Structures & Floating Systems Network Technical Note

Title: Human & Organizational Factors in Facilities Design of the Future		
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Summary

Experience with high consequence accidents, involving marine and non-marine systems, indicates that approximately 80% of these accidents have their root causes in human and organizational factors (HOF). Approximately 80% of the HOF-caused accidents occur in operations, but more than 50% of these have their antecedents in design and construction. If substantial improvements are to be made in safety of marine systems, HOF must be addressed at least as well the structural and hardware aspects of these systems.

Introduction (Description of an Accident)

It was 11 p.m. on July 6, 1988, and the night shift had just taken over operations on the Piper Alpha platform. This massive island of steel, installed in the mid-70s, supported drilling and production equipment, housed up to 250 people, and at its peak produced almost 350,000 barrels of oil per day. Earlier in the day, gas being produced from two adjacent platforms and sent via pipelines to Piper Alpha placed the platform on a code red status (max. production). One of the condensate injection pumps failed, and the spare pump was turned on. But the spare pump could not inject fluids into the pipeline because it had been taken out of service; it had been blind-flanged for maintenance of an emergency relief valve by the day crew. A gas leak occurred, and the gas ignited with a deafening explosion in the gas compression module.

The crew working on the pump and the production superintendent were killed instantly. The near-by control room was devastated, and the emergency and power systems were knocked out. There was no power to activate emergency shut-in controls. Unprotected fuel storage above the gas compression module was ignited and thick, dense, toxic smoke engulfed the quarters where surviving crew members were being mustered for evacuation in life boats. In the dark and confusion, the crew members were overcome by the smoke and died. The order to evacuate never came. The crew members that were saved did not muster in the quarters. They saved themselves by jumping into the water some 100 feet below where they were picked up by stand-by boats.

Water could not be pumped through the platform fire deluge system because the pumps had been placed on manual control. This precaution had been taken to protect divers from being sucked into the pump intake. The fire fighting pumps and deluge system could not be activated due to the loss of the production control room. Due to the intensity of the heat and the explosions, a fire fighting barge that had been moored adjacent to the platform withdrew without attempting to help control the fire.

Pipes in the vicinity of the explosion and blaze softened due to the intense heat, the oil piping leaked, and more fires developed in the adjacent separation module. It had been almost an hour since the first fire and explosion. High pressure risers bringing in gas production from the adjacent platforms ruptured, and there was a blinding explosion. The emergency shut-in valves intended to prevent gas from flowing out of the pipelines were located in the vicinity of the explosion and were destroyed. Now gas from the nearby platforms compressed into the import and export pipelines dumped an estimated 900,000 cubic meters of gas into the fire. The result was total destruction of the platform and loss of 167 lives. It was a $4 billion catastrophe.

Why did this happen?

Investigation into the accident resulted in recommendations for more than 100 "organizational" changes in similar types of operations. Clearly, there were undesirable interactions between operating crews, the organizations that were responsible for the management of these crews, and the platform systems themselves.

Very similar stories of unexpected and undesirable interactions of people and marine systems are behind other marine accidents such as the Tory Canyon, Amoco Cadiz, Exxon Valdez, Braer, Herald of Free Enterprise, and the Estonia, and more recently the P-36 semi-submersible offshore Brazil. These stories testify that the majority of high consequence, low probability marine accidents have a common theme: **a chain of significant errors made by people in critical situations involving complex technological and organizational systems.** The errors involved go far beyond the individuals directly involved in the accidents. In a majority of these accidents, the **organizations** involved provide **cultures** that invite excessive risk taking, demand superhuman performance, or develop complacency that result only in reactive safety management. Excessive cost-cutting and a focus on short-term results are frequently symptomatic of such cultures. The industry, government, and public all share in providing the operating environment that permit such cultures to develop and persist. Enron is a recent example of a corporate culture that led to its own destruction.

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Facilities Design of the Future

Researchers and safety professionals in the marine industry have slowly begun to realize that most of the safety work has been done on 20% of the problem. About 80% of major accident have root causes founded in human and organizational factors, HOF (Figure 1). About 80% of these surface in operations, and more than 50% of those have their antecedents embedded in poor design and construction. Our heritage in managing safety is rooted in fixing hardware and not people and their organizations. Hardware is easier to "fix" than people and organizations.

This observation is not unique to the marine industry. A similar observation can be made about major accidents involving complex systems such as buildings, bridges, dams, nuclear power plants, airplanes, trains, and automobiles. People are the primary problem, not the systems. There is much to be learned from the shared experience of others.

To "fix" the problem, systems must be designed by recognizing the potential blindness caused by pride, the enduring trait of wishful thinking, the human limitations caused by fatigue, boredom, confusion, and ignorance, and the reckless ways of some individuals. The human and organizational elements of our systems must be engineered, built, tested, and revised just as physical elements of our systems are, and each of these need to complement the other. Systems must be designed to be people and damage tolerant (fail-safe) systems and be more forgiving of errors and flaws.

HOF issues must be addressed at the level of the individuals: selection, training, testing, motivation, and verification to a degree commensurate with the needs for safety on the job. People must be trained how to manage crises situations in the systems they operate. Reduction in complexity of tasks, improvements in personnel selection procedures, provisions for self and external checking, planning and scheduling to reduce time pressures and fatigue effects, and provision for positive incentives to achieve high quality performance can all help reduce accidents due to HOF.

A very critical aspect of improving safety involves organizational aspects. Research has clearly shown that the dominant or contributing underlying cause of most high consequence accidents relates to the organization(s) that influence the life-cycle of a particular system. The same can be said for compounding causes that allow accident initiators to propagate and escalate to catastrophic proportions. A thorough understanding is required of corporate cultures, their powers and limitations, their flaws, the incentives they provide, and their capabilities to respond in a positive manner in quickly escalating and potentially catastrophic situations. The extreme importance of effective communications in organizations must be recognized, including information collection, archiving, retrieval, analysis, and dissemination. The potential for information filtering (e.g., things are better than they really are) must be recognized. Situation awareness needs to be promoted, as well as migration of decision making to those organizational levels with the most information.

The status of ergonomics applications to marine systems is discussed in [1]. A generic human factors engineering implementation strategy is reviewed in [2]. Much pioneering research on HOF has been done at the U. of Calif., e.g., [3].

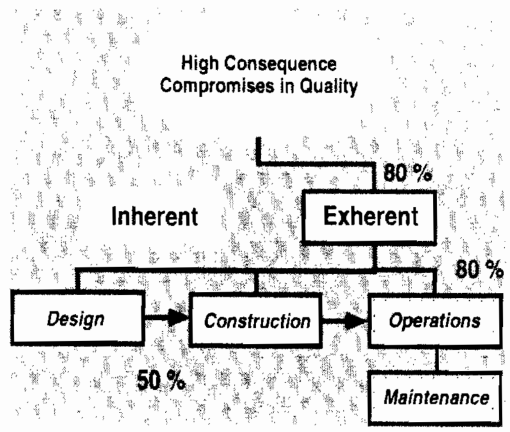

Figure 1 Lessons from the Past (after Bea)

Short and Long Term Implication

Lessons from the past need to be heeded or they will be repeated. The short term and long term implications of implementing HOF in design are more reliable operations, greater employee satisfaction, and more efficient and cost-effective operations for the company.

Conclusions & Recommendations

- Integrating HOF must be achieved for economic operations free of costly, devastating accidents.
- Evidence indicates that implementation of HOF throughout all life cycle phases of a project is necessary and cost-effective.
- Assure that BP operate confidently as a leading high reliability organization known for safe operations and protection of property, life, and the environment.

References

1. K.P. McSweeney, et al. "Revision of the American Bureau of Shipping Guidance Notes on the Application of Ergonomics to Marine Systems, " OTC 14291, May 2002.
2. D.B. McCafferty, et al., "Human Factors Engineering Implementation Strategy: A Generic Approach," OTC 14294, May 2002.
3. R.G. Bea, "HOF in Design and Operation of Deepwater Structures," OTC 14293, May 2002.

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