A SURVEY OF PERMIT-TO-WORK SYSTEMS AND FORMS IN SMALL TO MEDIUM SIZED CHEMICAL PLANT.

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The HSE report, "Dangerous Maintenance" identified that 30% of all reported incidents in the chemical industry were maintenance related, and that permit-to-work systems were implicated in over 20% of these maintenance incidents. This paper relates to human factors aspects and describes one of a series of projects initiated by the HSE's Chemical Manufacturing National Interest Group investigating permit systems in detail. The project studied some of the practicalities of operating permit-to-work systems, with particular reference to smaller plant. The results confirm previous findings, as reported by Scott in 1992, and identify some issues relevant to smaller companies. Recommendations are made in terms of factors to be considered when designing or reviewing permit systems including guidelines for permit form design.

Key words: Permit-to-work Systems, Permit System Design, Permit Forms.

BACKGROUND

In 1987 The Chemical Manufacturing National Interest Group (NIG) and The Accident Prevention Advisory Unit (APAU) within HSE, produced the report, "Dangerous Maintenance", which looked at unsafe incidents in the chemical industry. This report identified that 30% of all reported incidents involved maintenance activities. In particular it highlighted that permit-to-work systems (PTW), (either inadequate or non-existent) were implicated in 20% of these maintenance incidents. It was a source of some concern that such a long established and widespread system was implicated in so many accidents. It was decided that work should be done to investigate PTW systems in detail and provide appropriate guidance to the industry. This research forms part of a continuing series of projects initiated by the Chemical Manufacturing NIG with this purpose.

The objective was to investigate the practicalities and realities of operating PTW systems in the UK onshore chemical industry, in order to inform future guidance to the industry on how to design and implement effective PTW systems. Particular reference was made to small to medium sized plant, where only limited resources are available for developing and operating permit systems. These companies might, therefore, be expected to experience more problems with their permit systems than larger companies and be in greater need of guidance.

Existing sources of information on the operation of permit systems were reviewed. This drew information from other industries where permit systems are in use. Generally, committees had produced what was ostensibly a sensible way to manage hazardous operations, but had not referred in any formal way to the practicalities of working a PTW system.

Methodology

A detailed account of the design and development of the survey which was undertaken is not given here, but the survey covered three HSE regions, and the participating companies were selected in terms of size of workforce (fewer than 250 personnel). Because of the detailed nature of the information needed, and the expected variation and unpredictability of responses, a semi-structured form of interview was adopted. To gain a realistic view of the day to day workings of the PTW systems at the companies it was necessary to gain the views of staff with different responsibilities, and, hence, different perspectives on the system. Therefore, staff representing three levels of responsibility within the permit system were interviewed:

- Maintenance Fitters working under permits;
- Supervisors responsible for issuing permits, and;
- Managers responsible for the running the permit system.

A semi-structured interview was used, rather than a set of closed questions so that the views of the respondents would be minimally constrained by any structure which the researcher might impose. A richer and more detailed picture of the workings of the permit system could thus be obtained. Also, in order to avoid note taking, and maintain flow of the conversation, the interviews were recorded (with the respondent's agreement).

The interviews began with an explanation of the purpose of the visit and, most importantly, an assurance of confidentiality. The initial questions concerned simple biographical and site details before moving on to the main body of questions regarding the detail of the permit system. Areas covered included:

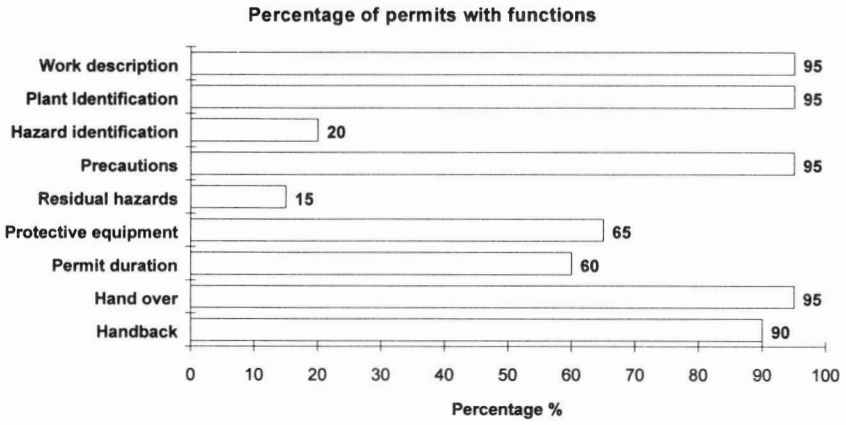
- The design of the permit system
- The design of the permit form
- Permit initiation
- Expiry time
- Specifying PPE
- Overlapping work and shift changeovers
- Following of instructions
- Permit hand-back procedures
- Monitoring of the system
- Practical problems
- Training for permit work

In total 19 companies were included in the study and 50 interviews were completed.

DISCUSSION OF FINDINGS

A simple method of identifying potential problems within a permit system is to look at the design of the permit form to see whether vital functions, as decribed in the HSE leaflet "Permit-to-work systems", are covered. Example permits were collected from each of the sites visited and analysed to determine whether important permit system functions were being presented on the permit.

The results of this exercise clearly demonstrated the lack of hazard identification as a formal step in permit initiation, with only 20% of companies having this function on the permit. This step in preparation is often done "in the authoriser's head", and relies entirely on the knowledge and experience of the authoriser to ask enough "what if?" questions. A list of prompts on the permit may help this.

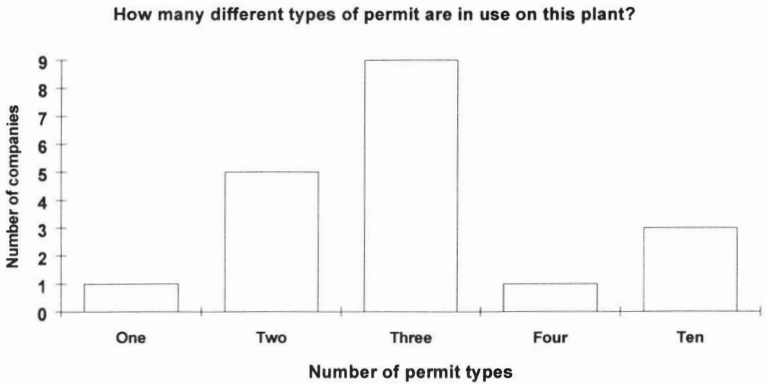


Analysis of the interview data

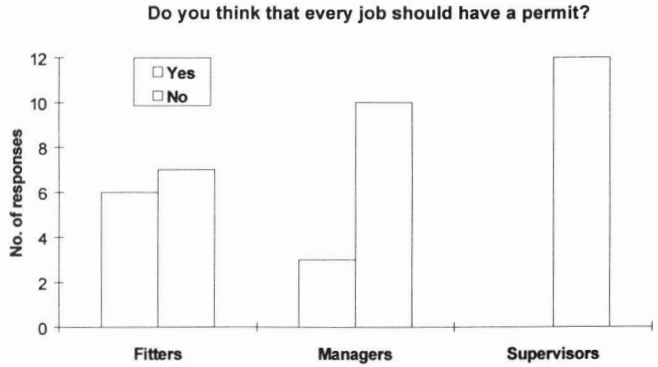
The design of the system

Interview data revealed that half of the companies were reported to have copied their permit system and permits, with or without modification from other sources and were consequently not site specific. Often this was a result of a parent company imposing a system. Systems were generally developed in a "top down" manner, management designing a system that appeared to be able to perform the necessary functions and implementing it. Consultation of users during design was not common. It is generally accepted that a user centred approach is more likely to produce a practical and acceptable design because the people who know most about the work have an input in the design process.

The most commonly encountered systems used 3 types of permit, those with 10 types were petrochemical sites and are perhaps not typical of small to medium sized companies. A three permit system appears to be appropriate for the type of plant and kinds of hazards found at small to medium sized sites. Typically these would be General Work, Hot Work (involving sources of ignition) and, Confined Space Entry. The number of permits issued per day was small, as would be expected from small to medium sized plant. Most companies issued less than 4 per day, those issuing over 20 permits per day were petrochemical sites.



When asked the question whether "all jobs should require a permit" the distribution of responses between managers, supervisors and fitters suggests that supervisors would definitely not want all jobs to have a permit. Similarly, most managers would not want all work to require a permit. However, fitters seem to be more divided on this issue.



The design of the permit.

A common problem was that the location of the work to be controlled by the permit was specified in general terms, e.g. "east side of building B". This type of statement would typically cover a large area and would be non specific, thereby, potentially placing workers at risk. A small number of sites used maps or diagrams to help describe the location of the work, the equipment to be worked on, or the boundaries of the work area. One company used this approach when tackling complex isolations. It is suggested that the use of diagrams or maps could be beneficial.

Typically there were similar problems concerning the description of the work to be done. Some permits were seen where the job description was simply "maintenance work". This kind of

statement clearly provides considerable scope for inappropriate action. The task should be described explicitly and unambiguously, otherwise the worker may stray into work that is not controlled by the permit.

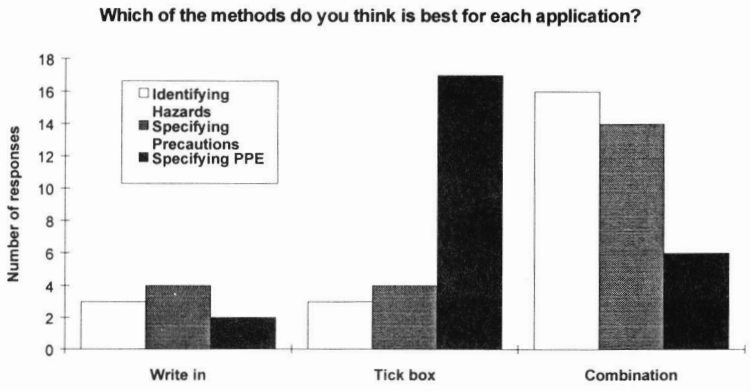
Most respondents interviewed accepted the concept of signing the permit to confirm that they had taken certain actions, such as isolations. However, fitters in particular expressed reluctance to sign in case they were later held responsible following an incident.

A number of participants (36%) were disatisfied with the amount of space available on permits for writting in details. It is suggested that this requirement should be evaluated by the company during the design of the permit.

The order of sections within permits was reported to be appropriate to the sequence of events that they relate to. However, 24% of participants thought that permit layout and presentation could be improved. The presentation of many of the permits was poor, with poor legibility of text. Additionally a single page permit was prefered by the majority of respondents. However, several companies used non standard, larger than A4, sheets to achieve this. It is of course important that permits are compatible with storage, displays, clipboards etc...

Thirty eight percent of respondents reported that handwriting was a problem with permit clarity. Reducing the amount of handwritten information on the permit would obviously help this aspect. However "write in" sections have an important advantage; they require the writer to think what to write instead of simply ticking boxes. They also allow very detailed and specific information to be entered. A balance between ease of completion, and the necessity for precise, unambiguous and clearly presented information is required. Training should emphasise the importance of this issue.

Examples were provided during the interview of three methods of entering information: tick box; writing in, and; a combination approach. The tick box method was popular for specifying PPE only, while solely writing in was not preferred for any application. The combination method retains the advantages of writing in information, but combines this with a list of prompts. The combination method was preferred for identifying hazards and specifying precautions. The combination method is most appropriate for those functions where an exhaustive list of options is difficult to produce.



Permit initiation

The use of a job request card to initiate work and also to indicate whether a permit is required is widespread (16 companies). This is potentially a useful and reliable way of initiating the permit system provided the right person has sight of the job request. Five of the companies approached this the "easy way", by making every job require a permit. This means that even routine low risk jobs, require a permit. Examples included changing light bulbs and jobs in offices. This approach can bring the permit system into disrepute because people will see it as an obstruction rather than a safety precaution. These kinds of routine jobs could be controlled by procedures. For some sites it may be possible to develop a list of jobs requiring a permit, depending on the type of work done.

While the majority of sites suffered from the problem of personnel not being able to find permit authorisers, there was little evidence of pressure from management for workers to get on with the job without a permit. It was understood and accepted by all that waiting might be necessary. The results also identified that permit expiry is not always addressed, 34% of respondents reported that permits were made out for the day. It clearly requires less effort to leave the expiry open than to decide a time. The danger is that the work may run on and conditions might change. A discussion with the fitter enables a realistic estimate of the time required to be made, and this is recommended.

Specifying personal protective equipment (PPE)

A significant proportion of sites appeared to have what amounted to a standing instruction for PPE. The authoriser might specify "gloves and goggles" on every permit, without really considering the hazards. Another problem encountered was that of PPE being over specified for the job. This could appear to occur for two reasons: to save the authoriser from having to consider the hazards, and / or to remove any blame from the authoriser should anything go wrong.

An additional issue in this area is that PPE requirements are likely to vary during the course of a job. For example: the amount of protection required when breaking a flange (Visor, gauntlets, PVC suit) might be greater than when subsequently working on the pipeline, having found no

residue (goggles, gloves and overalls). In this kind of situation it will appear that protection has been over-specified for the majority of the work.

Overlapping work and shift changeover arrangements

A number of accidents have occurred due to unforeseen interactions between jobs. Most companies did not address this type of problem on the permit (70% of responses). For this to be considered during permit initiation it is necessary that the authoriser has a good working knowledge of all relevant jobs. This highlights the importance of having a competent trained person as authoriser, in order to understand the possible interactions between jobs and to ask "what if?" questions.

One method of improving information flow would be to devise a method of displaying active permit work and the state of plant "at a glance" for authorisers. A schematic diagram of plant with magnetic markers for isolations and permit work, for example, could be an effective, cheap, and updateable way of acheiving this.

When questioned regarding the sequence of events at shift changeovers, respondents displayed considerable variability and perhaps this reflects the difficulty of achieving effective shift handover. This matter was less complicated for many of the smaller sites where maintenance staff only worked a single shift. However, production shifts may change during a maintenance shift, potentially introducing further problems of communication. The main difference, between the managers and the other two groups, was that a high proportion of managers thought that permits should be allowed to carry on over shift changes. How this might be achieved whilst keeping the incoming shift informed of the current work situation is a matter for debate. It is recommended that a formal procedure for shift changeover should be developed, where face to face communication between incoming and out-going supervisors can occur.

Permit hand-back procedures

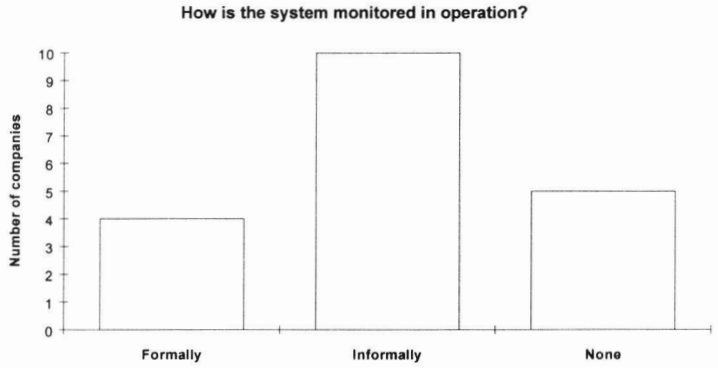
While most companies (17) had provision for a "hand-back" procedure on their permits, it was apparent that "hand-back" procedures were frequently not adhered to in practice. Cases were quoted of fitters leaving the site at the end of the day with permits still in their pockets. However, there were few suggestions from participants as to how this problem could be tackled. Having the

permit system linked to some method of time accounting was one possible solution adopted by one company.

The permit system should be compatible with plant reinstatement procedures and if the permit is a requirement in these procedures, this will ensure permits are returned. Training should emphasise the importance of "handback", but can only be considered a partial solution.

Monitoring of the permit system

This was generally poor, but in most cases an annual check of used permits was made, i.e. whether they have been completed properly. Sites with safety officers or a member of staff with specific responsibility for safety were more likely to have a formalised audit.



It is essential that the system is monitored effectively in order to know whether any part of it is failing or inappropriate. Monitoring should consist of: a management check on work in progress; checking the permit requirements; checking work descriptions and hazard identification etc.

Other Practical Problems

Delay to work was by far the most frequent complaint (40%). For permits to be effective, they will take time to complete and may require the authoriser to visit the work site to make checks on more than one occasion. Evidence suggests that authorisers are often difficult to locate when required, lengthening the delay. The practice of permits "catching up" with the work obviously has its dangers. Hazards need to be considered thoroughly and the most reliable way to achieve this is to use the permit system.

It is usually the case that authorisers issue the majority of permits at the beginning of the day or shift. Some companies have speeded up permit issue during normal operations by allowing the night shift to prepare permits and plant for jobs the following day. Another method is to increase the number of authorisers for certain types of work by enabling chargehands to issue permits. However, more authorisers can have the effect of increasing the need for effectively communicating plant status, as discussed above.

It appears to be the case that workers become familiar with certain frequently repeated jobs. In these cases it is probable that if a permit is issued for these jobs it is unlikely to be studied in depth. The principle danger is likely to be where a job appears to be routine at first glance, but in

fact differs slightly and is significant. In such instances, there is a risk that the fitter will assume the routine procedure applies and get on with the work. Perhaps jobs such as these could be controlled by a safe working procedure instead of permits. This would have the two advantages of:

- Saving time and effort;
- Not bringing the permit system into disrepute because permits are used for jobs that don't really need them.

In situations where, by necessity, the work required differs from that specified on the permit, there was a difference of opinion between those doing the work and those authorising permits. Most fitters (53%) said they would check with their Supervisor if they were unsure about a permit or what work was needed, but a significant proportion (35%) said that they would probably carry on and do what was needed. Few supervisors or managers stated that they expected fitters to carry on without recourse to them. It seems that the dangers of straying from the work specified on the permit are frequently not fully appreciated. Training should emphasise the possible dangers and state the course of action to be taken when this situation occurs. This could also be made clear on the permit itself.

Training

Not surprisingly, the majority of respondents (92%) thought that training on PTW matters was important. However, training had often been neglected when it came to permits. Typically, very little time was devoted to it, if any. Seventeen respondents (34%) had received none. Considering the important role of permit systems for safety and their often complex nature, this is surprising. It seems that workers are expected to "pick up" the working of permit systems by experience. Also, refresher training is rare, yet it is an essential part of the system. It is vital that all involved learn about any changes to the system. Refresher training could ensures that common views on the role and workings of the permit system do not diverge over time.

Suggestions for improvements to the permit specific training came mainly from fitters, who wanted a better conceptual understanding of the process and the hazards they work with, i.e. what might actually happen if something goes wrong. Members of both Production and Maintenence teams felt they would benefit from knowledge of the other's discipline, and vice versa.

SUMMARY OF RECOMMENDATIONS

From the results of the study, the following general recommendations for the design and working of a PTW system can be made:

- Make the permit system specific and appropriate to the site and hazards it will be used with. It is likely that a three permit system consisting of: general work; hot work and; confined space entry will be comprehensive enough for many small to medium sized operations.

- Consult and involve end users during design to ensure practicality and useability, i.e. "bottom-up" not "top-down" design

- Only use permits for jobs that need them. How this is decided is crucial. It is also important that there is consistency between authorisers on this decision.

- Make hazard identification a formal written step in the permit initiation sequence.

- Consider the hazards of interacting jobs in a formal way. State them on the permit to make fitters "concept" operators, rather than "programmed" operators.
- Specify appropriate PPE for each job following an assessment of the risk. Consider the variations in protection required throughout the job and make this clear on the permit.
- Provide a clear procedure for coping with shift changes (maintenance and production) and informing the incoming shift of work in progress.
- Display the current state of plant and maintenance work in an easily accessible way. eg. Mimic boards, tray systems.
- Make permits valid for a limited period appropriate to the job.
- Use hand-back procedures to ensure that the status of the work is known and plant is always left in a safe condition. The interaction/integration of handback procedures with plant reinstatement procedures should be considered.
- Ensure that authorisers have a comprehensive working knowledge of process and engineering issues applying to permit work, so that they can effectively assess the risks.
- Require a second person to check important actions to be taken in connection with the permit. This should be confirmed on the permit.
- Monitor operation of the permit system, make spot checks on work in progress, check the permit requirements etc...
- Review the permit system regularly so that it can be adapted to changing conditions.
- Provide formal assessed training on PTW systems operation. Training maintenance and production, fitters and authorisers, together will promote a better understanding of process and engineering matters.
- Provide refresher training at regular intervals and when monitoring indicates it is required. This will ensure that all involved will have a common view of the system and its purpose through time.
- Train contractors to an appropriate level. Ensure that only those who have received training are allowed to work.

Recommendations specific to the permit form are:

- Specify the location of work and the nature of the work to be done clearly and precisely in writing.
- Ensure there is enough space on the permit form for writing down information, use different methods for entering data where these are appropriate.
- Make the permit layout follow the sequence of events in its life cycle.
- Aim to use a single sheet for the permit.
- Consider the use of maps or diagrams where appropriate.

GUIDANCE ON PERMIT FORM DESIGN

Following the survey it was decided to prepare guidance on form design for inclusion in future HSE publications on permit systems. The principles outlined here are based on various sources and are primarily aimed at permit form design, however, they may be helpful with the design of documents, instructions and manuals.

The design process

The form writer should have a good understanding of the permit system, although having to learn about the permit system may in fact help to produce a clear and comprehensive form.
The design process can be broken down into three stages:

- Definition
- Design
- Evaluation

Definition

What information and functions do you need to include? This will be influenced by the nature of your plant and the design of your permit system. You will need to consider the requirements and capabilities of all who will use the form. This will follow the chain of responsibility in the permit system, from managers and supervisors through to the fitters. Remember that over 7 million people in Britain have reading difficulties, and age and eyesight influence the size of print that can easily be read. For some workers, English may not be their first language.

Design

Decide on the presentation of each section, whether it is best to present as prose, tables, or tick boxes etc. Consider: the space available; the easiest way of entering information; the easiest way of extracting information, and; how to get people to think.
The two main options are:
- a tick box method for sections where all the options can be listed, such as specifying personal protective equipment, and;
- a checklist of broad options followed by a section requiring the form filler to write in the details. For example:

Personal Protective equipment

Body		**Respiratory**		**Eyes**		**Hands**	
Disposable overall	☐	Dust mask	☐	Goggles	☐	HD gloves	☐
PVC overall	☐	Respirator	☐	Visor	☐	Insul gloves	☐
PVC apron	☐	Airline BA	☐	Welding goggles	☐	PVC gloves	☐
		Selfcontained BA	☐	Welding visor	☐	PVC gauntlet	☐
						Rubber gloves	☐
Head		**Hearing**					
Hard hat	☐	Ear plugs	☐				
Coverall	☐	Ear defenders	☐				

Hazard Identification

Hazard Type	Tick	Details
Acids / Corrosive		
Toxic dusts / Fumes		
Nuisance dusts / fumes		
Fire / explosion		
Mechanical / moving parts		
Noise		
Temperature		
Other hazard		

Evaluation

Use "experts" to check the content. These are usually the people closest to the work, so involve the engineers and fitters who use and work under permits. Try your draft out on the range of people who will actually have to use the form. Try it out with the job. Repeat the drafting and evaluation process until the form you have is acceptable and useable.

Content

If the permit system is to have credibility you must include all information which is necessary and none that is not. Research has shown that irrelevant, outdated and useless information often appears on permits. This not only takes up valuable space that could be used for important information but can mean that the system looses credibility with the workers. For similar reasons the permit must match up with the practicalities and realities of day to day work. For example, if a particular person's signature is required, then they must be available and capable of making any checks required. Your permit should therefore be specific to your site.

The order of the sections and the information or actions within them should follow the normal flow of the work, or the permit "lifecycle".
You should write in language that is easily understood by all users. Avoid the use of unfamiliar words or phrases that may have different meanings for different people. A general guide is to aim for 15 to 25 words per sentence. People find it hard to understand negatives in questions so they are best avoided. You should also avoid asking more than one question at a time, for example:

Is the tank uninsulated? Yes ☐ No ☐

Is the... and the...? Yes ☐ No ☐

Many will not answer these in the way the writer anticipated despite the simple logic.
Make it clear to the form filler what is required,

e.g. Please tick ☑ the correct boxes.

Other affirmative types such as circling or underlining the correct answers are widespread but in certain circumstances can lead to errors of interpretation and are best avoided. The "delete

whichever is inapplicable" method should not be used. A serious accident resulted from the misalignment of carbon copies of one permit system where deleting was used. To the reader the text appeared to be underlined It is important to arrange the layout of boxes so that boxes are not ticked inadvertently, and so that it is clear which box has been ticked.

Handwritten information should be given enough space, at least 8.5mm in height, and between 3.1-4.2mm horizontally per letter. It will help if you have some idea of the kind of information that will be written.

Another rule to follow is that each answer space should be nearer to its own question than any other. It has been common practice to left justify questions and right justify answer spaces. This means that the answer spaces are usually as far from the question as possible making it difficult to match the two together.

There are many other factors that should be considered and that have an impact on the usability of of a permit. These cannot be covered here, but include factors such as:

• Organisation and layout - Headings serve to structure the form and numbering can help to reinforce the sequence of sections. Margins should allow room for hole punching if you intend to store permits in a binder.

• Physical Elements - The size you choose should be compatible with other aspects of the system such as, wallets, pouches, clipboards, displays, and trays. You should also remember that standard paper sizes are easier to photocopy. The quality of the paper surface has special relevance to permits because some will be used in dirty conditions. A paper that has some resistance to damp and contamination will be an advantage, as will a resistance to tearing. The contrast between the text and the background should be 65% or above. Some coloured backgrounds and texts can greatly reducing the legibility of the text. However, some forms use a technique in which areas to be completed are left plain white out of a coloured or grey background (as previous examples). This technique gives a pleasing appearance and it is easy to see where answers are required.

•Typography - The type size, typeface, justification, line and word spacing, can all have a profound effect on the legibility of text an should therefore be considered.

• Printing and reproduction - In summary, when deciding on the method of reproduction you should think about:

- how many copies do you want?
- do you want colour?
- do you have any illustrations that may be difficult to reproduce?
- how quickly do you need the results.

SUMMARY

The study has identified several areas where permit system design and management can be improved. In particular, it highlighted the need for some practical guidance on permit form design relevant to small to medium sized companies. Recommendations for addressing the problems identified from the study have been made, and detailed guidance on permit form design is currently in preparation for publication by HSE.

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