



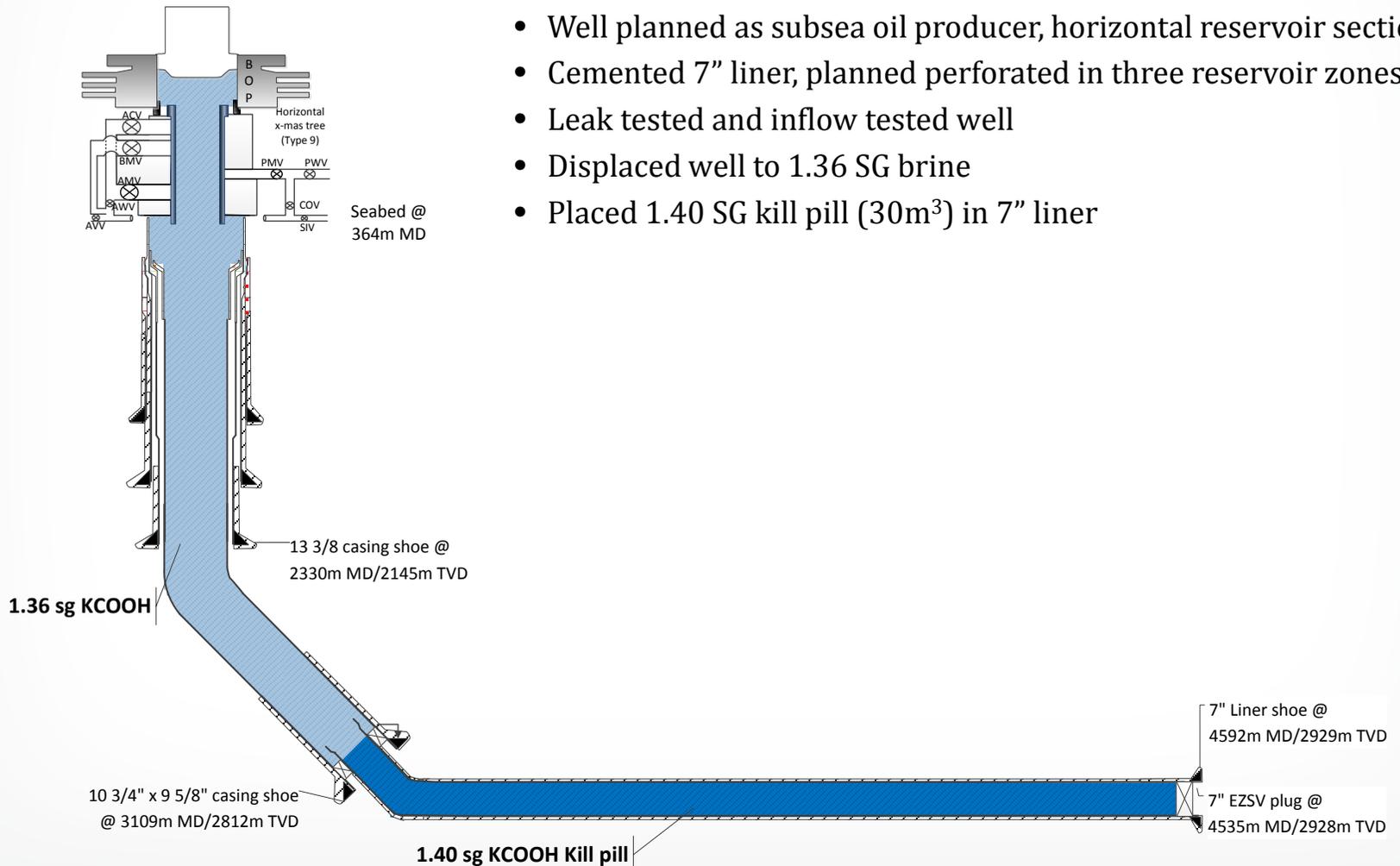
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# "Sharing To Be Better"

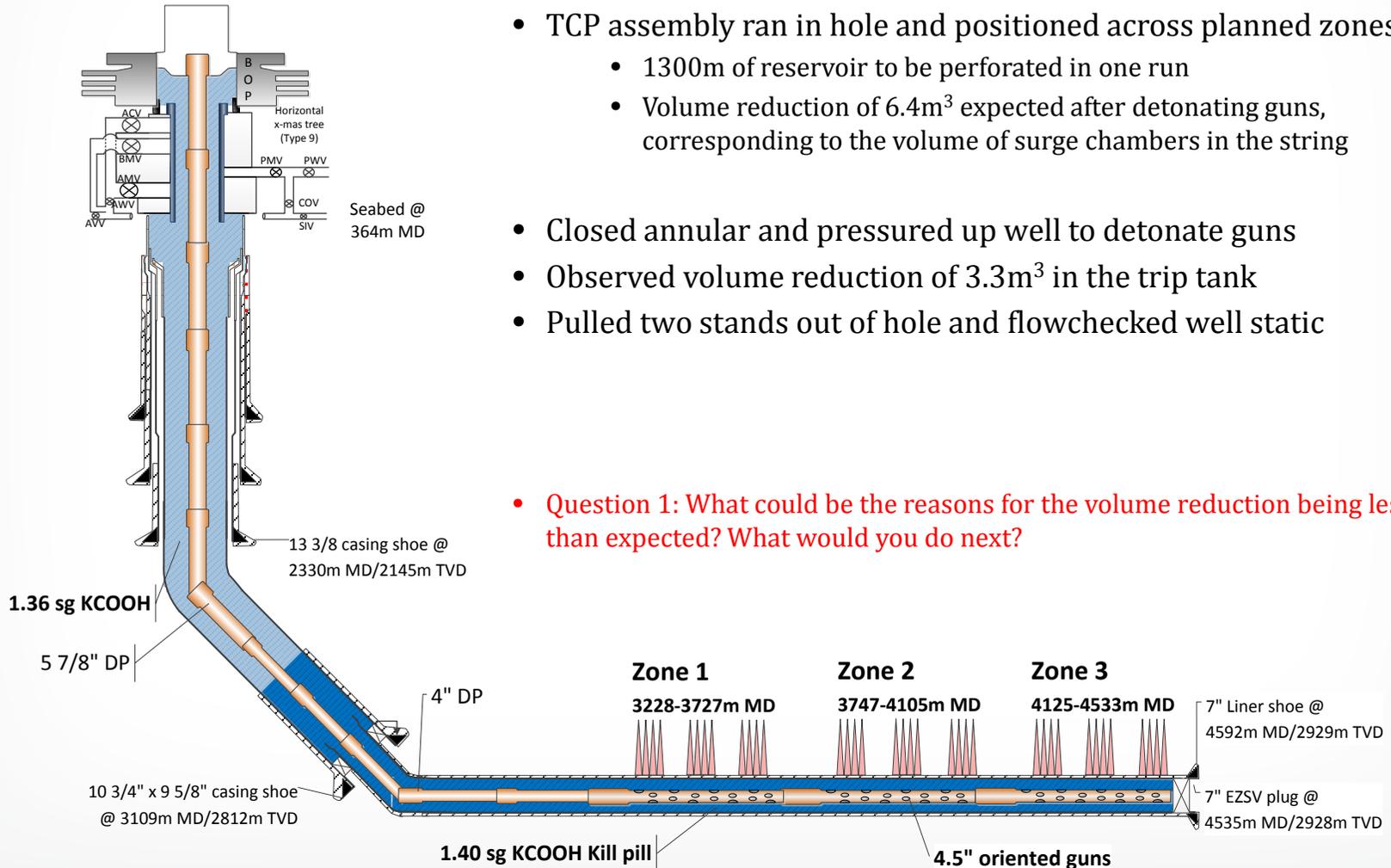
Serious (yellow) well control incident –  
Influx while pulling out of hole after perforating with TCP

# Well status – completion operations

- Well planned as subsea oil producer, horizontal reservoir section
- Cemented 7" liner, planned perforated in three reservoir zones
- Leak tested and inflow tested well
- Displaced well to 1.36 SG brine
- Placed 1.40 SG kill pill (30m<sup>3</sup>) in 7" liner

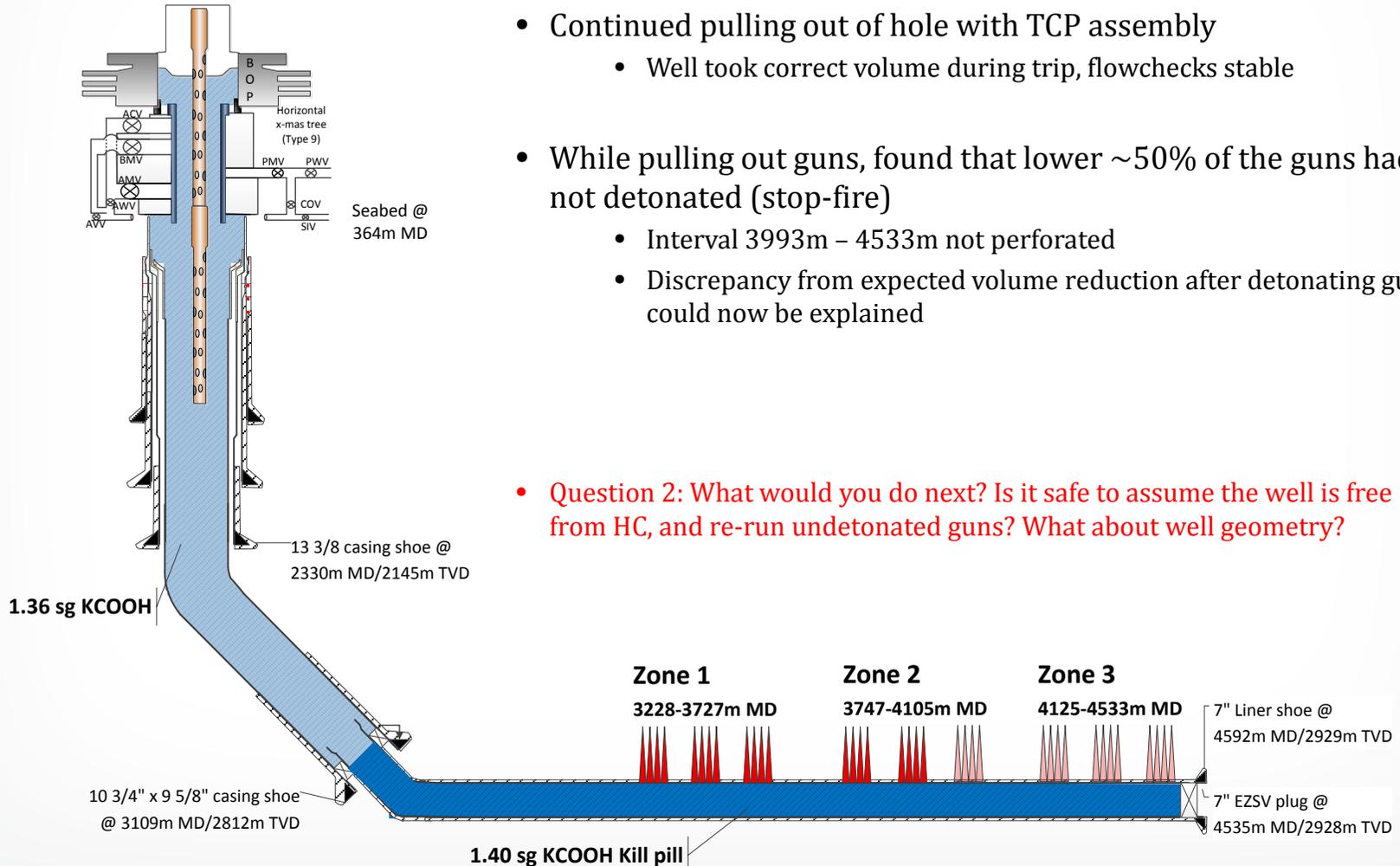


# Perforate reservoir zones with TCP



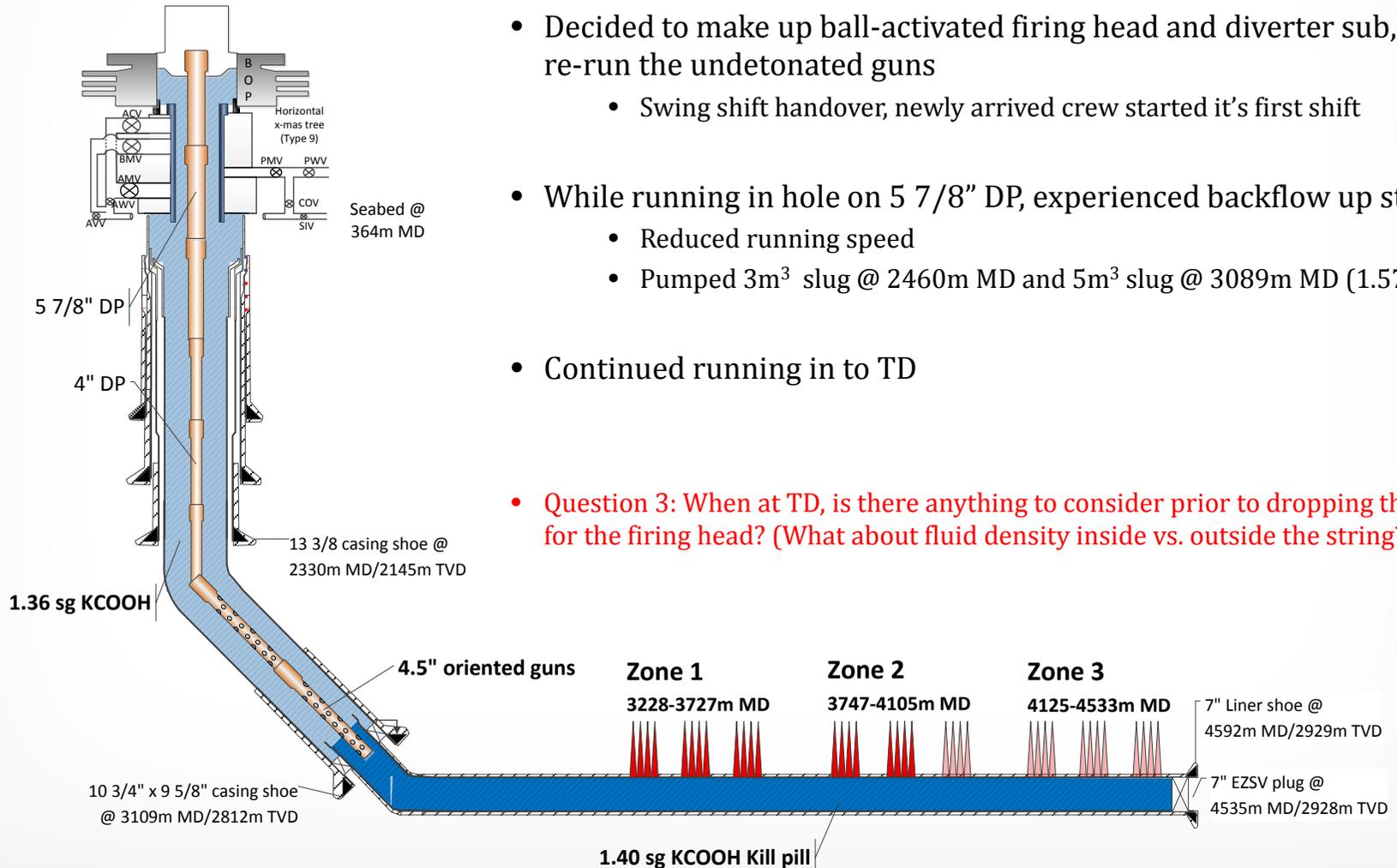
- TCP assembly ran in hole and positioned across planned zones
  - 1300m of reservoir to be perforated in one run
  - Volume reduction of 6.4m<sup>3</sup> expected after detonating guns, corresponding to the volume of surge chambers in the string
- Closed annular and pressured up well to detonate guns
- Observed volume reduction of 3.3m<sup>3</sup> in the trip tank
- Pulled two stands out of hole and flowchecked well static
- **Question 1: What could be the reasons for the volume reduction being less than expected? What would you do next?**

# Pulling out of hole with TCP



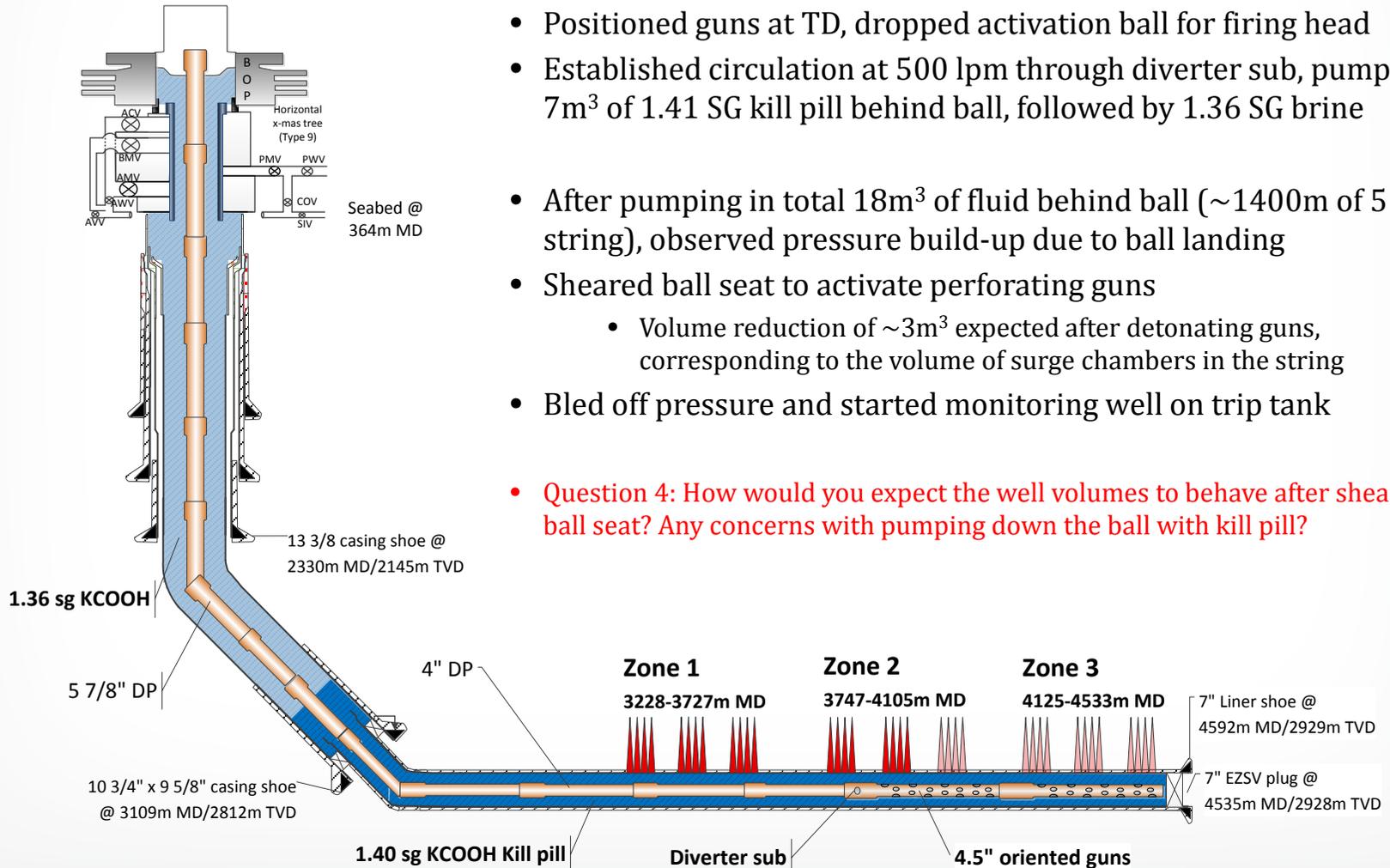
- Continued pulling out of hole with TCP assembly
  - Well took correct volume during trip, flowchecks stable
- While pulling out guns, found that lower ~50% of the guns had not detonated (stop-fire)
  - Interval 3993m – 4533m not perforated
  - Discrepancy from expected volume reduction after detonating guns could now be explained
- Question 2: What would you do next? Is it safe to assume the well is free from HC, and re-run undetonated guns? What about well geometry?

# Re-run undetonated guns



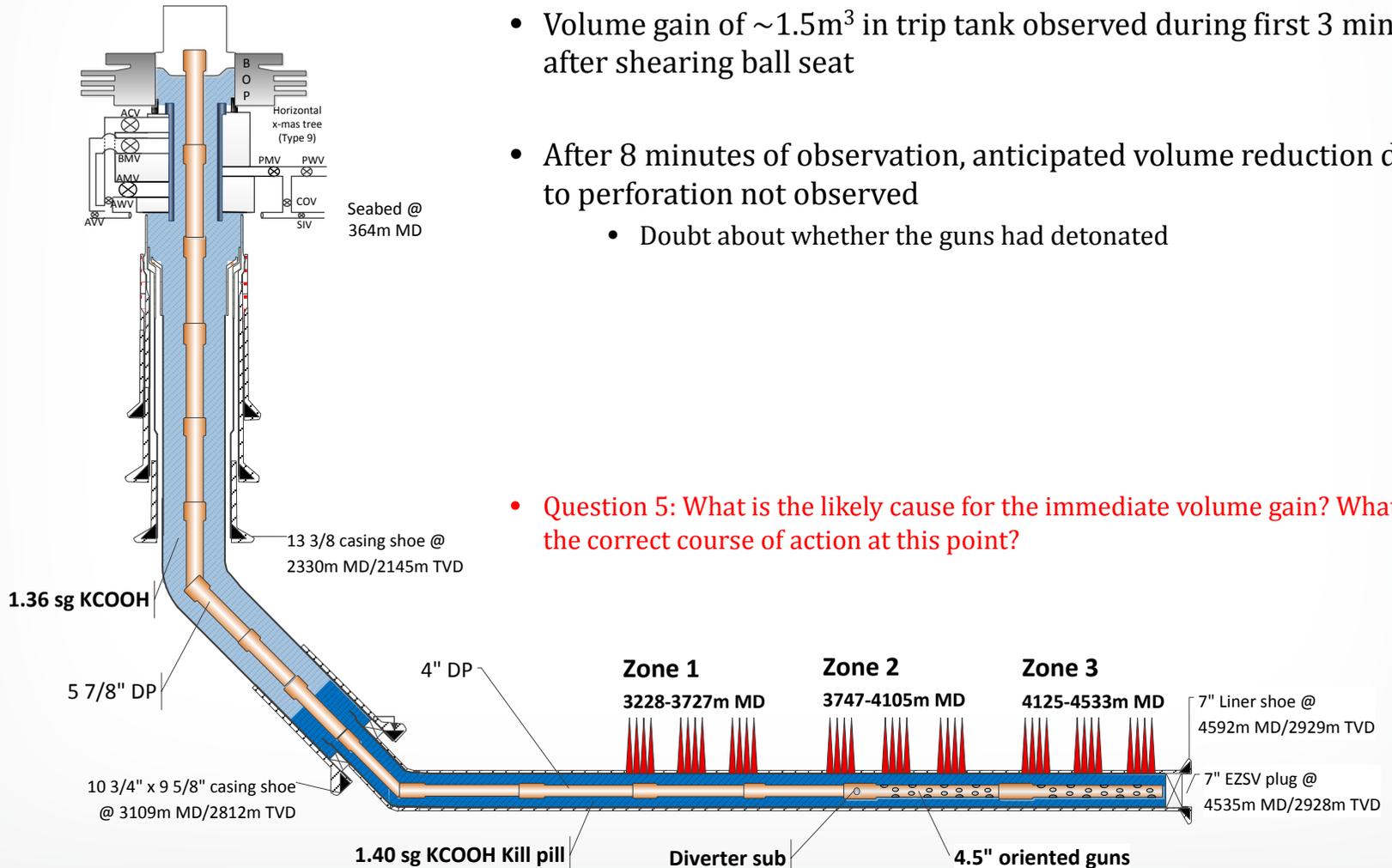
- Decided to make up ball-activated firing head and diverter sub, and re-run the undetonated guns
  - Swing shift handover, newly arrived crew started it's first shift
- While running in hole on 5 7/8" DP, experienced backflow up string
  - Reduced running speed
  - Pumped 3m<sup>3</sup> slug @ 2460m MD and 5m<sup>3</sup> slug @ 3089m MD (1.57 SG)
- Continued running in to TD
- Question 3: When at TD, is there anything to consider prior to dropping the ball for the firing head? (What about fluid density inside vs. outside the string?)

# Perforate remaining interval with TCP

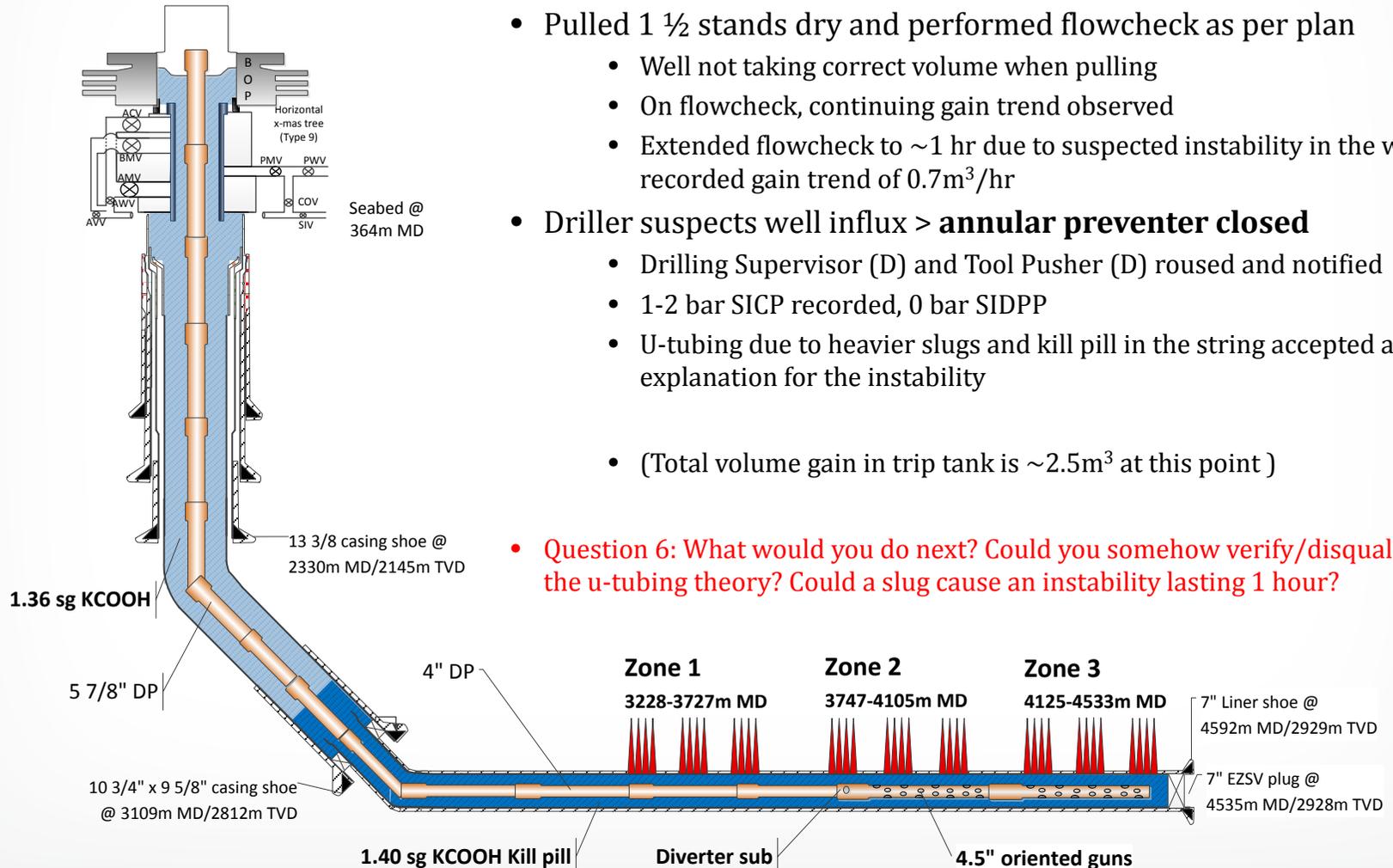


- Positioned guns at TD, dropped activation ball for firing head
- Established circulation at 500 lpm through diverter sub, pumped 7m<sup>3</sup> of 1.41 SG kill pill behind ball, followed by 1.36 SG brine
- After pumping in total 18m<sup>3</sup> of fluid behind ball (~1400m of 5 7/8" string), observed pressure build-up due to ball landing
- Sheared ball seat to activate perforating guns
  - Volume reduction of ~3m<sup>3</sup> expected after detonating guns, corresponding to the volume of surge chambers in the string
- Bled off pressure and started monitoring well on trip tank
- **Question 4: How would you expect the well volumes to behave after shearing ball seat? Any concerns with pumping down the ball with kill pill?**

# Volume response after perforation

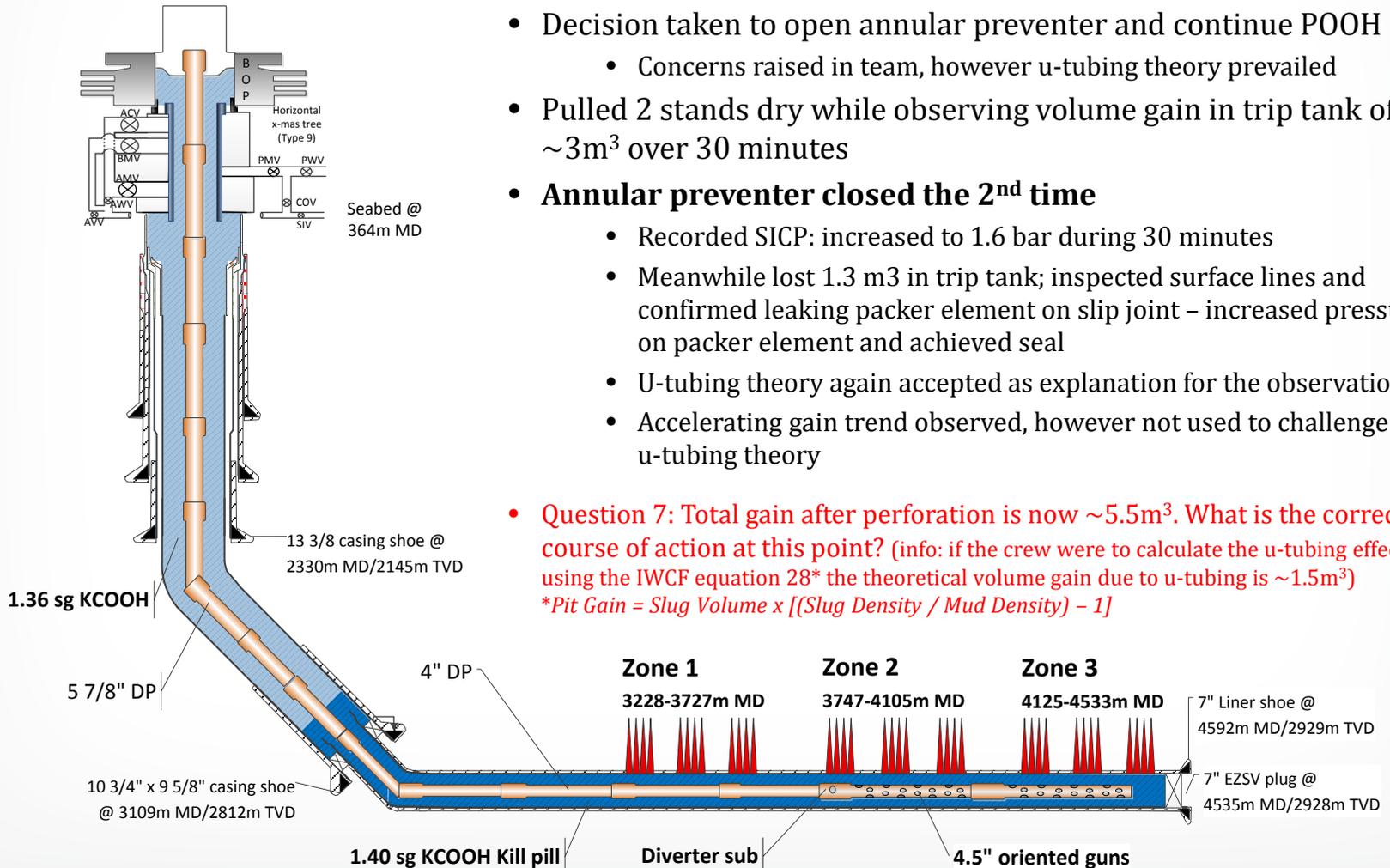


# Start pulling out of hole



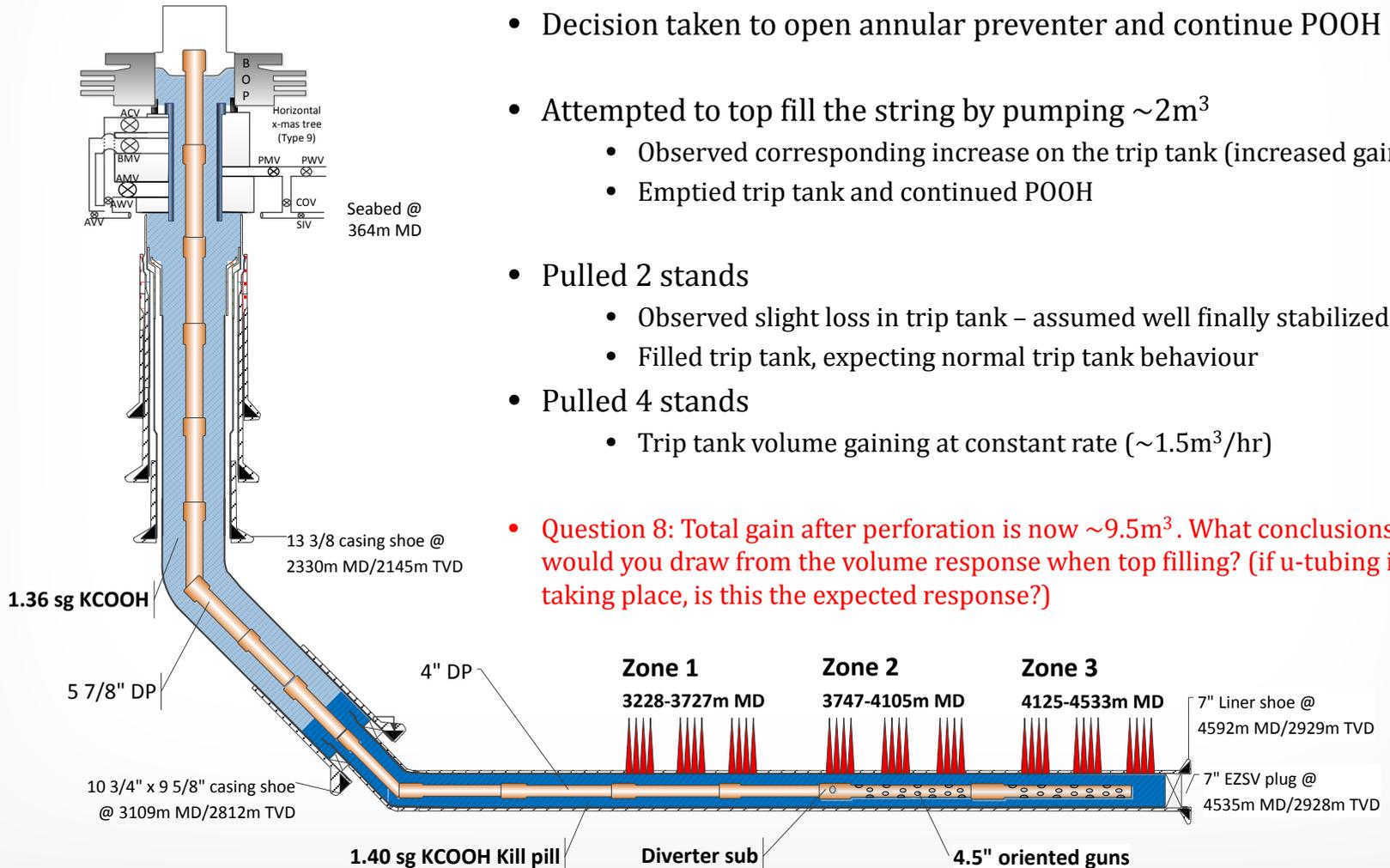
- Pulled 1 ½ stands dry and performed flowcheck as per plan
  - Well not taking correct volume when pulling
  - On flowcheck, continuing gain trend observed
  - Extended flowcheck to ~1 hr due to suspected instability in the well, recorded gain trend of 0.7m<sup>3</sup>/hr
- Driller suspects well influx > **annular preventer closed**
  - Drilling Supervisor (D) and Tool Pusher (D) roused and notified
  - 1-2 bar SICP recorded, 0 bar SIDPP
  - U-tubing due to heavier slugs and kill pill in the string accepted as explanation for the instability
- (Total volume gain in trip tank is ~2.5m<sup>3</sup> at this point )
- Question 6: What would you do next? Could you somehow verify/disqualify the u-tubing theory? Could a slug cause an instability lasting 1 hour?

# Open BOP and continue POOH

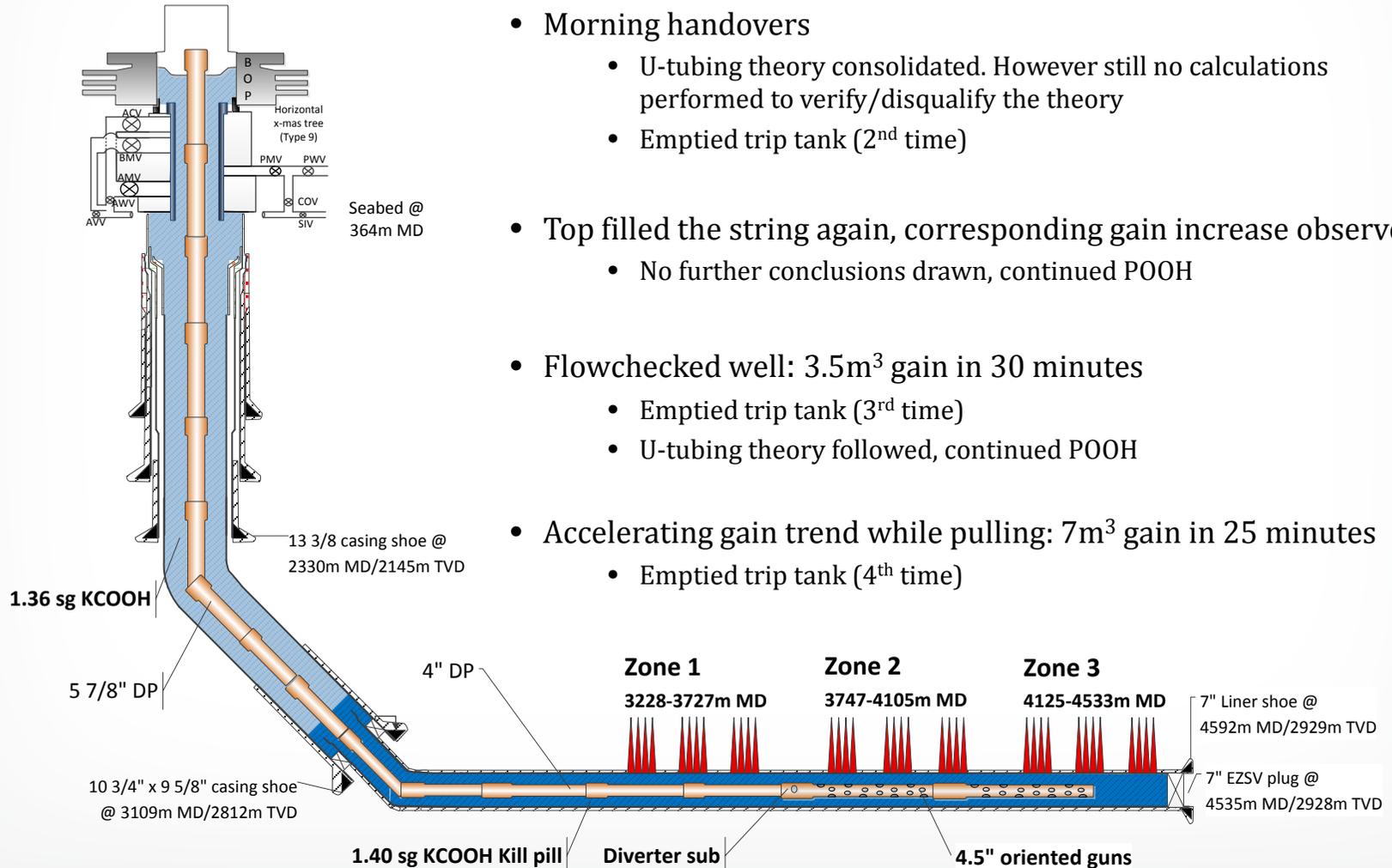


- Decision taken to open annular preventer and continue POOH
  - Concerns raised in team, however u-tubing theory prevailed
- Pulled 2 stands dry while observing volume gain in trip tank of ~3m<sup>3</sup> over 30 minutes
- **Annular preventer closed the 2<sup>nd</sup> time**
  - Recorded SICP: increased to 1.6 bar during 30 minutes
  - Meanwhile lost 1.3 m3 in trip tank; inspected surface lines and confirmed leaking packer element on slip joint – increased pressure on packer element and achieved seal
  - U-tubing theory again accepted as explanation for the observations
  - Accelerating gain trend observed, however not used to challenge u-tubing theory
- **Question 7: Total gain after perforation is now ~5.5m<sup>3</sup>. What is the correct course of action at this point?** (info: if the crew were to calculate the u-tubing effect, using the IWCF equation 28\* the theoretical volume gain due to u-tubing is ~1.5m<sup>3</sup>)  
 \*Pit Gain = Slug Volume x [(Slug Density / Mud Density) - 1]

# Open BOP (2<sup>nd</sup> time) and continue POOH

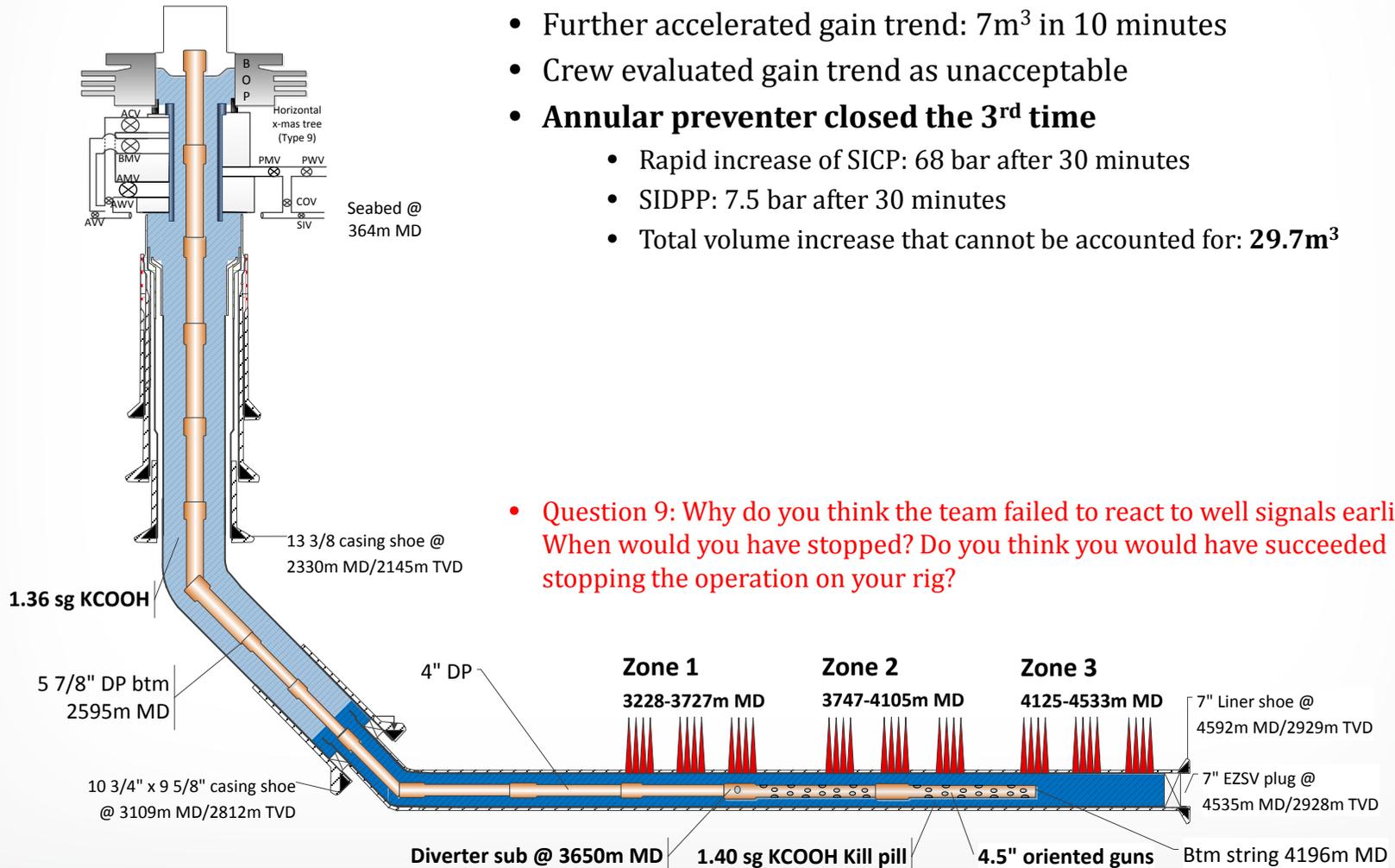


# Continue POOH



- Morning handovers
  - U-tubing theory consolidated. However still no calculations performed to verify/disqualify the theory
  - Emptied trip tank (2<sup>nd</sup> time)
- Top filled the string again, corresponding gain increase observed
  - No further conclusions drawn, continued POOH
- Flowchecked well: 3.5m<sup>3</sup> gain in 30 minutes
  - Emptied trip tank (3<sup>rd</sup> time)
  - U-tubing theory followed, continued POOH
- Accelerating gain trend while pulling: 7m<sup>3</sup> gain in 25 minutes
  - Emptied trip tank (4<sup>th</sup> time)

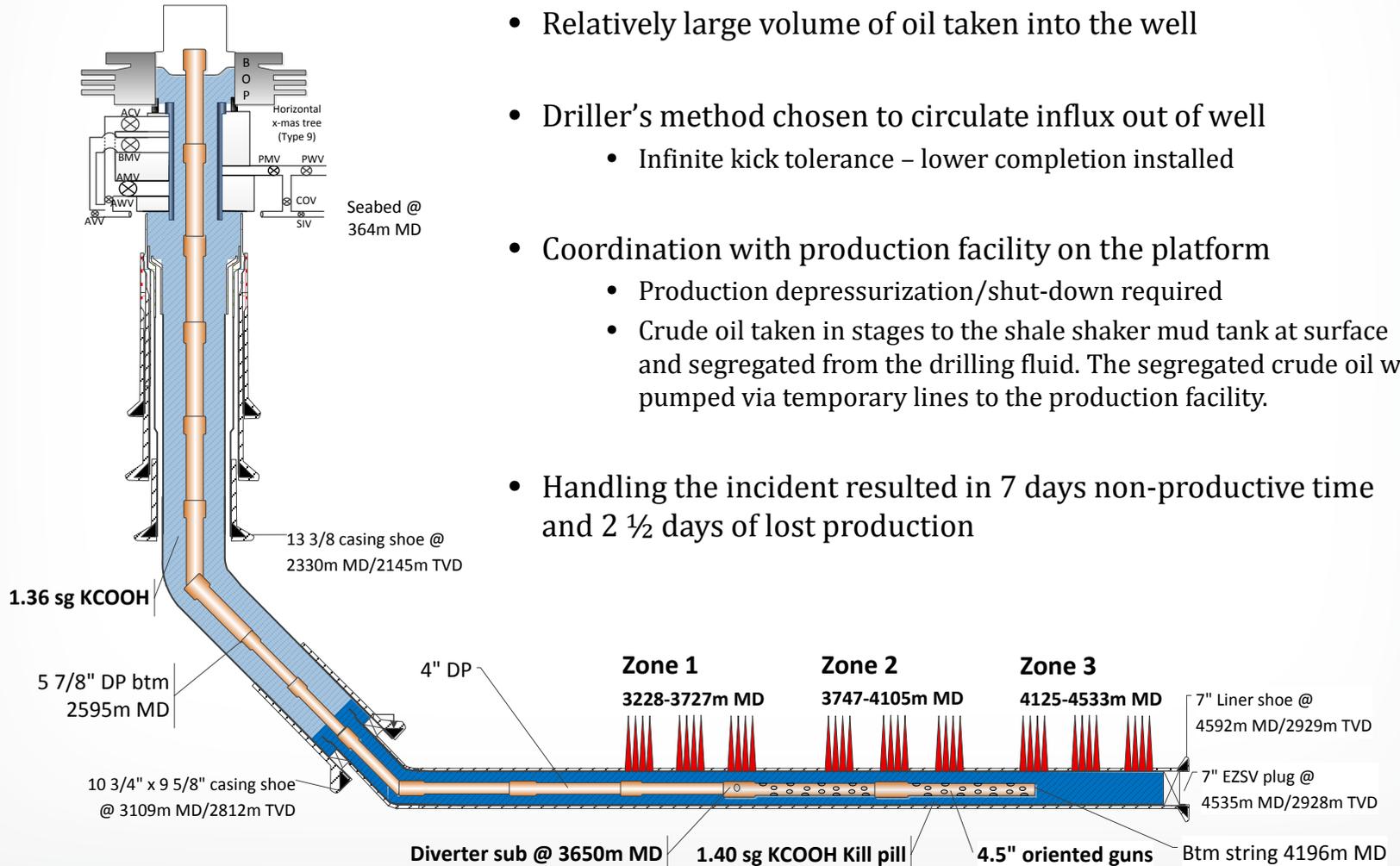
# Shut in well – kick identified



- Further accelerated gain trend: 7m<sup>3</sup> in 10 minutes
- Crew evaluated gain trend as unacceptable
- **Annular preventer closed the 3<sup>rd</sup> time**
  - Rapid increase of SICP: 68 bar after 30 minutes
  - SIDPP: 7.5 bar after 30 minutes
  - Total volume increase that cannot be accounted for: **29.7m<sup>3</sup>**

- **Question 9: Why do you think the team failed to react to well signals earlier? When would you have stopped? Do you think you would have succeeded stopping the operation on your rig?**

# Handling the influx



- Relatively large volume of oil taken into the well
- Driller's method chosen to circulate influx out of well
  - Infinite kick tolerance – lower completion installed
- Coordination with production facility on the platform
  - Production depressurization/shut-down required
  - Crude oil taken in stages to the shale shaker mud tank at surface and segregated from the drilling fluid. The segregated crude oil was pumped via temporary lines to the production facility.
- Handling the incident resulted in 7 days non-productive time and 2 ½ days of lost production

# Learnings and recommendations

- Well control
  - Calculate and log the weight and volume of pumped slugs and resulting volume increase at surface due to u-tubing
  - A stable system shall be established prior to an operation which may lead to an instability in the well (such as perforation)
  - Reinforce general well control procedures
    - Any discrepancies in the well shall be accounted for at surface; if in doubt, RIH and circulate B/U
    - Trip sheet log at drill floor shall be used
    - Total volume gained/lost in well shall be available at all times
- Communication
  - Ensure compliance with communication routines when instabilities in the well
  - Accumulated gain shall be noted in the time log and gain trend commented (mud logger)
  - Total volume count to be presented in shift handover
- Risk management
  - Ensure risk assessment is included in the change process. Here relevant:
    - When pumping slugs to reduce or prevent backflow
    - When planning to chase activation ball with kill pill
- Team and human factor
  - Introduce case based training: “How to recognize development of a false truth?”
    - How to act in a “team break down” scenario?