Human Factors Issues in Control of Work Systems

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In the UK, sites governed by the Control of Major Accident Hazard (COMAH) regulations are required to identify COMAH-critical tasks, analyse them for vulnerability to human failures, and the factors that might make those failures more likely.

Human Reliability Associates (HRA) has undertaken many such analyses on behalf of our clients over the past ten years or so. Tasks that are identified by this process often involve a break of containment, (e.g. to prepare a system for maintenance), as it is these tasks where the risk of a Loss of Containment (LOC) can be most easily anticipated. Because these are planned tasks, an organisation's control of work systems, such as permits and isolation management, are of vital importance. Often, when we have analysed one of these tasks, the findings related to control of work systems have been readily applicable to other tasks of the same type.

Every organisation, although taking broadly similar approaches to these tasks, implements them in different ways. For example, some organisations use electronic isolation management systems, whereas others rely on paper. This paper draws on our experience of analysing numerous examples of these types of tasks, across a wide number of different organisations, to illustrate some common human factors issues that occur in these processes, and give examples of good practice. The paper covers both the preparation activities performed to prepare a system for maintenance, and the reinstatement actions necessary to return it to an operational state.

Background

Scope of paper

In the UK, sites governed by the Control of Major Accident Hazard (COMAH) regulations are required to identify COMAH-critical tasks, analyse them to establish where they are vulnerable to human failure, and review the factors that might make those failures more likely (HSE, 2016). This process typically includes some form of task analysis, failure analysis, and Performance Influencing Factor (PIF) analysis (often this approach is collectively known as Critical Task Analysis, or Human Factors Critical Task Analysis). Ultimately, the aim is to optimise the performance of people undertaking COMAH-critical tasks, by ensuring, with reference to ALARP and hierarchy of control principles, that control measures are appropriate and PIFs have been optimised (for more detail on this type of analysis, see, for example, Energy Institute, 2011).

Human Reliability Associates (HRA) has undertaken many such analyses of this type on behalf of our clients over the past decade. Tasks that are identified by this process are often intrusive, requiring a break of containment (e.g. to prepare a system for maintenance), as it is these tasks where the risk of a Loss of Containment (LOC) can be most easily anticipated.

Whilst it may be possible to minimise the need for such tasks, by planning for maintenance to take place during shutdown periods, there will always be situations where intrusive work is required. For example, a filter may become blocked during operation, or a catalyst may need replacing. Where this is necessary, an organisation's Control of Work (COW) processes, such as permits and isolation management, are of critical importance.

The HSE provides a range of useful guidance for organisations on important technical aspects of these systems (e.g. HSE, 2016; HSE, 1997). However, when we have analysed these tasks as part of our COMAH consultancy work, we have found that often, even where organisations have high level procedures which meet most of the requirements set out in these guides, detailed task and failure analysis has identified Human Factors (HF) issues with the potential to undermine their practical application. These factors are discussed in detail in the following sections.

We have found that once one or two tasks of this type have been analysed at a site, alongside the identification of specific issues that must be addressed for the task, useful insights into the how well these control of work systems operate in practice are often identified. This information can be used to make general improvements to these processes. This paper collates some examples of these issues, based on our consultancy experience, to illustrate how HF issues have the potential to undermine and support execution of tasks which use control of work systems to support performance.

Description of typical elements of preparation for (and reinstatement after) intrusive work

Permits are normally used to authorise work of a particularly hazardous or non-routine nature, and, consequently, intrusive tasks, such as maintenance on live plant, often require the use of such systems. Sometimes, for more routine tasks, control is provided by task procedures rather than a permit. In our experience, intrusive tasks which require a significant process isolation are often controlled by both permits/isolation certification and procedures. This is important, because, whilst an isolation certificate is a useful reference guide, setting out the isolation points and their required states, it does not usually explain how the task is to be undertaken (e.g. how the system inventory is to be removed, how the isolation points are established and proved).

Typically, for larger process isolations, the preparatory (and subsequent reinstatement) tasks will be carried out by members of the site operating team, before they hand over the prepared system to the maintenance team responsible for carrying out the intrusive work. For example, a mechanic may be required to change a filter or replace a seal, but the system will first be made safe by the operating team, by isolating, depressurising and draining the system. Sometimes, for simpler isolations (e.g. of an instrument to allow for a function test), the whole task (preparation, maintenance/testing, reinstatement) will be carried-out by a single individual such as an instrument technician, these are sometimes referred to as 'own isolations'.

Regardless of the process plant in question, any maintenance preparation and reinstatement task will usually involve some variation of the following sub-tasks (adapted from HSE, 2006).

1. Planning for intrusive work

   This includes the risk assessment, the decision-making process for the required standard of isolation, preparation of documentation such as permits and isolation certificates, identification and review of relevant procedures, and development of marked-up Piping & Instrumentation Diagrams (P&IDs) for reference when installing the isolation.

2. Preparation of equipment for intrusive work

   This includes draining, venting, purging and flushing activities which will allow access to the equipment during maintenance. There is often overlap between this step and the subsequent step, installation of the isolation, as valves that will form part of the isolation will need to be closed to allow venting, purging, etc. to take place. Sometimes, isolation points that will not be moved during the preparatory work (e.g. boundary isolation valves) are secured at an early stage, with the other points secured at a later point.

3. Installation of isolation

   This is the process of effecting the isolation. HSG253 (2006) describes two stages:

   a) Initial isolation. Typically, for a process isolation, this is the use of valves to isolate the piece of plant to be worked on. This can be to allow for some of the actions described in the previous step (e.g. venting, draining, purging), to enable isolation points to be proved, or it might be to enable positive isolations to be applied.

   b) Final isolation. This includes securing the isolations to ensure that they remain in place for the duration of the maintenance activity. Ideally, this will involve the use of some form of lock to prevent inadvertent operation of the isolation points. For frequently performed, high hazard tasks this sometimes involves the use of trapped key interlocking systems (i.e. to ensure that actions are performed in the correct sequence).

4. Confirming and maintaining the effectiveness of the isolation

   This is the process of confirming that the system is safe before handing over to the team that will be carrying out the intrusive activity, and ensuring it remains that way during the task. This might include independent checking that the isolation has been correctly applied, proving the state of the system to the maintenance team, and monitoring the system during the maintenance task to ensure that it remains in a safe state (e.g. monitoring for gas). An important part of this is the process of handing over the system from one group of individuals (the operating team) to another (the maintenance team carrying out the intrusive work).

5. Carrying out the intrusive work

   The activity itself, such as cleaning filters, replacing catalyst, or carrying out an instrument test, is not covered by the scope of this paper.

6. Reinstatement of the plant following completion of the intrusive work

   This will involve the operating team receiving the system back from the maintenance team, safely removing the isolations and returning the system to an operating state.

Types of isolation

HSG253 (2006) organises isolations into three principal types. They are:

1. Positive isolation

   This is an isolation that achieves complete separation of the plant to be worked on from the other parts of the system. For example, the physical removal of a section of pipework, with ends blanked-off, or the use of spectacle blinds or spades.

2. Proved isolation

   This are isolations established using valves, where bleed and vent points are used to confirm that the individual isolation points are sound. Within this category there are approaches the provide different levels of confidence, with the highest provided by Double Block and Bleed (DBB) isolations (see later discussion).

3. Non-proved isolation

   This isolation also uses valves, but in this case, there is no use of bleed or vent points to confirm that the isolation is sound. Consequently, this provides the lowest level of confidence of the three classes of isolation, as such it is typically a last resort.

There are situations when each of these isolation types might be applicable, this will depend on the nature of the materials which the isolation will protect against, and the nature of the intrusive work. However, as a rule of thumb, HSG253 suggests that any live plant which contains a hazardous substance requires a standard of isolation higher than a proved single block isolation.

Examples of HF issues affecting intrusive work

The following sections give examples of some of the HF issues that we have identified, or had described to us, in our consultancy work related to control of work systems. The aim of these anecdotes is to raise awareness of the role that HF can play in undermining (if these issues are not addressed), or supporting (if they are properly managed) performance in intrusive work. Where appropriate, we have followed the examples with practical suggestions for improving the management of HF issues in this context. The examples given are not intended to be an exhaustive list. For convenience, they have been organised per the stages of intrusive work set out earlier in this document.

HF issues related to the planning process for intrusive work

Allowing one person to plan and install an isolation

Allowing one person to plan, apply and secure an isolation means that any failures can only be recovered by that individual. For example, if an individual misidentifies a valve in the field, and consequently applies the isolation to the incorrect point, there will be little chance of recovery unless they themselves notice their failure. This will potentially threaten the effectiveness of the isolation, increasing the risk of a Loss of Containment (LOC).

Many organisations have a category of isolations called ‘own isolations’, these are tasks where one person plans and installs an isolation, and carries out the intrusive work. Typically, this is reserved for specific tasks, which are usually quite simple and of short duration (e.g. carrying out a function test on a level trip).

Often, the risks of these types of failure are mitigated by the use of permits, which separate the preparation activities from the intrusive work, ensuring at least that more than one person is involved, and by requiring an independent check of the isolation prior to the system being handed over for the maintenance activity.

However, specific HF issues which may threaten the effectiveness of these controls include the availability of resources and time pressure. For example, if there is an unanticipated requirement to carry out intrusive work on a piece of equipment during a night shift, and there are not the staff available to fulfil all the different roles (e.g. to plan the isolation, to install it, and to check the isolation), then there may be a temptation for one individual to do everything, particularly if the equipment in question is critical to production. In these situations, there may also be a desire to re-define the task in a way that allows it to be performed. This is where the concept of ‘own isolations’ (see above), might be stretched to allow the task to be carried out.

To reduce the probability of these sorts of workarounds, and the failures that might follow, it is important that there are clear rules around what can and cannot be done, that these are communicated to the workforce, and that they are both formally and tacitly supported by management. For example, if an individual is congratulated for promptly returning a piece of equipment to service on a night shift, but in doing so they had to bend the isolation management rules in the manner described, then there is a danger that the workforce will start to regard important controls as optional.

Some organisations have permit and isolation certification IT systems which give some control over these types of action (e.g. by requiring more than one person to contribute to a permit or isolation certificate before it can be printed).

The difficulty of identifying failures made during the isolation planning process

When failures occur in the isolation planning process (e.g. if a planner misidentifies a valve from a P&ID) they can be difficult to recover from, even if an organisation has a subsequent requirement for an independent field check of the isolation installation this may not identify failures in the isolation plan. This is because the individual carrying out the check will be focused primarily on whether the field isolation points match those set out on the isolation certificate or permit, they will not necessarily be thinking about, or even know, whether the correct isolation points were specified in the original plan.

To reduce the probability of this type of failure, it may be useful, particularly for larger, more complex, isolations to have a formal requirement for a second check of the isolation plan.

The dangers of routinely accepting variations from isolation standards

If the condition of the plant means that variations from the standard become normalised, then this can undermine the entire approach to isolation management. For example, if a task procedure sets out the required isolation points for a piece of process equipment, but the operating team know from experience that a valve stipulated as part of the isolation passes, then even before the task has started, the value of the procedure will be undermined.

Similarly, if it is routinely not possible to achieve the required standard of isolation, for example if the design of the plant means that a proved isolation cannot be established, or a valve is passing, and yet, following a risk assessment, the task always proceeds, then there is a danger that the operating team will start to question the wider necessity of achieving the required isolation standards. This may increase the probability of deviations such as the one set out in the following section.

Several steps might be taken to address this issue. Firstly, it is important to appreciate the scale of the issue. To do this, sites should collect data on the proportion of occasions where deviations from the isolation standard are necessary. Secondly, to reassure the operating team of the importance of the isolation standards, they should see evidence of the site reacting to known issues. For example, if valves pass, or if the design does not allow for the required isolation standard, these issues should be addressed during shutdowns. Replacing valves or adding valves is not cheap, but if these actions are not taken, then over time operating teams' perception of the worth of the isolation management system may start to erode.

A related issue is that the inability to achieve isolations using the preferred valves (e.g. because they pass), may contribute to an overall drift in the use of valves for tasks for which they are not properly suited. For example, if a ball valve, which would be the best option for providing a seal in an isolation, is unusable because it passes, then other, less suitable valve types, might need to be used. A globe valve, used for flow control, will be unlikely, after a period of use, to provide a good enough seal to be used in isolations. The use of valves for inappropriate purposes may be a design issue (e.g. a failure to specify the correct valves given the modes of use) or a maintenance issue (e.g. failure to keep valves working), but once a site, and its operators, routinely start to use valves other than for their intended purpose, the ultimate effect will be increased maintenance costs.

Finally, issues can arise when variations from isolation standards increase the complexity of the task for the operator. This can create situations where mistakes are more likely. For example, at one site we saw a maintenance preparation task where the required isolation standard could not be achieved, but a workaround had been established to allow the task to proceed. This workaround involved changing the boundary of the isolation during the task to enable some key process instruments to remain online for as long as possible. However, it also changed the point at which the isolation was proved in the task to the very final action, after the instruments had been reinstated, at which point the system was live and there was pressure behind the isolation valves. Operators we discussed the task with explained that this requirement was not clearly explained in the procedure, and was different from the point at which they would normally prove an isolation, leaving open the possibility of incorrectly concluding that the isolation was sound (i.e. by testing for pressure build-up when no pressure was present behind the isolation valves).

HF issues related to the preparation of equipment and installation of isolations

The importance of clear expectations regarding isolation methods

Double Block and Bleed (DBB) is an important method for creating proved isolations. HSG 253 (HSE, 2006) suggests it as the most effective method of isolation for intrusive maintenance, without creating a positive isolation. However, without clarity regarding the expected method of application, there is a danger that the achieved standard of isolation will be lower than anticipated.

HSG (253 (HSE, 2006) suggests that "each part of the isolation should be proved separately, e.g. prove each valve in a double block and bleed scheme". This may also be the intention of company's isolation standard. However, we often see examples where only some aspects of an isolation have been proved.

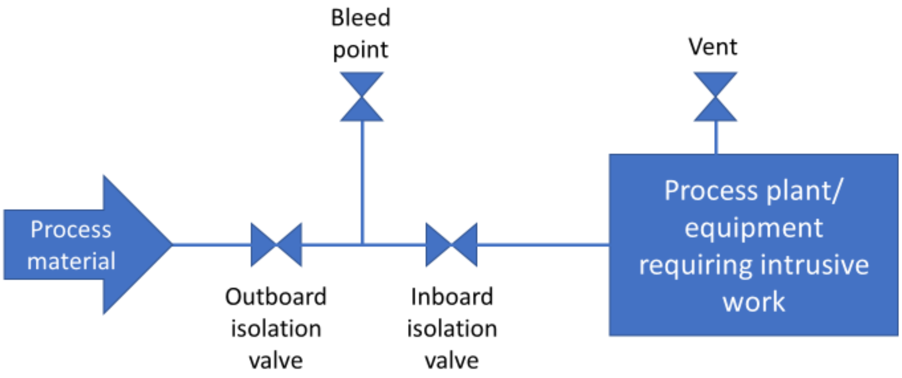

Figure 1 Basic illustration of principle of Double Block and Bleed (DBB) process isolation
(diagram does not show pressure gauges and drain points which may also be used as part of this process)

For example, assuming a requirement to isolate a piece of equipment on a gas plant, a company may wish for their operators to prove each valve in a DBB arrangement by first closing the inboard isolation valves, venting down the process equipment, and then testing for pressure build-up in the isolated section (i.e. to prove that the inboard isolation valves are sound), and then repeat the process for the outboard isolation valves, this time using the bleed to test for pressure build-up in the interspace between the inboard and outboard valves (i.e. to prove the integrity of the outboard isolation valves).

However, an alternative approach, which we have seen in use at several sites, is to close the outboard isolation valves, vent down the process equipment and test for pressure build-up in the isolated section (i.e. to prove the integrity of the outboard isolation valves), before closing the inboard valves. This second approach means that the inboard valves have not been proved.

The benefits of this to the operating team are clear: the latter method will be considerably quicker, and, moreover, it will not be obvious to anyone examining the final isolation which of these two methods the operating team has used. A manager who accepts the benefit of the more rapidly performed isolation is complicit in this. It might be that the latter approach is perfectly reasonable, given the risks involved. However, if the expectation is that that former approach is taken, then this should be clearly communicated to the operating team and reflected in the time allocated for carrying out the task. Brazier (2016) provides an excellent, more detailed, analysis of additional ways in which these types of isolation might fail.

HF issues related to confirming and maintaining the effectiveness of an isolation

The value of second checks of installed isolations

Many organisations now recognise the importance of a second independent check of an installed isolation. This issue is not covered in detail in HSG253, but the checklists included in Appendix 3 include a reference to a plant walk round to confirm that the correct isolations are in place. Without this, the success of an isolation depends solely on the individual applying it. If there is a second check, this provides an opportunity to recover any failures in the installation.

We have seen and heard of many examples of situations where isolations have been applied to the incorrect points. From an HF perspective, this might be the result, for example, of poor or absent labelling, confusing plant layouts, or a misunderstanding regarding which system is to be isolated. This can particularly the case where the operating team must identify the equipment to isolate from a choice of several similar pieces of equipment (e.g. from a bank of filters which are arranged in parallel).

Often failures of this type will not be safety critical, particularly if the incorrect equipment is identified, but the isolation and subsequent intrusive work is correctly performed. In the best case, this may just result in a delay following the identification of he failure. For example, one of our clients described a situation where scaffolding required for access during a maintenance task had been installed at the incorrect location. From that point on, all individuals involved in the task took their cues from the presence of the scaffold, and isolated, prepared, and carried out maintenance on the incorrect piece of equipment, even though the supporting paperwork suggested a different piece of equipment. More serious consequences may arise if, for example, one isolation point is in the incorrect place, or if the isolation has been tagged as isolated, but the valve is in the incorrect position.

In our consultancy work we have seen many examples of useful physical aids to support good practice in checking. In general, we believe that some active element to the checking process is useful. For example, there may be a space on an isolation tag for the checker to sign, or a part of the tag may be ripped-off to indicate that a check has been performed, we have also seen an example of a site using a tool, linked to specific individuals for traceability, to mark the isolation tags in the field. These systems increase the probability of the checker physically visiting the isolation points, which in turn should increase the chance of failures being identified.

The increasing use of electronic permit and isolation certificate issuing systems also have the potential to bring HF benefits. They can be used to reduce the probability of transcription errors when information is transferred between documents (e.g. they give the opportunity to use printed rather than handwritten isolation certificates), and allow easy allocation of isolation points, which makes status monitoring easier (e.g. V1234 is isolation point 1).

Dependency in checking processes

Where second checks of installed isolations are in place they should be as independent as possible. The problem of dependency between human actions has been identified and discussed for many years (see, for example, HSE, 2001). That is, that the person performing the second check should be as separate as possible from the individuals that installed the isolation. In practice, this might mean that the check is performed at a different time, and by an individual from a different function (e.g. a supervisor or permit controller, rather than another operator).

HF issues have a significant impact on the probable success of these controls. We have seen an incident where the nature of the check had not been described to the operating team, and their understanding was that two people had to perform the check as a team (i.e. one person checking the item, the other signing it off), rather than at different times (Henderson & Cross, 2005). Sometimes there can be reluctance amongst a workforce to accept the principle of checking, seeing it is a challenge to their competence. A further significant issue is the availability of sufficient resource to implement checks. For example, if a supervisor is especially busy, but they are expected to perform a second check of an isolation, they may be tempted to only check those isolations performed by the less experienced members of their teams.

The electronic permit and isolation management systems, discussed in the previous section, may also be useful in supporting independent checking, by requiring different individuals to provide electronic signatures before permits can be issued.

The importance of clarity regarding the purpose of a second check

For a system of independent checking to be effective, it is essential that the requirements of the checking process are as clear as possible. We frequently see documents which require a signature from the installer of the isolation and a signature from a second individual, alongside a general statement that the isolation has been correctly performed. In this situation, the second signature could be interpreted to mean anything from an acknowledgement that the second person has been told that the isolation is in place, through to a confirmation that a full visual plant check, to establish the presence of all the isolation points, against an isolation certificate, has been performed. Without a clear description of what is required, it leaves room for the checker to apply their own interpretation, and this might mean that some of the workarounds described in the previous section result (e.g. only doing field checks on isolations applied by less experienced operators, only performing field checks when time permits).

Therefore, we prefer to see documents which clearly state what the signature means. For example, that the signatory has confirmed, via a field inspection, that all isolation points are in place.

The importance of clarity regarding what is to be checked

A similar issue is the clarity of detail regarding how a check is to be performed. Even a very good independent checking process, requiring a field check of an installed isolation by an independent individual, might fail to identify some fundamental failures in the isolation process, if it is not clear what the check should involve. For example, a checker might diligently visit every isolation point specified on an isolation certificate, and establish all valves have been locked and tagged as being part of the isolation, but they might not think to check if the valves are in their correct positions (a failure we have had described to us on several occasions). Therefore, it is essential that supporting training for these activities includes a clear description of what is to be checked, and that it is easy as possible to confirm the valve position in the field. This is no always a given, as we often see valve position indicators which are difficult to see, or where the markings do not line up with the valve state.

The importance of the handover of a task between different site roles

An important stage in any intrusive work is the handover between the team that has prepared the system, typically the operating team, and the team or individuals that will perform the intrusive work, such as a mechanical technician. Some organisations have a formal requirement for the operating team to show the prepared equipment to the maintenance team and prove that the isolation is sound (e.g. by opening drain or vent points on the equipment). This is sound practice, as it reduces the probability of the technician attempting to start work on the incorrect piece of equipment, and provides another opportunity for failures in the isolation process to be identified.

However, this type of practice is also vulnerable to HF pressures such as those discussed for maintaining independent checks. Operators may, perhaps, be less likely to do this for a technician that they consider to be experienced, or they may not do it if they are very busy with other tasks. It may also be the case that the preparation is performed on one shift, and the intrusive work takes place on another, in these situations is it is probable that a different operator, other than the one that prepared the equipment, will demonstrate the isolation.

HF issues related to the reinstatement of plant

HF issues associated with valves that are maintained in a locked state

Locked valve systems are used to ensure that important valves are maintained in their correct position. For example, it is essential that a valve in the line to a Pressure Safety Valve (PSV) is always open, to enable the PSV to act in the event of a build-up of pressure. Locks are also often used on valves which can be used to isolate instruments, such as level transmitters, to prevent inadvertent isolation, which might mean, for example, a high-pressure trip failing to operate on demand. Sites typically maintain a register of valves that are ‘locked open’ and ‘locked closed’, and these registers are audited on a periodic basis.

There are several possible HF issues with these systems, including the overapplication of locks (e.g. for valves that are not critical from a process safety perspective), creating complexity, and potentially obscuring the focus on the most critical valves. Their misapplication in the field also has the potential to lead to confusion, we saw one example where a transmitter’s isolation valves were adjacent to its vent valves and an equalisation valve. Here a green cable lock had been wrapped around the isolation valves to indicate the importance of leaving them open, but, due to their proximity, it had also been wrapped around the vent valves and equalisation valve, which needed to be closed. Leaving the equalisation valve open would have made the related trip unavailable.

Instrument isolation valves are often needle-type valves, as these are less prone to inadvertent movement than, for example, 90-degree ball valves, which might be easily be knocked-out of position. However, unlike with 90-degree valves, an operator or technician cannot establish their position without physically testing it. This means that an instrument technician, distracted as they reinstate a trip following a function test, might easily leave a valve closed, rendering a trip ineffective. Interestingly, the use of locks in this case may compound such an error, as the type of lock required for a needle-valve will often cover the handle, making it impossible, until the lock is next removed, possibly at the next function test, to recover the failure. The best design we have seen for addressing these issues are lockable 90-degree valves, where the position can be established at a glance, but the lock means that the valves cannot be inadvertently moved.

Less emphasis on reinstatement than preparation

When reviewing these types of tasks in our consultancy work, it often appears that there is more focus and effort directed at preparing a system for intrusive work than for its subsequent reinstatement. Whereas preparation often involves the use of detailed supporting documents and checking processes, reinstatement appears to attract less attention, and often relies more on the performance of individuals. This is not across the board, and we have seen some excellent reinstatement processes, it is more of a general observation. Possible reasons for this might include failures in preparation having a direct personal safety consequence for the person breaking containment (e.g. the maintenance technician), and, consequently, there is a concerted effort to reduce these types of failures. However, it might be argued that the potential implications of a failure in the reinstatement process are more significant from a major accident hazard perspective (e.g. a failure to properly establish the mechanical integrity of the system prior to the reintroduction of process material).

The risk of overcomplicating control of work processes

Whilst in general, the types of systems we have discussed in this paper bring the benefits of greater control to tasks such as intrusive maintenance, from an HF perspective there can be a danger of making the control of work processes so onerous that the risk of circumventions increases. This may happen if the activities related to control of work appear to the workforce to be out of proportion to the benefits they bring, if for example, the time taken to carry out the control of work tasks is significantly greater than the time needed to perform the actual intrusive activity.

This might manifest itself as individuals seeking to reclassify tasks so that the full control of work requirements can be avoided (as in the case of own isolations, discussed earlier), or other workarounds. One area where we have seen the risk of violations increase is in the use of lock and key systems for securing isolations. Some organisations choose to secure isolation points using cable locks which can be attached and secured without the need for specific keys, whereas other organisations use padlocks and chains, which do have specific keys.

One advantage of the latter approach is that the specific keys can be returned to lock boxes in the permit office, giving confidence that the isolation will not be inadvertently disturbed during the intrusive work. However, specific keys do significantly increase the complexity of the control of work process, and we have discussed situations with operators where, on larger isolations, they have laid out the keys on the plant floor to try and find the correct one for the padlock they are trying to open, or where they have walked all the way to location of the isolation to find that they do not have the correct keys with them. These issues can be frustrating and may increase the probability of workarounds.

Therefore, it is important to keep the benefits that these systems provide under review. It might be argued, for example, that the primary purpose of isolation locks and tags is to alert individuals to the existence of an isolation, and secured cable ties, without specific locks, will be sufficient for this purpose, as well as being simpler to apply and remove.

In addition, the overall impact of related control of work systems should also be considered. Many organisations have several systems which are used in parallel to assure performance in intrusive work (e.g. Permit-To-Work, isolation certification, local risk assessments, certification at task handover between functions, certification for confined space entry, registers for critical valve positions). Whilst individually each of these systems are likely to bring specific benefits, taken collectively they may have the effect of making simple tasks very complex, meaning that critical aspects of tasks are lost in the significant amount of paper generated. For example, we saw one organisation that had an excellent process for managing trip tests, with well-designed forms for recording test results (e.g. as found/as left states, calibration/set point test results). However, within this process, the critical action of reinstating the system, which if performed incorrectly would render the trip unavailable, was barely mentioned in the procedure, and not covered at all in the forms which provided a record of the test.

Organisations should be conscious of this, and keep the collective benefit of these systems under review. For example, repetition should be removed where possible, and steps should be taken to ensure that the control measures are proportionate to the risks of individual tasks. Judicious application of techniques such as Human Factors Critical Task Analysis (HFCTA) can help with the identification and management of these critical actions.

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