IPO Gaslift Design Using Valve Performance

Gaslift Workshop 2008

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Abstract

- Gaslift design has been practiced successfully using the Thornhill/Craver equation to size ports but the gas flow predictions could be 3-4 times the actual flow rate for 1” IPO unloading valves.
- The use of Thornhill/Craver as the means for sizing ports is no longer necessary.
- Tested valve performance correlations are available that are within +/-15% of actual flow rates for all commonly used valves.

Contents

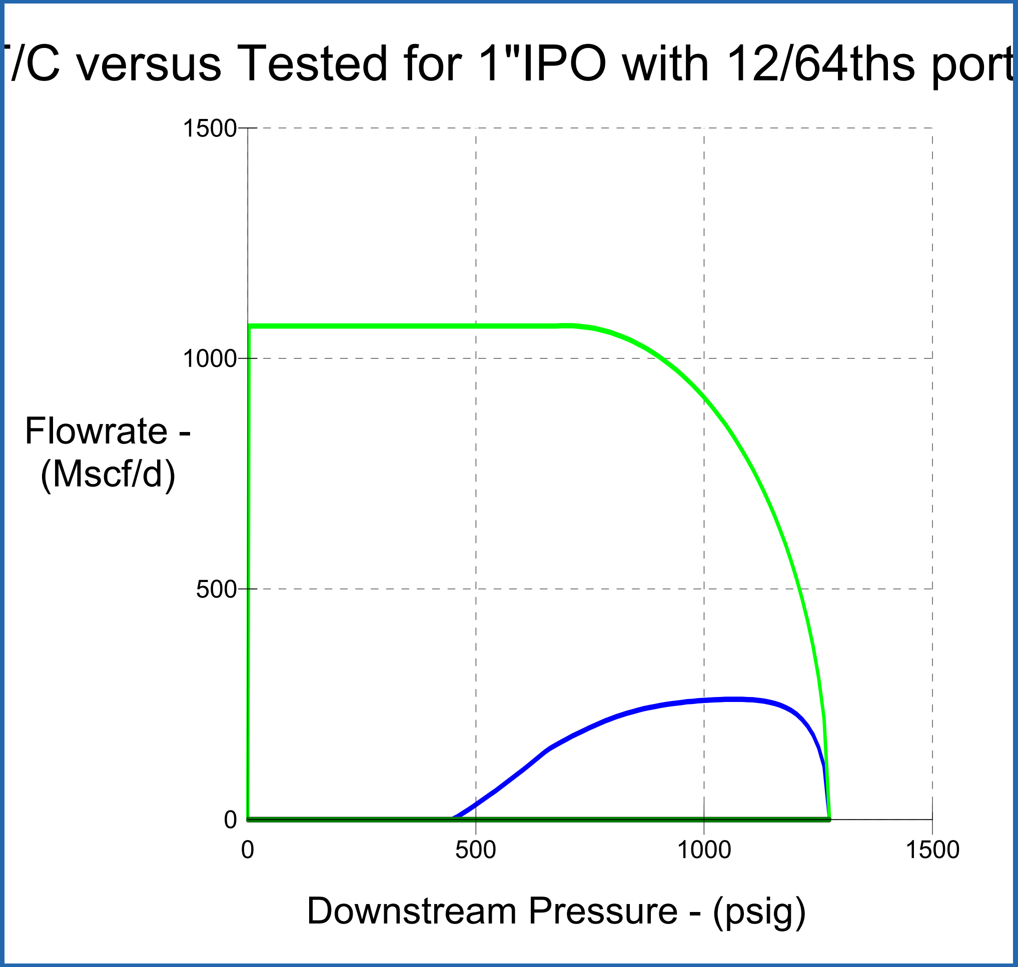
- Valve Performance
- API Gaslift Design Method Example
- Applying Valve Performance
- Recommendations
- Conclusions
- Questions

Thornhill Craver

- Use of TC to calculate flow passage through gaslift valves assumes the port is full open and the flow path is unobstructed but…
  - Loadrates of IPO valves do NOT allow the valve to fully open when annulus pressure (Piod) reaches opening pressure (PvoT).
  - IPO valves usually have downstream obstructions including the backcheck which further restricts flow passage.
- TC is OK for orifice valve gas passage calculations.
- Flow passage through 1-1/2” IPO valves is much better than for 1” IPO valves.

1” IPO Valve Performance

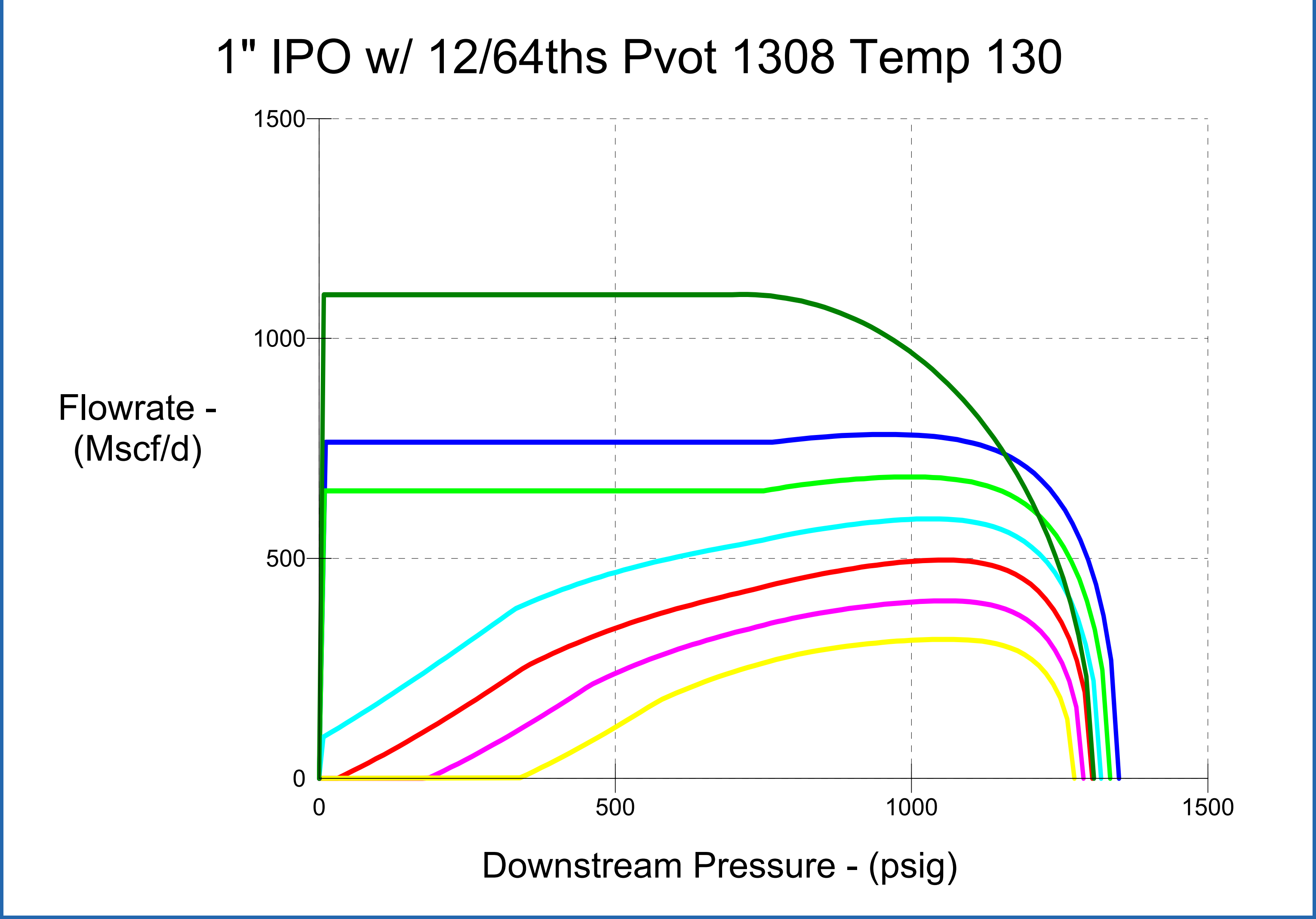
- TC will predict rates that are 3-4 times the actual flow rate
- T/C predicts orifice flow but valves throttle closed!
- TC was handy when nothing else existed but now something better does exist.



Typical Performance of 1” IPO Valves

- When the annulus pressure (Piod) is equal to the opening pressure of the valve (PvoT), the valve will throttle to the closed position when tubing pressure goes to atmospheric.
- Piod about 20-30 psig ABOVE PvoT is required to achieve orifice flow.
- Current gaslift designs will yield Piod about 20-30 psig BELOW PvoT. Net gap - about 40-60 psig.

Typical 1” IPO Flow Rate



Flow Rate Comparison

- At Piod = Pvot and Ptf = Transfer…
  - Thornhill/Craver predicts about 1.1 MMscfd
  - Actual valve performance is about 300 Mscfd at maximum flow and…
  - The valve throttles closed at Ptf = Transfer
- About 1/4th the gas passage at maximum flow and NO injection at the transfer pressure.

But the IPO Design Technique Works !!

- The current IPO design technique as practiced using the API RP 11V6 has been successful!
- TC flow rate prediction is far in excess of the actual amount the valve can pass but it seems to work !!
- There are several reasons…
  - Surface gas injection rate versus valve gas passage
  - Actual annulus pressure at the valve versus design pressure
  - Multiple unloading valves open rather than single point
  - Help from the reservoir

Injection Rates

- Boyles Law!
  - In a fixed volume (annulus) if more gas is injected at the surface than is flowing out through the valves, the pressure will rise.
    - When the first unloading valve uncovers, the surface gas injection rate is adjusted to the expected injection rate.
    - This rate is usually far in excess of the amount that can pass through the unloading valves consequently, the surface injection pressure will continue to rise.

Annulus Pressure

- The annulus pressure (Pinj) will be at kick-off pressure when the first valve uncovers.
- It is expected the annulus pressure (Pinj) will drop when the second valve uncovers but…
  - If the flow rate through the valves is less than is being injected at the surface, this will not happen!
  - The wellhead injection pressure will remain near kick-off pressure and the surface injection rate will drop to match the flow rate through the valves.
- The anticipated injection pressure drop did not happen!

Lower Valves Uncover

- The top valve remains open when the second valve uncovers and begins injection. This is expected.
- If the combined gas flow rate through both unloading gaslift valves is less than the amount injected at the surface…
  - The annulus pressure will not drop!
- Unloading valves will remain open until the total flow rate through all open unloading valves exceeds the amount injected at the surface.

Multipoint Injection

- Is this a problem?
  - NO! During unloading multipoint injection is not a problem.
  - YES! If the operator was recording the annulus pressure during unloading and expected to see a pressure drop as each lower valve uncovered, he will not see it. He does not know where injection is taking place!
- Is the designed annulus pressure drop of 20 psig at each valve necessary?
  - YES! The objective is to ensure that the valves close in sequence from the top to the bottom. Designed pressure drops at each valve will ensure this occurs.

Solution Gas Helps

- It is very possible that 3-4 unloading valves will be open and injecting gas before the operating valve is reached.
- As gas injection works deeper, eventually the reservoir will begin inflow.
- Help has arrived! If the GOR is reasonable then the lack of gas injection rate from the valves will be made up by the reservoir.

The API Design Works but…

- The API design technique does work but not the way it was expected to work.
  - Pressure drops may not occur as each valve uncovers
  - Multiple unloading valves will be open
  - Solution gas may be required to assist with unloading
- If the well has a higher PI than anticipated or the water cut is higher, it may not be possible to reach the operating valve.
- This is a little risky. Can we do better?

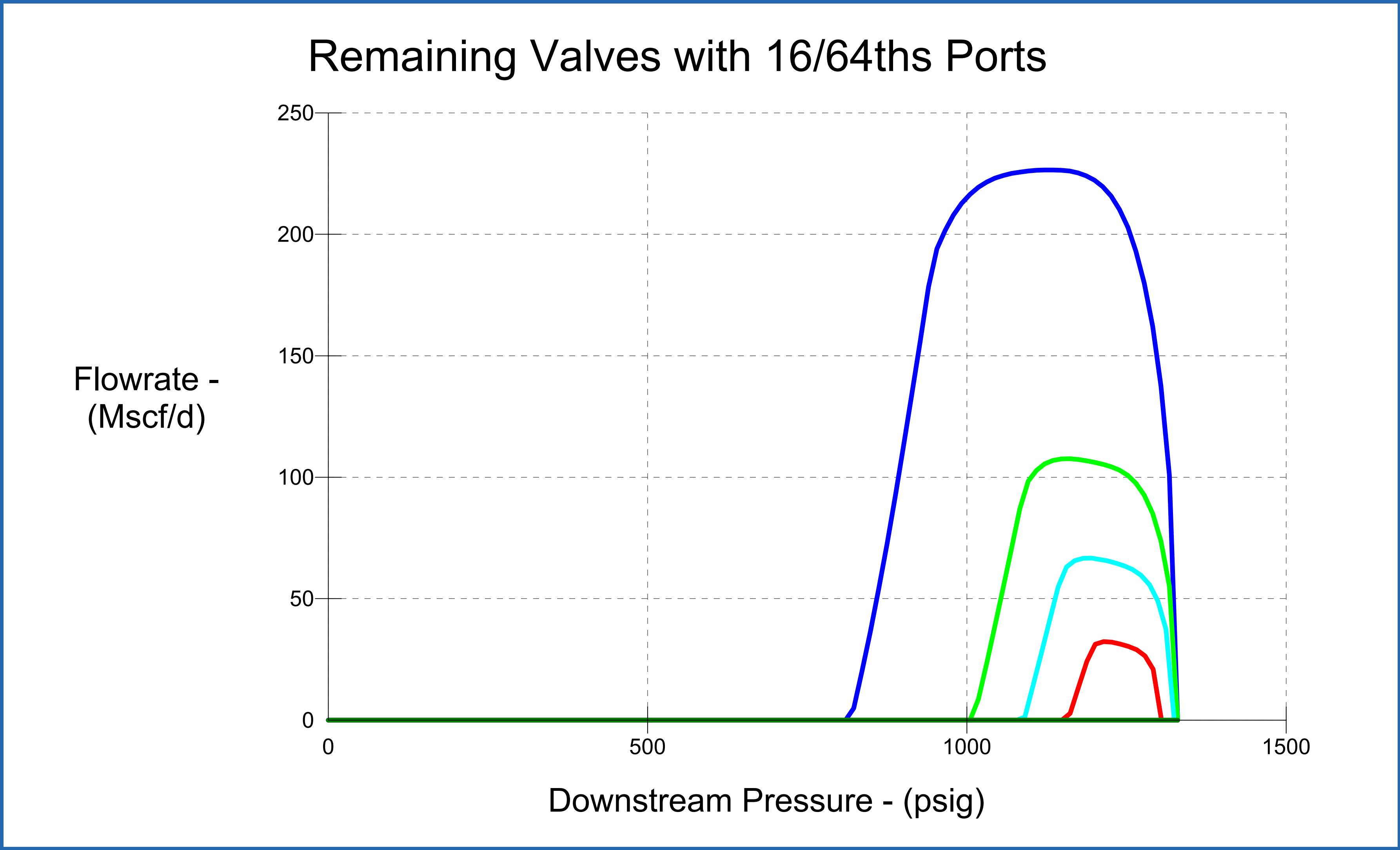
Can We Design Better!?

- Understanding the actual flow performance of 1” IPO valves gives us several choices…
  - Use larger ports
  - Take larger pressure drops between valves
  - Arbitrarily lower the set pressure of the valves
  - Reduce the kick-off pressure used for design
- Lots of options. What do we do?

Using Larger Ports

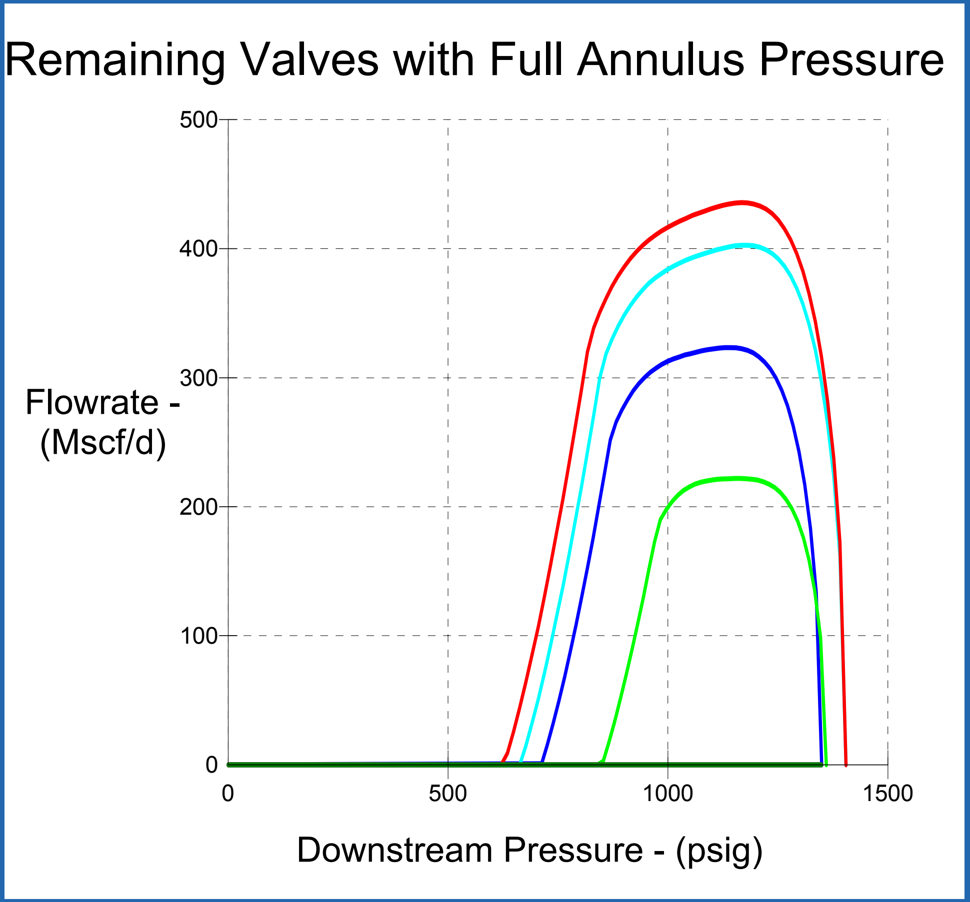
- For the remaining four valves in the example, at the designed annulus pressure, the valves with 16/64ths ports still do not pass as much gas as is being injected at the surface.
  - Consequently, the annulus pressure will be higher than anticipated. This is good!
  - There will be a slight annulus pressure drop as each valve begins injection but not as much as expected.
  - If the operator is recording Pinj and Qinj during unloading, the analysis could be confusing.

16/64ths Ports - Design Annulus Pressure



16/64ths Ports - Full Annulus Pressure

- If annulus pressure drops did not occur, then each lower valve has 20 psig additional annulus pressure.
- Flow rates through the valves are significantly higher!
- More pressure, more valve opening, and more flow rate!



Full Annulus Pressure

- With 16/64ths ports, the combined valve flow rates at full annulus pressure will be greater than the amount injected at the surface therefore…
  - The annulus pressure will drop as each lower valve uncovers but probably not the full 20 psig per valve
  - Multiple valves will be open
  - Valves will close and re-open many times
  - Unloading will experience many slugs
- Larger ports at the lower unloading valves is a definite possibility.

Larger Pressure Drops at the Valves

- Larger pressure drops (30-50 psig) at each valve will…
  - Increase the flow rate through the lower valves
  - Provide more positive indication on injection depth
  - Provide better protection against multipointing
- Larger pressure drops might work but…
  - The valve spacing will be closer
  - It may not be possible to reach the objective injection depth
  - If multipointing does occur, larger slugs
- This is a possibility if the objective injection point is shallow but for deep injection points and high PI wells this will not solve the

Lower the Valve Set Pressures

- If the spacing is left the same and the set pressures of the valves are arbitrarily lowered by 20 psig…
  - valves will flow more gas
  - It will be more difficult to close the valves when the orifice is reached
  - As the water cut rises, upper valves will open more easily
- Arbitrarily lowering the set pressures will invite multipointing and slugging at a later date.
- Not a good option as a long term solution

Lower the Design Pressure

- Decreasing the design pressure 50 psig from the available pressure has many benefits
  - Valves will have an additional 50 psig above opening pressure
  - Valves will have flow performance much closer to orifice flow
  - There is a good chance single point sequential injection will occur during unloading.
  - The annulus pressure will drop as each valve uncovers.
- The disadvantage is that the objective injection point will be shallower by several hundred feet.

Your Choice!

- Larger ports work for the lower valves
- Larger pressure drops at each valve significantly reduces the objective injection depth
- Lowering the set pressure could invite multipointing at a later date when water cut rises
- Lowering the kick-off pressure 50 psig below the available pressure reduces the depth of injection but is safe.

Knowledge and Experience

- The modifications suggested have been well known but experience with "the art" of gaslift was required to know which ones to use. Valve performance models add science to the decision making.
- Gaslift is forgiving and flexible. Anybody can produce a gaslift design without the use of valve performance models and it will probably work but…
  - Using valve performance models is a definite benefit!

Conclusions

- The existing API spacing technique works but will be much safer when the kick-off pressure is 50 psig less than the pressure available.
- Larger ports may be required at the lower valves.
- Increasing pressure drops between valves helps but reduces objective injection depth
- Arbitrarily lowering set pressures invites problems

- Having a valve performance model to help

Thank You!

- Using good valve performance models is possible today!
  - Several gaslift design programs now offer the ability to use valve performance models during the design stage.
  - WinGlue
  - SNAP
  - Prosper
  - and there may be others
- Thank you for your attention and patience!
- Please contact SPE for a copy of the paper - SPE 109694