Shell Exploration & Production

Penguins Subsea Gas Lift at 65 km

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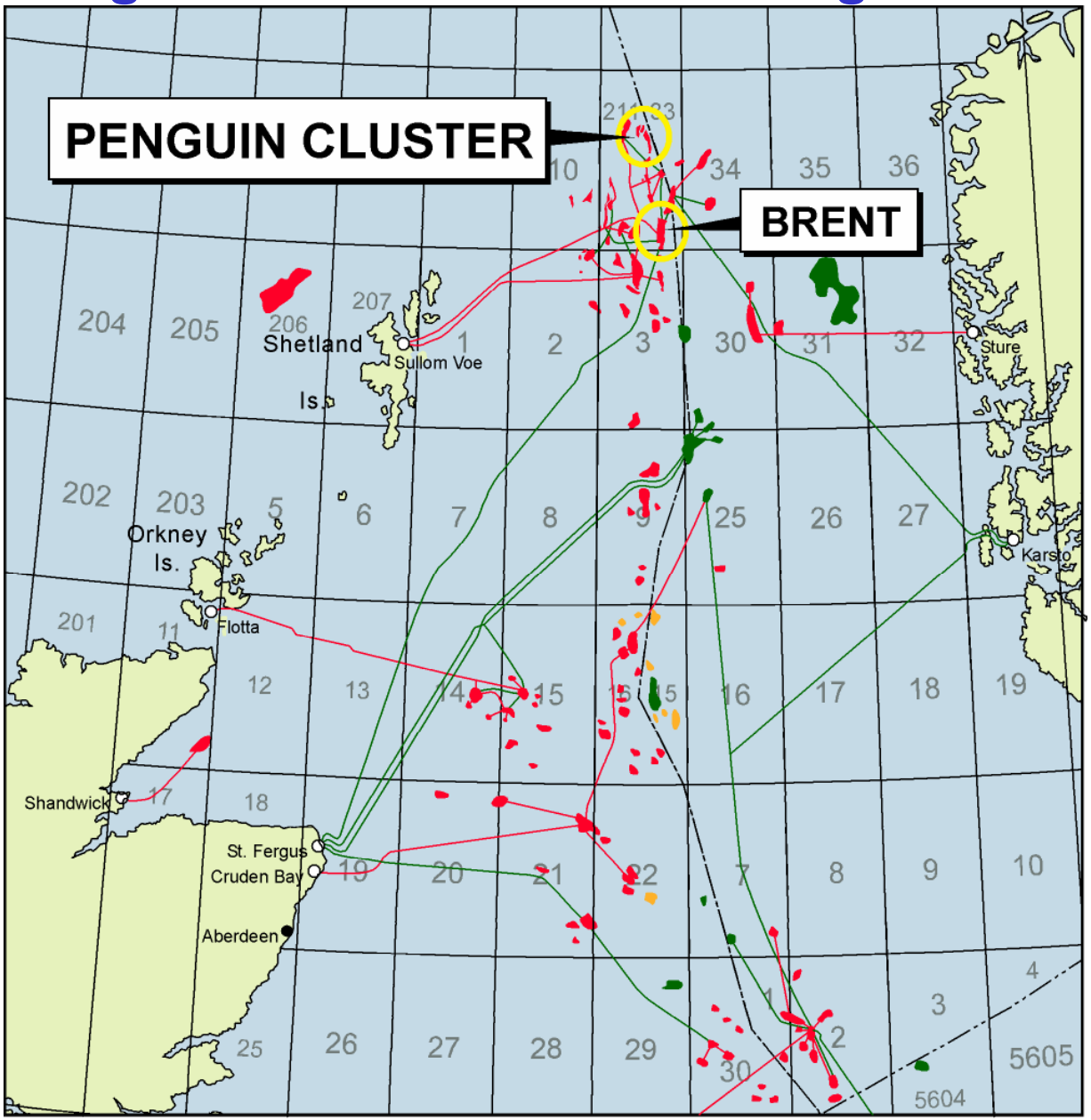
Penguins Gas Lift - Agenda

- Field Background
  - History
  - Hardware
  - Subsurface
- System Limitations / Flow assurance
- Commissioning
  - OLGA Modelling
  - Procedures / Personnel Training
- Continuous Gas Lift
  - Benefits
  - Compromises
  - Prosper / GAP optimisation
- Conclusions

Penguins Gas Lift – Field Background



Penguins Gas Lift – Field Background

- History
  - The Penguins field was developed from 2002 with 4 producers and has since had a further 5 development wells drilled (currently 9 producers).
  - Field development options were evaluated and the most economic solution was a 65km tie-back to the Brent Charlie platform.
  - No gas lift required initially, but anticipated in the well design.
  - Gas lift supply options were screened in 2005 and it was decided to install a 65km gas lift line back to Brent Charlie.

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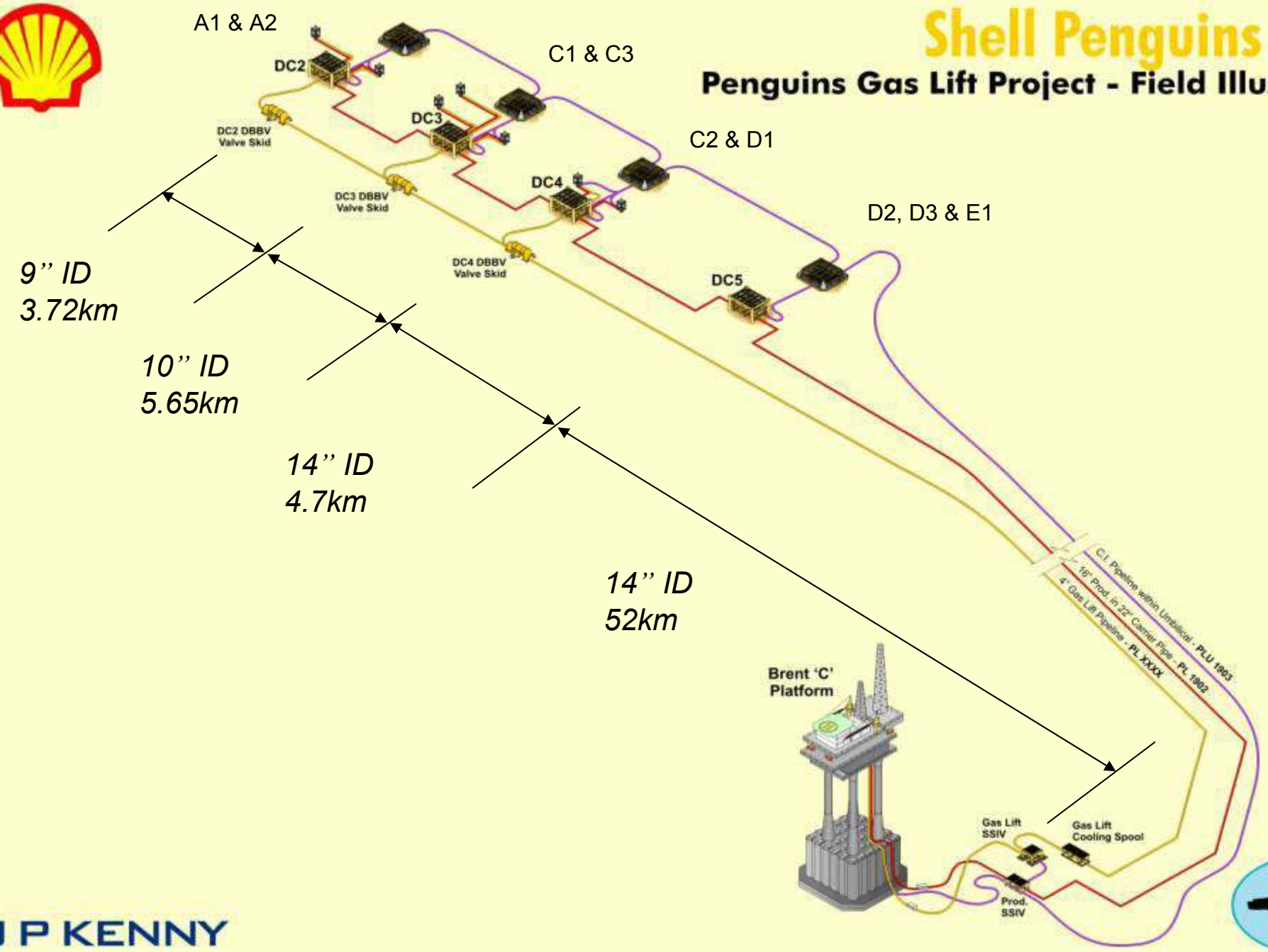
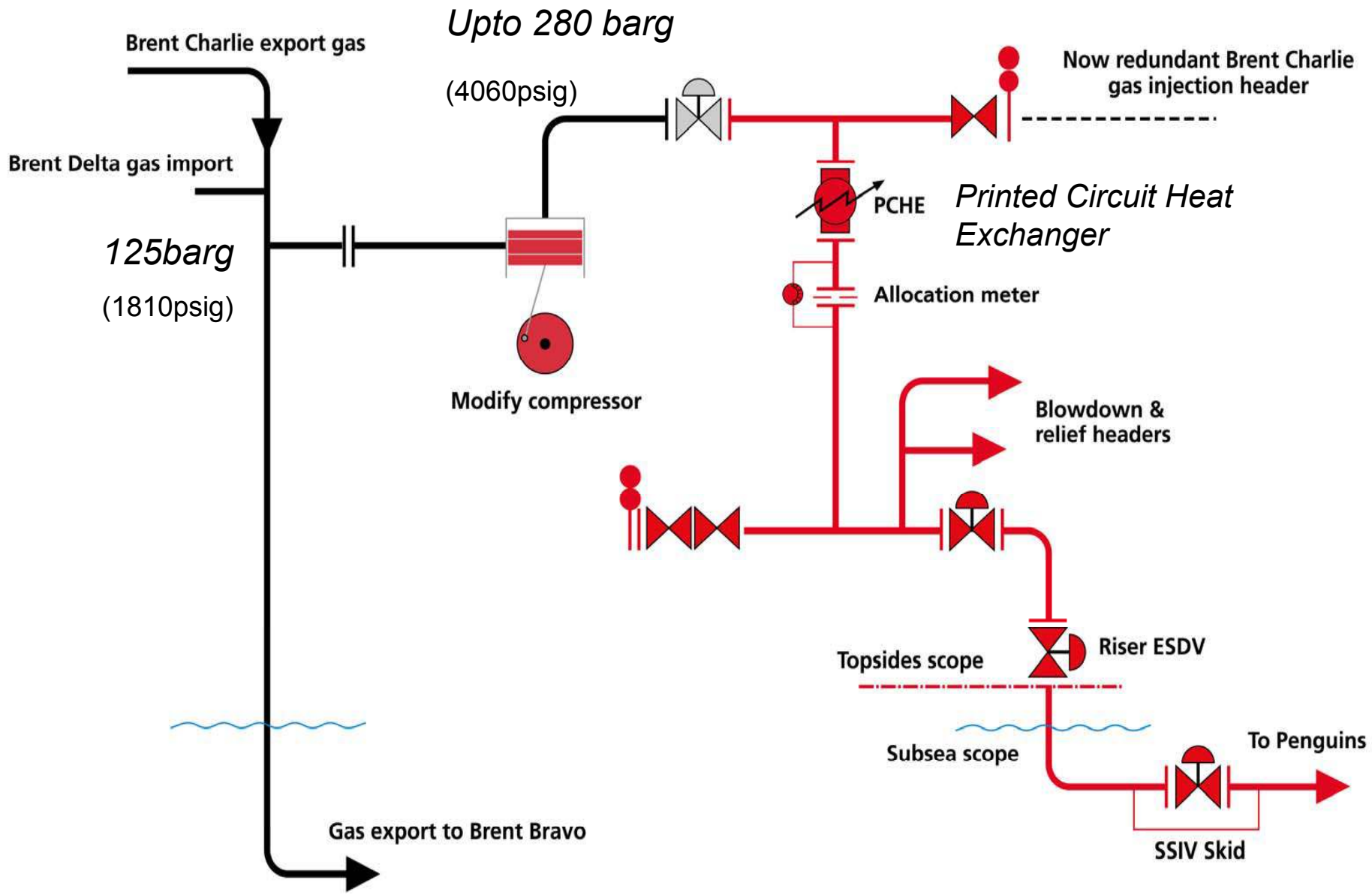
Penguins Gas Lift Project - Field Illustratio



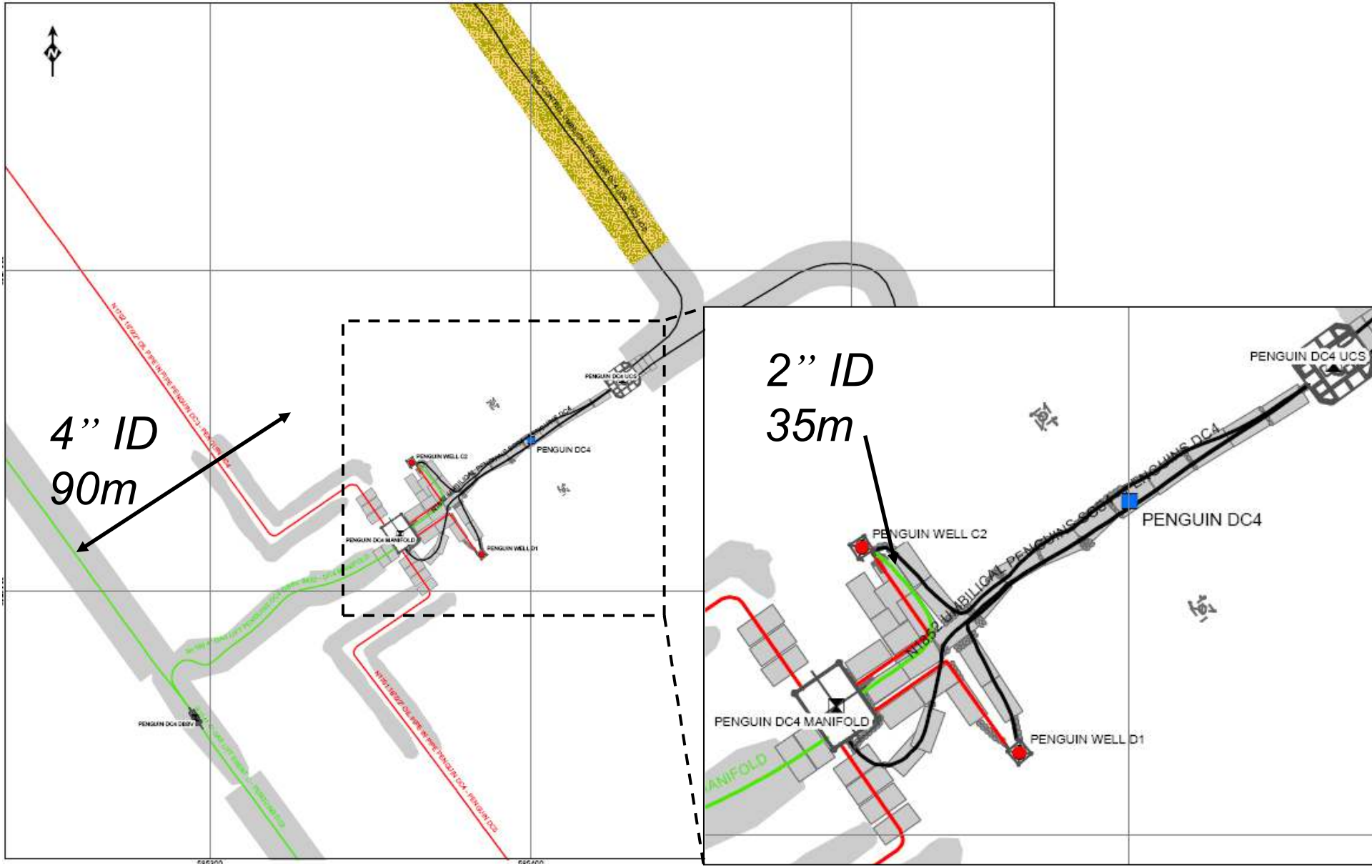
J P KENNY

Penguins Project

Penguins Gas Lift – Field Background

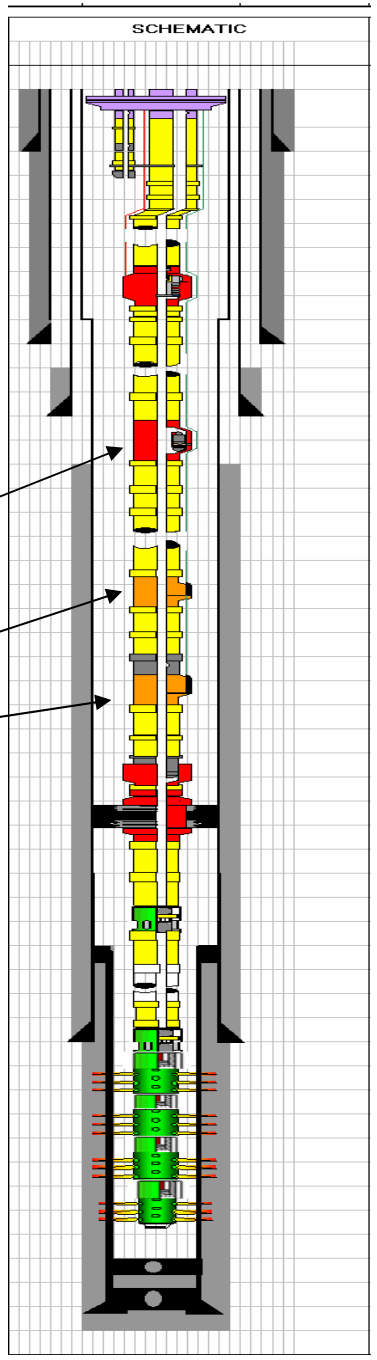


Penguins Gas Lift – Field Background

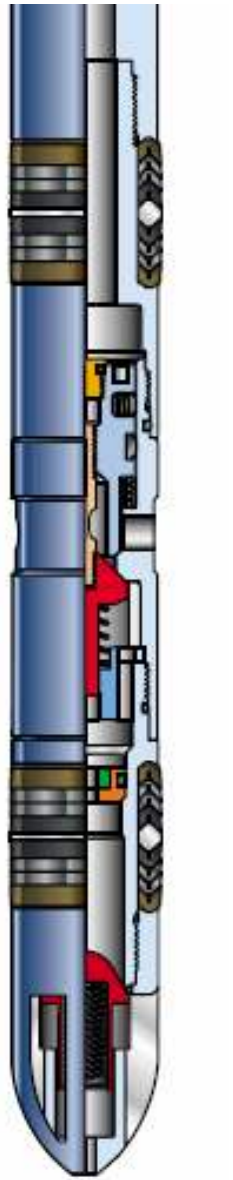


Penguins Gas Lift – Field Background

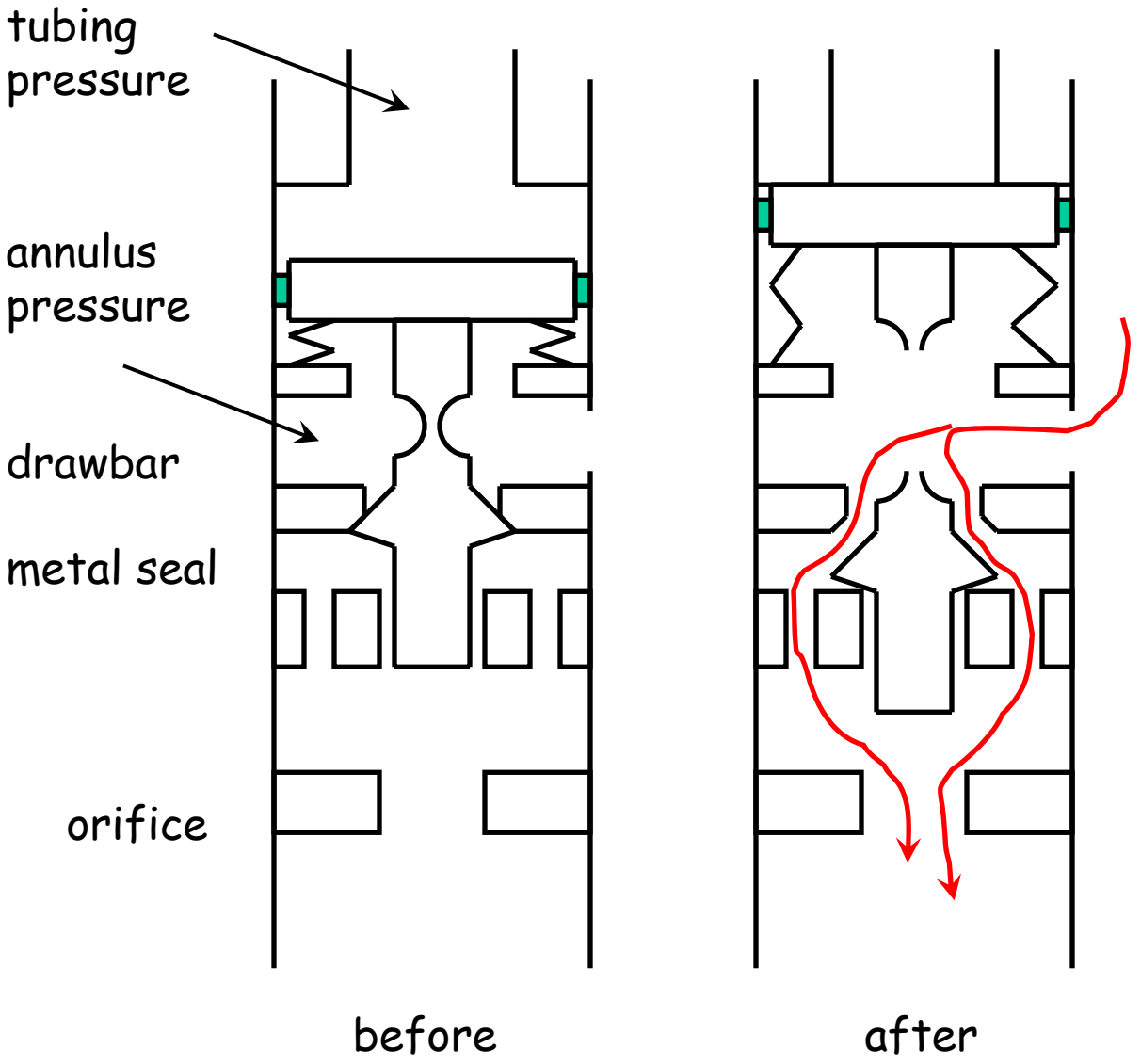
- **Completion**
  - Cemented and perforated 6 5/8” liner
  - 5 ½” tubing down to the packer
  - 4 ½” tubing below packer c/w TCP guns hung off bottom
  - 1 x GLM with shear orifice valve
  - 2 x P/T gauges mandrel



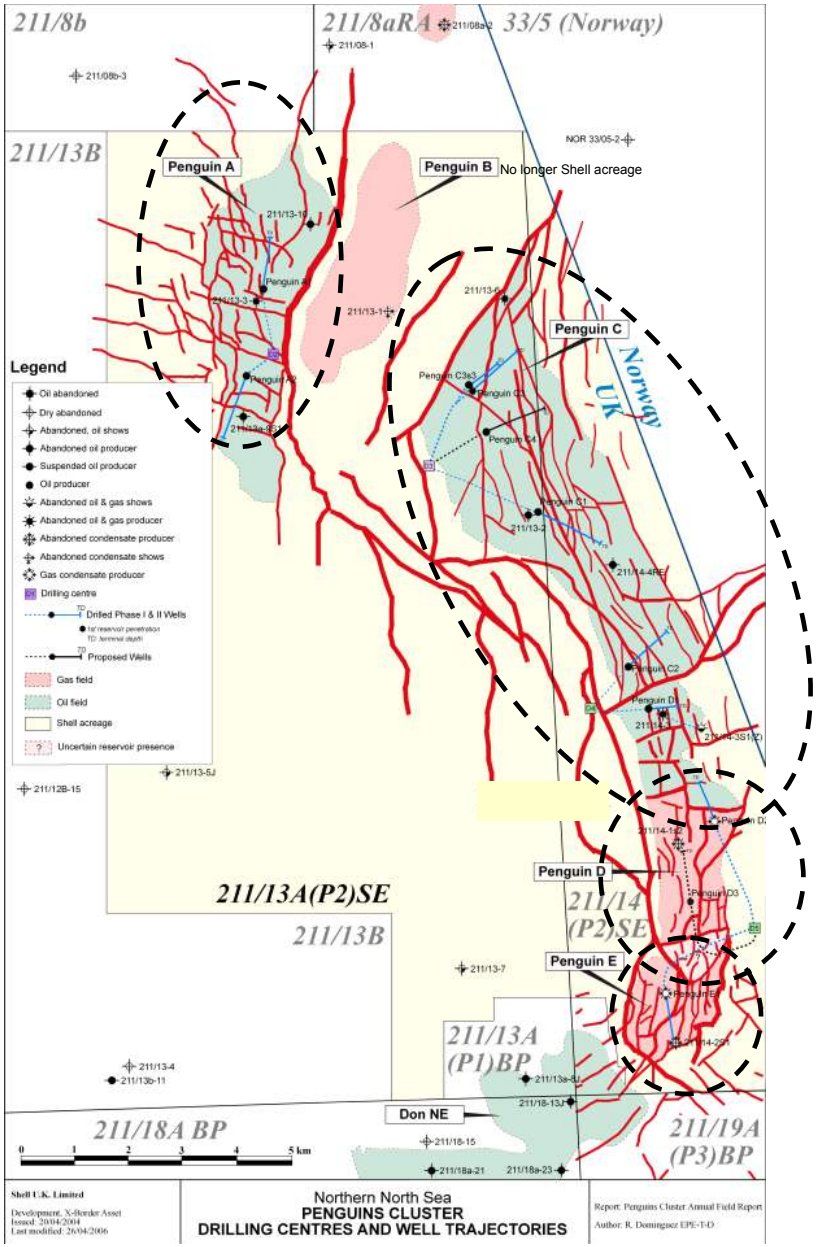
Penguins Gas Lift – Field Background



SO2-30R



Penguins Gas Lift – Field Background



- **Subsurface**
  - **Penguin A: Black Oil**
    2 Independent compartments;
    GOR 750 scf/bbl in south & 1500 scf/bbl in north. API 37 to 41 for both.
  - **Penguin C: Black Oil**
    GOR 1000 – 1400 scf/bbl. API 36 – 40.
  - **Penguin D; Light Oil in north**
    GOR 1900 scf/bbl, and heavy gas / **retrograde condensate in south**
    CGR 280 bbl/ MMscf
  - **Penguin E; heavy gas** / retrograde condensate CGR 210 bbl/MMscf

Penguins Gas Lift – System Limitations

Single commingled production pipeline

- Fluctuations in line pressure affect all wells
- Gas lift improves individual well performance but can have adverse effect on the system production
- Due to the absence of functional well specific flowmeters, well testing MUST be carried out using a "Testing By Difference" method although Geochemical fingerprinting is used in combination

Single commingled gas lift line

- Total GL flowrate and line pressure controlled by topsides compressor settings
- Line pressure governed by the well requiring highest pressure
- Individual well GL flowrates controlled by gas lift choke at the xmas tree
- Pre-installed GL venturi flowmeters unreliable, fallback is using the gas choke dP

Penguins Gas Lift – Systems Limitation / Flow Assurance

Equipment integrity

- Pressure and temperature limits of the system
- High pressure "surge" on the annulus translates into extremely high liquid velocities through the orifice which would damage the valve
- Temperature drop from large dP (~ Joule Thomson effect) is a big issue!
- Seabed ambient temperature ~ 5DegC

Flow Assurance

- Due to very long line (65km), flow assurance is extremely critical (hydrate risk)
- Gas lift specifications
  - Stripping gas introduced to TEG regeneration system, gas dewpoint down to –29.4 degC
  - In addition, methanol is spiked into the gas prior to sending down the line
  - OLGA modelling used to predict potential scenarios
  - Operational procedures changed to avoid problems

Penguins Gas Lift – Commissioning

OLGA Modelling used for:

- Optimising the commissioning process within the limits of system
- Mitigating threats to system integrity
  - Velocities of liquid through orifice
  - Low Temperature limits due to Joule Thomson effects
  - Pressure surges into the production line resulting in large slugs arriving at platform
- Modelling Gas Lift Line Clearing
  - Determine most effective/efficient means of clearing MEG
  - Answer question: Low rate initially (plug flow) then high rate to sweep line OR high rate directly?
- Well A-annulus unloading
  - OLGA used iteratively to obtain optimum unloading procedure
  - Predicts temperatures, pressures and velocities through the system
  - Obtain best starting gas lift line pressure for each well, rate of increase in gas lift rate etc.

Penguins Gas Lift – Commissioning

Simplified models used for the different cases

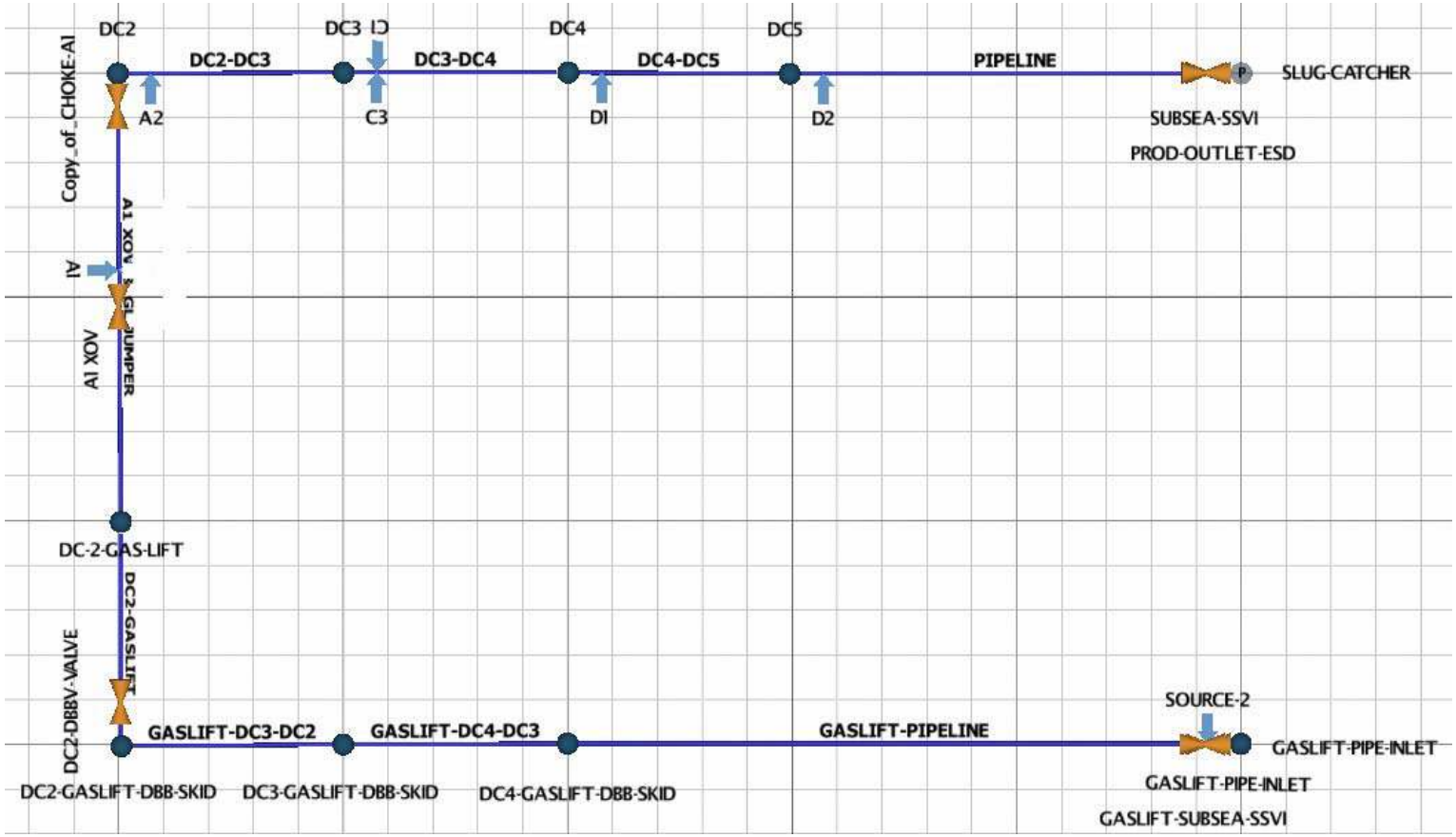
- **Wells that are not directly involved in the transient modelling are set up as sources**
- **Hence, a different model is used for each scenario**
- **This reduced run times from days to hours, hence large time saving in event of several re-runs**

Fully detailed procedures instructing onsite personnel

- **Commission the gas lift by clearing the MEG with liftgas**
- **Clear gas lift line via furthest away drill centre using XOV of A2 well in order that the entire line is cleared initially**

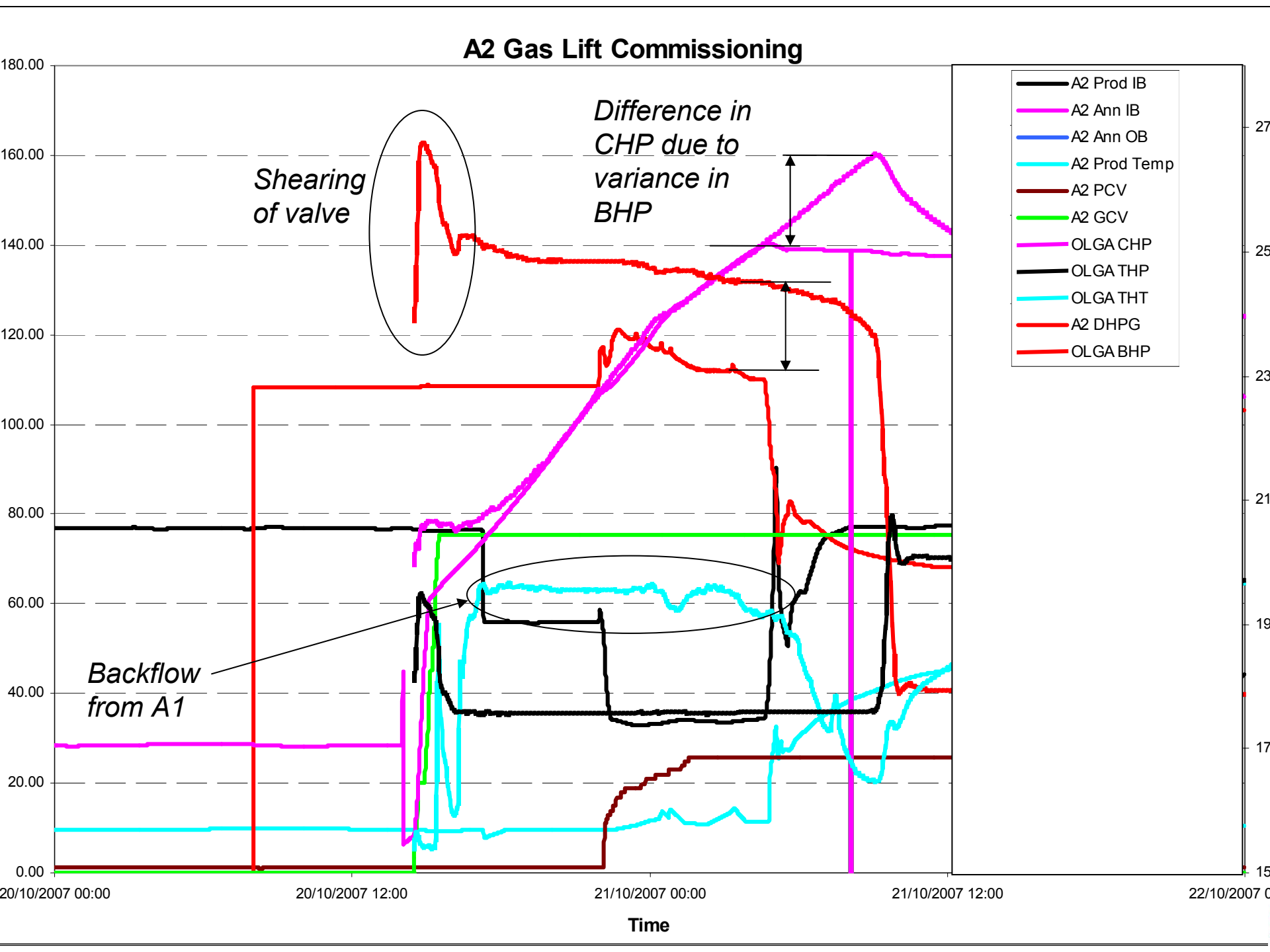
Penguins Gas Lift – Commissioning

- **Fully detailed procedures instructing onsite personnel**
  - **Unload each of the 5 wells individually in a controlled manner to ensure no damage to downhole equipment**
  - **Include expected pressure and temperature responses, and durations of each stage of commissioning based on OLGA simulations**



Penguins Gas Lift – Commissioning

- Training of onsite personnel
  - General gas lift theory
  - General subsea equipment and field specific training
  - Gas lift commissioning training, walk through procedures and what to expect
- Use of PI Processbook (real-time data trending tool)
  - The use of PI processbook was extremely important to
    - Keep track of the ongoing commissioning
    - Determine any requirements for changing of procedure “real-time”


A2 Gas Lift Commissioning
Shearing of valve
Difference in CHP due to variance in BHP
Backflow from A1
A2 Prod IB
A2 Ann IB
A2 Ann OB
A2 Prod Temp
A2 PCV
A2 GCV
OLGA CHP
OLGA THP
OLGA THT
A2 DHPG
OLGA BHP
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
20/10/2007 00:00
20/10/2007 12:00
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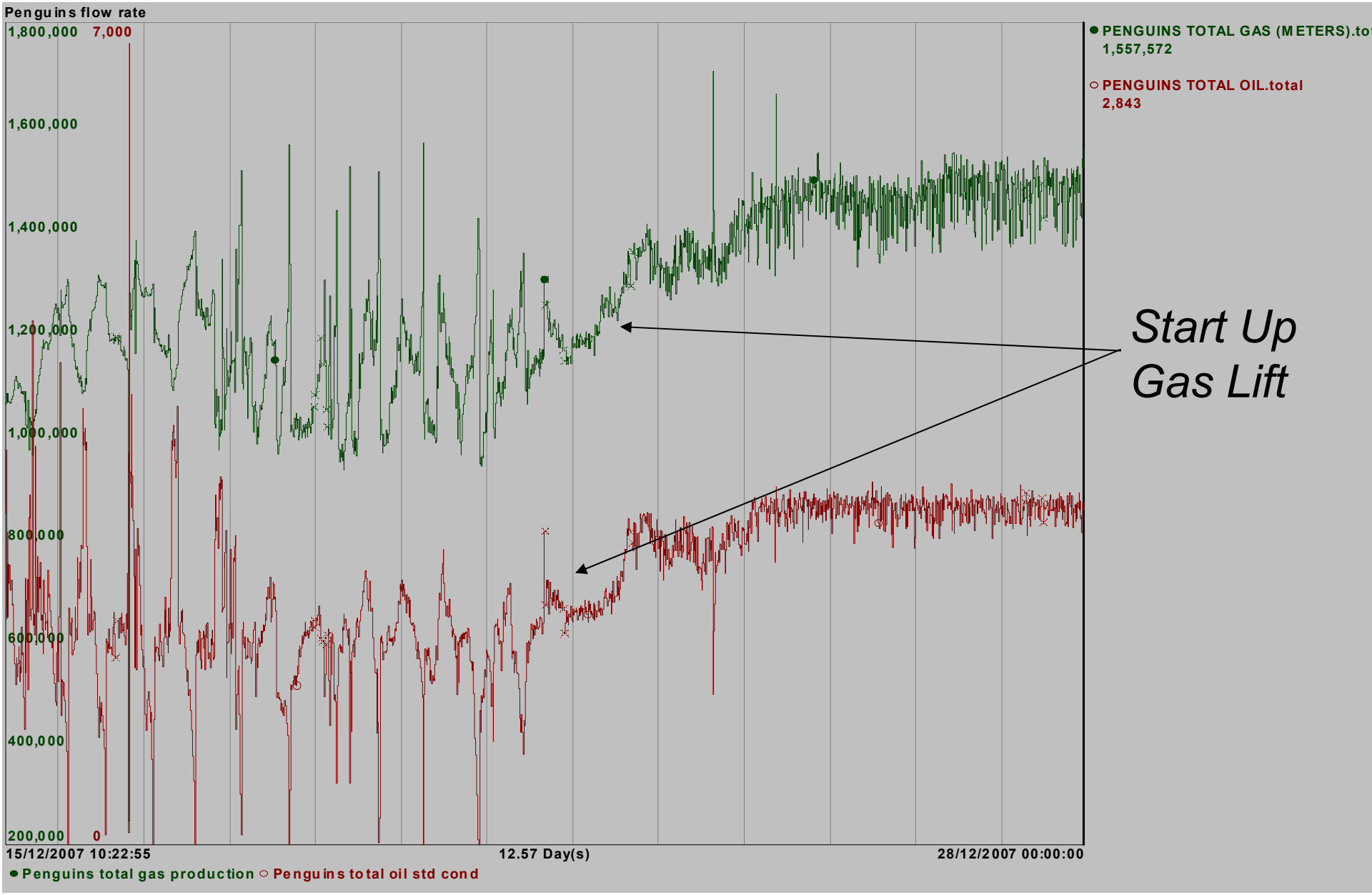
Time

Penguins Gas Lift – Commissioning



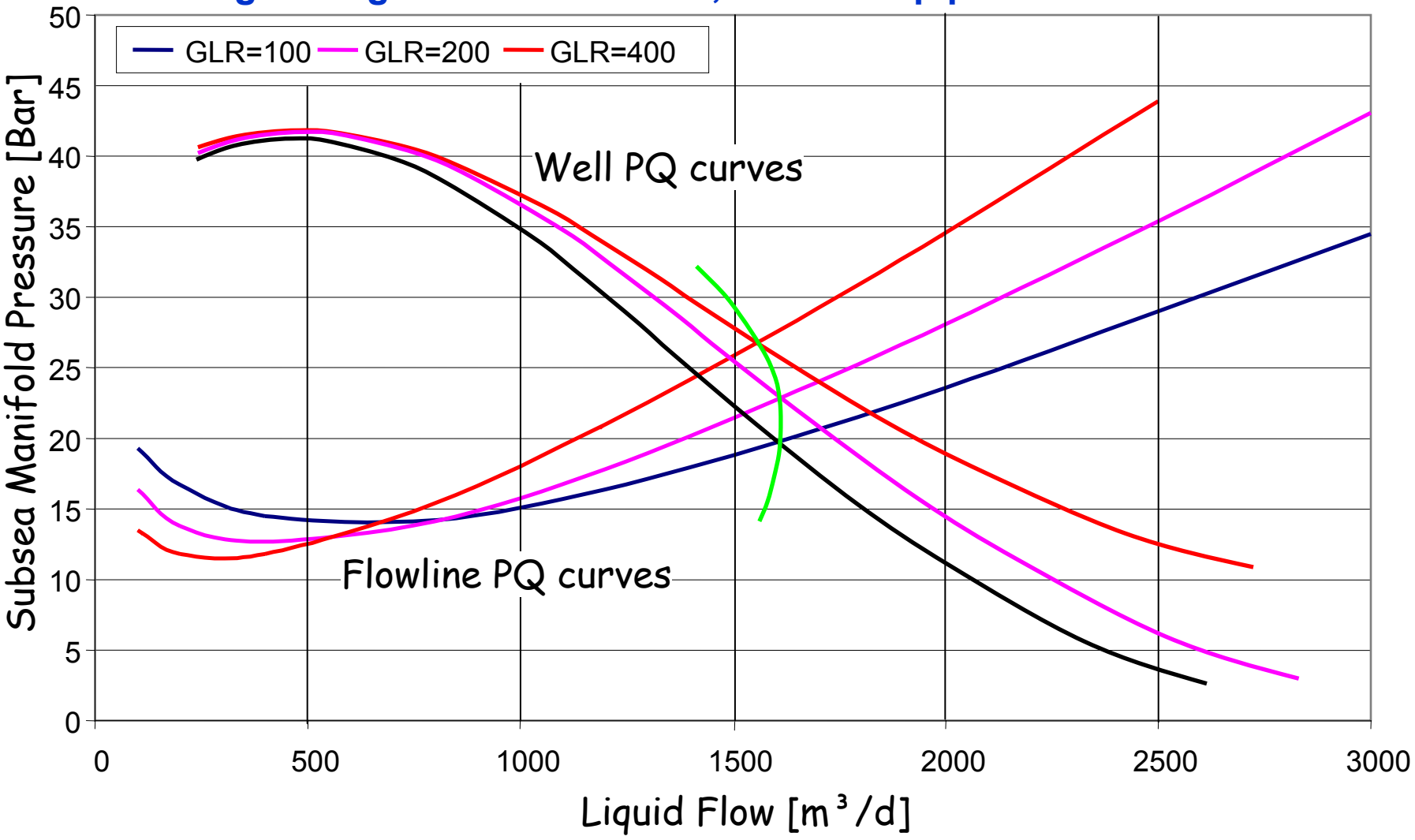
Penguins Gas Lift – Continuous Gas Lift

Benefits

- Original economic approval of project was based on well kick-off only!
  - As wells depleted they required lower and lower pipeline pressure for kick-off and also for continuous flow
  - As project final execution was approximately 6months after the original plan, wells had depleted further and now some are unable to flow without lift assistance! THEY NEED CONTINUOUS GAS LIFT
- Continuous gas lift for one well possible?
  - C2 no longer flows naturally, A2 had struggled on occasion
  - By gas lifting C2, the slight increase in pipeline pressure kills A2
  - By then also gas lifting A2 the pipeline pressure increases further and kills A1, then…….etc. ….C1 & C3
- Hence, continuous gas lift is now required on ALL 5 wells, NOT just to flow C2 !
- Increase in liquid production of some 15 – 25% !!!
- No increment in gas production due to backout of gassier wells

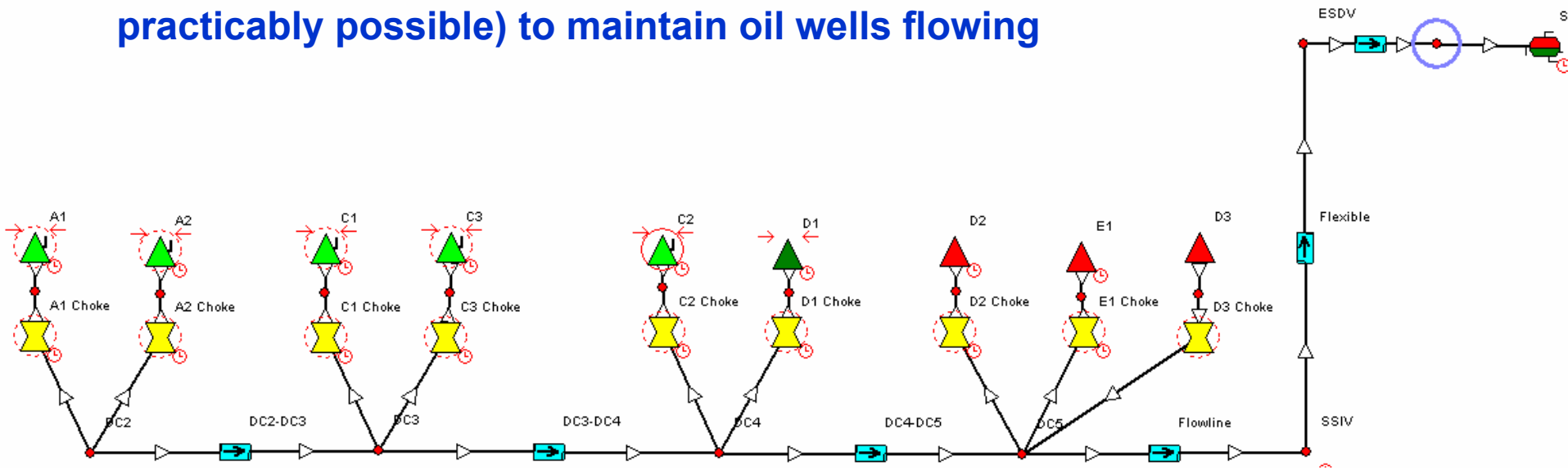
Penguins Gas Lift – Continuous Gas Lift

- **Compromises**
  - **More gas lift gas better for wells, worse for pipeline!**



Penguins Gas Lift – Continuous Gas Lift

- **Prosper / GAP optimisation**
  - **Testing by difference (TBD) now much more practical, feasible and justifiable**
  - **In fact TBD is essential to optimise field production!**
  - **Essentially due to gas lift assistance of "weak" oil wells, gas wells that have been choked back by some +50 barg (725psig) may be opened up further!**
  - **Pipeline operating pressure not limited to ~40barg (580psig) (as high as practicably possible) to maintain oil wells flowing**



Penguins Gas Lift – Challenges encountered

- Modification of the existing recip compressor to reduce throughput was not straight forward (from 6 to 2 pistons !)
- Various initial leaks in topsides piping within compressor vicinity
- Strainer “blockages” clearing and filling-up lasted longer than anticipated, several strainer replacements/cleanouts required
- Gas lift riser “guides” had issues with slackening off due to creep of the material
- Well A1 subsea manual isolation valve had NOT been opened by DSV during initial commissioning

Penguins Gas Lift – Conclusions & Recommendations

- Gas lifting at extremely long distances (65km) is possible and very beneficial
- Correct gas lift specifications and methanol dosage MUST be planned and used
  - Avoiding hydrates always better than dealing with them!
- Use of OLGA was very useful and is recommended for future similar projects
- Use of shear valves is good in theory but care must be taken so that there is sufficient differential pressure available to shear the valve!
  - Valves can leak over time and liquid in A-annulus can go to the tubing over time (vacuum in annulus!)
  - Hence, this MAY be an integrity issue where MinAP is required
- Although initial planning for GL was for kick-off, continuous GL proves highly beneficial!
- Production optimisation model such as Prosper / GAP is required for such complex system
- Ultimate recovery of field does require continuous gas lift
  - Hence good upfront investment when completing the wells to account for future GL

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