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Developing and Implementing a Human Reliability Improvement Program for a Multinational Petrochemicals Company

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Achieving highly reliable human performance, whether in the production and efficiency of operations, health and safety, environmental protection or elsewhere is essential to achieving the highest levels of safety, reliability and industrial effectiveness in all aspects of chemical manufacturing and associated operations. While Braskem's personal and process safety data show performance comparable with industry leaders, opportunity for improvement was identified through a focus on improved human reliability. Drawing on leading edge scientific thinking and industry best practices in Human Factors, Applied Psychology and Behavioural Science, twenty-two specific improvement elements were identified in three strategic pillars: Leadership and Culture; Fitness and Competence; and Technology and Work Systems. The pillars and improvement elements have been integrated into Braskem's corporate management system, supported by Directives and associated training. This paper summarises the work done in developing and validating Braskem's Human Reliability programme, including the rationale for the strategic decisions made.

1. Introduction

Delivering extremely high levels of production and industrial effectiveness while simultaneously achieving high levels of personal and process safety performance and avoiding harmful environmental impact, represents something of a 'holy grail' for most petrochemical companies. They are goals every company aspires to though most fall short of the ideal performance in one way or another.

Stimulated by the Deepwater Horizon incident in 2010, considered by many as the worst environmental disaster in US history, the Society of Petroleum Engineers (SPE, 2018), drew on the experience of more than 850 senior leaders in the upstream oil and gas industry, to determine what is needed to deliver the widely expressed target of "zero" incidents (i.e. no-one is injured at work, and there are no releases of toxic, flammable or environmentally damaging substances). Central to the goal of zero incidents is the widespread recognition of the need to improve the reliability of human performance. "Human error" (i.e. the opposite of "human reliability") continues to be cited as one of the main barriers to delivering on the expectation of achieving zero. Agencies such as the US Chemicals Safety Board and the UKs Health and Safety Executive regularly identify failures in the management of human and organizational factors as being significant causes or contributors to major incidents in petrochemical operations. Industry bodies such as CCPS, API, IOGP, the Energy Institute and many others have published guidance on best practices to improve human reliability in process operations. While at the same time, standards bodies, government agencies and regulators (such as OSHA, the CSB, and the UK's HSE) have set requirements about the actions and analyses operating companies are expected to take in planning, engineering and operating petrochemical plants to mimimize risk from loss of human reliability in critical operations. Reliable human performance therefore, whether in the production and the efficiency of operations, health and safety, environmental protection or elsewhere, is essential to achieving the highest levels of safety, reliability and asset integrity in all aspects of chemical

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manufacturing and associated operations. Among the recommendations made by SPE in their study of how to deliver on the expectation of achieving “zero” was to progress the application of human factors by applying knowledge and experience from more mature industries.

2. Development of Braskem’s Human Reliability Program

As an international petrochemicals company, Braskem recognises the need to set clear corporate expectations and to ensure the correct culture, organisational systems and processes are in place to lead to improved human reliability in its manufacturing operations. The company’s corporate Human Reliability (HR) program was initiated with the appointment of a corporate HR team, reporting directly to the head of corporate HES and Industrial Effectiveness. The team reviewed experience and good practices that already existed within the company, and engaged in benchmarking with external companies in the chemicals and oil and gas sectors. A particular focus was given to learning lessons, good practices and current thinking from the oil and gas industry. Both the report of the Baker Panel following the explosion at the Texas City oil refinery in 2005 (Independent Safety Review Panel, 2007) and, more particularly, the extensive investigations and studies that were initiated by the loss of the Deepwater Horizon drilling platform in the Gulf of Mexico in 2010 (for example CSB, 2016) have led to significant learning and progress in managing the contribution of human and organisational factors to the development, initiation and response to major incidents.

3. A 3-Pillar model of Human Reliability

Following internal reviews and external benchmarking, a model representing the scope of HR effort was developed during a week long workshop facilitated by a specialist external consultant (the first author of this paper). Taking account of lessons learned in the work to-date and existing experience in Braskem, consideration was given to widely used sources such as the scope of Human and Organizational Factors as they are defined by the UK Health and Safety Executive (see http://www.hse.gov.uk/humanfactors/) and the characteristics of High Reliability Organizations (Weick and Sutcliffe, 2007). Consideration was also given to research and experience emphasizing the impact that human cognition and thought processes can have on the reliability of human performance in industrial settings (Kahneman, 2011, IOGP, 2012; McLeod, 2015, 2017) as well as experience gained from reviewing many incidents through a Human Factors ‘lens’ – such as recognition of the number of incidents that are associated with front-line operators misunderstanding, or being actively misled about the real-time status of hazardous or critical equipment.
This workshop led to the adoption of a 3-pillar model comprising a total of 22 individual HR improvement elements. The 3-pillar model is illustrated on Figure 1.

Figure 1: Three-pillar model of the scope of Human Reliability

The descriptions of the pillars and individual improvement elements are shown in Table 1. In summary, the three pillars are;

1. Leadership and a culture where loss prevention and reliability are highly valued by everyone.
2. People who are fit to work, competent, properly supervised and organized, and have the skills, knowledge and motivations to work and behave efficiently and with a high degree of discipline.

3. Work systems, technology, work environments, tools and processes that are designed and implemented to be compatible with human expectations, physical and psychological capabilities and the realities of the context of environment.

The critical point of the 3-pillar model is that to achieve improvement in Human Reliability, it is essential to achieve a balanced treatment across all three pillars: Leadership and Culture; Fitness and Competence; and Technology and Work Systems. Failure to adequately attend to any one of the pillars will lead to lack of success: for example, concentrating on leadership and culture, and training and competence – while essential topics in their own right - without attending to issues relating the design and layout of equipment or to the design, format, content and ownership of procedures, will not achieve success. However competent and well led front-line operators are, and however strong the culture people work in, if equipment is designed and laid out in ways that makes work difficult or confusing, or critical procedures are technically incorrect or unable to be complied with in the real-world of front-line work, errors and non-compliances will continue to occur.

Although identifying 22 HR improvement elements may appear to complicate the subject, there is a major benefit in being clear about the risk, scope and purpose of each element. Doing so lends itself to identifying specific interventions. The alternative, which has been common in recent years, is to over-simplify the scope of HR by combining a large number of what are really individual drivers of human behaviour and performance into a small number of more abstract, non-specific themes. Indeed, it can be argued that such over-simplification is part of the reason why it has proved so difficult to demonstrate significant and sustainable improvements in human reliability.

For example, Braskem's corporate HR team took some time considering whether the two items 'Procedures' and 'Execution Discipline' should be treated as a single element, integrating the importance of complying with procedures into the wider issue of willingness, belief and attitude towards performing work in a disciplined manner. After discussion, the team concluded that it would be clearer and more practical to treat them as distinct elements, each needing a focused and tailored approach.

Table 1: Improvement elements for each of the HR Pillars

Leadership and Culture	Fitness and Competence	Design of Work Systems
Leadership	Fatigue Management	Human Factors in Design & Automation
Reporting Culture	Training and Competence	Maintenance Completion
Deference to expertise	Motivations and Incentives	Operational awareness of critical equipment
Avoiding Complacency	Supervision	Procedures
Learning and improvement	Staffing and Workload	
Personal Responsibility	Team Working	
Execution Discipline	Management of Change	
	Pre-job risk assessment	
	Critical Communications	
	Critical Tasks (Process Safety & Routine)	
	Shift Handover	

While Braskem's HR programme was initially motivated by recognition of risks associated with both personal, and process safety, it was quickly recognized that there are also significant benefits to be achieved by reducing the contribution of human error to lost production and improving the reliability and availability of equipment. Unlike some global companies however, Braskem's HR effort does not attempt to cover the full scope of Human Performance affecting all aspects of the company's activities. For example, it does not incorporate health issues unless they have a clear and direct impact on operational reliability (such as fatigue). Similarly, the programme is focused on manufacturing, and does not attempt directly to address the performance of people who are not in safety or production critical roles: it is however anticipated that many of the benefits of a focus on Human Reliability in manufacturing will generate wider impact across the company.

4. What do the topics mean? What is expected?

Central to the strategy for achieving improvement in Human Reliability, was a policy of being clear about what Braskem, as represented by its Executive leadership down, expects of the people it employs and contracts to run and support its operations and what those expectations imply in terms of corporate action. In practical terms, this involved defining as clearly and simply as possible what any senior leader in the company could reasonably be assumed to expect for each improvement element. These expectations were documented in a manner that makes the scope, purpose and rationale for each element clear.

Clarification and definition of each of the 22 improvement elements was driven by three motivations;

i. Recognizing the specific risk for each element;
ii. Being as clear as possible about what Braskem senior leadership, from the CEO down, expects to manage those risks, and;
iii. Making clear commitments about what Braskem intends to have in place to ensure those expectations are delivered in the work environment.

Taking the element of *'operational awareness of critical equipment'* as an example, consideration of numerous incidents, both internal and across the petrochemicals industry, led the HR team to recognize that *"people attempting to work on the wrong equipment, or not recognizing the state of equipment"* is a significant risk. There are innumerable examples of incidents illustrating this, both in the public domain and in companies' own records. To take just one example, the US Chemical Safety Board (CSB, 2017) reported an investigation into an incident where an offloading hose from a chemical tanker was mistakenly connected to the wrong transfer line, causing chemicals to be offloaded into the wrong storage tanks: 150 people needed medical attention and 6 were hospitalized as a consequence of the resulting toxic gas release. There are innumerable other examples of incidents reflecting this same risk associated with equipment ranging from valves, gauges, switches, compressors and the content of reactors, to information displayed on graphical displays in control rooms.

Recognition of the risk leads to a number of expectations that the company leadership must believe will be met if the risk is to be adequately managed across their operations. For this example, these can be expressed as follows;

1. No one performing hazardous tasks or critical work will have any doubt about…
   - the equipment they are to work on;
   - the state of that equipment;
   - that they are working on the correct equipment.
2. All critical or hazardous equipment will be easy to identify.
3. The status of critical or hazardous equipment will be clear.

Having identified clear leadership expectations, a number of commitments naturally follow that the company needs to ensure are met if the expectations are to be met and the risk is to be mitigated. In this example, commitments include;

1. All equipment will be easy to identify at the workplace.
2. The status of critical or hazardous equipment will be clear and unambiguous.
3. Risk assessments and procedures will recognise the potential for carrying out work on the wrong equipment or equipment in a hazardous condition.

Figure 2 illustrates this process of going from recognition of risk to HR commitments;

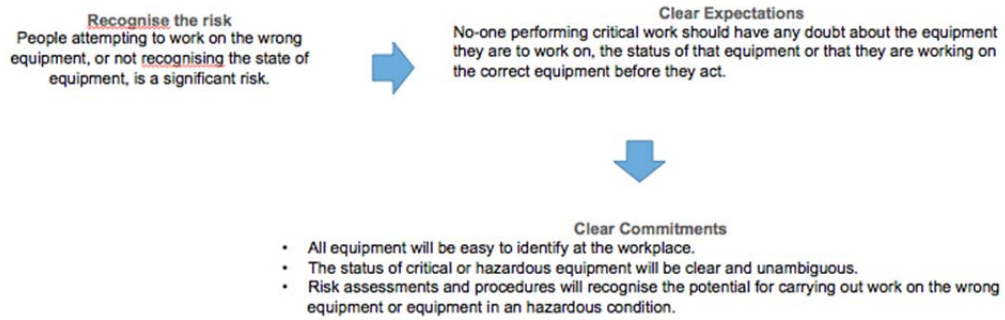

Figure 2: Deriving commitments from leadership expectations based on recognition of risk.

A similar process was followed for all 22 of the improvement elements to identify expectations that would adequately mitigate the identified risks. These have been documented in a corporate Guidebook.

5. Topic Prioritisation

While the corporate HR team recognised that the 3 pillars and 22 elements all need to be included in a comprehensive HR improvement programme, it was clear that the scope was too extensive to form the basis for a practical improvement programme. Attempting to simultaneously initiate change across 22 HR elements is clearly neither practical nor likely to have much chance of success.

A workshop was therefore conducted to identify those elements that should be prioritised as the basis of initial effort in implementing HR improvement across Braskem. The prioritisation workshop used a variation of a method reported by McLeod and Bowie (2018). Each element was assessed on a 5-point scale (where 1 meant “Disagree”, and 5 meant “Agree”) in terms of the *Practicality* of taking action to improve on that element, and the anticipated *Impact* if the effort was initiated. Table 2 summarises the dimensions used in making these assessments.

Table 2: Practicality and Impact dimensions used to prioritise HR elements.

	Practicality	Weight
Ease of Implementation	There are simple actions that are easily defined and can be implemented with little effort.	1
Resources	Little capital or resource requirement	1
Stakeholders	Few stakeholders involved.	1
Change	Requires little change from existing practice.	1
	Impact	Weight
Scope	Improvement on the element will also reduce risk in other areas.	1
Exposure	Exposure to risk associated with the element are frequent and arise in many different situations.	1
Effectiveness	There is confidence that improvement action would be effective and would have an impact quickly.	1
Expected risk reduction	The element is recognized as a risk that would benefit from improved control.	1

The corporate HR team conducted the initial prioritisation. The results were subsequently shared and discussed with representatives from Braskem’s assets through a series of one-day regional workshops held in Brazil, Mexico and the US. To achieve leadership awareness and commitment, a one day workshop was also held in Brazil attended by around 70 senior leaders immediately below the Executive level, comprising Industrial Directors, Plant Managers, and Heads of Production, Engineering and Maintenance. Results of the prioritisation exercise, as amended and validated by the subsequent leadership workshops, resulted in four topics being selected as amenable to immediate action:

- Leadership
- Human Factors in Design and Automation
- Procedures
- Fatigue Management.

In addition, while it is recognized as being more complex and difficult, the element “Avoiding Complacency” was raised so frequently both in the leadership workshops and in discussions in the corporate HR team, that it has been adopted as a fifth priority element. (Note recognizing the widespread interest, and previous work both in industry and in scientific research, the terms “Mindfulness” and “Chronic Unease” were also considered as describing this element. On balance, the term “Avoiding complacency” was adopted as being easier to understand, as well as more clearly indicating the risk and being a more direct description of the objective). Table 3 summarizes the expectations identified for these priority elements.

Table 3: Summary of expectations for lead HR elements

Topic	Expectations
Leadership	Leaders understand the significance of their decisions, actions and behavior on human reliability They possess the right knowledge, skills and attitudes. They demonstrate visible commitment.
Human Factors in Design and Automation	The design and layout of work systems and equipment allows personnel to move around, get their hands, eyes and ears 'on the job' and communicate with each other without risk to their health or safety. The human interfaces to equipment are designed to minimise the potential for human error. Automation is designed and implemented in a way that recognises the role of operators, especially the need to monitor the automation and to intervene if the automation fails.

Procedures	Procedures are technically accurate, up to-date and easy to understand and follow. Consistent with the operational realities facing front line workers who use them. "Work-as-imagined = "Work-as-done".
Fatigue Management	No one comes to work at Braskem without having had sufficient sleep to be able to stay awake and alert for his or her full shift every day. Staffing and shift arrangements ensure everyone has the opportunity for adequate sleep. Operational arrangements ensure that the risk of fatigue-induced incidents is managed to ALARP.
Avoiding Complacency	No one is complacent about safety or reliability. Everyone close to hazards or involved in planning, performing or supporting critical work is vigilant to the possibility that their decisions or actions could lead to injury or loss.

6. Conclusions

A focused effort to improve Human Reliability across Braskem's manufacturing operations has the potential to deliver many benefits, both in HES performance and overall industrial effectiveness. While there are expected to be some relatively 'quick wins' (such as improvements in the quality of labeling and signage in assets, and awareness of the importance of sleep) sustained effort will be needed over the long-term: it is a journey, not a 'quick fix'. Braskem's approach is grounded in scientific research and global best practices. It is comprehensive, based on recognition of risk and being clear about management expectations and commitments. Success can be measured, both in terms of HES performance as well as potentially via global metrics for industrial production, maintenance and reliability. Success, however, starts and ends with leadership commitment: leadership that 'walks-the-talk'; that recognizes the impact of management decisions on the front-line; that rewards the way work is executed rather than simply outcomes; and that does not let deviations from expected work discipline become normalized.

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