WE FUEL AMAZING

Annular pressure management

OISD Well Integrity Workshop, 25th and 26th November 2013

Agenda

- Current international standards followed
- Sources of annulus pressure
- Barrier philosophy and causes of sustained annulus pressure
- Annulus pressure management philosophy
- Calculation of maximum and minimum operating pressures
- Examples of Well Integrity dashboards
- Challenges to Annulus pressure management
- Conclusions

International standards followed governing management of annulus pressure

- Well integrity – Part 2: Well integrity for the operational phase ISO/TS16530-2

- Annular Casing Pressure Management for Offshore Wells - API RECOMMENDED PRACTICE 90

Sources of annulus pressure

- Applied pressure
- Thermal induced pressures
  - Thermal expansion of fluid
  - Dissolved gas evolution from annulus fluid
- Ballooning of adjacent annuli
- Sustained annulus pressure
  - Barrier failure
  - Poor design
  - Unforeseen source of pressure

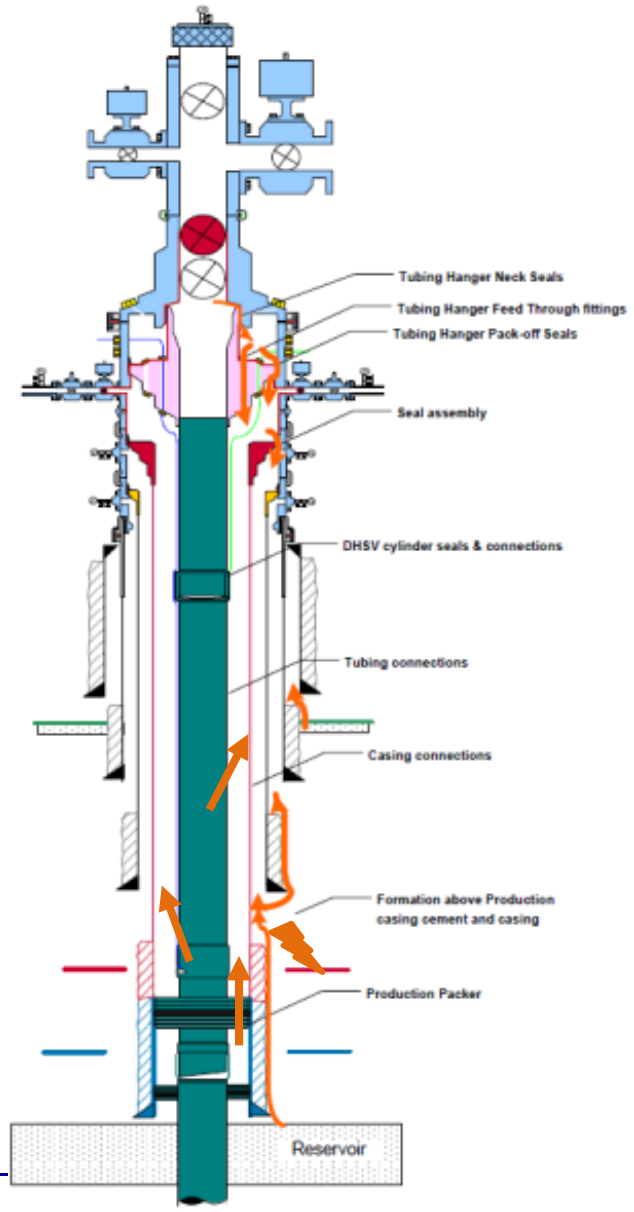
Barrier Philosophy

- Capable of sustained flow? - Two **independently** tested well barrier **envelopes** should be maintained.
- Well barriers are pressure containing envelopes of one or several Well Barrier **Elements** (WBE).
- The **primary** barrier is the barrier exposed to the source, source being formation, lift gas, injection.
- The **secondary** barrier is the barrier that is exposed to the source only if the primary barrier fails
- Two well barriers are **independent** if any loss of integrity of one well barrier does not jeopardize the integrity of the other

Source : Well integrity – Part 2: Well integrity for the operational phase ISO/TS16530-2

Sustained annulus pressure - causes

- Tubular leaks
- Hanger seal failure
- Loss of cement integrity
- Loss of formation integrity
- Loss of packer / seal integrity
- Leaking control line
- Subsea Crossover valves leaking
- Shallow pressure source

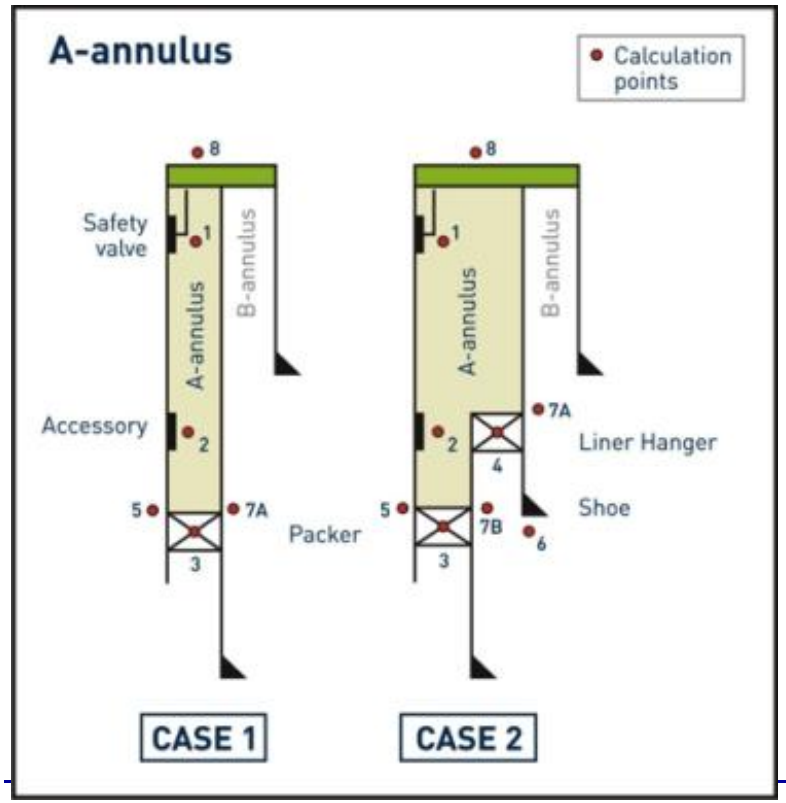


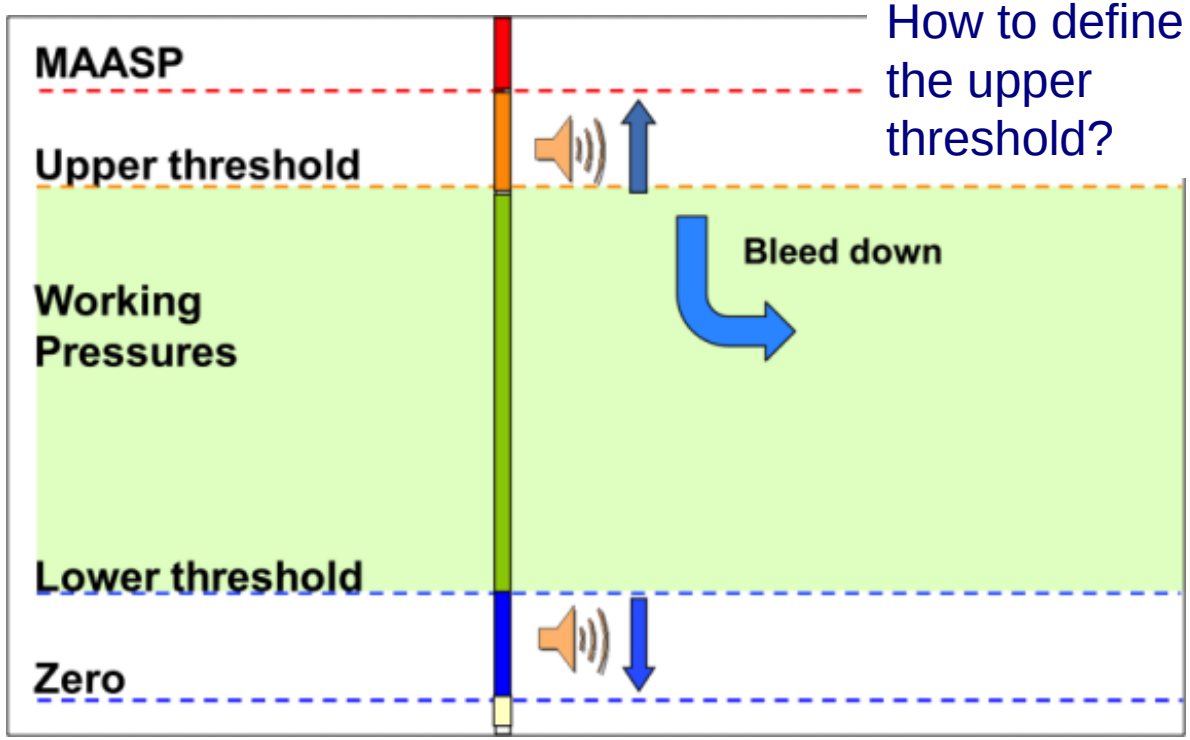
How to define the Operating envelope

- Draft ISO standard is not prescriptive whilst API RP90 is
- ISO defines Maximum Allowable Annular Surface Pressure (MAASP) as the lowest of the calculated strength cases
- Operator decides Max operating pressure (MOP) as % of MAASP
- ISO gives guideline that MOP should not exceed 80% MAASP
- API RP90 does not recognise MAASP – instead talks about Max allowable operating pressure (MAWOP)
- API RP 90 defines annulus MAWOP as:
  - 50% of the MIYP of the casing being evaluated or
  - 80% of the MIYP of the next outer casing
  - 75% of the MCP of the inner tubular pipe body
  - For the outer most pressure containing casing MAWOP can not exceed 30% of it's MIYP

Annulus pressure management

- Calculate maximum allowable annulus pressure (MAASP)
- Determine minimum operating pressure
  - observation pressure - avoiding vapour phase generation (corrosion acceleration) - preventing air ingress





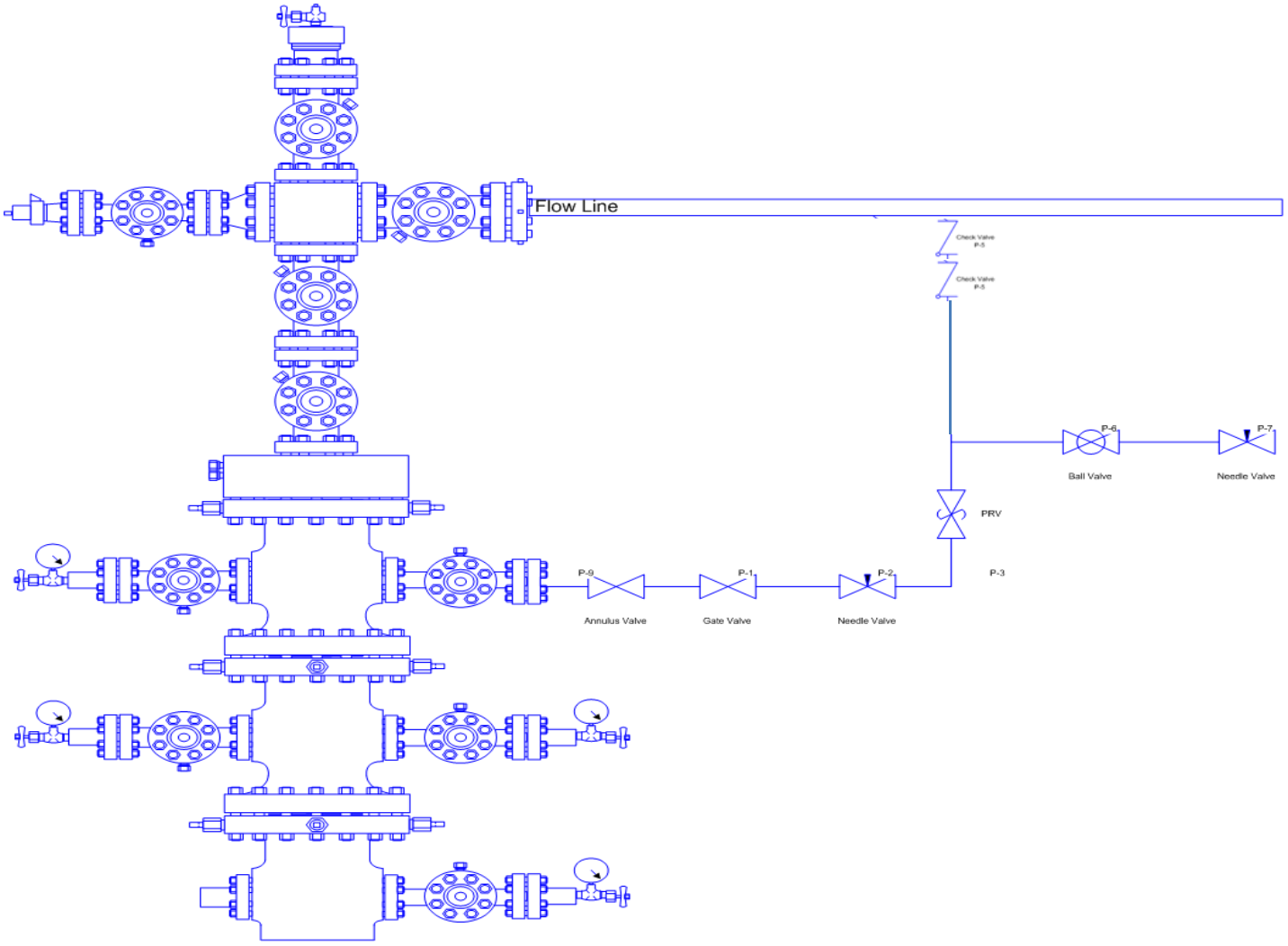
Annulus pressure monitoring procedures

- Monitoring and trending of pressures
- Recording of fluid types / volumes added / removed
- Establish frequency and type of monitoring
- Periodic testing of well barriers
- Operational changes to the well or other wells / surroundings
- Calibration and function checks of the monitoring equipment
- Periodic review of well stock
- Third party audit of the WIMS

Acceptable Pressure / Leak Rate Determination

- Wells with <100 psig annulus pressure should be monitored only.
- Wells with >100 psig but < MAWOP if they can be bled to zero within 24hr presents an acceptable risk
- Wells with annulus pressure above MAWOP or where the pressure cant be bled off must be dealt with on a case by case basis.
- How to deal with “rogue” wells is left to the operator – it is not prescribed in API RP 90 or Norsok standard.
- Each country will have its own jurisdiction on how rogue wells must be reported

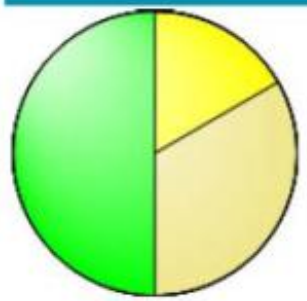
Automated pressure bleed off system



AUTOMATED PRESSURE BLEED OFF SYSTEM

WIMS dashboard example 1

Risk Status Summary

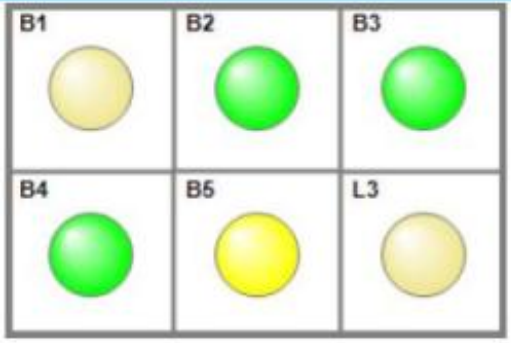


Well Integrity Status

- Critical
- High Concern
- Medium Concern
- Medium Concern
- Low Concern
- No Concern

	Description	Requirement
Critical		Shut In Well. Carry out Formal Technical Review within seven days to determine mitigating actions.
High Concern		Perform a formal and documented risk assessment
Medium Concern		Perform a formal and documented risk assessment within one month to ensure it is safe to continue operating. Continue to check, test & maintain. Repair within 3 months.

Well Status Summary



Well Status

- Undefined
- Flowing

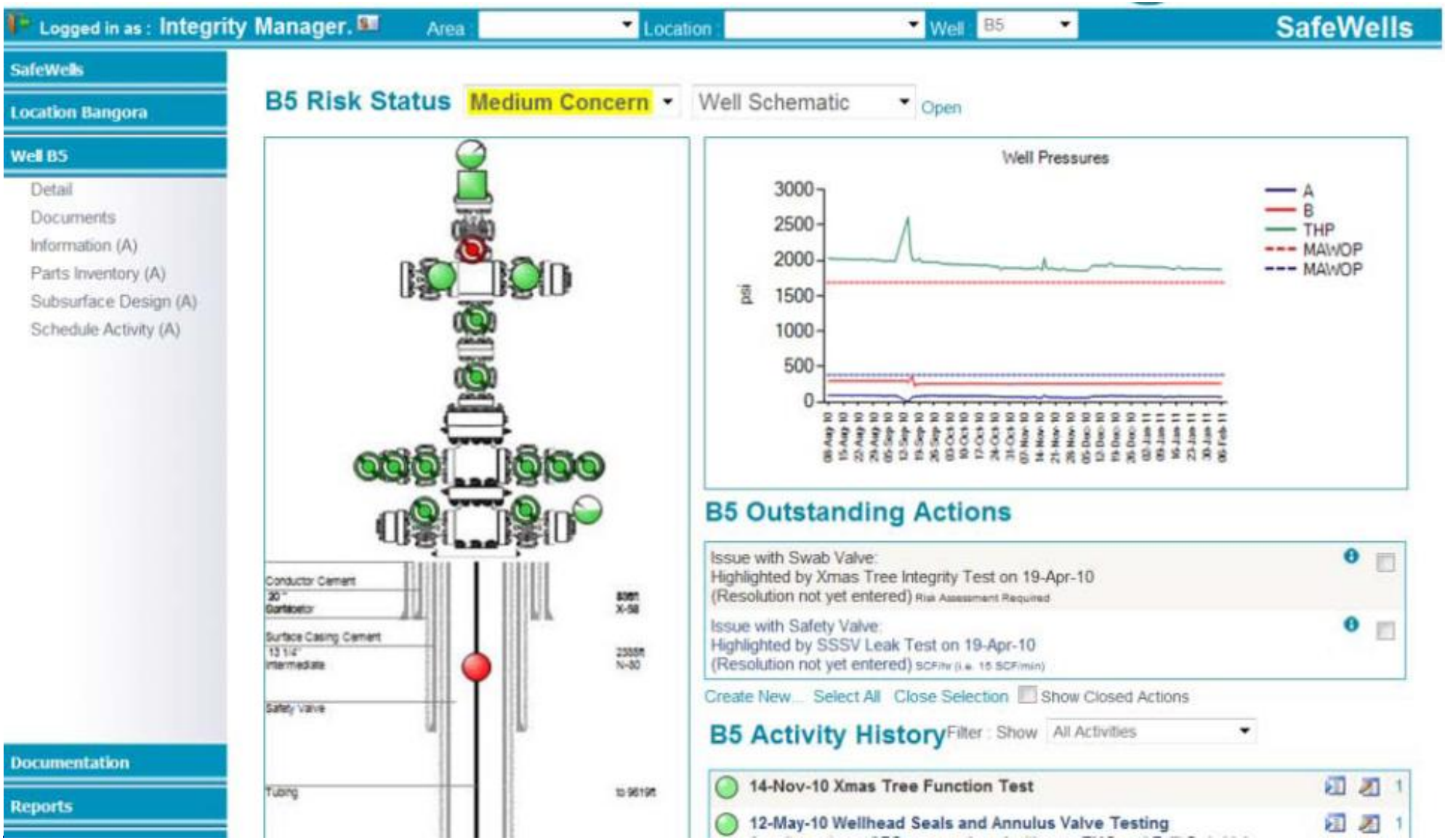
Well Integrity Status

- No Concern
- Low Concern
- Medium Concern
- Medium Concern
- High Concern
- Critical

Component Test Compliance Summary

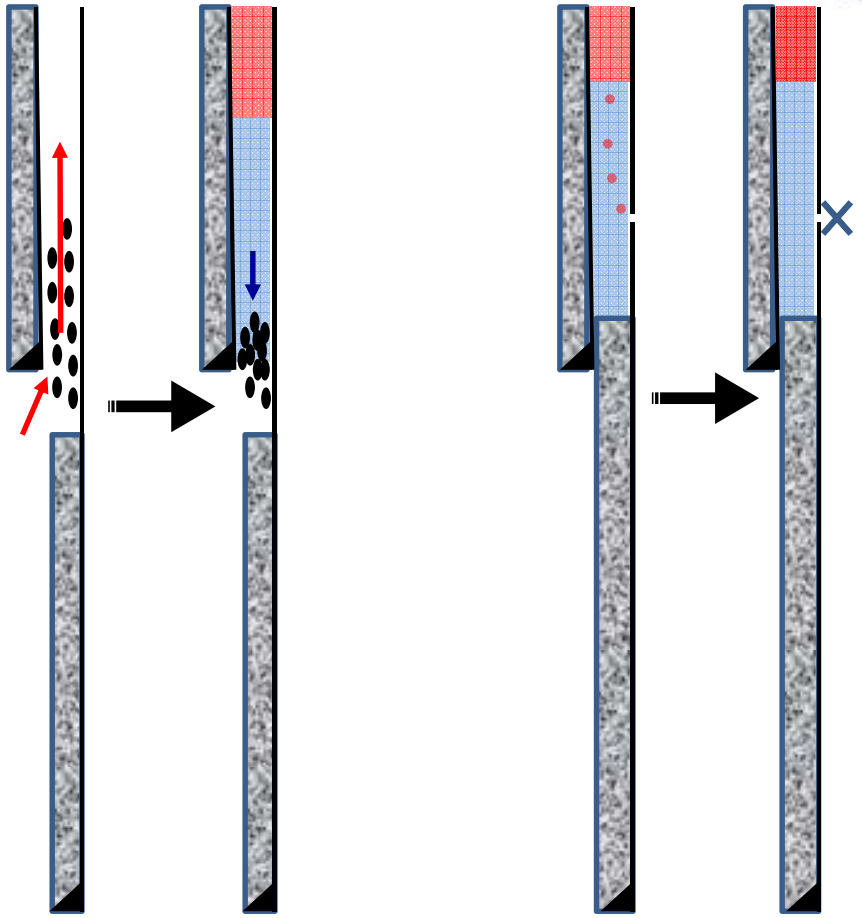
Test Type	Frequency (months)	Components	Compliance
Wellhead Seals and Annulus Valve Testing	12	36	67%
Xmas Tree Function Test	12	25	0%

WIMS dashboard example 2



Are leaks simple?

- No!
- One-way leaks exist.
- Leak paths can allow gas to pass but not liquids.
- Annular debris can act as a check valve.
- If the leak is below liquid level, gas will bubble up through the liquid but liquid will be trapped.



What if there is lack of access to annulus?

- This occurs in subsea wellheads
- Leave the shoe open to allow for bleed off
- This is not assured – see previous slide
- Rupture disks to provide leak points in the casing
- Nitrogen foamed spacers to provide a gas cap
- Include compressible beads in the annular fluid
- Collapsible foam wrap on casing – controlled collapse
- Vacuum insulated tubing (reduce heat transfer)

Threats to well integrity - SCE assurance

- Good design
- Knowledge of the material of construction and QA/QC of assembly
- Proper storage
- Correct installation
- Functional testing
- Pressure testing (one part of a bigger picture)
- Life cycle maintenance and verification

- Relying only on pressure testing (or missing any part of the assurance process) can be dangerous

Threats to well integrity - Material degradation & loss of functionality

- Corrosion (well fluids)
  - Sweet
  - Sour
  - Oxygen
  - Cathodic
- External casing corrosion
- Erosion / Casing wear
- Sand production
- Elastomer degradation
- Fatigue and tubing & casing stress (pressure, thermal, tectonic)
- Scale formation (e.g. $BaSO_4$, $CaCO_3$)
- Hydrate formation

Cement life cycle assurance

- Reliance on consistent mixing and QA/QC
- Possibility of lost returns
- Poor remediation effectiveness
- Thermal cycling during wells life
- Inability to monitor condition of cement

Key to successful Well Integrity Management

- Organisational Competency
- Develop proactive rather than reactive well integrity management
- Designing for the Life Cycle - Embedding well integrity in the equipment design
- Solid well construction practices and well life cycle management
- Management commitment

Thanks