Next Generation Kick Detection during Connections: Influx Detection at Pumps Stop (IDAPS) Software

Brian Tarr, Shell
When Do Kicks Occur?

<table>
<thead>
<tr>
<th>Percentage of Kicks</th>
<th>Drlg./Circ.</th>
<th>Connections</th>
<th>Tripping</th>
</tr>
</thead>
<tbody>
<tr>
<td>25%</td>
<td>25%</td>
<td>50%</td>
<td></td>
</tr>
</tbody>
</table>

Based on Operators GoM Internal Data

Focus of Current Rig Based Kick Alarm Systems:
1. Drilling/Circulating

Smart Kick Detection System

Fault Tree Analysis

Influx Volume

False Alarm Rate

“SMART” Current

SMART Kick Alarms for:
1. Drilling/Circulating
2. Connections
3. Tripping
PERFORMANCE GOALS FOR IDAPS

1. Kick probability of detection (PD): Required PD > 0.95, Target PD = 1
2. Kick false alarm rate (FAR): Required FAR < 1/100, Target FAR < 1/1,000
3. Time to detect (Td) a kick: Required Td < 240 sec, Target Td < 120 sec
4. Provide feedback if sensor data appears inconsistent
5. Adaptive to all well conditions
6. Use available surface sensor data
7. Simple to install and use

Good connection, no kick
Possible kick detected
Kick confirmed
Event Detection & Alignment
Extract Relevant Event Features
Any Data Validity Issues?
Compare With Previous Events
Sum Cumulative Differences
Any Alert Threshold Exceeded?
IDAPS PUMPS-OFF EVENT COMPARISON DISPLAY

Possible influx detected
Probability: Medium

- Possible sensor errors detected
- Fossil fuel source measurement
  Range: 122 - 400
- Influx indicated medium confidence
  Range: 237 - 400
- Abnormal amount of flow back to pit
  Range: 200 - 281
- Possible influx issues detected
  - 144 Probability = Low
    - Continuing flow out excessive
    - Pit volume gain excessive
  - 236 Probability = Medium
    - Continuing flow out excessive
    - Pit volume slope excessive
    - Pit volume gain excessive

IDAPS event processing terminated due to influx.

If Desired Remove Data From IDAPS Template List

Show Influx Analysis
IDAPS EVENT ANALYSIS DISPLAY

- Current pumps-off event
- Comparison Signature (derived from prior events)

Likelihood Derived Factor (LDF)

\[ \text{LDF} = A (V1 \times V2 \times V3 \times V4) + B \times V1 + C \times V2 + D \times V4 \]

V1 to V4 = Cumulative sum Variables
A to D = Constants
IDAPS DATA FLOW DIAGRAM

**RIGSITE**
- Electronic Drilling Recorder
- Communication Protocol
  - WITS
  - OPC
- Rig In A Box Database Acquisition System

**OFFICE**
- Database Acquisition System
- Communication Protocol
  - WITS

**IDAPS**
- IDAPS Outputs
  - Influx Alarms
  - Data Validity Flags

**IDAPS Inputs (1 Hz)**
- Hole Depth
- Bit Depth
- Flow In
- Flow Out
- Pit Volume

**Communication Protocol**
- OPC
### IDAPS Validation Using Historical Data Set

<table>
<thead>
<tr>
<th>Filename</th>
<th>Event Number</th>
<th>Comments</th>
<th>Estimated Influx Volume [bbl]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well1</td>
<td>16</td>
<td>Verified Influx</td>
<td>15</td>
</tr>
<tr>
<td>Well2</td>
<td>25</td>
<td>Suspected Influx</td>
<td>10</td>
</tr>
<tr>
<td>Well3</td>
<td>29</td>
<td>Verified Influx</td>
<td>22</td>
</tr>
<tr>
<td>Well4</td>
<td>12</td>
<td>Verified Influx</td>
<td>8.5</td>
</tr>
<tr>
<td>Well5</td>
<td>30</td>
<td>Verified Influx</td>
<td>14</td>
</tr>
<tr>
<td>Well6</td>
<td>17</td>
<td>Suspected Influx</td>
<td>10</td>
</tr>
<tr>
<td>Well7</td>
<td>12</td>
<td>Possible Influx</td>
<td>16</td>
</tr>
<tr>
<td>Well8</td>
<td>17</td>
<td>Possible Influx</td>
<td>N/A</td>
</tr>
<tr>
<td>Well9</td>
<td>8</td>
<td>Possible Influx</td>
<td>35</td>
</tr>
<tr>
<td>Well10</td>
<td>18</td>
<td>Suspected Influx</td>
<td>17</td>
</tr>
<tr>
<td>Well11</td>
<td>12</td>
<td>Suspected Influx</td>
<td>20</td>
</tr>
</tbody>
</table>

**Key Results:**

- **All 4 Verified Kicks Detected**
  - PD = 1.0
- **Only 7 IDAPS False Alarms** in 1362 connections
  - FAR = 1 per 195 Connections
- **Time to “confirmed” alarm** ranged from 84 to 263 seconds
IDAPS TESTING

**Functional Testing**
- Unit Testing
- Integration Testing
- System Testing
- Acceptance Testing

**Non-Functional Testing**
- Performance Testing
- Usability Testing
- Compatibility Testing
EXAMPLE Connection Event Display Evolution

Excessive Pit Vol. Gain
Possible Sensor Error?
Pit Vol. Gain > \( \Sigma \) Flow Out
EXAMPLE Connection Event Display Evolution

Event Data

Possible influx detected
- Probability: Low
- Event volume gain excessive
- Possible Source: Excess

Influx indicated medium confidence:
- Probability: Medium
- Event volume gain excessive
- Possible Source: Excess

Influx indicated high confidence:
- Probability: High
- Event volume gain excessive
- Possible Source: Excess

Estimated influx volume (bbl) = 22.0

EXAMPLE INTERVENTION #1

Operation: Pumping out of the hole.

Action: RTOC Engineer Notified the Rig.

No indication of flow during remainder of trip out.
EXAMPLE INTERVENTION #2

Operation: Reaming tight spot.

Action: RTOC Engineer Notified the Rig.

Flow checked well (no flow).

Ballooning?
CONCLUSIONS

1. By using advanced machine learning and optimal trend detection processing IDAPS achieved:
   • Probability of detection (PD) of 1.0 (no kicks missed)
   • False alarm rate (FAR) of 1/195 connections
   • Confirmed kick alarm in as little as 84 seconds

2. Overlay plots of recent pumps-off event flow and pit volume data are being used by the operators RTOC engineers to validate anomalous connection signatures identified by IDAPS.

3. IDAPS possible influx alerts and confirmed influx alarms are now taken seriously by the operators rig teams.

4. New Formation Breathing/Ballooning Discriminator now being tested.
THANK YOU

QUESTIONS & COMMENTS


Next Generation Kick Detection during Connections: Influx Detection at Pumps Stop (IDAPS) Software