Where Technology Shapes Solutions.

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Structured Approach to Shift Handover
Improves Situation Awareness
Topics

• Introduction
• Background to problem
• Experiment Overview
• Experiment Details
• Project Results
• Best Practices
• Conclusion
Introduction

- In the refining industry, control room and field operators document their daily activities using shift logs
- Shift logs are an important part of the shift handover process and are the mechanism by which activities are coordinated and situation awareness is shared across shifts
- Industrial research has argued for the benefits of imposing structure on shift handovers in the form of structured logs, checklists, and displays
Background

• Approximately 80% of industrial operations lack a structured approach to shift handovers
• Numerous disasters have illustrated the potential consequences of poor shift handovers
• Lack of structure increases likelihood that critical information will be missed and misunderstandings will occur
• Value of a structured approach has never been demonstrated experimentally
Examples of disasters attributed in part to inaccurate or incomplete communication of information from shift to shift

- 1968: Fire and explosion on the Piper Alpha offshore platform due to poorly documented relief valve status
- 2002: Pipefitter exposed to toxic chemical at an undisclosed facility due to poorly documented tank maintenance status
- 2005: Fire and explosion at the BP refinery in Texas City, TX, due to failure to log information, resulting in flammable liquid overfill condition
Background (Cont’d)

• Most common causes of incidents related to shift handover
  – Poor logbook design
    • Lack of structure
    • No clear indication about what to log and how to structure entries
  – Poorly conducted shift handovers
    • Lack of complete and accurate reporting
    • Reliance on operator memory
    • Time pressures
    • Ineffective two-way communications
Recent Experiment

- Shift handover experiment was sponsored by ASM® Consortium and conducted by Engen Petroleum, Ltd., Honeywell, Inc. and Nanyang University of Singapore
- Engen is an Africa-based energy company focused on downstream refined petroleum products
- Engen’s Durban, South Africa, refinery has capacity to refine 135,000 barrels of crude oil per day
• Experiment at the Durban refinery compared the quality of shift handovers using a structured checklist-integrated logbook to a traditional, less structured logging approach

• Tests focused on shift handover between first shift and second shift operators

• Checklist-integrated shift log provided sub-categories of information, which prompted operators to acknowledge each detail even if there was nothing relevant to report

• To ensure statistical robustness, ten test trials of the semi-structured handover and ten trials of the structured handover were conducted and observed
# Recent Experiment Details

- **Standard Engen logbook**

## Safety

<table>
<thead>
<tr>
<th>Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 person sustained minor injury due to the steam burns. Injury no 3614</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam line ruptured releasing steam. Incident no 3245</td>
</tr>
</tbody>
</table>

## Environment

| Noise complaints received when steam line ruptured. Noise levels recorded West of the mosque: 67/68 and South of P99: 69/72. |

## BLOWDOWN

| None |

## Energy

| No changes. |

## People

| Shift supervisor: Arnold |
| Dectaniser: Marko |
| Depropaniser: Lindi |

## Equipment

| None |

## Shadowplant

<table>
<thead>
<tr>
<th>Production Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy feed was increased to 360 and light feed increased to 15m3/d for ullage constraints at tankage.</td>
</tr>
<tr>
<td>Instrument technician took a permit to replace the positioner on 11FV19, now 11FV19 is on bypass control.</td>
</tr>
<tr>
<td>Debutaniser was shutdown when the steam line ruptured.</td>
</tr>
<tr>
<td>Permit issued to maintenance to do repairs on the steam system, so repairs are in progress.</td>
</tr>
<tr>
<td>Permit issued to DCS to replace the screen on TDC.</td>
</tr>
<tr>
<td>Chemical truck on standby to offload chemicals to the unit.</td>
</tr>
<tr>
<td>Borehole readings: No1 = 307803 and No2 = 704644</td>
</tr>
</tbody>
</table>

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Recent Experiment Details (Cont’d)

- Checklist-integrated logbook

## Health, Safety, Environmental

<table>
<thead>
<tr>
<th>Safety or environmental issue addressed or status?</th>
<th>Reported?</th>
</tr>
</thead>
<tbody>
<tr>
<td>There was a spillage in department, still investigating cause of incident.</td>
<td>Yes</td>
</tr>
<tr>
<td>System was 354.</td>
<td>Filled for 3 minutes.</td>
</tr>
</tbody>
</table>

| 502 occurrences | none |

<table>
<thead>
<tr>
<th>Disabled and/or nuisance alarms</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence alarms repaired 1H51AA, 1H51BA, 1H52AA, 1H52BA.</td>
<td></td>
</tr>
</tbody>
</table>

| Emergency Shutdown Systems or Relief Systems bypassed or blocked in | None |

| MUPS™ implemented or enforced during shift. Reason for undertaking | 11PC16 setpoint alarm setting was changed from 1600 to 1400. |

<table>
<thead>
<tr>
<th>Operations</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating plan status (rates, feeds, yields, energy, special samples, etc.)</td>
<td></td>
</tr>
<tr>
<td>C4's was reduced to 0.9% as per planned request.</td>
<td></td>
</tr>
<tr>
<td>Unit was shut down due to equipment issue.</td>
<td></td>
</tr>
</tbody>
</table>

| Operating Instructions Status (special instructions, orders, etc.) | |

| Change increases, decreases, composition changes | none |

<table>
<thead>
<tr>
<th>Process changes (pipeline reconstructions, reactor start-up, etc.)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 5 (upset) was built. Note Task 4</td>
<td></td>
</tr>
</tbody>
</table>

| Process controls or instrument problems or issues (valves & tank levels) | none |

<table>
<thead>
<tr>
<th>Chemicals or product inventories and/or delivered</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals that will/will not be offloaded from previous shift. Unable to offload due to equipment issue. Stock has been sent in to avoid curfew and busy offloading.</td>
<td></td>
</tr>
</tbody>
</table>

| Inventory trends, issues, concerns | None |

<table>
<thead>
<tr>
<th>Equipment out of service, backup equipment unavailable (pumps, fans, etc.)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>P63 and P69 - not yet handled back</td>
<td></td>
</tr>
</tbody>
</table>

| Equipment control valve bypass open | none |

<table>
<thead>
<tr>
<th>Maintenance</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance work in progress / scheduled. Status</td>
<td></td>
</tr>
<tr>
<td>Still trying to repair P63 and P69.</td>
<td></td>
</tr>
<tr>
<td>$11000.00 overhead fans have been installed and handled back.</td>
<td></td>
</tr>
</tbody>
</table>

### Any new information since logbook submission
- None

### Other information not covered above
- None
Recent Experiment Details (Cont’d)

• Test plan and participants
  – 20 console operators with varying experience
    • 1 to 25 years behind DCS (median = 6.5)
    • 6 to 35 years of operations experience (median = 20.35)
    • 27-62 years of age (median = 39.5)
  – 20 operators → 10 pairs of Operator 1 & Operator 2
    • Trial A: Operator 1 hands off to Operator 2
    • Trial B: Operator 2 hands off to Operator 1
    • New integrated logbook introduced during every second trial of the day
    • Two scenarios (power failure & steam leak) alternated between Trial A & B
Recent Experiment Details (Cont’d)

- Experiment protocol

**Trial A**
- Incident: Power interruption or Steam leak
- Current Logbook Part A. Incident and unit shutdown 45 minutes
- First Shift Handover 15 minutes
- Summary of the situation 7 minutes
- Current Logbook trial Part B. Unit startup after incident 45 minutes

**Trial B**
- Incident: Power interruption or Steam leak
- Checklist integrated Logbook Part A. Incident and unit shutdown 45 min
- Second Handover 15 min
- Summary of the situation 7 min
- Checklist integrated Logbook Part B. Unit startup after incident 45 min
Recent Experiment Details (Cont’d)

• Operator test setup
Recent Experiment Details (Cont’d)

- Experienced operators were put through two simulated emergency scenarios
  - Steam pipe rupture
  - Power failure that caused pumps to fail
- The scenarios were designed to force a significant amount of interaction between the console operator, field operators, supervisor and other plant operators
- Operators had to recognize abnormal situation, shut down affected unit, and communicate status of situation to second shift operator during shift handover
- Second shift operator’s task was to understand situation and safely bring unit back into operation
Recent Experiment Details (Cont’d)

- Events of each scenario were designed to include at least one instance of each information category in the checklist-integrated logbook, thus generating a significant number of key items of information affecting unit startup during the second shift.
- Additional events, not related specifically to the checklist, were included in the scenarios to serve as distractions.
- Scenarios were designed to force a significant amount of interaction between console operator and various other plant personnel such as field operators and supervisors, role-played by senior operations engineers from the Engen refinery.
Recent Experiment Details (Cont’d)

• Data collected during experiment
  – Digital audio recording of the entire experimental session
  – Completed Shift logs
  – Still photos
  – Scripts and probes
Experiment Results

• Engen’s experiment showed the benefits to situation awareness that derive from the more structured shift handover approach
  – Checklist-integrated logbook generated higher-quality log entries compared to model logbook entries generated by Engen operations experts (+18.6%)
  – Second shift operators were able to provide more accurate and comprehensive account of the unit situation (+9%)
  – Operators were better at answering questions without the need to consult supervisors and team members (8%)
  – Structured handovers took only a minute or so longer than those conducted in less structured way (+16%)
Project Results

- Based on the experiment outcome, a structured shift log has now been rolled out at the Engen refinery.
- Although the introduction was generally successful, it revealed some key issues:
  - Structured logbook is much longer than the previous electronic logbook.
  - Acceptance of the log as a structured handover tool has not been fully entrenched.
  - Too much usage of the “Other” fields to communicate information remains.
Project Results (Cont’d)

• Engen’s ongoing change management effort will address remaining issues
  – Follow up training to reinforce behavior change
  – Development of separate shift handover report that is a distinct subset of the full reporting log
Best Practices

• Engen’s experience with the structured shift handover experiment has been used to implement the following best practices
  – Use structured shift logs clearly indicating what should be reported in the handover presentation
    • Structure shift logs around vital categories and subdivisions of information needed by incoming second shift operator
  – Set clear expectations for complete and accurate shift handovers and for individual responsibility
    • Require outgoing first shift operator to acknowledge every key category of information in the logbook during shift handover, even if no new events have occurred during his or her shift
Best Practices (Cont’d)

– Plan ahead for sufficient time to conduct a complete shift handover
– Train operators in the skill of conducting effective shift handovers and in effective two-way communication
– Emphasize to both first and second shift operators that they have a joint responsibility for effective communication of the situation
Conclusion

• Shift handovers are more effective when supported by a structured shift log based on a checklist of important categories of plant information
  – Differences are not large, but evidential statistical trends exist
  – Results are consistent across all measures of shift handover effectiveness

• Structured approach reduces risk that critical information is not communicated during a shift change

• Accurate and consistent understanding of plant situation is shared from shift to shift
Question & Answer
Thank You