Sand production continues to be a major challenge in many producing oil and gas assets worldwide. It can choke off production, reduce hydrocarbon recovery, eliminate the integrity of production facilities, and possibly cause disastrous facility failures and harm to personnel and the environment. As such, sand management becomes a priority when selecting appropriate sand control methods and equipment, and mitigation plans need to be addressed to reduce risks and harm resulting from sand production. Undertaken by PTTEPI, the Zawtika gas development project, located offshore Myanmar in the Moattama Basin, covering Block M-9 and a portion of Block M-11, lies within the Zawtika Development & Production Area. The area is situated approximately 300 km south of Yangon and 290 km west of Tavoy off the Myanmar coast. Nine structures of discovered gas resource volumes have been dedicated to the Zawtika gas development project. They will be developed over 3 phases, i.e. 1A, 1B and 1C, at a Daily Contract Quantity of 300 MMscfd sales gas. The GSA was concluded and signed between all parties on July 30, 2010. Gas production from Phase 1A development, comprising the first three 3 structures, has been being delivered to buyers since March 10th, 2014.
Sand Production Management:
The Critical Challenge in Zawtika Gas Production

Tanawat Junmano, Sutasinee Kittisupala, Lee Boo Soon, Anan Amornprabharwat,
Rangsan Bhengbhun - PTTEP
Outline

• Why sand production management is important?
• Where is Zawtika field?
• Zawtika facilities
• Zawtika reservoir characteristics
• Challenges in Zawtika gas production
• Zawtika sand production management
  ➢ Sand production observed from well testing
  ➢ Geo-mechanical study (Sand production prediction modeling)
  ➢ Causes of sand production
  ➢ Zawtika Well Completion Strategy
  ➢ Zawtika Well Operating Procedure
  ➢ Zawtika Historical Production and Challenges
  ➢ Mitigation plan and Way forward
• Q&A
Why sand production MNG is important?

- Leakage at downstream of choke valve
- Choke valve totally damaged
- Sand probe totally damaged
- Sand recovered from monobore completion
- Erosion at Sandtrap while SCO operation
- Leakage at inlet of gas buster while SCO operation

Passion to Explore for a Sustainable Future
Where is Zawtika field?

• ZPQ (CPP + LQ)
• 3 Well Head Platform (Phase 1A) & Intra field Line
• 230 km. Offshore Export Pipeline
• 70 km. Onshore Export Pipeline
• Onshore Facilities, ZOC, ZMS, and 2 Block valves
Zawtika reservoir characteristics

- Series of tidal delta plain, shoreface and shelfal deposits
- Unconsolidated to weakly consolidated sands from Pliocene to Pleistocene geologic sequences
- Multi-stacked reservoirs with sand shale lamination and mostly with underlying fluid contacts
- Highly faulted area resulting multiple isolated structures
Zawtika reservoir characteristics (cont’d)

- Normal reservoir pressure & temperature,
  Hydrostatic gradient 0.433 – 0.44 psi/ft
  Temperature 40-120degC
- Dry gas with low CO₂ (0.1-0.4%) and no H₂S and Hg with max N₂ 25% in KKN area.
- Heating value in the range 850-1,000 BTU/SCF
- Poor to fair reservoir with permeability 30-900mMD
  *poor due to clay contents & very fine grain size
- Very fine to medium grain size with poor-moderate to moderate sorting
- Clay content in the range 10-40%, illite & mica, kaolinite, chlorite and mixed-layer illite/smectite and etc
Challenges in Zawtika gas production

- Unconsolidated sands are major reserves contributions for Zawtika (60% of Reserves)
- Zero or minimal critical drawdown pressure for onset of sand production in shallow and intermediate reservoirs.
- Large variation in particle size distribution and poorly sorted, large percentage of fines (<44 μm) → Challenge in Sand Control Completion Selection & Design.
Sand Production Management – Part of the multidisciplinary team!
Sand production observed from well testing

<table>
<thead>
<tr>
<th>Reservoir Name</th>
<th>Formation Unit</th>
<th>SPH-1 Gas Rate (MMscfd)</th>
<th>Zawtika-1A Gas Rate (MMscfd)</th>
<th>Zawtika-2 Gas Rate (MMscfd)</th>
<th>Zawtika-3 Gas Rate (MMscfd)</th>
<th>Zawtika-4 Gas Rate (MMscfd)</th>
<th>Zawtika-5 Gas Rate (MMscfd)</th>
<th>Zawtika-8 Gas Rate (MMscfd)</th>
<th>Zawtika-9 Gas Rate (MMscfd)</th>
<th>Kakonna-1 Gas Rate (MMscfd)</th>
<th>Kakonna-2 Gas Rate (MMscfd)</th>
<th>Kakonna-3 Gas Rate (MMscfd)</th>
<th>Kakonna-4 Gas Rate (MMscfd)</th>
<th>Gawthaka-1 Gas Rate (MMscfd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Res.07-00</td>
<td>S1</td>
<td>Sand Prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res.08-00</td>
<td>S1</td>
<td>Sand Prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res.09-00</td>
<td>S1</td>
<td>Sand Prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res.09-45</td>
<td>S1</td>
<td>Sand Prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res.10-40</td>
<td>S1</td>
<td>Sand Prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res.10-50</td>
<td>S1</td>
<td>Sand Prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res.12-50</td>
<td>S1</td>
<td>Sand Prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res.13-30</td>
<td>S1</td>
<td>Sand Prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res.14-00</td>
<td>S1</td>
<td>Sand Prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res.14-75</td>
<td>S1</td>
<td>Sand Prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res.15-25</td>
<td>S1</td>
<td>Sand Prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res.16-50</td>
<td>S1</td>
<td>Sand Prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res.17-50</td>
<td>S1</td>
<td>Sand Prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res.19-05</td>
<td>S1</td>
<td>Sand Prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res.20-50</td>
<td>S1</td>
<td>Sand Prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res.21-00</td>
<td>S1</td>
<td>Sand Prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res.23-50</td>
<td>S1</td>
<td>Sand Prod.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend:
- **Sand production**
- **Sand free**

- **Shallow** → observed sand most of TSTs
- **Intermediate** → Some TSTs found sand
- **Deep** → No sand found from all TSTs

Passion to Explore for a Sustainable Future
Zawtika Sand Production Prediction Modeling

- Sand production prediction modeling highlighted that:
  - HIGH sanding risk for sands <1150 mTVDss (Shallow reservoir)
  - HIGH to moderate sanding risk for sands 1150-1700 mTVDss (Intermediate reservoir)
  - LOW sanding risk for sands >1700 mTVDss (Deep reservoir)
Causes of sand production

**Static → Formation or reservoir factors**
- Poorly consolidated formation, generally a "young sandstone problem"

**Dynamic → Fluid flow effect**
- Other factors influencing tendency of a well to produce sand is "fluid flow effects"

- Depletion of reservoir pressure
- Production rate
  Higher production rate, increase drawdown pressure
- Increase of water production,
  Tends to weaken cohesion between sand grains

- Rock mechanics
  e.g. overburden, intergranular friction

- Formation lithology
  e.g. cementing material, particle size, shape

- Reservoir fluid characteristics
  e.g. viscosity, velocity (friction)
Zawtika Well Completion Strategy

3-1/2” Monobore completion

- For Deep reservoirs below 1,700 mTVDss
- Allow sand free production until 40% of reservoir pressure depletion.
- No need sand control completion in early stage of reservoir life.
- Sand management policy at surface is strictly applied.
- At later stage of reservoir life when sand production starts to observe, other sand control technologies will be considered e.g. Thru-tubing gravel pack (TTGP) and sand consolidation technology

Downhole Sand control completion

- For Shallow and Intermediate reservoirs above 1,700TVDss.
- High risk of sand production since early stage of reservoir life due to no & marginal critical drawdowns
- Sand control completion is a must in early stage of reservoir life.
Zawtika Well Completion Strategy (cont’d)

Cased hole gravel pack (CHGP) completion

High rate water pack (HRWP)
- Limited sand thickness/gas column
- Ensure proper proppant/gas column placement into all perforation tunnels and obtain a high quality annular pack

Frac-pack (STIMPAC)
- Sufficient sand thickness/gas column
- Allow higher volumes of proppant to be placed deeper behind casing
- Well productivity and well service life can be enhanced
Zawtika Well Completion Strategy (cont’d)

**Well location**
- Development wells have been placed at crestal locations to delay water encroachment to the well

**Perforation stand-off & perforation length**
- Optimize perforation interval length and maximize perforation stand-off above GWC to delay water production

**Well inclination > 45° and Oriented-perforation with 0° phasing (MNB)**
- Provide more stable perforation tunnels achieved by lower stress anisotropy under influence of the 2 horizontal stresses
Zawtika Well Operating Procedure

### Start Up
- Data from E&A Well Testing
- Sand prediction model

### Production Optimization
- Well start-up
- Bean up/bean down policy
- Well prioritization
- Choke opening procedure
- Regular well clean-out

### Well Life
- Confirm Metal Loss/Sand rate
- Production Test (Monthly)
- Sample Analysis

#### Real Time Sand Monitoring
- (Sand probe) + Acoustic Sand Monitoring (ClampOn)

#### Real Time Water Monitoring
- through Well Surveillance Workflow

- Confirm Metal Loss/Sand rate
- Production Test (Monthly)
- Sample Analysis

#### Water Coning
- Water Breakthrough

---

**Critical drawdown limit**

- Maximum sand Free Rate (MSFR)
- Maximum Allowable Sand Rate (MASR)

**90 degree orientation**

- Initial State
- Proven limit
- Current State

---

**Schlumberger**

**Passion to Explore for a Sustainable Future**
Zawtika Historical Production and Challenges

Zawtika Historical Production

Gas Production By Completion Type

- Production contribution from MNB decreases due to sand and water production
- More wells become online after sand control completion is completed.
- Potential gain from well bean-up activities as per targeted at MSFR and MASR
Mitigation plan and Way forward

Well intervention

• HUD, downhole sample & LPSA

• PLT and water shut-off using tubing patch

• Sand clean-out by CTU
• Additional perforation
• zone change for sand control well

Surface and subsurface measurement

• Monthly UT scan

• Choke valve passing test
• Monthly choke valve inspection & replacement

• Tubing corrosion survey by EMIT tool
Mitigation plan and Way forward (cont’d)

Online sand probe + Acoustic sand monitoring and Production envelope

Online sand probe

Acoustic sand monitoring and production envelope

Production Envelope
Mitigation plan and Way forward (cont’d)

Thru-tubing gravel pack (TTGP)

- Squeeze Gravel Pack System
- Stand Alone Screen (SAS)
- Prepacked Screen
- Vent Screen System
- Circulating Gravel Pack System
- Circulating Gravel Pack System with SAS Opening

Overall results shows average of 55% retained permeability and UCS of 700 and 1,300 psi for top and bottom portions respectively

- Considered for short newly perforated interval

- Deployment by CTU

- Squeeze Gravel Pack System (Screen Stacks with Frac Valve System)

- Screen size
  ID = 1.61”
  OD = 2.25”
  Clearance diameter = 0.742”

Sand consolidation “SandTrap®”

- Overall results shows average of 55% retained permeability and UCS of 700 and 1,300 psi for top and bottom portions respectively
- Considered for short newly perforated interval

Horizontal well with gravel pack completion