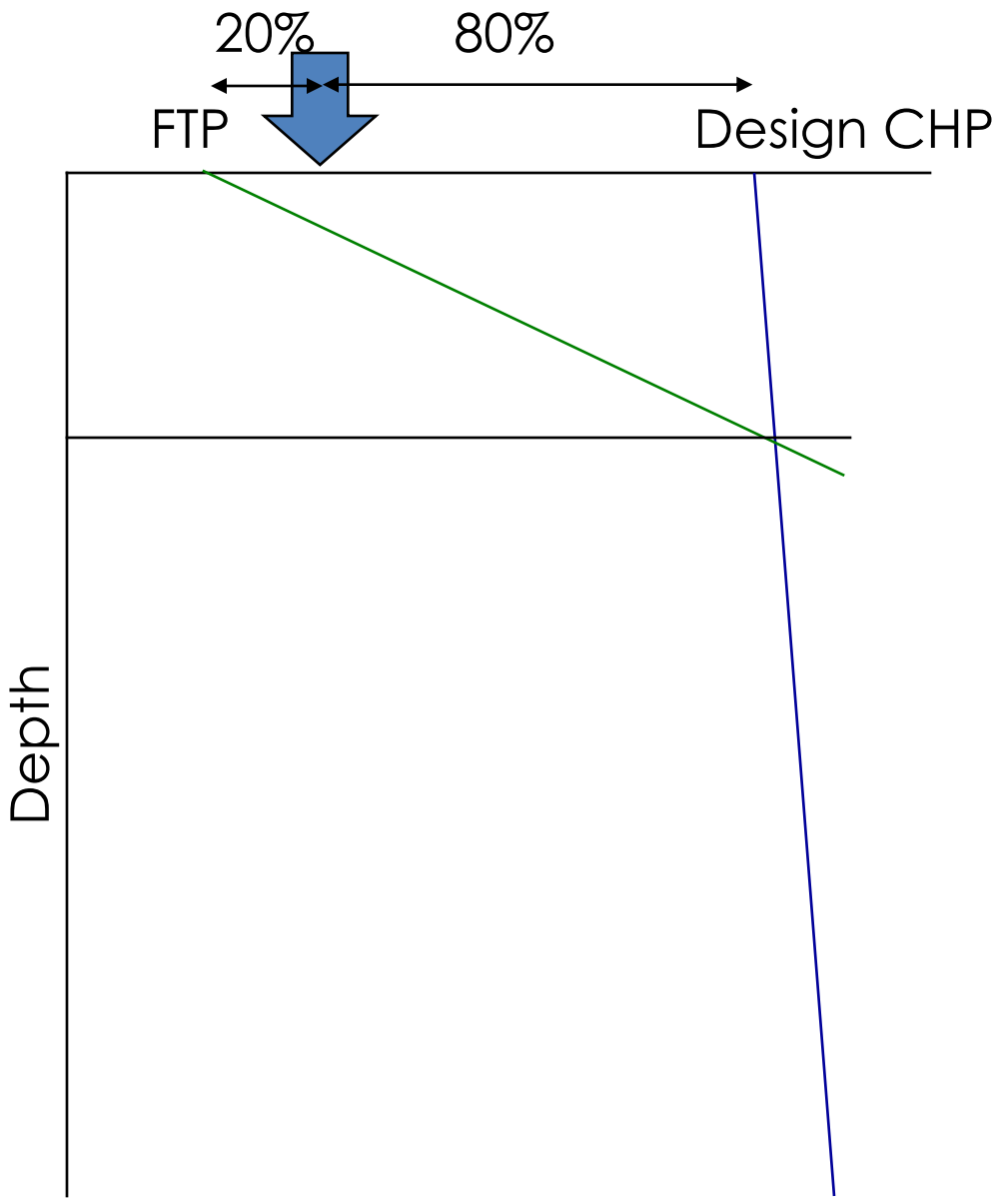
Draw an unloading gradient equal to the completion brine gradient starting from the expected FTP under gas lift conditions.



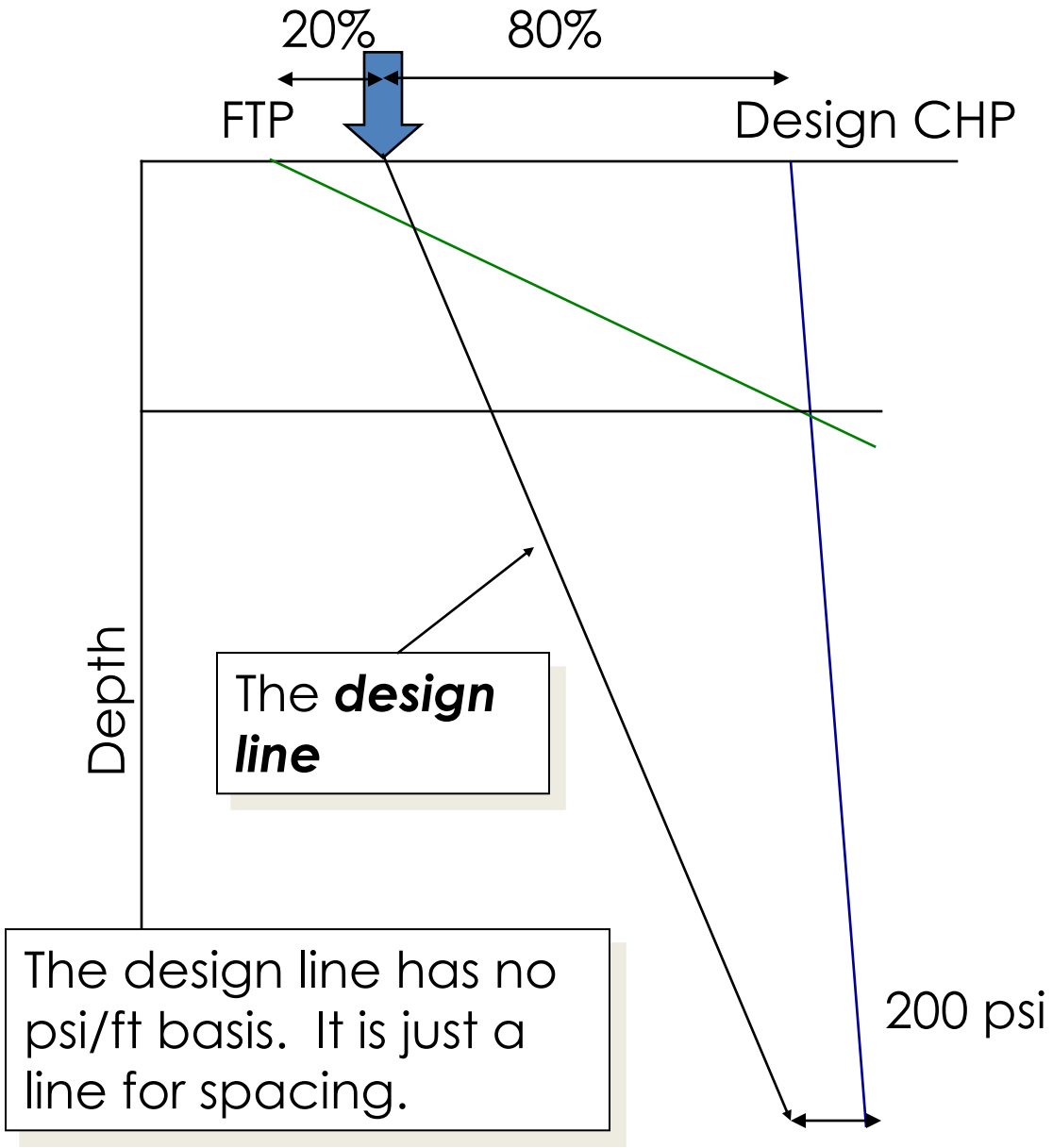
The intersection with the design injection pressure gradient is the top mandrel depth.



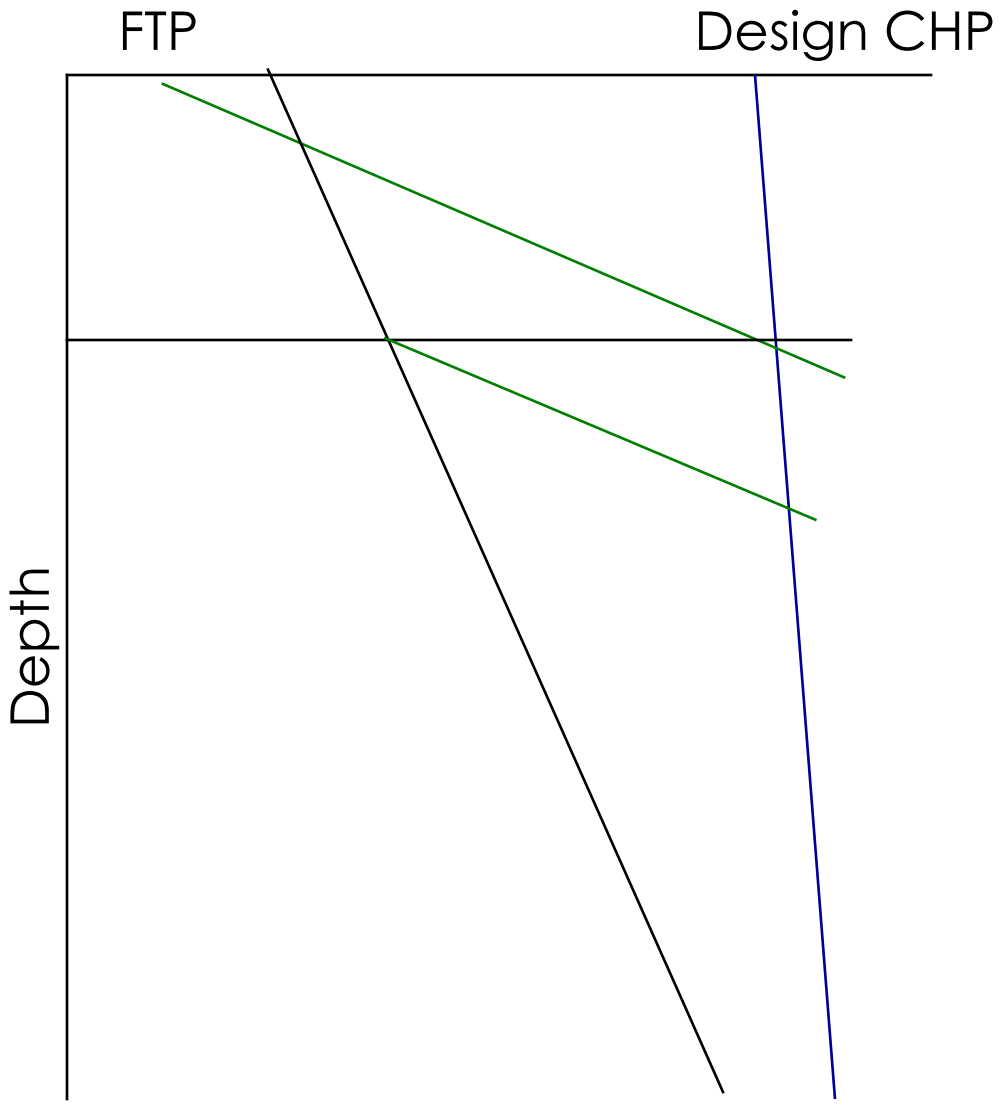
Find a surface pressure 20% of the way between the FTP and the design CHP.



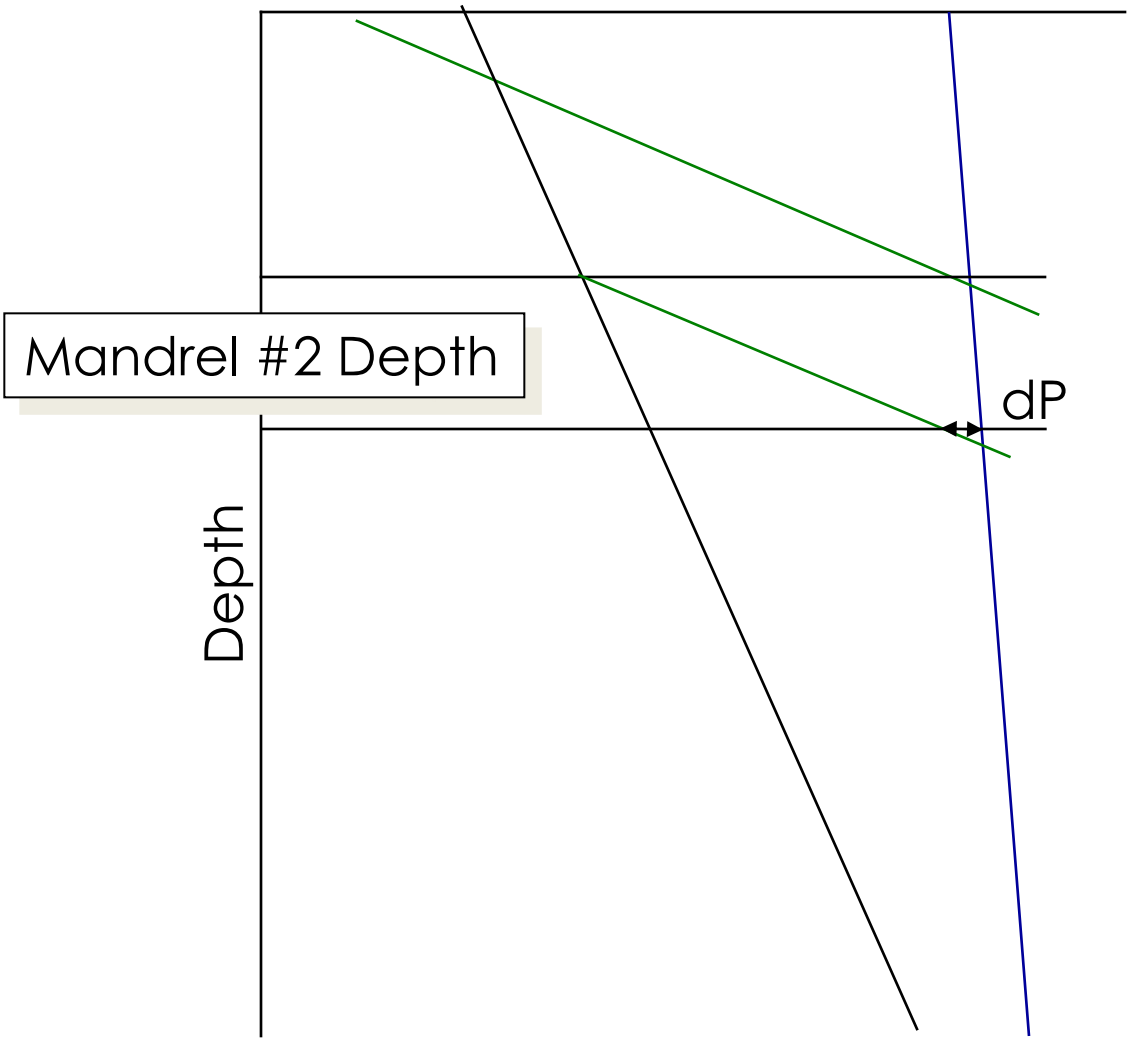
Draw a line down to a point 200 psi less than the injection pressure at the packer (or the perforations, it does not matter).



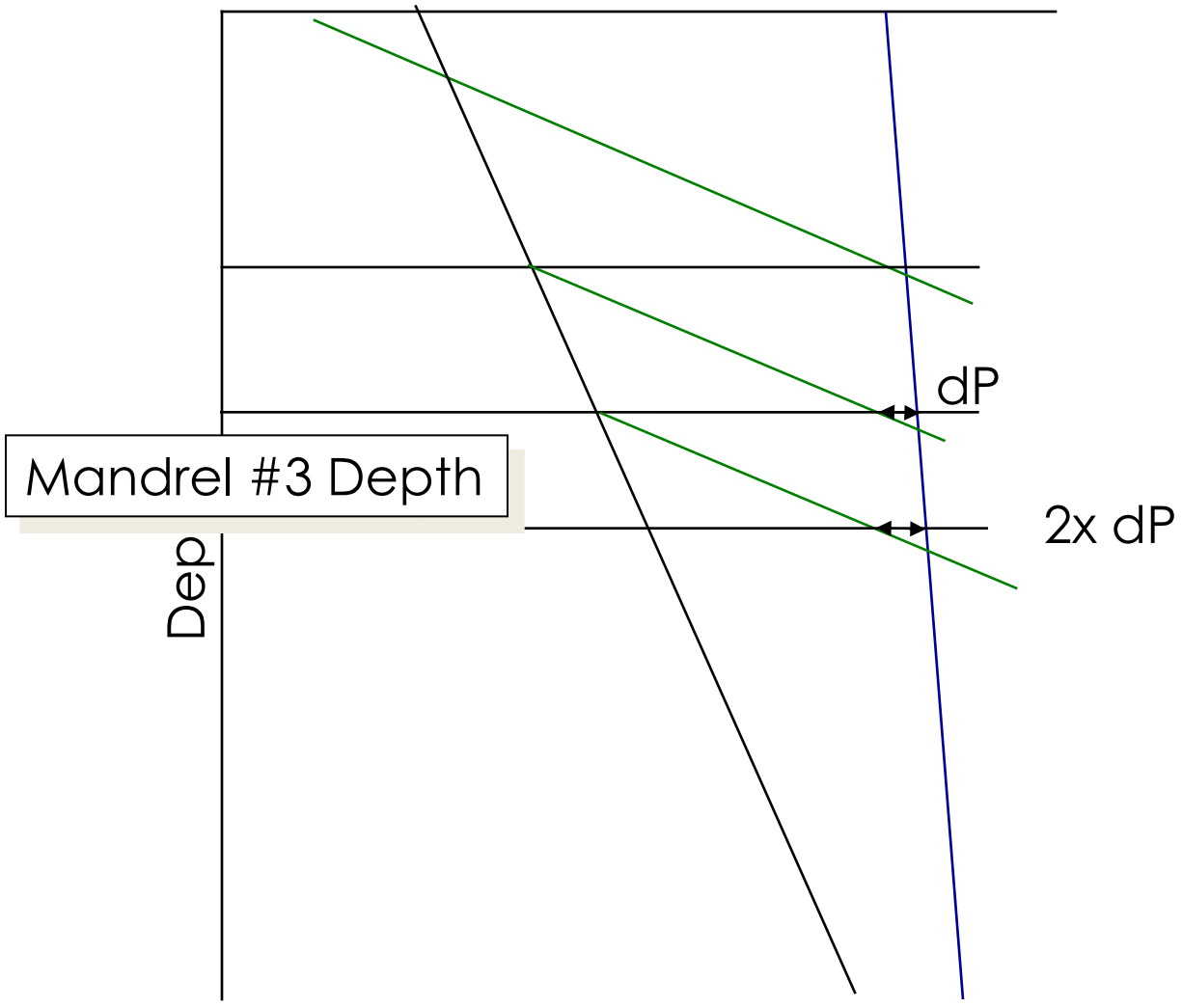
Draw a line at the unloading gradient down from the intersection of the design line to the design injection pressure.



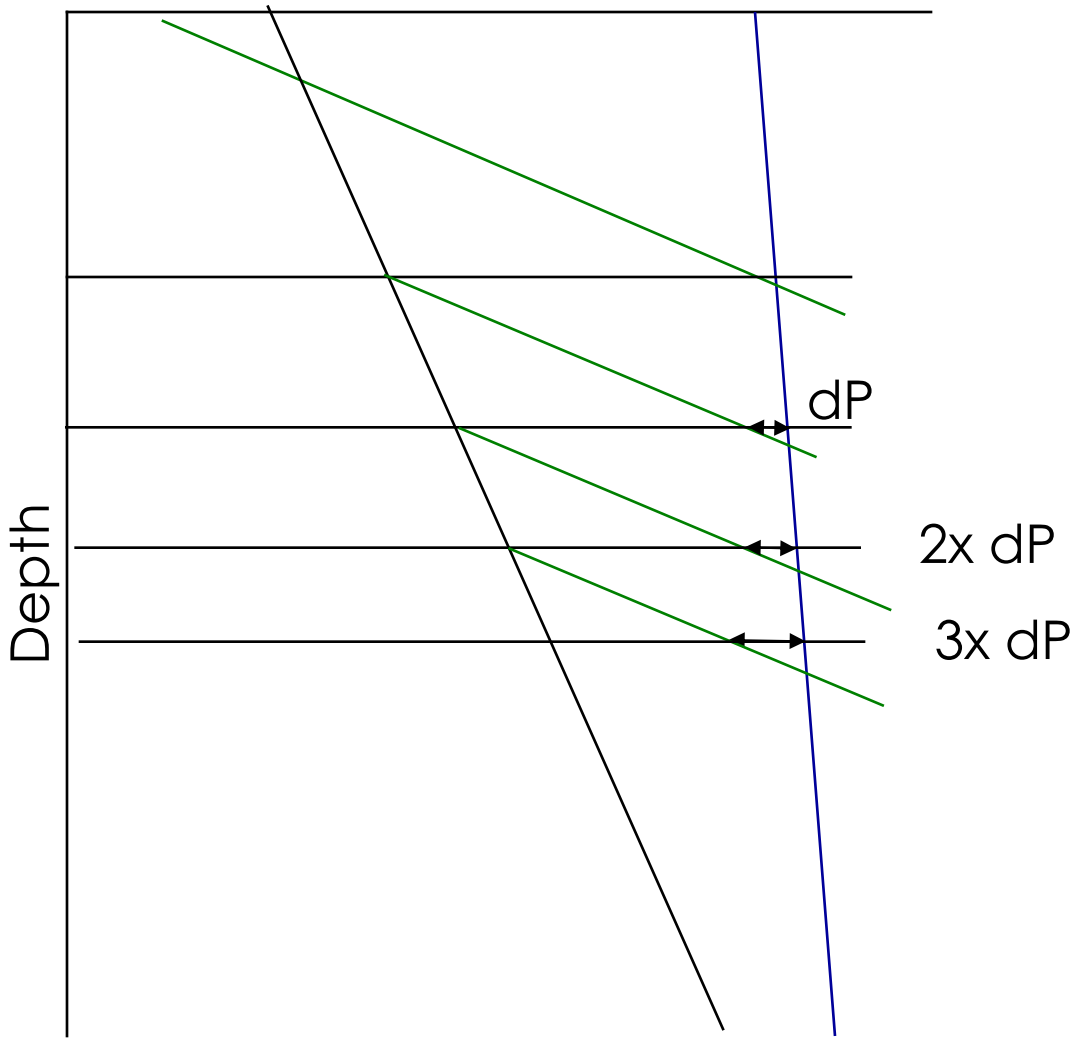
Draw the second mandrel depth where dP exists between the design injection pressure and the unloading gradient. For a system pressure between 1000 and 1400 psi, use dP = 50 psi. Lower system pressures may use less, and higher pressures more.



Draw in another unloading gradient. Draw the third mandrel depth where 2 times dP exists between the design injection pressure and the unloading gradient.



Draw in another unloading gradient. Draw the fourth mandrel depth where 3 times dP exists between the design injection pressure and the unloading gradient.



The mandrels are getting progressively close together. We need a minimum spacing or we will end up at the bottom with nothing but mandrels screwed together.

A practical minimum mandrel spacing is 500 feet.

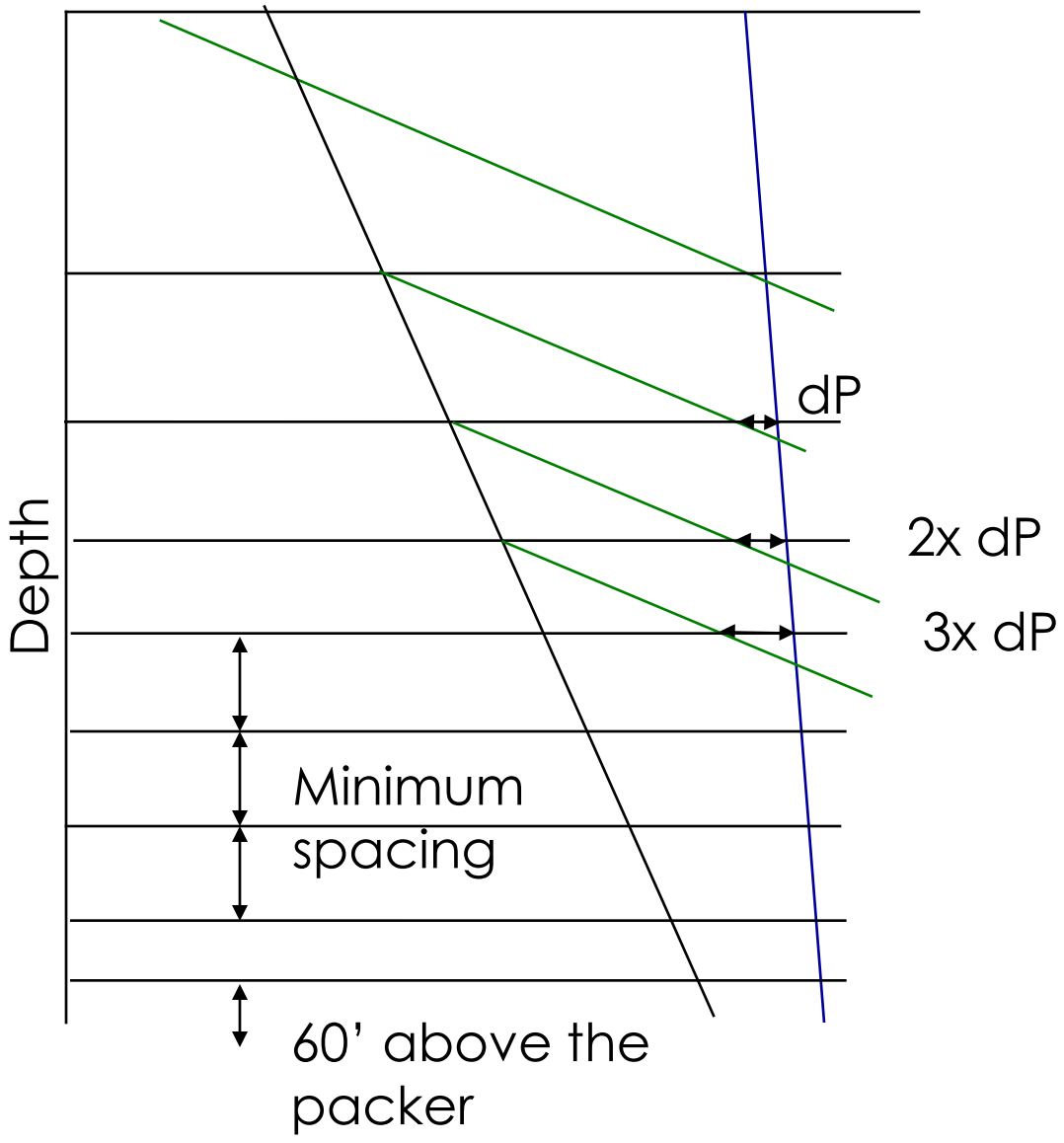
In very high productivity wells, you might go as low as 300 feet.

In very low productivity wells, you might stop at 1000 feet between mandrels.

The minimum mandrel spacing should be appropriate for the benefit of lifting one mandrel deeper, compared to the cost and risk of changing the gas lift valves to a new design.

When the minimum spacing is reached, space the mandrels to the packer at this minimum spacing.

Position the bottom mandrel 60’ above the packer by either adding one more mandrel, or by adjusting the minimum spacing.



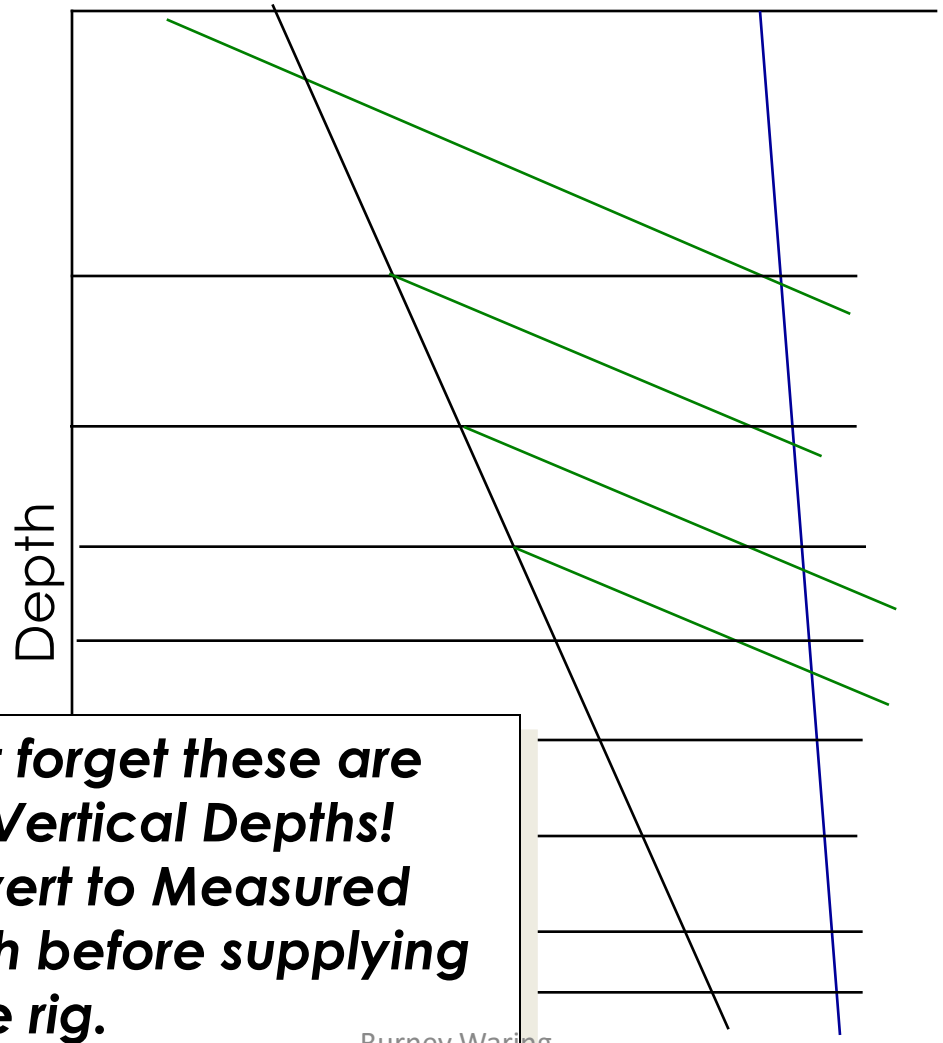
Check the design with the 4 rules of good spacing design:

1) Can u-tube liquids to the surface facilities.

2) Can unload to the operating range.

3) Have mandrels spaced correctly in the operating range.

4) Have mandrels spaced deep enough.



Don't forget these are True Vertical Depths! Convert to Measured Depth before supplying to the rig.

This spacing is independent of the valve design.

Use the best information possible and be a bit conservative in making the valve design.

Place the operating valve, usually an orifice, a bit higher the maximum depth you think you can reach.

It is better to get the well producing in a stable manner at first, then get measurements of well performance, then make an optimum valve design for maximum production.