Linking task analysis with other process safety activities

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Task analysis is not new and it has been used in the process industry for many years. But a growing interest in human factors means that the methods and approaches being used are coming under increased scrutiny. Companies are particularly keen to ensure that they maximise the benefits they get from the effort they put in to carrying out task analysis; and they want to integrate task analysis with other process safety activities.

This paper will propose a method that:

- Uses an engineering approach to identify tasks in a systematic and logical way;
- Identifies the most appropriate analysis method to use for different types of task;
- Creates direct links between task analysis and other process safety methods;
- Gives reassurance that all relevant tasks have been considered.

The basis of the method is to examine process parameters (e.g. level, pressure, temperature) and consider what human tasks will be performed at different points across its possible range. These will include elective tasks (i.e. performed to create a rise or fall in the parameter), responsive tasks (i.e. responding to a rise or fall) and maintenance.

The main aim of the proposed method is to ensure the most appropriate methods are used according to the type of task. This will help companies to determine what approach they should take to address the risks of different types of task; and to demonstrate that they have carried out suitable and sufficient assessments.

Keywords: Task Analysis, Process Safety, Risk Management, Human Factors

Introduction

Task analysis is a formal method of describing and analysing actions performed by people. It started to be used in the early 1900s, and from the 1940s played a key role in helping to understand the relationships between people and technology. In the 1960s a method known as Hierarchical Task Analysis (HTA) was developed, which proved to be particularly practical and effective (HSE 2012). When combined with a formal human failure analysis HTA is usually considered to be the default method when assessing human factors in the field of process safety. The UK's the Health and Safety Executive (HSE) has promoted its use in the management of major hazards since the early 1990s. However, people have not always had good experiences of task analysis; often because it has been applied to the wrong types of task or the wrong approach has been taken.

Unfortunately, the study of human factors in the process industry has often been carried out as a stand-alone exercise. This means that completed task analyses have not always achieved their potential impact. Too often the people able to drive improvement have not been involved in the assessments or failed to take ownership of the outcomes. Also, the human role in accident causation and prevention has often been misapplied during process safety studies because the people carrying out these studies have not had sufficient understanding of human factors. There is little doubt that a more joined-up approach is beneficial in both improving the way risks are managed and reducing the effort involved in performing safety studies.

The good news is that in recent years the benefits of studying human factors have started to be recognised more widely. Whilst entirely welcome, it means that human factors practitioners are coming under increased pressure to adapt their ways to fit more closely with other process safety studies. Also, the outputs of studies are coming under more scrutiny. Human factors has started to move from a niche, sometimes considered to be of relatively low priority, to a more integral part of the process safety agenda. A consequence of this is that people are starting to ask more searching questions about task analysis. They include:

1. How do you identify tasks in a systematic way?
2. Which tasks should be subject to formal analysis (i.e. HTA and human failure analysis)?
3. What should be done with other types of task?

This paper aims to present a method that answers these questions. It proposes that a more 'engineering' approach that links with other process safety methods is likely to be beneficial because it achieves a better understanding of all risks and how they can be controlled. Also, it improves buy-in of non-human factors practitioners, which is important as it is operators, engineers, plant managers etc. who can contribute most to the task analysis process and are able to implement the outcomes and hence improve the management of risks.

Identifying tasks to analyse

There is a general consensus that formal task analysis should be applied to tasks considered to be "safety critical." This makes perfect sense as you want to spend your time and effort on the tasks where you are likely to get the greatest benefit with regard to reducing risks and improving safety. However, there are a number of stumbling points:

- The term 'safety critical' is used rather loosely and applied in many different ways;
- At a major hazard facility it can be argued that a very high proportion of tasks performed on site are potentially safety critical;

- Tasks come in many different forms and they do not all lend themselves to formal task analysis.

This has led to some confusion, with people not being clear about what tasks they should be analysing or what analysis methods they should be using. In some cases the method has been discredited because people feel that they have 'wasted' a lot of time and effort for relatively little benefit. In other cases the analyses have been perfectly appropriate and adequate but the company has failed to follow them up or implement recommended actions. Using a method of identifying tasks that is closely linked with other process safety methods can help to avoid these problems.

How do you develop a comprehensive list of tasks?

In the early stages of implementing task analysis people are generally happy that something is happening (i.e. they are not too concerned which tasks have been analysed). However, as human factors is becoming a more integral part of the wider process safety agenda people want to understand the basis for deciding which tasks have been analysed; and want reassurance that all necessary tasks are being covered and that the work has been prioritised appropriately.

Methods exist (e.g. HSE 1999 and Energy Institute 2011) to prioritise tasks for analysis, but these rely on a comprehensive list of tasks being available. There is little guidance available about how to identify tasks in the first place.

The existing procedures at a facility are often used as a starting point for identifying tasks. Companies feel that they set an objective to write a procedure for every task and so this should generate a comprehensive list of tasks. Unfortunately, experience shows that procedures cannot be written for every type of task; and the reality is that companies often have fairly significant gaps in the procedures that they have written.

Watching people work and asking them to list tasks is useful at filling some of the gaps in task lists. However, it is most useful for the routine and frequently performed tasks whereas the ones of most interest from a task analysis perspective are often the ones performed infrequently or in a response to a condition or event, which means they are unpredictable. The approaches being used are little more than brain-storming and sometimes lack enough structure to form an adequate demonstration that an appropriate method has been applied.

Using Process Safety Studies as the starting point

HAZID and HAZOP are well established methods that are likely to be performed for most significant new projects in the process industry, and may have been applied retrospectively for some quite old facilities. Linking the task identification process with these can potentially reduce the work required, but more importantly integrate human factors into process safety more effectively. Also, although reliant on the knowledge and skill of the people involved, the methods are considered to be structured and systematic, which is something that has been lacking from the human factors approaches. This paper explores the possibility of using HAZID and HAZOP as the basis for identifying tasks requiring formal analysis.

Common features of HAZID and HAZOP are that they consider process parameters and use guide words to prompt consideration of consequences of possible deviations. For example, the possible deviations for the pressure parameter include:

- More – high pressure;
- Less – low pressure;
- None – no pressure or vacuum.

Hazard Identification (HAZID) Studies

HAZID is an effective method of identifying hazards and performing a qualitative assessment of risks and controls. The use of guidewords provides a degree of structure. Reading a HAZID study report before starting a human factors study or task analysis is a useful way of obtaining a high level understanding of hazards, potential consequences and risk controls. Also, extracting more detailed information about the process events that can lead to major accidents is useful for prioritising analyses and integrating the findings into the wider process safety agenda. For example, if the HAZID identifies that overpressure is a hazard that can lead to a major accident, it makes sense to prioritise tasks that are carried out to increase pressure in a system, achieve control or are performed in response to a pressure excursion.

It has been observed that guidewords such as 'human error' or 'human factors' have been introduced to HAZID studies. This appears to be a good way of ensuring human factors are considered. However, the nature of HAZID and the background of the study participants sometimes mean that the treatment of human factors is not consistent with latest understanding and guidance. Identifying this from a HAZID study report is a good way for a human factors practitioner to gauge the maturity of human factors within an organisation, which can be useful when putting plans together.

Hazard and Operability (HAZOP) studies

There are a number of features of a HAZOP study that can be used to structure the identification of tasks. They include:

- The plant nodes used during the HAZOP can be used to group tasks;

- The consequences of deviations identified in the HAZOP as being potential major accidents can be used to prioritise the task identification;
- The causes of deviations considered in the HAZOP and certain safeguards can be linked to tasks performed by plant personnel;
- The process parameters related to the deviations can used as a basis for identifying tasks related to planned changes, control and response to an excursion;
- Using consistent causes and consequences in both the HAZOP and task analysis studies helps the integration of human factors into the process safety agenda.

Proposed Method

The following steps map out a high level approach that uses information from HAZID and HAZOP to guide task identification and analysis:

- Use the HAZID to identify the process parameter considered to be most critical with regard to major accident potential;
- Identify the HAZOP nodes where the critical parameter has been identified as most relevant;
- Identify the deviations linked to possible major accidents in the HAZOP;
- Identify any tasks referred to in the HAZOP as either causes of a deviation or suggested as a safeguard;
- Use the information gained from the steps above to identify the tasks associated with changing, controlling or responding to process changes;
- Identify other human tasks associated with the HAZOP node;
- Carry out formal task analysis as deemed appropriate using information related to causes and consequences extracted from the HAZID and HAZOP;
- Cross check the findings of the task analysis with the HAZID and HAZOP to ensure consistency and identify any gaps.

This approach is illustrated in more detail below.

Example of how to identify tasks

As described above, HAZID and HAZOP studies can be used to identify the process parameters of most interest from a process safety perspective. This section demonstrates how a focus on a chosen parameter (in this case pressure) can be used to identify tasks in a structured and systematic way.

A simple plant cycle

Diagram 1 illustrates a simple plant cycle. With the plant shutdown and pressure at zero (i.e. atmospheric) it would require a human intervention to create more pressure, which would be an intended outcome of the plant start-up. Having achieved the target or normal pressure, it is likely that there would be some variation, which could be as a result of operator action as well as automated control. There may also be attempts to optimise the process, which would normally mean the pressure variation would be reduced as the aim becomes to operate to a tighter specification. The final stage of this planned sequence would be shutdown, where the pressure is returned to zero.

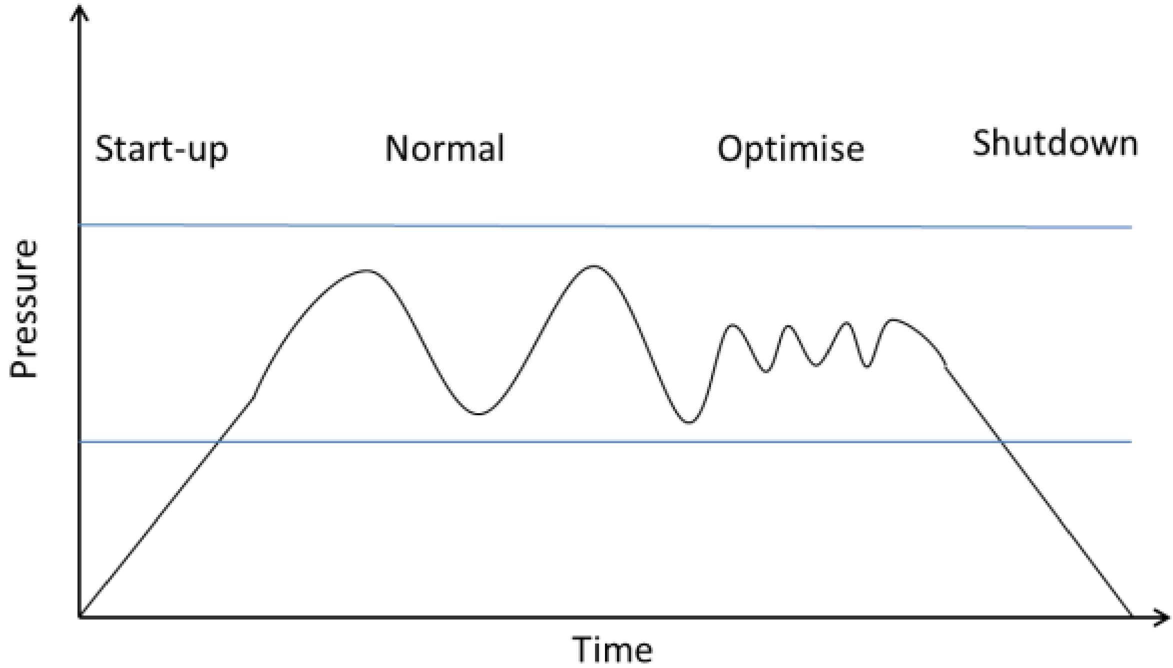

Diagram 1. Planned parameter changes

Based on this sequence of events we can identify four tasks:

1. Start-up - increase pressure from zero to normal range
2. Control – make intervention to keep pressure within its normal range;
3. Optimise – continue the control task, but to a tighter specification;
4. Shutdown - decrease pressure to zero.

Identifying other 'normal' operations tasks

Having identified the simple operating cycle it is important to consider whether there are situations that may mean additional tasks are required during the control and optimise stages. Issues to consider include upstream and downstream deviations (i.e. changes to what is entering or leaving the node) and deviations to components within the node. If any of these require more than the already identified control or optimise tasks, it is necessary to add the additional tasks to the list. They may include starting or stopping equipment to keep the pressure within the desired range whilst changes occur upstream or downstream; or changing over equipment within the node for technical reasons (e.g. allow servicing, managing running hours).

Also, it is important to recognise that a node may have several modes of operation where the pressure may change because of different requirements (e.g. change of product, stages of a batch operation). Again, if these changes of mode require more than the already identified control or optimise tasks, they should be added to the task list.

Unplanned operations deviations

Having identified the planned and/or normal operating tasks it is necessary to consider unplanned changes or deviations. Diagram 2 provides a representation of what can occur.

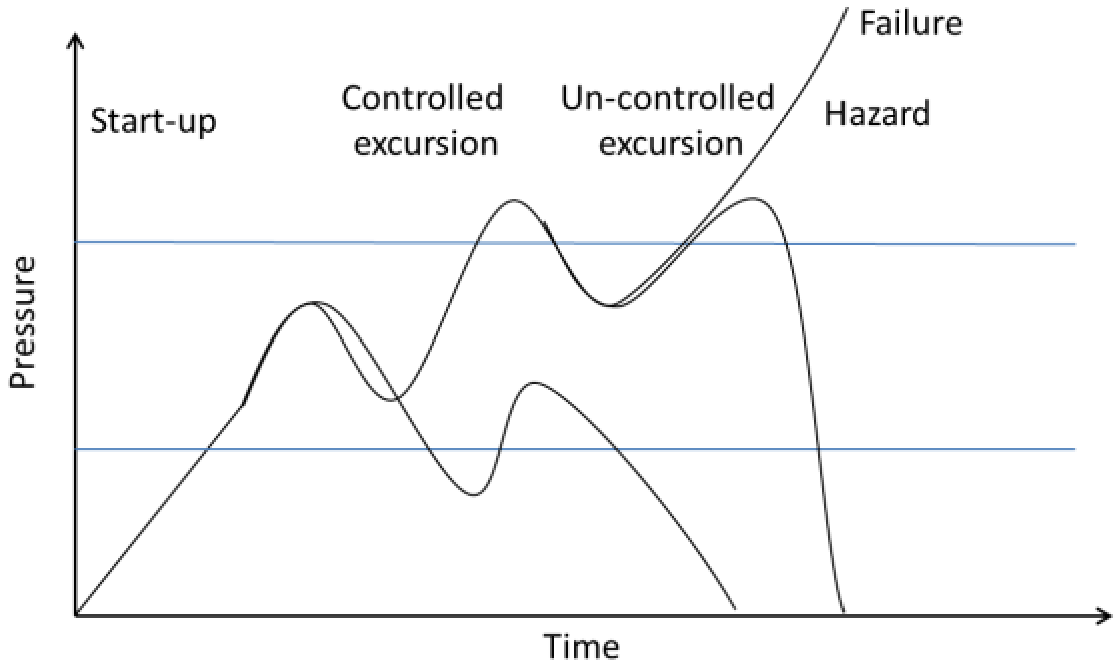

Diagram 2. Un-planned excursions

Based on this sequence of events we can identify four tasks to be performed in response to unplanned parameter changes:

- Decrease or increase pressure in order to control an excursion (i.e. bring under control);
- Stop the process in response to an excursion that cannot be controlled (i.e. manually trip the plant);
- Respond to a hazardous situation that has developed because an excursion could not be controlled and the process could not be stopped (i.e. evacuate the area);
- Respond to a failure event caused by excessive pressure (i.e. initiate rescue and mitigation measures).

Tasks associated with protective devices

One outcome of HAZOP is the identification of existing or planned protective devices. This is often backed up by other process safety studies including Layers of Protection Analysis (LOPA) or Bow Tie Analysis. The existence of protective devices within a node inevitably introduces additional tasks to be considered.

In the case of pressure the protective devices are likely to include alarms, automated trips and relief devices (e.g. relief valve, bursting disc, blowdown system). These can introduce both operations and maintenance tasks. It is important to recognise that devices may be made up of several components, each or which may introduce different tasks. In our example the tasks added to the list as a result of considering pressure protective devices may include:

- Check/calibrate pressure transmitter;
- Test trip valve;
- Remove relief valve, calibrate and replace;
- Replace bursting disc;
- Respond to plant trip;
- Restart plant after trip;
- Respond to pressure relief.

Maintenance Tasks

Most nodes will need to undergo maintenance at some time. This may have been considered in a HAZID or HAZOP; and tasks related to maintenance should be identified in human factors studies.

One of the problems with attempting to identify maintenance tasks is that the list can potentially be very long. This is because multiple maintenance tasks can apply to each item of plant or equipment; and even each component. This has been one of the stumbling blocks with implementing task analysis for maintenance. Our HAZOP approach demonstrates that we are only interested in the tasks that relate to our selected parameter. In the case of pressure we are interested in maintenance tasks that may affect the ability to create pressure, increase or reduce it; or affect the ability to withstand the pressure. For example:

- We need to be able to generate pressure so we need to identify tasks related to the maintenance of process equipment used to do this;
- We need to be able control pressure so we need to identify maintenance tasks performed on the devices used to do this;
- We need to be able to reduce pressure rapidly (e.g. in an emergency) so we need to identify maintenance tasks associated with devices used to do this (these may already have been addressed when considering protective devices);
- Joints need to be pressure tight so we will need to identify maintenance tasks that involve breaking joints;
- Equipment needs to be assembled correctly so that pressure can be contained, so we need to identify tasks that involve disassembly of pressure containing items;
- Materials properties (e.g. composition, thickness, protection) need to be selected for pressure service so we need to identify tasks that may change these (e.g. cutting, welding, shot-blasting, painting);
- Plant and equipment needs to be properly supported so we need to identify tasks that may affect structures holding pressure containing items;
- We need to be able to demonstrate that plant and equipment is fit for purpose so we need to identify inspection tasks.

Another factor to consider in relation to maintenance is preparing plant and equipment for maintenance and return to service afterwards. For pressure it becomes clear that isolation in preparation for maintenance and de-isolation following maintenance are potentially critical tasks. Also, there may be the requirement to carry out leak or pressure testing as part of the node's return to service.

Dealing with technical failures

In many cases the failure of plant or equipment results in a shutdown, which is unlikely to introduce any additional tasks. However, in some cases operations may continue and this may involve performing certain tasks not discussed above. For pressure these may include:

- Inhibiting or overriding a protective device;
- Creating a temporary repair on a leaking item;
- Rerouting the process to bypass a failed item.

These are the final type of task to be included in the identification exercise. The remainder of this paper explains how decisions can be made about which tasks may benefit from formal analysis.

Determining Which Tasks Require Formal Analysis

So far this paper has been focussed on answering the first question posed, which was "how do you identify tasks in a systematic way?" It shall now move on to present an answer to the remaining questions: "which tasks should be subject to formal analysis?" and "what should be done with other types of task?"

There are two main criteria that determine which tasks require formal analysis:

1. Is the task process safety critical?
2. Does the task lend itself to formal analysis?

What is a Safety Critical Task?

It is unfortunate that the term 'safety critical' is used widely in different contexts, and this causes confusion when people are determining which tasks they should analyse. In general terms a task is considered safety critical if it interacts with a hazardous system and the task has features that make it prone to human failure.

One area where people often need some guidance is differentiating between process and personal safety. They will often be more aware and concerned about the potential to hurt individuals carrying out a task rather than the potential to cause a major accident. The fact that a task involves 'normal' health and safety hazards (e.g. work at height, confined space entry, manual handling etc.) is rarely enough to justify carrying out a formal task analysis. One advantage of using HAZID and HAZOP as the basis for identifying tasks means that a focus has already been put on process safety.

Which tasks lend themselves to formal analysis?

General advice is that task analysis is appropriate for tasks that have a clear start and finish, involve discrete steps, result in a change of status and are specific to clearly defined circumstances. However, it is only effective if the factors that make the task critical are the potential for human failure, and hence it is less useful if those factors a not human related including:

- When to perform the task – task analysis will give little insight into the timing of tasks and alternative methods (e.g. reliability centred maintenance) should be used to define frequency, schedules etc.
- Tools and equipment used – technical rather than task requirements will generally determine what tools and equipment should be used to perform a task;
- Information presentation – if the critical aspects of the task are related to obtaining and interpreting information other methods should be used to determine the best way of presenting this;
- Decision making – this is a complex process that is usually overly simplified in a task analysis;
- Responding to signals – the immediate response to a signal usually involves interpreting information and decision making, which as stated above are not handled well by task analysis;

Example of how to categorise tasks according to analysis suitability

The example above generated a list of over 30 tasks. Given that pressure was selected because of a link with the major accidents demonstrated through HAZID and HAZOP it means that all of these tasks could be considered to be safety critical. However, this does not mean that they should all be subject to formal analysis. A categorisation process is used to slim down the list to only include those where analysis is likely to be beneficial; which is then subject to a prioritisation process (HSE 1999, Energy Institute 2011) in order to develop a plan.

Tasks most suited to formal task analysis

Tasks that have a clearly defined start and end point, consist of discrete steps and/or result in a status change are most likely to lend themselves to formal analysis. Table 1 lists tasks likely to satisfy these criteria.

TASK	EXPLANATION
Start-up the node: • After planned shutdown • After trip	Node start-up will normally involve a defined sequence of events and will result in an obvious status change. Experience shows that accidents are more likely to occur during start-up and shutdown. Task analysis used to identify critical steps, including requirement to perform steps in order and achieve certain conditions before progressing.
Shutdown the node	Same as start-up the node
Start/stop main items of equipment within the node during normal operation	Same as start-up the node for complex items. Shutdown of equipment is often simpler and so task analysis is often not required.
Remove relief valve, calibrate and replace	Task analysis is effective at highlighting critical aspects of task that are usually related to organisational interfaces (operations to maintenance and/or contractors), communication of valve set point and ensuring correct valves are removed and replaced.
Replace bursting disc	Same as relief valve
Carry out leak or pressure test	Tests will normally involve sequence of steps to achieve the required pressure rise and to confirm system integrity.

Table 1: Tasks most suited to formal analysis

Because of the nature of the task and the fact that they have been identified with reference to other process safety studies, we can be fairly confident that there will be some benefit in carrying out formal analysis of these tasks.

Tasks that are unlikely to be suitable for formal analysis

At the other end of the scale there are tasks for which formal analysis is unlikely to be beneficial. However, given that they have been identified with reference to other process safety methods they may still be considered safety critical. Table 2 below lists the tasks that would not normally be subject to formal analysis along with an explanation of why this is the case and alternative methods of assessment that should be applied instead.

TASK	EXPLANATION
Control process	Continuous task, no discrete steps. Critical because good control reduces demand on protective devices. Operator needs process information to be presented clearly in suitable form; and clear specification of acceptable operating range. Assessments related to Human Machine Interface (HMI) (graphics and alarms) apply (EEMUA 191, EEMUA 201, ISO 11064)
Optimise process	Same as 'control process.' but less critical
Return to normal control range following an excursion	Usually an extension of 'control process.' Task risks controlled through HMI, particularly alarm design and presentation (EEMUA 191). Possible exception is if response requires a separate task to be performed (e.g. equipment start-up or shutdown).
Initiate emergency action due to a hazardous situation	Impossible to predict the exact scenario and hence cannot define discrete actions. Task risks covered by emergency planning. Staffing assessment used to confirm staffing arrangements are sufficient implement emergency procedures when required and appropriate culture in place (HSE 2001).
Initiate rescue and mitigation following a failure or process accident	Same as 'Initiate emergency action due to a hazardous situation.'
Make and break joints	Task is unlikely to apply to a specific circumstance. May be handled by a generic task analysis, but task risks usually controlled through joint design/selection and skill of personnel performing task. Personal safety risks will be controlled through permit to work.
Maintain materials of construction	Unlikely to be a routine task. Normally performed in response to a failure or to implement a change; and so not possible to predict. Task risks controlled through management of change. Personal safety risks will be controlled through permit to work
Maintain structures	Same as 'Maintain materials of construction.'
Inspect plant and equipment	Task is unlikely to apply to a specific circumstance. May be handled by a generic task analysis, but usually task risks are controlled through selection of correct inspection methods and equipment; and skills of personnel performing task.
Respond to plant trip	In most cases the operator actions should be minimal following a trip. Covered by analyses performed for Safety Instrumented Systems (SIS) (IEC 61511)
Respond to pressure relief	In most cases the operator actions should be minimal following a pressure relief. Covered by layers of protection analyses (or equivalent). If a hazardous situation may develop the response should be the same as for 'Initiate emergency action due to a hazardous situation' as above
Inhibit or override protective device	Every circumstance will be different and specific risk assessment and management of change apply. Task analysis of how to inhibit or override unlikely to be of benefit.
Create temporary repair on a leaking item	Every circumstance will be different and specific risk assessment and management of change apply. Personal safety risks will be controlled through permit to work
Re-route process to bypass a failed item	Every circumstance will be different and specific risk assessment and management of change apply. May be covered by other tasks depending on how bypass is achieved.

Table 2: Tasks that are unlikely to be suitable for formal analysis

Tasks that may benefit from formal analysis depending on circumstances

The sections above have accounted for the majority of tasks identified in our example. However, there will always be cases where a judgement needs to be made about whether a formal analysis will be beneficial. Table 2 below lists these tasks along with an explanation.

Task title	Explanation
Change operating mode	May already be covered by other tasks including 'control process' or 'Start/stop main items of equipment within the node during normal operation.' Separate analysis only required if mode change involves significantly different steps.

Manually stop/trip plant following an excursion	In most cases this will involve simple steps. Main issue is decision making and culture (willingness to stop production).
Check/calibrate pressure transmitter	In most cases this will involve simple steps. May be handled by a generic task analysis, but usually task risks are controlled through selection of correct calibration methods and equipment; and skills of personnel performing task. Frequency of checks is important. Determined from analyses performed for SIS (IEC 61511). If check/calibration requires changing process parameters outside of normal, may require formal analysis.
Function test a trip system	Task is unlikely to apply to a specific circumstance. May be handled by a generic task analysis, but usually more likely to be covered by analyses performed for SIS (IEC 61511)
Maintain process equipment	Requirement and benefit of task analysis will depend on the specific circumstances including the type of equipment and who is performing the maintenance. In many cases it is not possible to identify specific maintenance tasks that are critical in their own right because most of the risk is managed in the way equipment is prepared for maintenance and returned to service afterwards. In other cases maintenance can introduce latent failures in the system, and hence task analysis may be required. There can be difficulties in getting task analysis performed if maintenance is performed by third parties (e.g. vendor, contractor). However, this is not a reason to not perform such analyses.
Maintain control equipment	Same as 'maintain process equipment.'
Maintain protection devices	Same as 'maintain process equipment.'
Reassemble components	Same as 'maintain process equipment.'
Prepare plant for maintenance	Will depend on circumstances. In some cases preparation will simply involve the normal process shutdown followed by isolation, which is covered by specific guidance such as HSG 253 (HSE 2006). If preparation for maintenance is more involved (i.e. involves draining, purging etc.) formal analysis may be appropriate.
Return plant to service after maintenance	Same as 'prepare plant for maintenance' in reverse.

Table 3: Tasks that may benefit from formal analysis depending on circumstances

Conclusions

This paper has explored two main issues. The first concerned the identification of tasks in preparation for carrying out formal task analyses. A method has been demonstrated based on other process safety methods including HAZID and HAZOP. Although this provides a systematic approach to task identification, it will always involve a degree of subjectivity. In isolation it may not be significantly different to other methods currently used human factors practitioners. However, creating links with HAZID and HAZOP can have great benefits by improving the consistency with which process safety risks are assessed, integrating human factors into the wider process safety agenda and getting buy-in from the people who are the best position to contribute to analyses and implement the outcomes.

The second issue explored in this paper is the fact that all tasks considered to be safety critical (which is demonstrated through links to HAZID, HAZOP etc.) need to be subjected to some form of assessment, but only certain types of task lend themselves for formal analysis (i.e. HTA and human failure analysis). Tasks have been categorised and alternative assessment methods have been proposed for those where formal analysis is unlikely to be appropriate or beneficial. This should help people when developing their plans for implementing task analysis to ensure they make best use of their resources, but also address all the potential human factors risks.

As well as being beneficial for human factors studies, the approach described in this paper has the potential to have a wider impact across the process safety agenda. Using an iterative process means that human factors studies can be improved by referencing other process safety studies; but also those studies can be improved by referencing the human factors findings. Experience has shown that HAZID and HAZOP sometimes fail to identify potential major accident scenarios because they focus on technical failures and overlook the potential role of human failures. Also, the solutions proposed to potential human failures are sometimes inconsistent with what is considered appropriate or good practice from a human factors perspective.

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