Human Factors issues and solutions when undertaking major projects on operational sites

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Identifying and managing human factors risks associated with major projects normally focuses on the human reliability for the operations and maintenance teams after the project has ended. This is a suitable approach for a project where construction and commissioning activities take place in the absence of process hazards on a non-operational site.

Different issues exist however where major projects are undertaken on an operational site, where construction personnel may be subject to the hazards of the operational facility. Suspending operations whilst the project takes place is rarely palatable or practicable due to the timescales involved. Ensuring process hazard risks are As Low As Reasonably Practicable (ALARP) may be relatively easy when the project and existing operations are considered in isolation, but the interfaces between the two create Simultaneous Operations (SIMOPS) risks that can be difficult to predict and manage.

Recent subsurface well intervention projects at a gas storage facility have demonstrated the benefit of using human factors to better understand and manage major project construction and commissioning risks, including the interaction between the project and existing site operations. The temporary and dynamic nature of projects means that the opportunity to engineer out construction and commissioning risks linked to human reliability is reduced compared to a permanent facility, so greater reliance is put on actions of people.

A Human Factors integration approach was adopted to consider the project construction and commissioning activities and their interaction with site operations by:

- Producing a Human Factors Integration Plan (HFIP) to identify the Human Factors studies required, aligned to project phases.
- Identifying safety-critical construction tasks from project plans and safety studies, which were evaluated in detail using task and human error analysis.
- Identifying further safety-critical activities relating to the commissioning, testing and maintenance of temporary equipment brought to site by the project.
- Undertaking a fatigue assessment on project contractor personnel undertaking safety-critical tasks.
- Assessing the human-control system interfaces and alarm management for rental packages, where alarm settings and responses may be specific to the individual project, phase of the project and even the specific activity.
- Consideration of safety critical communications between the project and operations team, such as issuing of Work Control Documents and coordination of vehicle movements.
- Assessment of Emergency Response processes, not only relating to the project activities but how these interacted with the operational site's emergency response process.

These Human Factors studies required much greater input from contractors than is typically the case but proved to be a very effective way of engaging site operators, project representatives and contractors in a constructive forum. It was clear that some contractors were not used to so much scrutiny of their work methods and procedures, but the multi-disciplined discussion that took place led to a better understanding of potential vulnerabilities and allowed practical and effective solutions to be identified. This contributed significantly to the successful implementation of the projects by avoidance of human error-related safety incidents or delays during project implementation.

Although the unique characteristics of the subsurface well intervention projects referenced in this paper may set them apart, the lessons learned on the importance of collaboration and human factors in successful project management are universally applicable. While the operating company has responsibility for its site and every right to ask for full disclosure from the project team, collaboration is a more effective approach and results in a common understanding by everyone involved. Risks at the interfaces of project and operations are complex and inevitably reliant on people. Human Factors Integration is a critical enabler for successful risk management in any project setting.

Key words: Human Factors, Human Factors Integration Plan, HFIP, Simultaneous Operations, SIMOPS, major project, temporary project, project lifecycle, construction and commissioning, rental equipment, contractors

Introduction

The importance of considering Human Factors in major projects and the benefit of developing Human Factors Integration Plans (HFIP) has long been recognised within the major hazard industries [HSE RR001, IOGP 454]. Human Factors Engineering (HFE) has emerged as a discipline that applies Human Factors knowledge to the design and construction of systems to optimise the human contribution to, and minimise health and safety risks of the system when it is in the operations phase of its lifecycle. This is hugely important because residual risks remaining after the design, construction and commissioning phases of the project have to be dealt with for many years. However, significant risks can be encountered before entering the operations phase, particularly during construction and commissioning on an existing major hazard facility. These can be sufficient to put the viability of the project in jeopardy.

Recent subsurface well intervention projects at a gas storage facility highlighted the challenges of managing the perennial risks of the 'normal' operation alongside temporary project activities. Many of the potential issues were clearly related to Human Factors and so HFIPs were developed to systematically identify threats and develop effective controls. This proactive approach led to a better understanding of the potential risks and improved communication between the parties involved, which assisted with managing project implementation.

Setting the scene

The gas storage facility uses underground salt caverns to store natural gas. The basic business model is that gas is bought, imported from the grid and injected into storage during periods of low demand. It is then sold, withdrawn from storage and exported to the grid during peak demand periods. It helps to balance supply and demand, especially during periods of increased gas usage (typically cold weather) and revenue is generated by price differentials. Gas storage sites operating in the UK are covered by the Control of Major Accident Hazard (COMAH) regulations due to the hazardous inventories involved. COMAH historically emerged from the EU SEVESO directive.

During plant construction the subsurface caverns were created by leaching voids in a salt layer approximately 1800 metres below ground level. The ability to inject and produce gas to/from the cavern is achieved by fixing casing and tubing between the reservoir and surface, with a wellhead assembly creating an interface with surface plant. Most of the equipment is recognisable to anyone familiar with process plant but some, including critical subsurface safety valves, is more specialised. The primary hazards relate to storage and processing of large inventories of flammable gas at high pressure (>200 barg). Maintenance and upgrading of the equipment has some specific challenges.

It is not feasible for operating companies to retain all the skills required for work on subsurface and wellhead plant. Specialist contractors are available that generally work globally. Although gas production and storage facilities have many similarities, the arrangements at each site are unique, and gas storage is a less common application.

Simultaneous Operations

Gas storage operations and subsurface intervention projects are both high hazard undertakings in their own right. Conducting both in close proximity has the potential to increase risks of both. Stopping operations whilst the project takes place is rarely feasible. Also for the project to be financially viable, the main hazard (natural gas at high pressure) would remain both in the storage caverns and the external gas grid and therefore will not be a fully inherently safe solution.

It is recognised that the existing operation and the project each being able to manage their own risks in isolation is not sufficient to address the potential interactions between the activities or escalation of events from one area to the other. This is particularly the case for complex activities that can be difficult to predict and manage. The requirement for Simultaneous Operations (SIMOPS) procedures has been recognised in high hazard industries to provide a proactive and coordinated approach. The procedures typically provide guidance on:

- Risk Assessment and planning;
- Communication and coordination;
- Demarcation and zoning;
- Cross referencing of work control documents;
- Continuous monitoring and review;
- Emergency Preparedness.

Human Factors of SIMOPS

It appears that Human Factors in SIMOPS is an area that has received relatively little attention. One reason for this may be that the level of adoption of Human Factors at permanent facilities has yet to be replicated by companies that are involved in temporary project work, especially when they work globally. However, it is easy to see that many of the concerns about SIMOPS are directly or indirectly related to Human Factors. Also, the temporary and dynamic nature of projects means that the opportunity to engineer out construction and commissioning risks linked to human reliability is reduced compared to a permanent facility, placing a greater onus on people involved in the project. This also leads to the situation where arrangements that are baseline expectations and considered acceptable and appropriate for the permanent plant and operations to achieve risk that are As Low As Practicable (ALARP) are not necessarily aligned with expectations for the temporary project.

Developing a HFIP

In-house guidance on developing a HFIP required that potential Human Factors risks for all significant projects should be identified and evaluated. Elimination through design should be the aim wherever possible, whilst ensuring transfer of risk is avoided (i.e. replacing one risk with another). Residual Human Factors risks should be identified and methods of control shall be demonstrated as achieving ALARP.

The guidance identified the following minimum contents for a HFIP:

- Focus on Human Factors issues that are known to contribute to major accidents;
- Identify constraints on the ability to optimise Human Factors Integration;
- Plan Human Factors studies for key stages of the project;
- Identify dependencies to and from other development activities;
- Ensure user involvement;
- Monitor progress against the plan; and
- Create a forum to optimise between the ideal and practicable solutions to problems.

The guidance is primarily aimed at Human Factors risks in the operational phase of projects. However, it was noted that there was no equivalent guidance for construction and commissioning phases. The basis of this paper is the application of this guidance and the development of an HFIP for major projects.

Initial screening

Based on experience from addressing Human Factors at the gas storage facility, including more routine well intervention work, it was decided that some formal evaluations would be required for two planned major projects. One of the drivers for this was the recognition that the projects in question would create temporary operations teams, which would be operating alongside permanent operations. It was clear that the temporary teams would have significantly different experience, procedures and expectations compared to the permanent team. However, the operating company would ultimately be responsible for their actions.

Initial screening was carried out based on high-level plans for the projects. Human Factors topics that should be a priority requiring formal study were identified. They included:

- Task and human error analysis of safety-critical tasks – identified from project plans and other safety studies covering construction, commissioning, testing, maintenance and operations activities expected to be performed during the project;
- Safety critical communications between all parties involved, including issuing of work control documents, and team and shift handovers;
- Fatigue risk management;
- On site Performance Influencing Factors (PIF);
- Human Machine Interfaces (HMI);
- Alarm management;
- Emergency response;
- Staffing arrangements.

From this list of priority items, a series of workshops was arranged, with key personnel from each of the relevant parties involved. It was immediately apparent that this would involve a much greater level of input from the contractors than is typically the case as they were responsible for the specification and selection of much of the equipment and responsible for its operation on site. It is fair to say that in most cases this was the first time that they had been engaged in these workshops with their client; and probably the first time they had been involved in formal Human Factors studies.

Findings and observations

The following summarises some of the learnings from Human Factors studies carried out as part of the projects.

Critical tasks and procedures

It was possible to develop a fairly detailed HFIP in the early stages of the projects because clear and detailed plans had been developed to engage with contractors who needed to identify the equipment they would need. When asked, contractors were able to provide procedures for most of their tasks.

Tasks identified in the HFIP were classified as being related to a Major Accident Hazard (MAH) or not. The MAH tasks were then ranked, with criticality (high, medium, low) assigned using a scoring system based on guidance from HSE [OTO 092/1999].

Although the projects involved work that was mostly quite standard for the contractors, there were some unique aspects. The result was that contractors did not have suitable procedures for every task, including some that had been ranked as being high criticality. What was not clear was when and how the required procedures were going to be developed. Without identifying this via the HFIP it is entirely possible that the task method would have been developed 'on the hoof.'

Task and human error analysis was carried out for the high criticality tasks. It proved to be effective at reviewing task methods and planned risk controls, highlighting numerous minor discrepancies but few significant concerns. However, it was noticeable that terminology in procedures was sometimes quite ambiguous. For example, one procedure specified actions to take when certain equipment was shut down during the project. The actions depended on the type of shutdown (e.g. short vs long term), without clear definitions. Different groups of people were likely to interpret this differently and it could have led to equipment being left unattended for indeterminate periods, exposing operations to increased risk. The agreed solution was to consider an extended shutdown as being any case where responsibility for the plant and process was surrendered by the contractor to the permanent plant team, noting that until it was surrendered there would be full-time contractor oversight.

Another issue was the occasional use of colloquial terminology in procedures. In one case a step said to “gag in” a pressure transmitter if the pressure was seen to be dropping. When this was probed during the task analysis it became clear that this was an informal way of overriding a low-pressure trip, and the instruction could be interpreted as saying that avoiding a trip due to low pressure was more important than investigating its cause. Use of informal language left room for misunderstanding and compromised the clarity and safety of some procedures. Identifying and investigating this issue allowed potential causes of the trip initiating to be addressed in the procedure and the likelihood of it happening minimised. This investigation also highlighted that the standard contractor design included trips which were not necessarily identified through the project hazard identification risk assessment processes. On the one hand this could be seen as a positive - the project benefits from the experience gained by the contractor on other projects. On the other hand it demonstrates that the equipment can be used for a wide range of applications and all the features are not necessarily required or helpful in all circumstances.

Control of work

Although the project site was segregated from the operating site, project work was being controlled by the site’s normal safe systems of work. There was going to be an inevitable increase in workload for the operations team.

It had been a key objective during planning to adopt inherently safer task methods where possible. This reduced the number of safety documents that would need to be issued. As an example, wellhead completions at the site are located in cellars, meaning a confined space entry is required to undertake work on them. The Human Factors studies were able to assist with minimising the number of entries required. By adopting inherently safer practices, it was possible to reduce the requirements for Confined Space Entry certificates.

Even with good planning, the number of work control documents required by the project could have been significant. During Human Factors studies, the operations team reported previous experience that contractors often assumed that work control documents could be obtained at any time on request, resulting in delays to the project or disruption to other activities. Identifying requirements in advance and better communication of the schedule allowed the operations team to manage staffing resources with the workload created.

Vehicle movements on site was another aspect of the project where SIMOPS coordination was important vs. other operational, maintenance and project activities. Provision of a vehicle holding area near to but outside of the main site meant that vehicles could be brought onto site at a mutually agreed suitable time, rather than having to be dealt with as and when they arrived.

Safety critical equipment

It was clear that the temporary equipment used by the project did not always have the Safety Instrumented Systems (SIS) and other safety critical equipment that would be expected at a permanent operational site. This inevitably resulted in higher reliance on human monitoring and response, which was captured via the Human Factors studies. For example, the high pressures of gas in storage leads to potential for low temperatures downstream of choke valves as a result of the Joule-Thomson effect. During phases of the project where high pressure gas was being vented the project’s operations team would be monitoring using fixed gauges and handheld infrared devices. A SIS would have been preferred but difficult to justify by cost vs. benefit due to the short duration of risk exposure. Although not ideal, identifying this risk did create higher awareness and scrutiny of the activity.

Despite there being fewer automated safety devices on the project equipment when compared to the permanent facility, there were trip systems, mechanical safety devices including Pressure Safety Valves (PSV) and some critical non-return valves (NRV). The HFIP identified functional testing of safety devices as critical tasks. Discussion with the contractors identified that this was not an activity they carried out routinely. They were usually satisfied that components were tested and certified before transport to site; and did not plan to carry out formal tests of overall system performance when installed. This did not sit easily with the operating team, especially for some of the more sophisticated equipment being used in the projects. There has been significant learning about design, installation, commissioning, maintenance and testing of safety systems over recent years that has not yet filtered through to the temporary projects.

Alarm management

Alarm management was another factor where expectations for permanent operational sites were not matched by temporary project equipment. One of the challenges was that many of the alarms were fixed by the Original Equipment Manufacturers (OEM). In many cases they were not aligned to the alarm philosophy for the permanent operating site or latest standards or guidance [BS EN 62682], [EEMUA 191]. However, the package systems and associated alarms were familiar to the contractor operators and so making changes would introduce potentially significant risk (and was impractical given timescales).

Further analysis found that according to latest standard and guidance some would actually be considered to be ‘Alerts’ only and so less of a concern. Others would be considered to be ‘Highly Managed’ and require a higher level of scrutiny.

Looking at the configured alarms in detail identified a number of different types, that were not immediately apparent. These included:

- Fixed alarm (absolute) – activated at a defined set-point based on design information;
- Fixed alarm (requiring local set-up) – activated at a defined set-point that is determined during initial commissioning of the system on site;
- Adjustable – activated by a datum setpoint that is defined at steady state and liable to change at different stages of the project;
- Deactivated at times – alarms are active for some stages of the project but deactivated for others.

One particular concern raised as a result of this analysis was that some alarm set points would be adjusted during the project with no formal record or approval. In some cases, the setpoint was determined by the operating conditions at the time, which could compromise the alarm's contribution to safety. The solution in this case was to identify in the project plans which set points could be changed and when; and to have a formal record of each change with a mechanism for approval.

Critical communications

All parties had identified communication as being critical, with telecommunications devices set-up for continuous communications and plans in place for regular meetings. The Human Factors studies highlighted that terminology and potential ambiguity were a concern due to different backgrounds of people involved. Project and operations personnel misunderstanding the importance of information being exchanged could result in under or over reaction to events, including emergencies. One way of reducing risks was for project personnel to attend the operational team's daily morning meeting and weekly maintenance planning meeting to ensure that each team had a good understanding of the other's plans, and to identify and address potential SIMOPS issues.

One specific example where ambiguity could create risk was action taken to clear a low-pressure trip, which was required to allow plant start-up. The more long winded but safer approach would be to fill and pressurise pipework so that the trip would be healthy. However, without defining the action to be taken it was easy to give the impression that overriding it was acceptable or even required. The solution in this case was to expand the procedure to specify clearly how the trip was to be cleared.

Fatigue management

There was a significant difference in accepted working arrangements between the operations and project teams. Both work 12-hour shifts but contractors were often happy to work three (or more) weeks without a break. Further discussion highlighted that on top of this there was very little control over what people were doing immediately before starting on the project or how far they would be travelling to get to site. On top of this, contractors did not expect to formally review the actual hours worked by their personnel or assess any changes including overtime for fatigue risks. In this case contractors were asked to ensure sufficient personnel were made available to allow them to manage fatigue risk effectively and to monitor hours worked.

Emergency response

The contractors all had emergency plans with good overall coordination that would have been effective for a stand-alone project. Interfaces with the operating site were not so clear. Assumptions had been made on both sides that that were not always valid. Muster coordination was one particular activity where roll call of project personnel and communication to the operating site may have been compromised at times. Coverage for full site emergencies affecting both the operating and project plant was particularly difficult to address.

Communication during emergencies highlighted potential issues with terminology and understanding. Some well control events may be labelled as emergencies by the contractor based on the impact to project cost / schedule but not create an immediate threat to personnel, whilst others could escalate rapidly and so an immediate plant shutdown and evacuation would be required. The creation of standard messages to be used in emergencies was identified as a way of reducing the potential for confusion. Emergency exercises were built into the early stages of the project plan to ensure that processes were tested and any learning identified prior to the main activities taking place.

Reviewing the operating site's emergency arrangements highlighted that people may be involved in the response who would not be located on site and may not be familiar with the project. These included the operating team at a sister site that would act as 'Silver command' in a serious emergency, providing tactical support; and duty managers who would provide out of hours cover. Informing them of the project activities and updating them with status and plans, specifically prior to weekends but also in advance of critical project activities, was identified as a requirement.

Site visit findings

A key requirement of Human Factors studies is an evaluation of the circumstances that increase the likelihood of human error. A site visit was carried out to evaluate these Performance Influencing Factors (PIF) towards the end of equipment set-up, before initial operations were due to start.

General arrangements across the site were found to be neat and tidy, which was commendable given the complex and dynamic nature of the project. Equipment was arranged in a logical and accessible way, with good walkways and platforms provided for elevated items.

It was found that multiple contractors were working together as a single team. There had been good work on communication that was expected to be effective into the operations phase. Most people working on the project were very experienced in their given job and some were familiar with the site from previous projects. In fact, some had been actively involved in the original development of the site and possibly knew more than about certain aspects than some employees from the operating site.

Work areas, including portable cabins used as offices and control rooms, fell short of what would be expected of a permanent facility but were generally considered to be fit for purpose. Labelling of valves and other items was variable, but in most cases all critical items were labelled, and others could be identified easily by their relationship with other items of equipment.

Some detailed observations were made that caused some concern. They included:

- Two PSVs with different settings, with a valve arranged to allow the duty PSV to be selected depending on the activity taking place. There was no locking mechanism on the manual valve or labelling regarding its operation.
- Open ends on pipework were observed, with reliance on manual valves to prevent releases. This was not consistent with policies applied at the operating site, where open ends expected to be plugged or blanked.
- A mobile pump had been located outside the defined hazardous area and assumed to be acceptable. However, the site had specific rules for all mobile equipment related to control of ignition that were not being complied with.
- Filling an open tank was planned using a hose dangled over the side. Manual handling issues were apparent and an alternative method would have significantly reduced the risk of harm to personnel;
- The contents of tanks were not displayed on prominent labels. Some would be hazardous, and so a lack of labelling could cause issues in an emergency.

This snapshot of PIFs was a useful exercise and highlighted some minor issues that could be resolved quite easily.

Discussion

This paper came about because of a realisation that risks of temporary projects being undertaken at operational sites may not always be appreciated fully and the safeguards put in place may not always be fully effective or practical. It was noted that many of the issues are related to human performance and so some of the techniques available in the Human Factors toolkit may be useful for highlighting potential issues and developing effective solutions.

Benefits of HFIP

Traditionally HFIP have been developed during the concept, engineering and design stages of projects for permanent facilities, with the scope limited to the risks of the operational phase. The aim with this paper has been to demonstrate that there are benefits from a similar approach applied to construction and commissioning phases of projects. Whilst the case study applies to temporary projects it seems likely that the benefits apply equally to construction and commissioning of permanent facilities.

Developing HFIP allowed potential issues to be identified early enough in the project to make a difference and created a constructive dialogue between all parties. Generating HFIP was not an onerous activity and whilst the follow-up studies and analyses did require resource there was a general agreement that the benefits for all involved made this worthwhile.

HFIP are not a silver bullet because the dynamic natural projects makes it difficult to consider every human factor at every stage of the project. The site visit that took place provided a useful snapshot of the working arrangements (PIF) but a more complete solution would require ongoing evaluations to become an integral part of the overall day to day project management.

Findings related to subsurface well intervention projects

It is fair to say that well intervention projects used as the basis for this case study are more hazardous than most. This is beneficial in some ways because the specialist contractors used have a good understanding of the potential issues of their own activities and an appreciation of the hazards being handled on the operating site. However, most work globally and may expect to conduct their work in the same way each time; and may not be fully aligned to the rules and procedures of the operating site or appreciate local regulations and expectations.

Well intervention projects are clearly complex and dynamic to the outside observer but seem normal to the experienced personnel working for specialist contractors. Operating companies tend to exhibit a natural inclination toward risk aversion, prioritising the mitigation of change and uncertainty more than is feasible for construction and commissioning tasks, which encounter new challenges on an almost daily basis.

The well intervention sector is very aware of the safety implications of what it does and employs a wide range of safeguards. Ensuring more than one barrier is in place at all times has become the “two barrier mantra” that may not always reflect the fact that not all barriers are equal. Technology and higher expectations are contributing to increasingly sophisticated safety critical devices being used, introducing additional opportunities for error at design, construction, initial testing, transportation, installation and commissioning. There is a clearly a balance to achieve between reducing reliance on human reliability to manage safety vs. introducing technology that is inherently complex. A key observation is that the balance point is significantly different for projects and operating sites.

Findings related to projects in general

Many of the observations made as a result of the case study apply far more widely than temporary subsurface well intervention projects. Any project introduces hazards and the SIMOPS element when conducted at an operating site can increase the risk for both project and operating site. Cultural differences between contractor and operating company, attitudes to process safety systems (e.g. control of work, management of change), approaches to personnel management (e.g. competence, fatigue) and application of the hierarchy of risk control all affect risk perception and influence decision making. The opportunity to engineer out construction and commissioning risks linked to human reliability is reduced compared to a permanent facility, so greater reliance is put on what people do. However, competing priorities can lead to project teams multitasking, with its associated distractions.

Whilst managing risks of SIMOPS has been recognised by high hazard industries it appears that human factors may not have been fully recognised. The result is that baseline expectations for risk management for construction and commissioning are not aligned with operating sites.

Conclusions

Companies handling major accident hazards have legal and moral obligations to manage and reduce risks to As Low As Reasonably Practicable (ALARP). Human Factors have been identified as making a critical contribution. Over recent years, effective approaches have emerged to manage the associated risks. Experience from the well intervention projects referred to in this paper highlight that this has not yet filtered through to temporary projects. This is a concern because in many ways the activities being carried out are higher risk and rely on human actions and vigilance more than the associated operating site. Also, events at either the operating or project sites can affect the other. The temporary nature of projects may reduce the time at risk but the overall risk to everyone involved at the time is higher than normal.

While it may be possible to delegate some responsibility for project activities on a major accident hazard site to contractors, the site operator ultimately retains accountability for how risks are managed at the site. The site operator therefore needs to ensure that the contractors are identifying and managing their risks to ALARP, including Human Factors-related risks, while recognising their competency and expertise in these matters.

Delegating responsibility for project activities to contractors may appear to be a neat solution for the operating company but does not reduce exposure to risk. Ultimately, if a major accident occurs on a site whilst a project is taking place it will not really matter whether it was initiated by normal operations activities or something happening on the project. It will be the operating company's reputation on the line, and subsequent allocation of responsibility through the courts will not make up for loss of production and profitability. Subsequent allocation of responsibility through the courts will not make up for any impact on individuals, the environment, production or profitability.

The Human Factors studies carried out as a result of the HFIP were effective at highlighting potential issues and means of managing the risks. Input from contractors proved to be a very effective and Human Factors studies were effective at engaging everyone involved including site operators, project representatives and contractors in a constructive forum. It was clear that contractors were not used to being asked in so much detail about how they planned to carry out their work and there was often reluctance to engage where they could not see the benefits, or appreciate the project concerns. However, the multi-disciplined discussion that took place led to a better understanding of potential vulnerabilities and allowed practical and effective solutions to be identified in an open and constructive forum. It was noted that many of the risk controls used during construction and commissioning activities are similar to those employed at operating sites. Equally, some are quite different and a better understanding those differences can assist with effective communication and collaboration.

The hierarchy of risk controls suggest that we should implement engineered solutions instead of relying on administrative controls (i.e. procedures and human vigilance). This encourages wider use of automated systems that operate without human intervention, but can be vulnerable to human errors in other non-operational aspects (e.g. design, installation, maintenance and testing). For permanent installations the risk reduction achieved by these systems can be significant, easily outweighing any risk from the non-operational tasks. For temporary projects the time at risk is less, reducing the benefits of safety systems accordingly. Also, reliance on rental packages designed for a variety of applications significantly reduces the opportunity to select the optimum solution. The result is that fewer safety controls are automated and more reliance is placed on human performance. How this sits with the generally accepted approaches to process risk management is not clear.

Although the unique characteristics of the well intervention projects referenced in this paper may set them apart, the lessons learned on the importance of collaboration and Human Factors in successful project management are universally applicable. There is always an expectation that project teams will be honest and disclose what they know about potential risks and how they will be controlled, a collaborative approach is a most effective approach because it results in a common understanding by everyone involved. One of the striking features of temporary projects is that there are far fewer opportunities to develop and refine risk controls compared to a permanent operating facility. This actually strengthens the case for increased scrutiny at the planning stage of projects, which historically may not have taken place.

Risks at the interfaces of project and operations are complex and inevitably reliant on people. A different perception of risk between operating companies (typically risk averse) and specialist contractors (accepting of risk) can make it difficult to achieve a shared and objective understanding of what is at stake and what has to be done to achieve risks that are ALARP. The case study referred to in this paper suggests that formalised Human Factors Integration can be a critical enabler for successful risk management in any project setting.

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