

## White Paper

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## **Structured Approach to Shift Handover Improves Situation Awareness**

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## 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.

The following white paper describes a recent experiment conducted at an Engen Petroleum, Ltd. refinery in South Africa, which demonstrated how a structured approach to shift handover improves situation awareness among operations personnel at process plants.

## Background

Approximately 80% of industrial operations lack a structured approach to shift handovers. Numerous disasters have illustrated the potential consequences of poor shift handovers. A lack of structure in shift handovers increases the likelihood that critical information will be missed and misunderstandings will occur. However, the value of a structured approach has never been demonstrated experimentally (See Fig. 1).



Figure 1. Approximately 80% of industrial operations lack a structured approach to shift handovers.

There are numerous examples of disasters attributed, at least in part, to inaccurate or incomplete communication of information from shift to shift. In 1968, for example, a fire and explosion on the Piper Alpha offshore platform was attributed to poorly documented valve status. In 2002, a pipefitter was

exposed to toxic chemicals at an undisclosed facility due to poorly documented tank maintenance procedure. A fire and explosion at the BP refinery in Texas City, TX, in 2005 resulted from the failure to log shift startup procedure which, in turn, led to a flammable liquid overfill condition.

The most common causes of incidents related to shift handover include poor logbook design (e.g., lack of structure, no clear indication about what to log and how to structure entries) and poorly conducted shift handovers (e.g., lack of complete and accurate reporting, reliance on operator memory, time pressures, ineffective two-way communications).

## Recent Experiment

A recent shift handover experiment was sponsored by the ASM<sup>®</sup> Consortium and conducted by Engen Petroleum, Ltd., Honeywell, Inc. and Nanyang University of Singapore. Engen is an Africa-based energy company focused on the downstream refined petroleum products market and related businesses. The company's core functions are the refining of crude oil, the marketing of its primary refined petroleum products, and the provision of convenience services via an extensive retail network.

The Engen refinery at Wentworth, South Durban, was South Africa's first crude oil refinery when it was commissioned and has remained at the forefront of the country's petroleum industry ever since. Although the refinery has been in existence since 1954, there has been significant capital investment in new processing units, rebuilds and upgrades in the intervening years. New units and processes have been added to increase crude throughput, yields, processing efficiency and product quality, while at the same time meeting increasingly stringent environmental standards. The refinery has capacity to refine 135,000 barrels of crude oil per day (See Fig. 2).



Figure 2. The Engen Refinery at Wentworth, South Durban, was South Africa's first crude oil refinery.

The experiment at the Durban refinery compared the quality of shift handovers using a structured checklist-integrated logbook to a traditional, less structured logging approach. The tests focused on shift handover between first and second shift control room operators. A 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 (See Fig. 3).

### Safety

#### Injuries

1 person sustained minor injury due to the steam burns. Injury no 3614

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#### Incidents

Steam line ruptured releasing steam. Incident no 3245

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### Environment

2 Noise complaints received when steam line ruptured. Noise levels recorded West of the mosque: 67/68 and South of P69: 69/72.

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### BLOWDOWN

None

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### Energy

No changes.

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### People

Shift supervisor: Arnold  
 Debutaniser: Marko  
 Depropaniser: Lindi

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### Equipment

None

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### Shadowplant

#### Production Performance

Heavy feed was increased to 360 and light feed to increased to 15m<sup>3</sup>/d for ullage constraints at tankage.  
 Instrument technician took a permit to replace the positioner on 11FV19, now 11FV19 is on bypass control.  
 Debutaniser was shutdown when the steam line ruptured.  
 Permit issued to maintenance to do repairs on the steam system, so repairs are in progress.  
 Permit issued to DCS to replace the screen on TDC.  
 Chemical truck on standby to offload chemicals to the unit.  
 Borehole readings: No1 = 307803 and No2 = 704644

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Figure 3. Less structured logbook.

Engen's checklist-integrated logbook employs Honeywell's OM Pro software application for operators and others to keep an electronic record of what happens during a shift. The logbook provides operations staff with a common window to access information related to plant operations. Information from different sources is brought together to provide a consistent, up-to-date window into key operating data, problems, operating plans, shift log, etc. (See Fig. 4).

<p><b>Health, Safety, Environmental</b>                  Safety or Environmental limits exceeded or issues. Reported?                  There was an explosion in substation, still investigating cause of incident.                  3 injuries report no 3245.                  Injury no 3614                  Flared for 5 minutes.</p> <hr/> <p>SO2 exceedances                  none</p> <hr/> <p>Disabled and/or nuisance alarms                  Nuisance alarms repaired 11HS14A-F, 11HS19A-D, 11HS62, 66, 68</p> <hr/> <p>Emergency Shutdown Systems or Relief Systems bypassed or blocked in                  None</p> <hr/> <p>MOC&amp;C™s implemented or initiated during shift. Review for understanding                  11PC16 overheads alarm setting was changed from 1600 to 1400.</p> <hr/> <p><b>Operations</b>                  Operating plan status (rates, specs, yields, energy, special sample, etc.)                  C4's was reduced to 0.9% as per planners request.                  Unit was shut down due to explosion in substation.</p> <hr/> <p>Operating Instructions Status (special instructions, orders, etc.)</p> <hr/> <p>Charge increases, decreases, composition changes                  none</p> <hr/> <p>Process lineup changes (off spec product corrective actions, tank transfers, etc.)                  Tank 2[offspec] was full, Xed to Tank 4</p> <hr/> <p>Process controls or instrument problems or issues (vessel &amp; tank levels)                  none</p> <hr/> <p>Chemicals or catalyst inventories and/or deliveries                  Chemical truck still waiting to offload from previous shift, unable to offload due to explosion in substation, truck has been sent in to offload and busy offloading.</p> <hr/> <p>Inventory trends, issues, threats                  None</p> <hr/> <p>Equipment out of service, backup equipment unavailable (pumps, fans, etc.)                  P63 and P69 not yet handed back</p> <hr/> <p>Equipment/control valve bypass open                  none</p> <hr/> <p><b>Maintenance</b>                  Maintenance work in progress / scheduled. Status                  Still trying to repair P63 and P69.                  E110G/H overheads fan belts installed and handed back.</p> <hr/> <p>Preparation of equipment for maintenance (PM&amp;C™s, regular maintenance, etc.)</p>	<hr/> <p>Permits: equip locked out: instrument work, DCS system work</p> <hr/> <p>Emergency Notifications</p> <hr/> <p><b>Any new information since logbook submission</b></p> <hr/> <p><b>Other information not covered above</b></p> <hr/>
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Figure 4. Checklist-integrated logbook.

## Test Plan

The structured logbook study at the Durban refinery was based on the following test plan:

- 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 to 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

Experienced operators were put through two simulated emergency scenarios: a steam pipe rupture and

a 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. The operators had to recognize the abnormal situation, shut down affected unit, and communicate the status of situation to second shift operator during shift handover. The second shift personnel's task was to understand the situation and safely bring the unit back into stable operation.

Events of each emergency 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 (See Fig. 5).

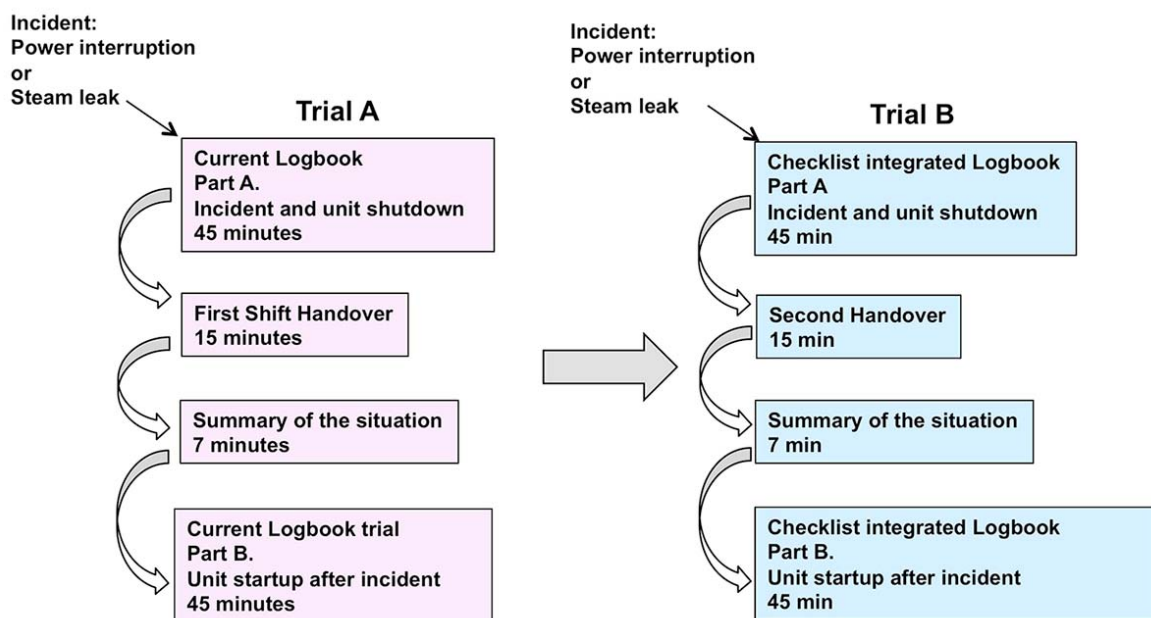


Figure 5. Experiment protocol.

Data collected during the experiment consisted of digital audio recordings of the entire experimental session, completed shift logs, still photos, scripts and probes.

## Project Results

Engen's experiment showed the benefits to situation awareness that derive from a more structured shift handover approach. The 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 a more accurate and comprehensive account of the unit situation (+9%). Operators were also better at answering questions without the need to consult supervisors and team members (+8%). In addition, structured handovers took only a minute or so longer than those conducted in a less structured way (+16%) (See Fig. 6).



Figure 6. Engen's experiment showed the benefits to situation awareness that derive from a more structured shift handover approach.

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. For example, the structured logbook is much longer than the previous electronic logbook, and acceptance of the log as a structured handover tool has not been fully entrenched. There has also been too much usage of the "Other" fields to communicate information.

Engen's ongoing change management effort will address the remaining issues among refinery personnel, and follow up training will be conducted to reinforce behavioral changes. The refinery also plans to develop a 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 operators 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
- 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**

As demonstrated at Engen's Durban refinery, shift handovers are more effective when a structured checklist of important categories of plant information supports them. The results of Engen's experiment were consistent across all measures of shift handover effectiveness. Moreover, a structured handover reduces the risk that critical information is not communicated during shift changes. This approach also ensures an accurate and consistent understanding of the plant situation is shared from shift to shift.

The Durban study found structured shift handovers do not necessarily require "more time." Structured handovers took only slightly longer on average than a less structured approach, and there were relatively low time costs for improved handover quality. The experiment did show that filling out a checklist-integrated logbook was more "time-consuming." In the real world, however, logs are updated periodically throughout the entire shift.