

THE APPLICATIONS OF JET PUMP SYSTEMS TO BOOST PRODUCTION

Recent applications and experience

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Extracting more

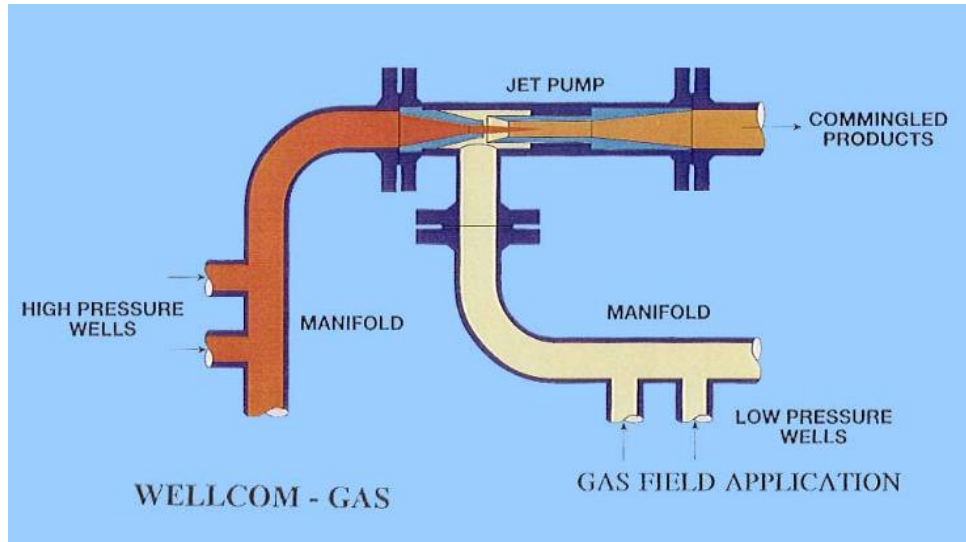
Main causes of restriction to production & total recovery

- Low reservoir pressure/aging field
- Tight, fragmented reservoirs, poor permeability/poor PI
- Deep reservoirs/deep wells
- Low GOR /liquid loading
- High water cut
- Long distance transport
- High density and viscosity oil
- Process requirements (minimum acceptable pressure for transport by pipeline or for process system)

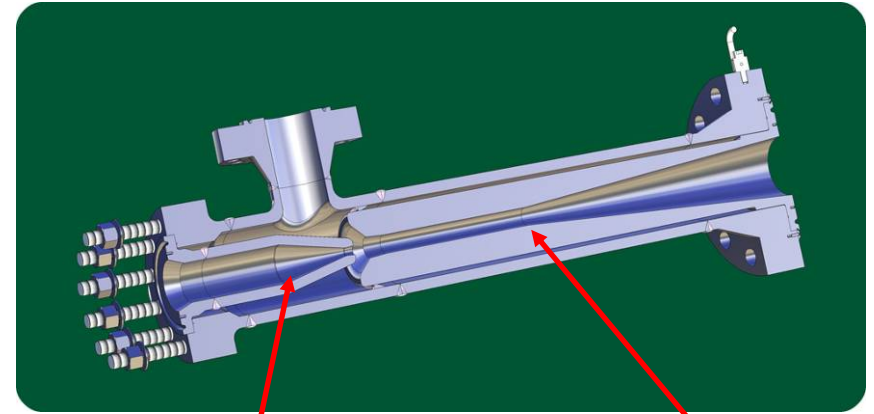
A boosting system is therefore needed to maintain or increase production and total recovery



Jet Pump Technology



Patented Universal Design Ejector / Jet Pump



Removable
Nozzle

Removable
Mixing tube /
Diffuser

Some possible HP sources-;

- HP WELLS (oil or gas wells)
- HP GAS FROM PROCESS SYSTEM
- HP LIQUID(OIL,WATER)
- COMPRESSOR GAS/ RECYCLE GAS
- A SINGLE PHASE (LIQUID) PUMP



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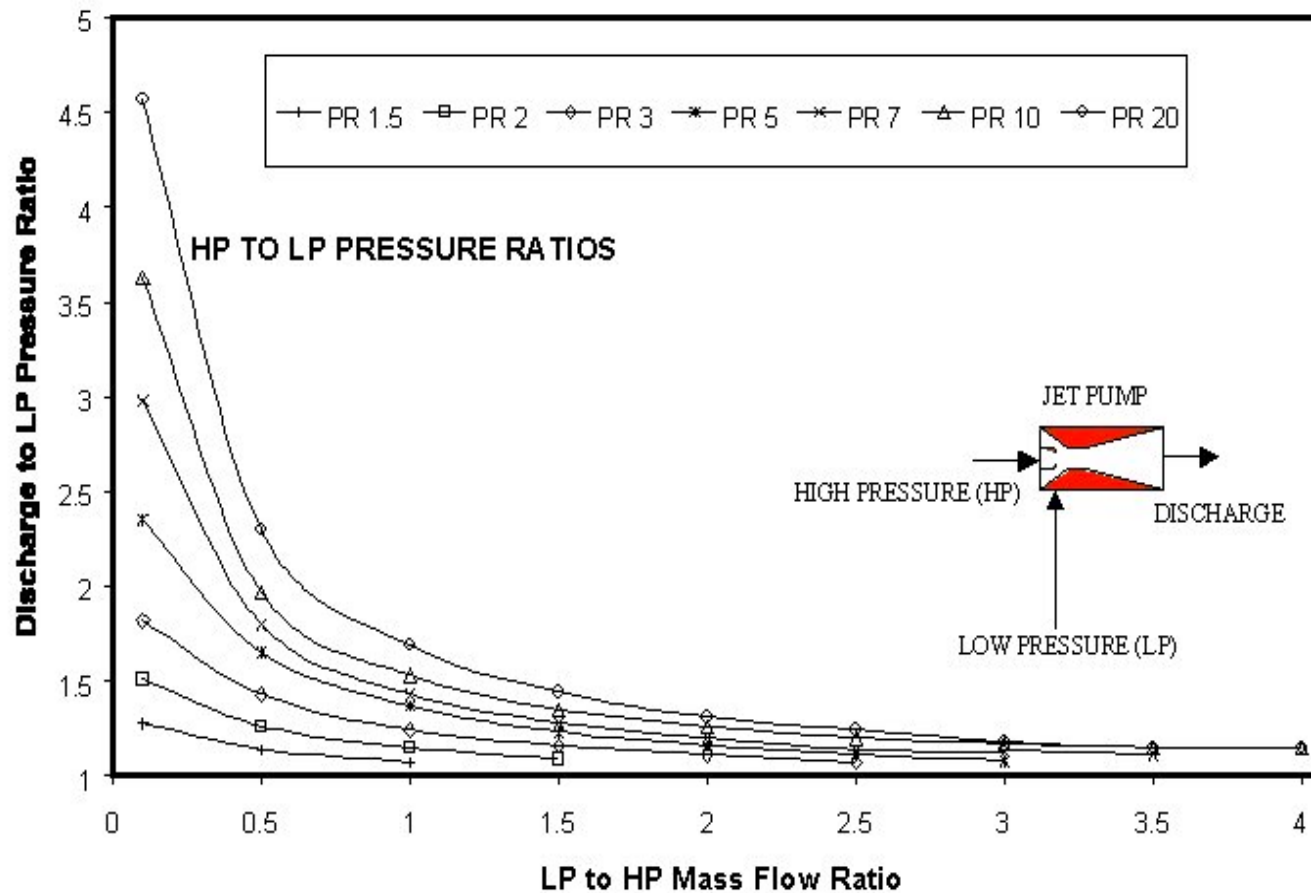
MAIN FACTORS AFFECTING THE PERFORMANCE

~ HP/LP PRESSURE RATIO

~ GAS/LIQUID RATIO(LP FLOW)

~ HP/LP FLOW RATIO

(oil production cases)



Secondary factors;

- Mol. weight
- Temperature
- Liquid content in gas



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TYPES AND RANGES OF APPLICATIONS

- **Revival of dead wells (oil&gas wells) / well de-liquefaction**
- **Boost production from oil or gas wells**
- **Boost pressure of LP gas in a process system**
- **De-bottleneck compressors**
- **Eliminate intermediate compressors**
- **Prevent HP wells to impose excess back pressure on LP wells**
- **Prevent flaring LP gas**

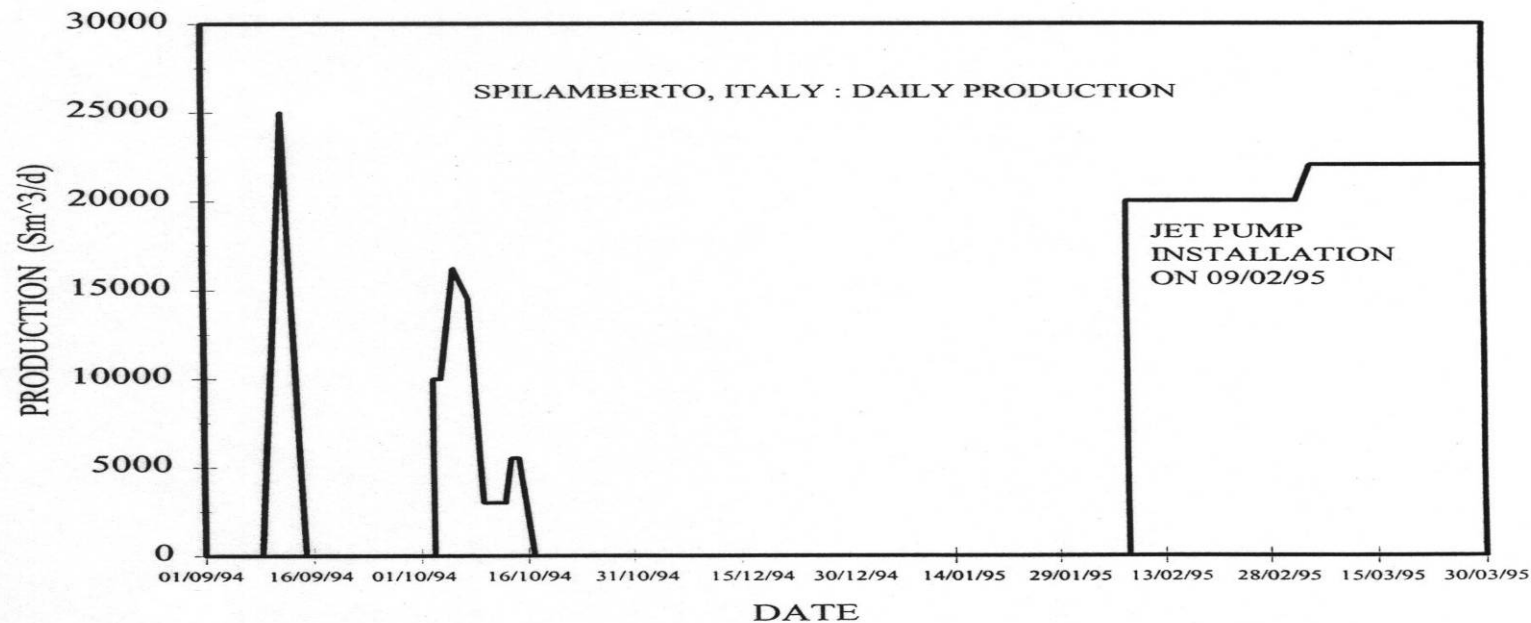
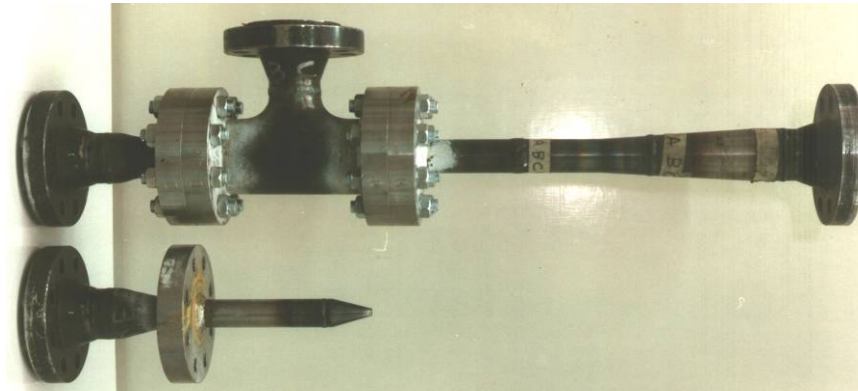


WELL REVIVAL –SPILAMBERTO FIELD,ITALY

Source of HP flow; HP gas well

Benefits;

Gain in gas production by 23,000 sm³/d (0.812MMscfd) For almost two years



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APPLICATION: Onshore Europe

PROBLEM

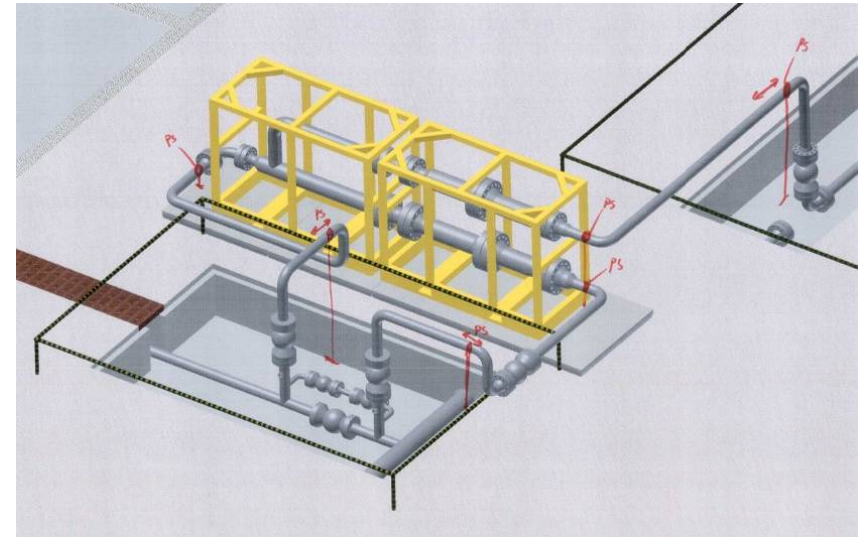
High pressure gas well backing out a low pressure well .

Solution

High pressure gas well used as the HP source to reduce back pressure on LP well.

Benefits

- The closed LP well is back in production & is now producing 140,000 Nm³/d.
- Pressure boost of 130%
- The total production is going directly to HP compression suction, thus allowing the LP compressor to be switched off.
- Additional saving on the fuel gas of the LP compressor.



Shell, Ameland, North Sea

PROBLEM

Existing compressor operated within its recommended envelope by having a constant recycle.

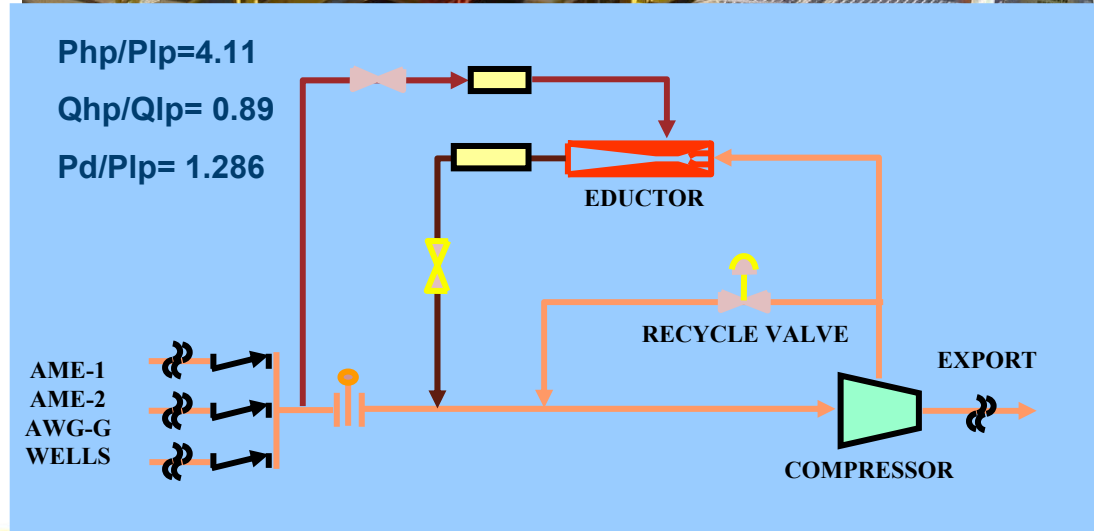
increase in production was not possible without re-wheeling the compressor or the installation of jet pump.

SOLUTION

Universal design jet pump was installed, using recycled HP gas to lower the FTHP of the wells, thereby boost production.

Benefits to Client

- Total gas production increased by 91MMscfd
- Jet pump internals can be replaced easily to maximise production as well pressures decline
- Jet pump has no moving parts, requires minimal maintenance
- Jet pump produces no emissions to atmosphere
- Avoided re-wheeling compressor



BP Amethyst, UKCS

Problem

Weak low pressure wells were backing out due to high pressure wells and high line pressure.

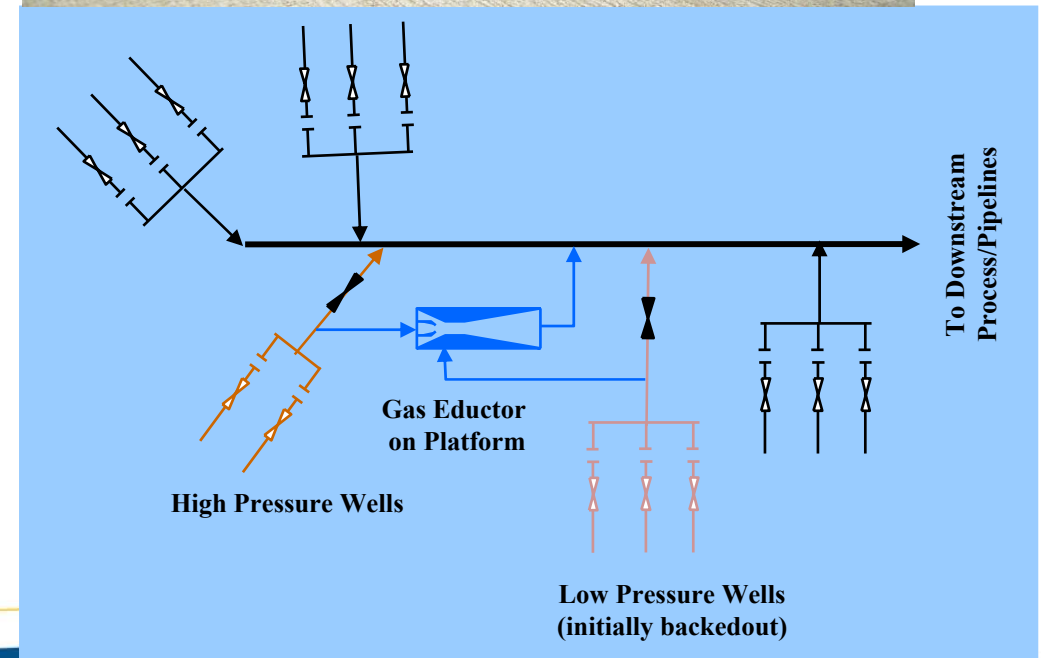
Solution

Use gas from the high pressure wells to power a jet pump, enabling reduction on the back pressure on a line serving satellite wells.

(HP/LP pressure=5.4,HP/LP Q = 2.,Pd/Plp= 1.54)

Benefits

- Backpressure on LP wells reduced by 5 bar, extra 22 MMscfd of gas (production increased by 110%).
- Better use of available energy ,with minimum modification to the existing piping.
- Increased production life and stability of the LP wells.
- Delivered the combined flow at the required downstream pressure.



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Chevron, USA (GOM)

Problem

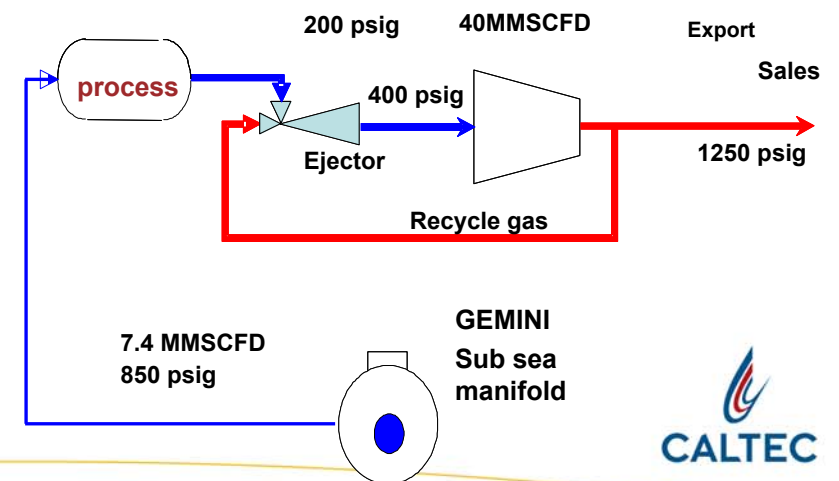
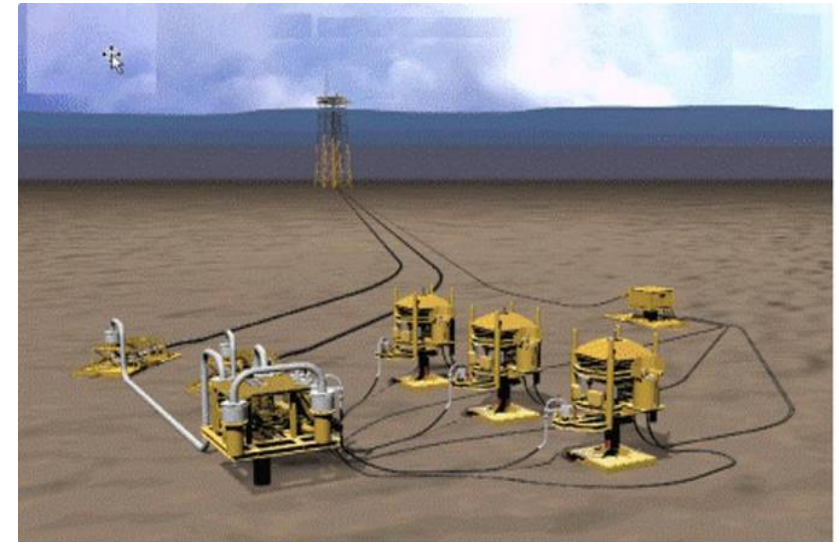
Three satellite subsea wells 27 miles away from production platform. Long distance transport + excessive liquid build-up in the wells and the pipe line.

Solution

HP gas from the existing compressor on recycle used to power the jet pump ($P_{hp}/P_{lp}=4.9, Q_{hp}/Q_{lp}= 2.11, P_d/P_{lp}=1.67$)

Benefits

- Lowered gas arrival pressure at the platform by 200 psi
- Higher gas velocities, lowered liquids accumulated in the pipeline, causing a further 140psi drop at the wellhead (340 psi total pressure drop).
- Production rate increased by 24% due to wellhead pressure reduction and lower pipeline loss.
- A total of 2.5 Bscf of otherwise lost reserves recovered.
- Combined flow delivered at higher pressure to compressor suction to increase compressor throughput.



BP Inde, UKCS

Problem

Restricted production from near-by satellite Shell wells.

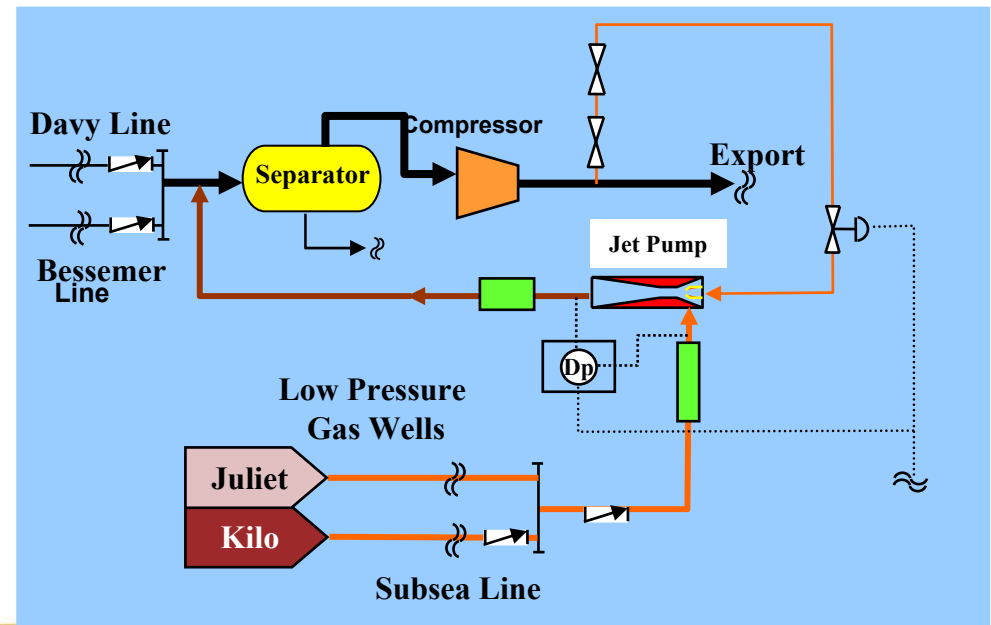
Solution

Used HP recycled gas to power jet pump, to draw-in low pressure Shell wells



Benefits

- Tied-in 68 MMscfd of gas from low pressure Shell wells into the exiting facilities.
- Production increased by 25%
- Increased intake capacity of compressor
- De- bottlenecked exiting compressor
- Award Winning application/extremely cost effective



($P_{hp}/P_{lp}=17.6, Q_{hp}/Q_{lp}=0.82, P_d/P_{lp}=1.44$)

SOLUTION TO ELIMINATE INTERMEDIATE COMPRESSOR

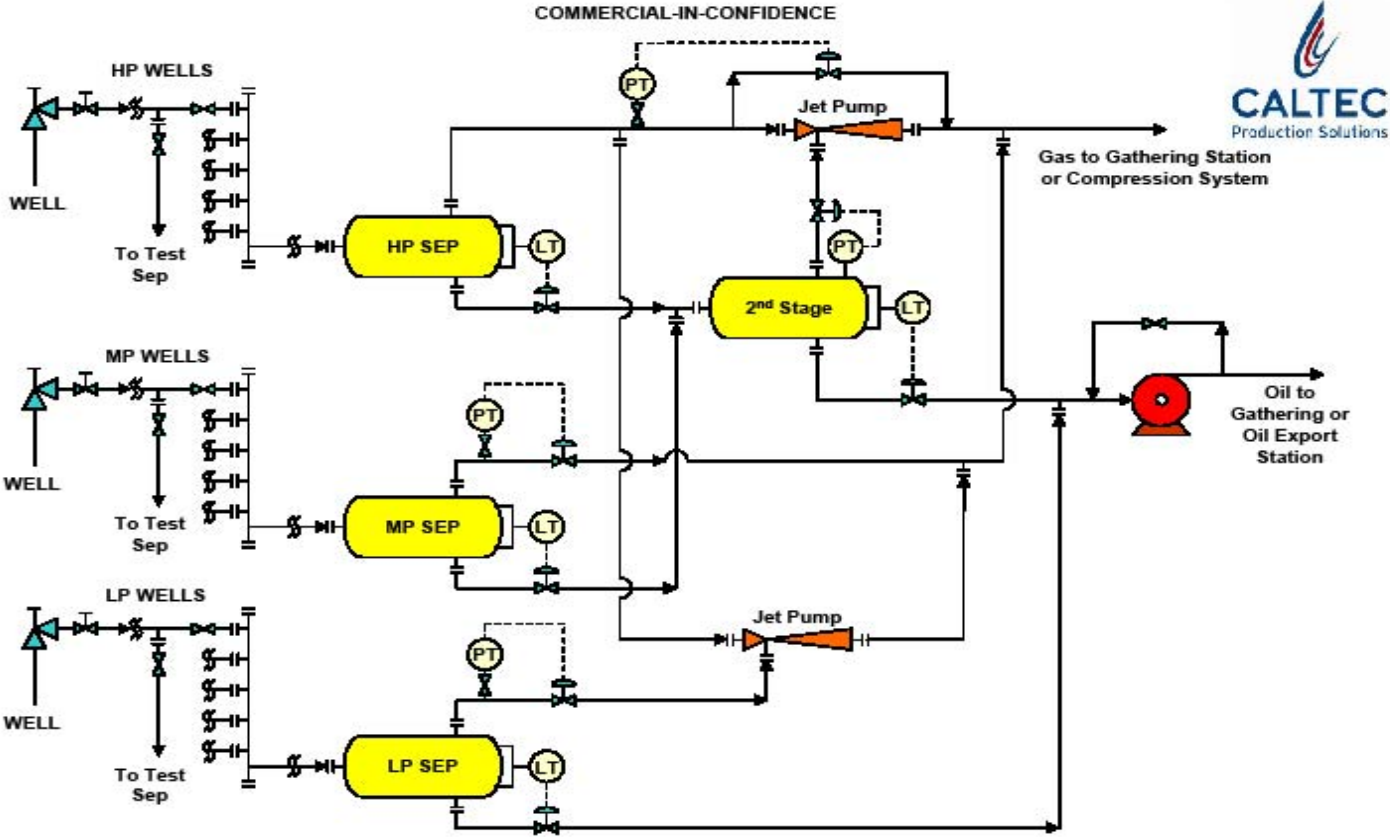


Figure 4: A SOLUTION TO MAXIMISE PRODUCTION AND RECOVERY AND USING JET PUMPS TO ELIMINATE THE USE OF COMPRESSORS AT INTERMEDIATE PRODUCTION/GATHERING STATIONS

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Middle East : Compressor replacement

Aim

Capture low pressure gas currently being flared, using a jet pump & replace 4TH stage compressor.

Solution

High pressure gas from the 1st stage separator was used to power the jet pump.

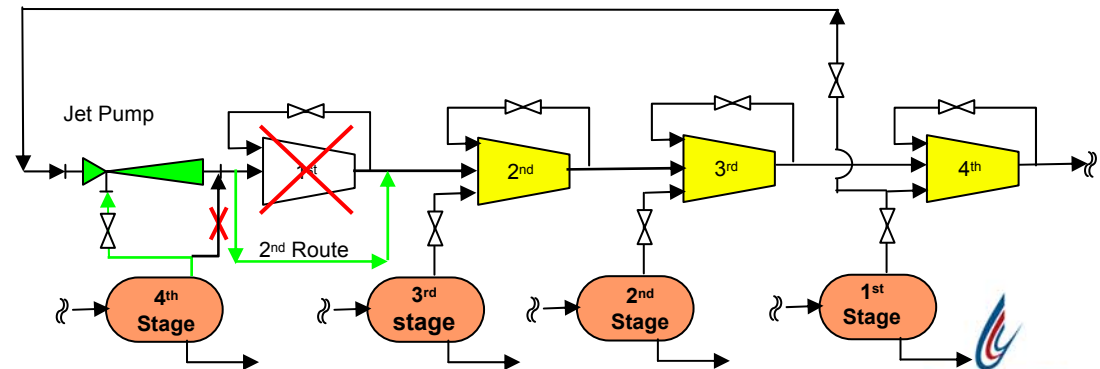
Benefits

- 2 MMscfd at 1bara captured , using HP gas from 1st stage separator, and delivered at the suction pressure of 2nd stage compressor.
- Used energy that is available
- The 1st stage compressor was removed from service. This simplified system operation.
- Gas no longer burned to power this compressor,
- Savings on maintenance costs and space.



Existing compressors

Installed jet pump after compressor removal



($P_{hp}/P_{lp}=35.6, Q_{hp}/Q_{lp}=2, P_d/P_{lp}=2.07$)



BP (ARCO), Indonesia

Problem

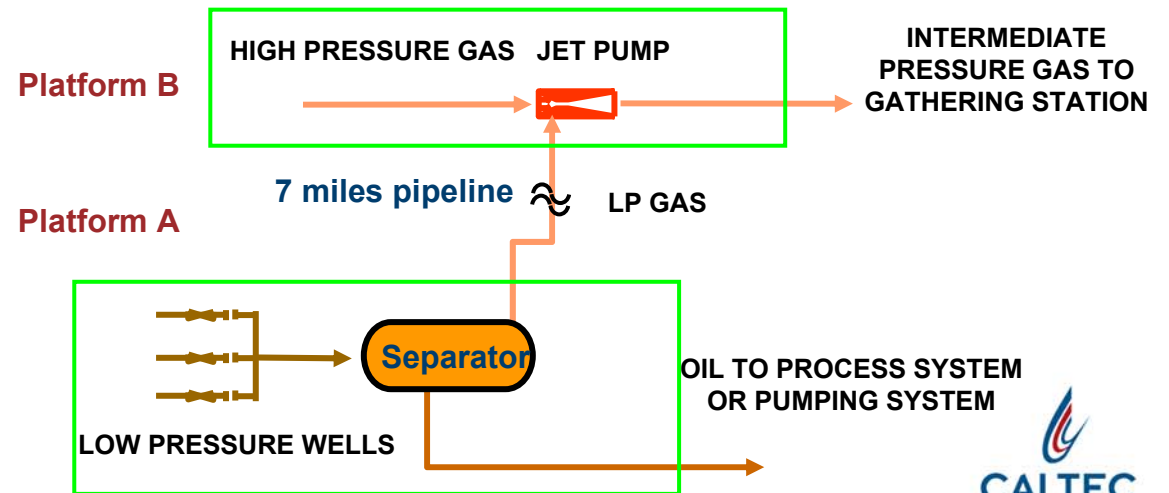
Oil production restricted due to back pressure on existing production separator.

Solution

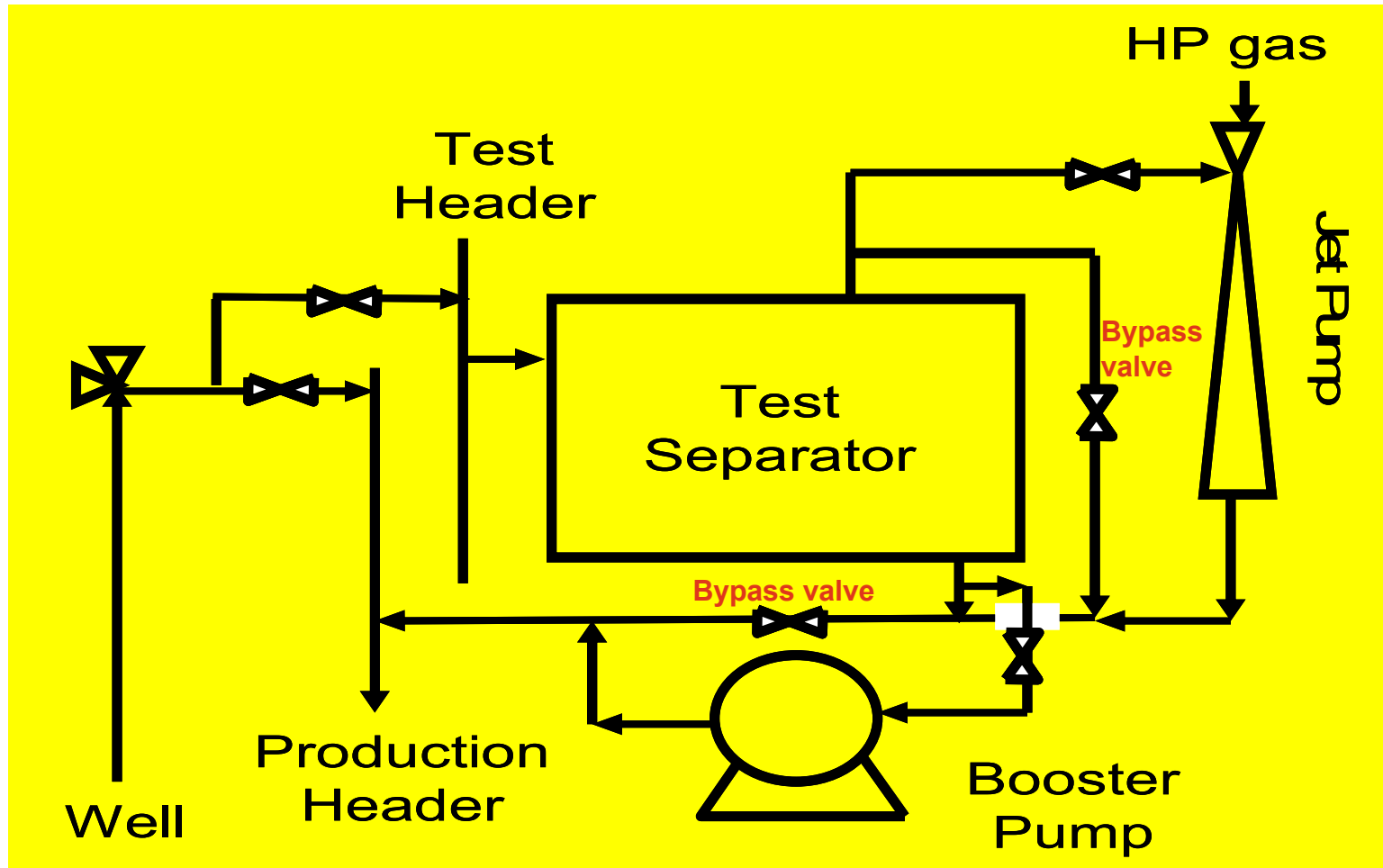
Use a jet pump and high pressure gas from a satellite to reduce the operating pressure of the separator and draw more production through the separator on platform A

Benefits

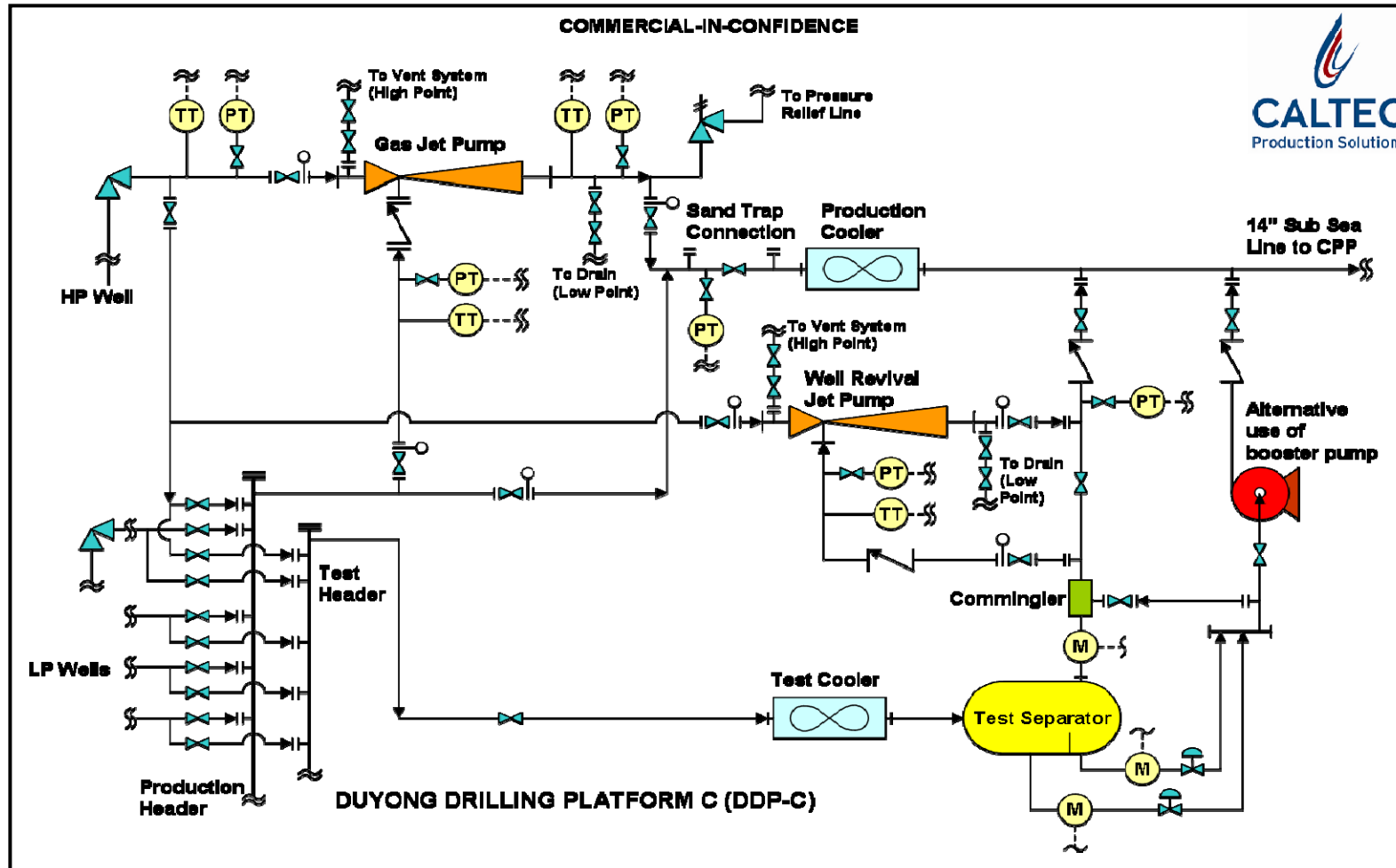
- Lowered separator pressure by 105 psi.
- Used existing source of energy
- Extra oil production of 400 bbl/d was achieved with additional associated gas
- Low cost solution



USE OF TEST SEPARATOR FOR WELL REVIVAL

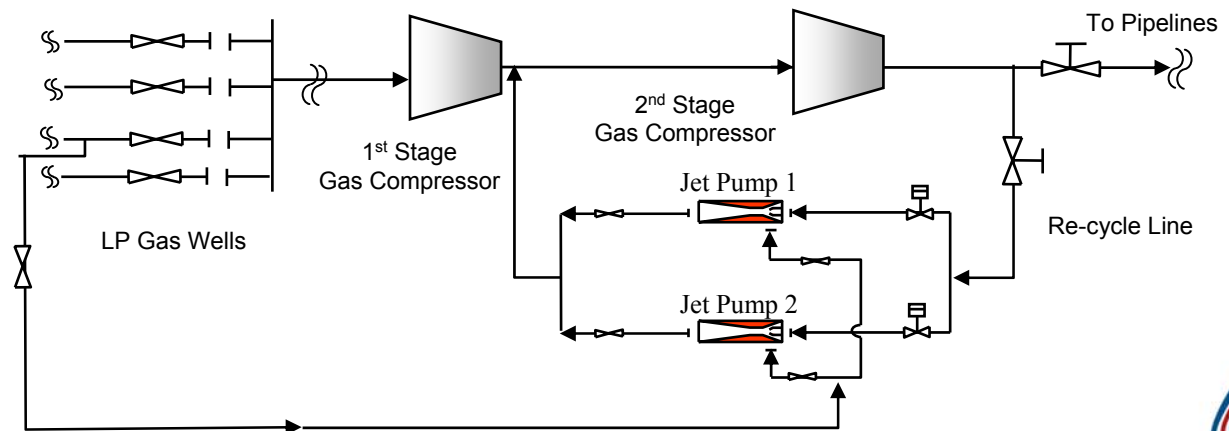


OFFSHORE MALAYSIA : Prevent new HP well restricting production from LP wells



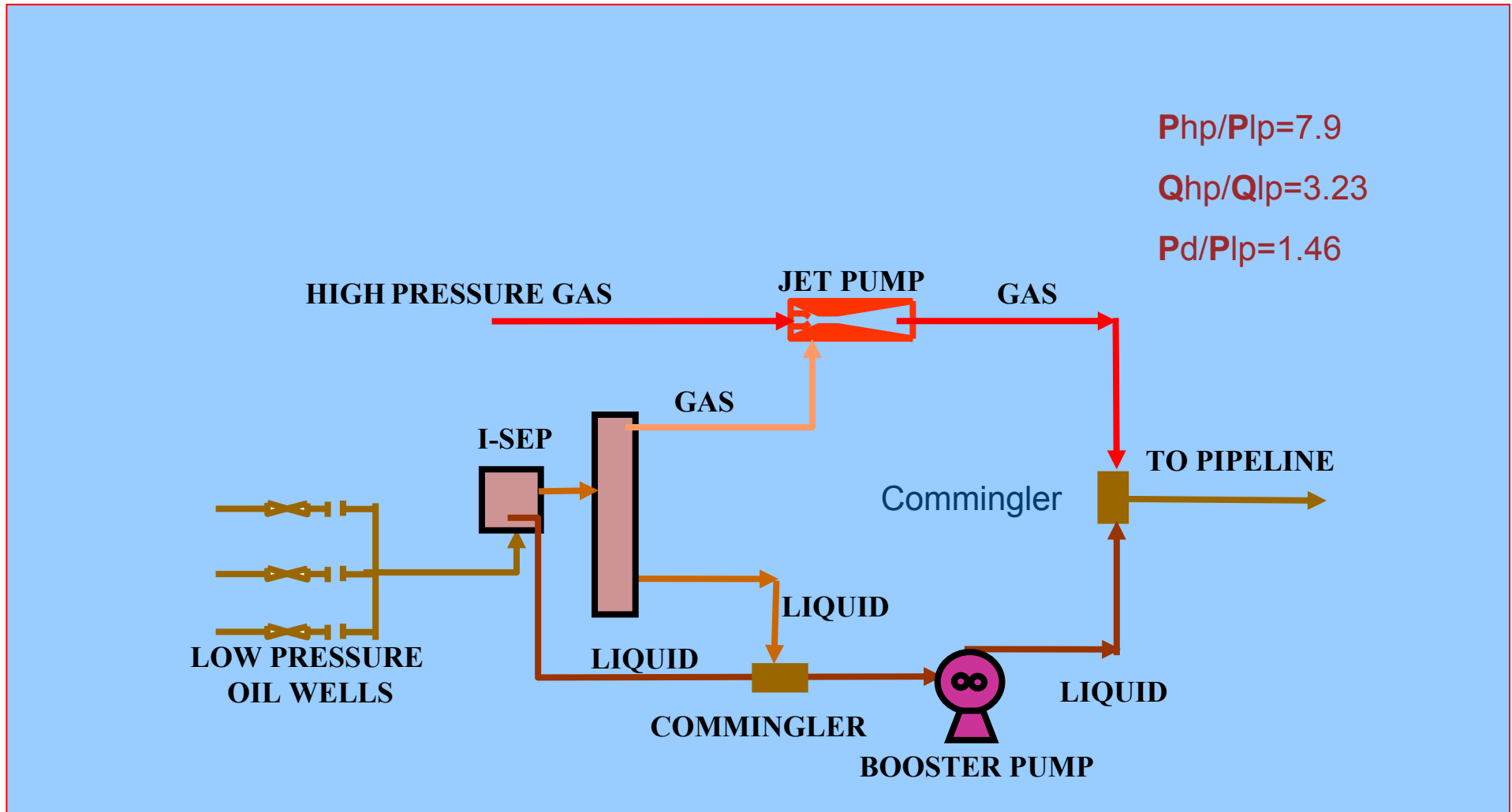
VICO –INDONESIA : De-bottlencking 1st stage compressor

- GAS FROM 3rd STAGE USED TO BOOST PRESSURE OF SOME OF THE GAS FROM 1st STAGE TO THAT OF 2ND STAGE
- SYSTEM GAS HANDLING CAPACITY INCREASED
- INLET PRESSURE OF 1ST STAGE MAINTAINED
- ELIMINATED RE-WHEELING THE COMPRESSOR



$P_{hp}/P_{lp}=6.6, Q_{hp}/Q_{lp}= 6.8, P_d/P_{lp}=2.36$

WELLCOM BOOST SYSTEM



WELLCOM SYSTEM OFFSHORE MALYSIA

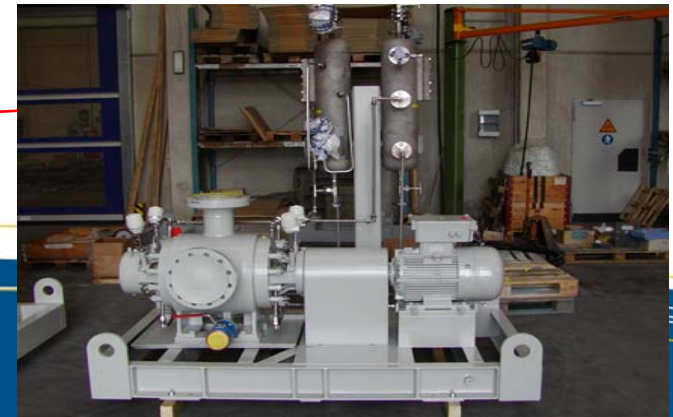
Lift gas as the motive flow+ A booster pump to boost the liquid phase

HI-SEP

Jet pump

I-SEP

Booster
Pump



APPLICATION: Cendor, Malaysia

Problem

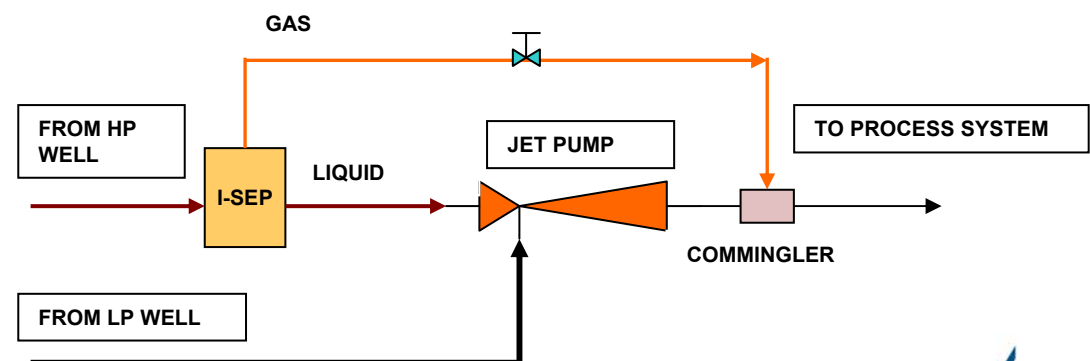
low pressure oil wells unable to produce due to back pressure imposed by production manifold. Erratic production, leading to liquid build up in the well

Solution

Wellcom oil system ; multiphase HP wells were used to bring in closed low pressure oil wells.

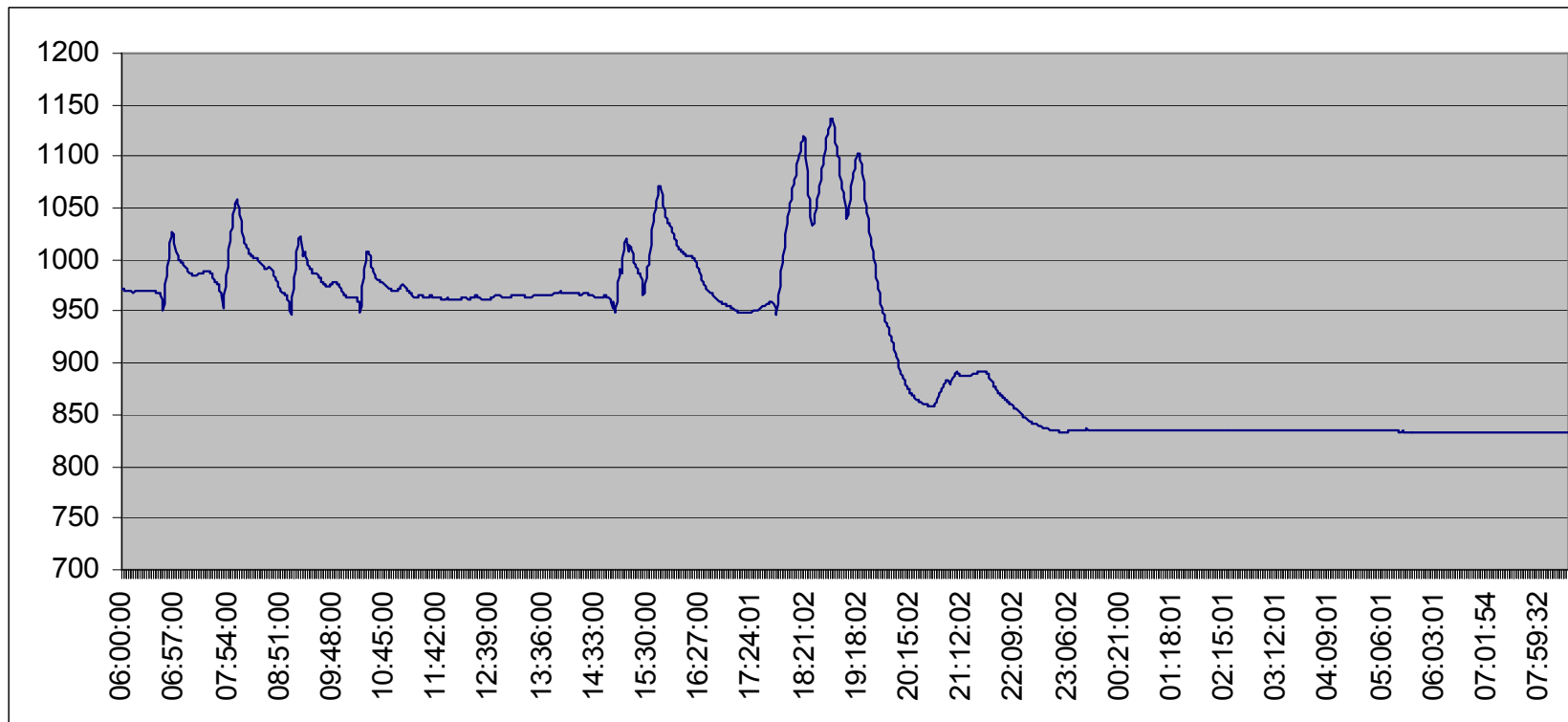
Benefits

- Used available energy from HP well
- 20% pressure boost for LP wells.
- Increased production by over 35%(150 b/d)
- Improved flow regime in well bore, stabilising production.



Record of flowing bottomhole pressure before and after installing the jet pump system

Flowing bottomhole pressure (FBHP)



ECONOMICS

- **Low capital cost**
- **Recovery of capital within a few weeks to a few months**
- **Short delivery period ,8 to 14 weeks**
- **Practically no operation cost/passive operation**
- **Practically no maintenance cost**
- **Alternative solutions more complex and costlier**
- **Rental option available to minimise capital cost**
- **Short life period is economically acceptable**

LESSONS LEARNED

- **Change of the internals recommended to maximise benefits & cope with changes in production during field life**
- **In short term applications, temporary piping can be used to speed up implementation**
- **Prevent nozzle blockage by debris if needed by using a strainer spool**
- **Noise can be kept below 85 dBA by using silencers**
- **Rental option simplifies decision making process as risks are minimised and delivery period is short**
- **No operation problems encountered which impose any risks**
- **In most cases no active control needed**



CONCLUSIONS

- **Simplicity and cost effectiveness makes jet pump solutions very attractive & economical**
- **In addition to economic benefits, eliminating intermediate compressors, deferring compressor upgrading or reducing liquid hold up in pipelines are additional benefits**
- **The system can work well with gas lift or use of downhole ESPs**
- **Rental option justifies very short operation life, if the HP source has a short life**

