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A New Mode of HSE Risk Management for Construction Projects

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Abstract

The HSE case, developed by Shell Co., is a quite famous HSE risk management tool for construction project, but too much content makes it difficult to compile it before the start of a project. Even though the HSE case is finished, it is hard to have so much content to be mastered by the persons concerned in so limited time just before the start of a project; it is thus called “the case sits on the shelf.” In order to make such a tool much more practical, we adapt it according to its application environment, and the mode of “Two Documents and One Checklist” is thus formed. The mode contains two documents and one checklist. One of the documents is a relatively static document, named “work-post HSE guide,” which is designed to manage the relatively static risks; the other document is a changing document, named “project HSE plan,” which is designed to manage the changing risks. Both documents are designed mainly to guide workers to work or operate in a standard and safe manner. The checklist is designed to verify whether the condition of the workplace such as machines, equipment, tools, and so on is safe or not. Owing to the feature of the mode of “Two Documents & One Checklist,” it is not only quite easy to compile but also very convenient to apply in daily work by eliminating the problems that appear in the HSE Case.

Keywords: HSE risk, construction projects management, front-line organization

1. The features of risk management of construction projects

The risk management can be applied in many fields wherever risks exist. In the field of health, safety, and environment management, it is called HSE risk management; in the field of finance, there is finance risk management and so on.

Just as for safety risk management, different objects need different risk management modes because of their different features; therefore, many different risk management modes are developed to manage different kinds of things. As for construction project, its obvious feature is the change; the change may cover personnel, machinery and equipment, raw materials and products and semi-finished products, technology, environment (natural environment and social environment), etc. Therefore, the mode for the safety risk management of construction project should meet its changing feature.

Safety case and HSE case are two typical modes applied for the safety and HSE risk management of construction projects. Although they are used widely around the world, many problems aroused during our application of the method in our daily HSE management of the construction projects.

2. The problems and the objectives

Although we pay more attention to accident prevention from the state to our corporation, we own little effective safety risk prevention method before. What we have done is to learn the lessons after the accident happened instead of taking prevention beforehand. We have been exploring a suitable method to apply the risk management theory to the daily production and operation of grassroots organizations since the introduction of HSEMS [1]. When we got to know the HSE case [2], we found it was a good method to prevent accident beforehand at least in theory, but many problems aroused during our application of the method in our daily HSE management of the construction projects in the frontline organizations.

HSE case is a comprehensive document for risk prevention [3, 4]. It is rich in content and covers a wide range, which however will not only increase the preparation workload but also affect its implementation. To prepare a HSE case, it is necessary to comprehensively identify HSE hazards and assess their risk, develop corresponding risk prevention measures, and establish documents in writing before a project started [5]. Since all these work must be done before the project is started, problems such as tight schedule and burdensome task may be encountered, leading to failure in compiling such kind of a huge document, let alone its quality. On the other hand, as HSE case is rich in contents, there is usually no enough time to organize a process to educate relevant personnel in the project preparation phase. Even if the education process is implemented, the effect will always be too poor due to its too many contents. In view of the above problems, some companies only regard HSE case as “a letter of guarantee” and submit it to relevant stakeholders, emphasizing their concern for project HSE risk prevention while downplaying relevant education. As a result, even the companies within Shell Co. once internally dubbed HSE case as “the case sits on the shelf.” In a word, although there are many problems mentioned above, the key problem is its too much content of the HSE case. Because of too much content, it is difficult to compile such a huge document within the limited time just before the beginning of a project especially for the frontline organizational persons, let alone train the workers with it in such a short time.

According to the above analysis, the main objective is to reduce its content and to make the document of HSE case a bit simple in order to compile and apply it in daily HSE management of the construction projects in the frontline organizations smoothly. Based on the analysis, a new safety risk management mode for construction project, called the HSE-TDOC (two documents and one checklist), was developed in 2001 [6] and was modified in 2007 according to the problems met in practice [7]. The underlying principle and application of the model, as well as the document structure and steps of compilation, were described in the following, through which the model is well explained.

3. The methodology used to develop the HSE-TDOC

HSE case is a kind of HSE risk management document developed to enhance the project HSE risk prevention capabilities. Its biggest advantage lies in the organic integration of HSE risk management theories and the practice. It applies risk management theories to effectively guide actual HSE risk management, especially the project HSE risk management.

Based on the problems met in the application of HSE case, a new safety risk management mode, named the HSE-TDOC (two documents and one checklist), was developed for construction project, and it will be introduced in this section.

3.1 The analysis of the HSE case

In fact, HSE case has become not only “the case sits on the shelf” but has been questioned by some experts and scholars for its way of managing operational risks. For example, in the co-authored paper “Integrating Safety Management Through the Bowtie Concept—A move away from the Safety Case Focus,” Australian scholars Acfield et al. [8] believed that HSE case is applicable to managing risks arising from changes in the project or activities, and it should not be used to manage operational risks.

Through the study of risk management theories and systematic analysis of various risks, we believe that the risks encountered in practice can be roughly divided into two types, i.e., “relatively stable” risks and “changing” risks [9]. “Relatively stable” risks have two characteristics. The first feature is just as the name implied that they are relatively stable, e.g., in oil or gas well-drilling industry, the blowout risks while drilling is a “relatively stable” risk. As long as there are no great changes to the work object, process and technology, equipment, and facilities, such risks will keep being stable; whenever, wherever, or whoever has an oil or gas well drilled, the risk of well blowout will always exist. Because the underground high-pressure fluid layer may be meted while drilling, the well blowout will happen if the preventive measures are null and void. The second feature is that they are specialty-related. The blowout risks, for example, may only exist in business areas related to the underground high-pressure fluid layer, such as drilling, logging, and workover, while in other unrelated fields such as refining and chemical and transport, blowout accidents are impossible.

Such “relatively stable” risks are actually the so-called operational risks by Acfield et al. [8]. They are often called as conventional risks or conventional operational risks, because they generally occur in the course of conventional operations. Conventional operations refer to those operations with relatively fixed work contents and environment that can be carried out according to preset procedures, which is also named standard operating procedure (SOP). Therefore, risks arising from conventional operations can be prevented by complying with the corresponding operating procedures, working procedures, SOP, etc. that aim to regulate the behavior of operators. As conventional risks are relatively stable, and the measures to control them are also stable, there is no need to manage such kind of risks based on project-specific HSE case which is changed from one project to another.

Compared with conventional risks, unconventional risks have unique characteristics. Firstly, unconventional risks are changing. Prevention of such risks requires pertinent measures considering many associated factors, not like conventional risks which can be prevented by developing operating procedures, working procedures, SOP, etc. Such risks are called as “change risks” by Acfield et al. [8]. Secondly, although there are many types of unconventional risks (risks arising from unconventional operational activities and changes), the total amount of is quite less than that of conventional ones. Thirdly, unconventional risks are unrelated to specialties and may exist in any field. Because of the above characteristics, unconventional risks are more suitable for HSE case. As different projects may encounter different unconventional risks, it is necessary to identify, evaluate, and develop control measures of unconventional risks from one project to another.

3.2 The development of HSE-TDOC

As the abovementioned, since one kind of risk is specialty-related, a relatively stable document can be developed to meet such kind of needs. Therefore, according to different kinds of specialties, we develop relatively stable HSE guidance which are specific to the specialties or work post. Preparing HSE guidance may take a

lot of time and effort because contents of such risks management are quite wide. However, seeing that such kind of risks is relatively stable and there is no deadline for completion, HSE guidance can be used for a long time once completed.

Another type of risk is changing risks which we call unconventional risks. Unconventional risks refer to the risks other than conventional risks (**Figure 1**) [10]. They include not only the risks arising from a variety of unconventional operational activities (operational activities that cannot be carried out according to established procedures due to changes in job contents, environment, etc.) such as risks arising from hot work, excavation, work at height, etc. but also the risks brought about by changes, such as the risks brought about by changes in personnel, equipment, raw materials (finished and semi-finished products), process and technology, environmental factors (natural environment and social environment), etc.

As mentioned earlier, a large amount of contents on the prevention of conventional risks has been formed into a new document called specialty-specific HSE guidance, resulting in much of the content of the former HSE case being stripped out, with the contents on the management of unconventional risks (including project emergency management) being included in the HSE case. In this case, we take a new name for HSE case, i.e., project-specific HSE plan (HSE plan). Actually, HSE plan is a downsized HSE case. As different projects may encounter different unconventional risks, each project should be prepared with its own HSE plan according to its characteristics. Generally, a project may not encounter too many unconventional risks, so the HSE plan is usually easy to prepare and communicate. Furthermore, as the unconventional risks are the risks that exist in the project but are not included in HSE guidance, they are the ones known as the new additional risks of the project in practice; therefore, HSE plan is also called the document for managing additional risks of the project.

As the abovementioned, HSE plan is a downsized HSE case, so the HSE plan will be prepared and applied just as the HSE case. To prepare a HSE plan, before a project started, people concerned should go to the worksite of the project to conduct site surveys and collect relevant information and data in order to comprehensively identify and assess HSE hazards, develop corresponding risk prevention measures, and establish documents in writing. Certainly, those that have been already managed by the HSE guidance will not appear in this document. The HSE plan mainly deals with the risks caused by the change of personnel, machinery and equipment,

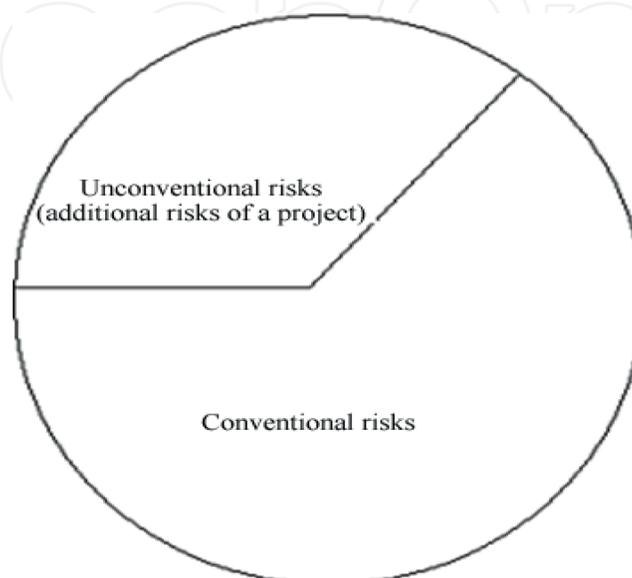


Figure 1.
Conventional risks and unconventional risks.

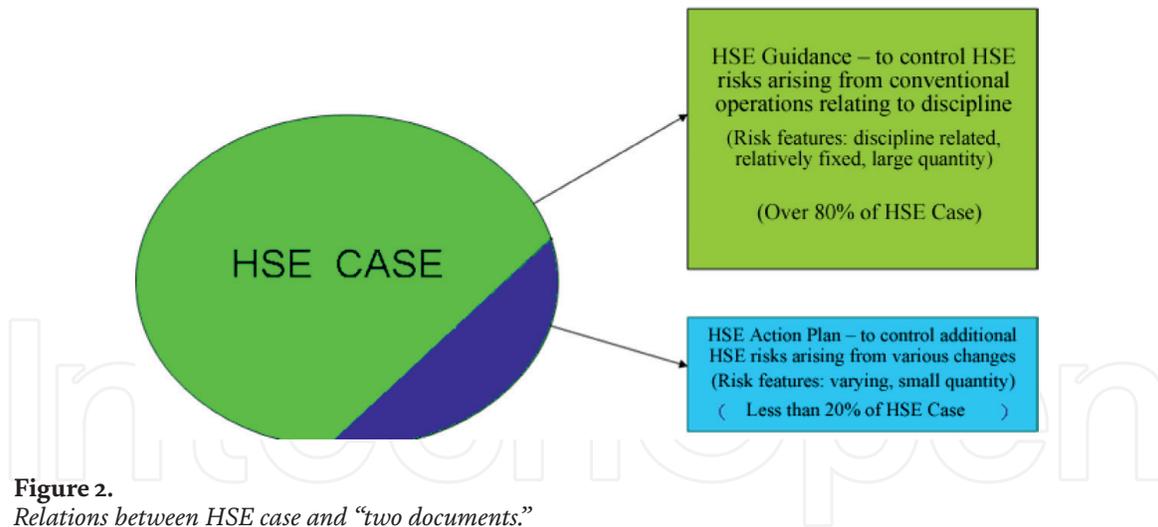


Figure 2.
Relations between HSE case and “two documents.”

raw materials and products and semi-finished products, technology, environment (natural environment and social environment), etc. For example, a grassroots team which usually works in plain areas may occasionally go to mountain areas to work there. Due to changes in the natural environment, the grassroots team may encounter mountain torrents, landslides, and other natural disasters that will not happen in plain areas before. No matter what kind of unconventional risks, if they are needed to be controlled, they should be included in the HSE plan as long as they appear in the project.

As mentioned in the “two documents and one checklist” previously, the “two documents” are essentially the results of dividing HSE case based on the nature and characteristics of HSE risks (Figure 2).

4. The “two documents and one checklist” risk management mode

In this section, the mode of HSE-TDOC will be introduced thoroughly. First is the overview of HSE-TDOC, and then its content and compilation and application will be followed; at the end, its function and effect will be mentioned too.

4.1 Overview of HSE-TDOC

HSE-TDOC refers to the specialty-specific HSE guidance (HSE guidance), project-specific HSE plan (HSE plan), and position-specific HSE checklist (HSE checklist) [11]. Among them, the HSE guidance may have much content, while the HSE plan may either have much content or just a few pages depending on the project.

4.1.1 Specialty-specific HSE guidance (HSE guidance)

HSE guidance is a guiding document which is used to reduce the HSE risks arising from discipline-related conventional operations to the ALARP level through risk management. Through the risk management process, countermeasures against the HSE risks to be managed are developed. Then these countermeasures that are distributed to relevant positions with written records are kept. After being reviewed by the competent department (personnel), the written records are compiled into the HSE guiding document specific to the discipline.

As the HSE risks arising from discipline-related conventional operations are relatively stable, there would be no change in the corresponding prevention and control measures as long as no change occurred to process, technology, equipment,

facilities, etc. If there are risks that resulted from temporary changes, control of such risks should be carried out by means of the HSE plan. Certainly, if there are risks that resulted from forever changes, the HSE guidance should be modified. Therefore, the HSE guidance is relatively stable.

4.1.2 Project-specific HSE plan (HSE plan)

The HSE plan is a document intended to control the risk result from all kinds of change. It is prepared before the project/activity started in accordance with the risk management process by the operating personnel involved in the project/activity after site surveys, considering the “person, machine, material, method, and environment, etc.” influencing factors and changes thereof. It shall be reviewed and approved by the competent department (personnel) upon completion.

The HSE plan is prepared on the basis of the HSE guidance. It is a supplement to HSE guidance and covers the prevention and control measures against HSE risks of the project/activity that are not included in the HSE guidance. Together, the HSE plan and the HSE guidance are documents to control all the identified risks of the project/activity. Comparison of the characteristics of the two is shown in **Table 1**.

4.1.3 Position-specific HSE checklist (HSE checklist)

The “one checklist” in the “two documents and one checklist” refers to the position-specific HSE checklist. It is a form designed according to a scientifically reasonable route (order) to prompt inspection personnel to pay more attention to critical parts or vulnerable components of field hardware facilities that are used or controlled by employees on each position, such as tools and machines, equipment, etc., in order to improve the efficiency of discovering hidden dangers. Each position has its own corresponding checklist. Through using the checklists of all positions, all the field hardware equipment, facilities, tools, and machines can be fully inspected to ensure that they are in a safe condition. The position-specific HSE checklist can not only ensure full inspection and effective management on field objects that are in an unsafe condition but also improve the efficiency of safety inspection.

Features	HSE guidance	HSE plan
Object	Post or discipline, compiled by post as much as possible	Project, activity
Compilation time	No strict restrictions on compilation time. At best, it should be compiled when such organization is established	Before the project/activity commencement (strictly restricted)
Features	Rich contents, relatively fixed, available for long-term use	Simple content, a temporary document of “one case one meeting”; the plan is annulled after the project is completed
Application	Reference in daily work, the main training data for centralized study and training. Via the daily or centralized study and training, the employees’ professional qualities will be enhanced, and the conventional risks will be effectively prevented	Before the project/activity commencement, education is carried out for all employees involved in the project/activity, so that they will know additional conventional risks and know how to implement corresponding prevention measures. In this way, additional conventional risks of the project/activity can be prevented

Table 1.
HSE guidance vs. HSE plan.

4.2 The content and compilation and application of HSE-TDOC

4.2.1 The HSE guidance

4.2.1.1 The content of HSE guidance

The content of HSE guidance includes, but not limited to, the following contents; in other words, the main contents of the HSE guidance are as follows:

- Job qualifications
- Job responsibilities
- Standard operating procedures
- Patrol inspection and main contents
- Emergency response procedures
 - “Job qualifications” and “job responsibilities” are the basic requirements for a position developed by the personnel department based on the characteristics of the position. It is the responsibility of an employee to do a good job in his post. While meeting the qualifications for the position, an employee must also be aware of the responsibilities of the position. Therefore, job qualifications and job responsibilities are the most basic requirements that an employee must meet.
 - “Standard operating procedures” and “emergency response procedures” are the core content of the HSE guidance. With the deepening of standardized management in enterprises, basically each conventional operation is provided with standard operating procedures. But due to poor education on these procedures, they were not well understood by employees. So usually operations were carried out beyond the standard procedures, which are the main causes of most accidents. One of the functions of the HSE guidance is to have the employees understand the standard operating procedures by providing them in print to the employees. If necessary, employees may refer to the HSE guidance in advance to prevent nonstandard operations. Emergency response procedures are actually the operating procedures in a state of emergency. Since it keeps relatively stable once established and modified, we can analyze various emergencies that may occur to a specific position and incorporate the corresponding “emergency response procedures” into the HSE guidance specific to the position, so as to improve emergency response skills of employees.
 - “Patrol inspection and main contents” aims to ensure the overall safety of objects. First of all, set the main contents of inspection according to the characteristics of the tools, machines, equipment, facilities, and other hardware items used or managed by the employees on the post, especially critical parts and vulnerable components, based on the principle of territorial management. Then, devise an inspection route to find problems and hazards of the mentioned hardware items, aiming to ensure the overall safety of objects effectively. By the way, “patrol inspection and main contents” in the HSE guidance is just to govern the use of its HSE checklist.

Except for the “patrol inspection and main contents,” all the rest are readily available. Incorporate them into the HSE guidance after modifications are made to relevant contents through risk management activities.

The revised position-specific HSE guidance (version II) mainly contains the basic requirements that employees should meet. Unlike version I, the contents on the management of conventional risks relating to the discipline in version II were incorporated into position-specific operating procedures and other relevant contents, facilitating the education on the HSE guidance.

In addition, we also recommend the use of “bowtie” model and other effective methods to reinforce the prevention of significant risks. Significant risks generally fall into the category of conventional risks. In addition to the normal prevention means such as operating procedures, we recommend using the “bowtie” model (Figure 3) to strengthen the prevention of significant risks. Depending on the circumstances, the “key tasks” and “key facilities” generated by the “bowtie” model should be allocated to relevant positions and included in the position-specific HSE guidance.

4.2.1.2 Compilation and application of the HSE guidance

The HSE guidance should be compiled considering the nature of grassroots organizations. For grassroots organizations of the same type, a consistent HSE guidance could be compiled since their disciplines and position settings are the same. The discipline-specific HSE guidance should be compiled usually by the enterprise or its subsidiaries. When compiling the discipline-specific HSE guidance, attention should be focused on the discipline and related activities and potential abnormalities and emergencies in the entire process of the project, followed by hazard identification, risk assessment, and development of appropriate risk control measures. The HSE guidance shall be reviewed and approved by the competent department.

Since the HSE risks arising from discipline-related conventional operations are relatively stable, risk prevention measures may stay the same as long as no change occurred to the process, technology, equipment, facilities, etc. Hence the HSE guidance is a kind of relatively stable document. It can be used as a working guide for relevant employees in their day-to-day work and can also be used as a resource for self-study. More importantly, grassroots organizations should regard the education on the HSE guidance as a management action that should be persisted for a long time, so as to enhance the staff’s professional quality and risk prevention capability.

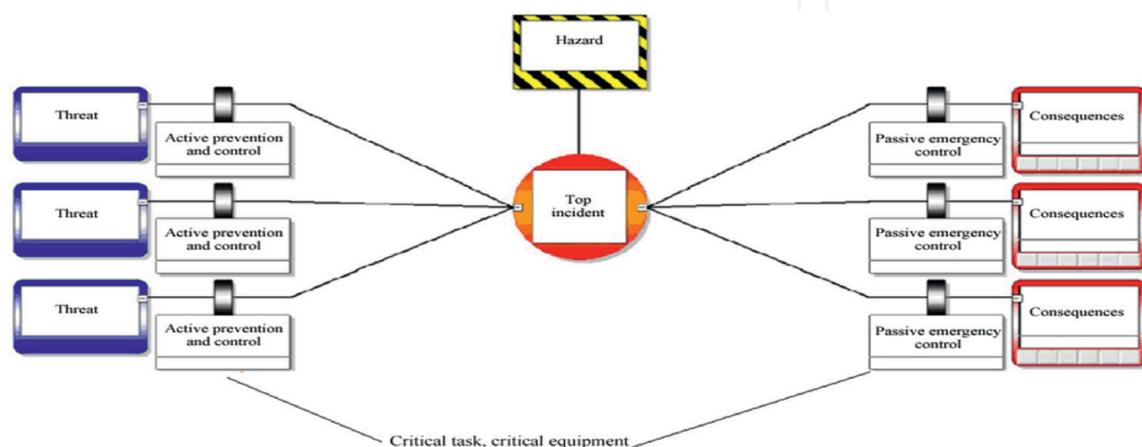


Figure 3.
Bowtie model for preventing significant risks.

As the HSE guidance has relatively fixed content, its compilation and education could be a part of day-to-day work, avoiding the problems (heavy compilation and education workload before the start of a project) and faced by HSE case.

All in all, through the education on the HSE guidance during daily work, relevant employees will understand the conventional risks and characteristics thereof related to their positions and know how to implement the specific measures to prevent these risks, thus effectively improving their ability to control the discipline-related conventional risks.

4.2.2 *The HSE plan*

4.2.2.1 *Content of HSE plan*

The content of HSE plan includes, but not limited to, the following contents; in other words, the main contents of the HSE plan are as follows:

- Project overview, worksite, and the surroundings
- Personnel and equipment
- Identification of additional hazardous factors and main risk warnings
- Risk prevention, mitigation, and
- Emergency response plan
 - “Project overview, worksite, and the surroundings” and “personnel and equipment” are set up to identify hazardous factors. For projects of mobile operations, changes may most likely happen to the project itself and the surrounding environment, personnel, equipment, and facilities, so the HSE plan focuses on these two parts for comprehensive identification of hazardous factors. Specifically, in the “personnel and equipment” part, potential risks are identified through analyzing changes (placement, shifts, etc.) in project personnel (especially those in key positions), and appropriate measures are developed. Regarding equipment and facilities, risks arising from frequent relocation and installation are considered, such as safety accessories lost, damaged, etc.
 - “Identification of additional hazardous factors and main risk warnings” and “risk prevention, mitigation, and control” are the focus of the HSE plan. When compiling the plan, the first step is to identify hazardous factors through analyzing the “project overview, worksite, and the surroundings” and “personnel and equipment.” On this basis, the next step is to refer to the HSE guidance to determine additional hazardous factors of the project (i.e., hazardous factors of the project that are not included in the HSE guidance), then find out the to-be-controlled hazardous factors and main risks of the project through risk assessment, and develop risk control measures against additional hazards. As to the control of main risks, given that the main risks are mostly discipline-related conventional risks whose control measures have been included in the position-specific HSE guidance, there is no need to develop risk control measures against additional hazards in the HSE plan. But if the main risks of the project are unconventional risks, control measures must be included in the HSE plan.

- “Emergency response plan” is not the main content of the HSE plan but an annex to the plan for educational purpose. According to the current situation of emergency management work, at present every grassroots organization will develop a variety of emergency response plans based on the characteristics of the discipline, so there is no need to repeat the preparation of emergency response plan when compiling the HSE plan. But if the emergency response plan is not operable, you need to modify and improve it. In addition, it should be noted that the “emergency response plan” in the HSE plan and the “emergency response procedures” in the HSE guidance are different but related. The “emergency response procedures” is a part of the “emergency response plan.” Being included in the position-specific HSE guidance, the “emergency response procedures” is provided for educational purpose. The “emergency response plan” is set up considering significant risks of a project, which is provided for communication before the start of a project. Once there are significant risks spreading out of control, the “emergency response plan” shall be launched immediately and call for the professional rescue force to minimize the consequences of the accident.

In order to further simplify the preparation of HSE plan for small projects or activities and to enhance the dynamic risk management of long-cycle projects, we added the risk management sheet (**Table 2**) to the version II template of the HSE plan. When using the HSE-TDOC, grassroots organizations may conduct risk management referring to the risk management sheet in the following cases:

Case one: for operating projects with long cycle and relatively fixed location (e.g., drilling of exploratory wells and critical wells and refinery shutdown for maintenance), compile the project-specific HSE plan, and incorporate the risk management sheet into the HSE plan before construction. During the construction process, carry out identification of hazardous factors on a regular basis, identify additional hazards which may arise as time changes, develop appropriate risk mitigation and control measures based on the HSE plan, and fill in the risk management sheet as a supplement to the HSE plan.

Case two: for operations with long cycle and mobile location (e.g., geophysical exploration operation and pipeline construction), compile the project-specific HSE plan, and incorporate the risk management sheet into the HSE plan before construction. During the construction process, timely identify additional hazards which may arise as time and environment change; develop appropriate risk mitigation and control measures based on the HSE plan, and fill in the risk management sheet as a supplement to the HSE plan.

Case three: for operational activities with short cycle and mobile location that are carried out in the same block (e.g., drilling of development shallow wells, downhole repair and fracturing, mud logging, wireline logging, and cementing operations that are carried out in the same block), compile the block-specific HSE plan, and incorporate the risk management sheet into the HSE plan before construction. Before single-well construction in the same block, identify additional hazards which may arise as time and environment change; and develop appropriate mitigation and control measures based on the HSE plan, and fill in the risk management sheet as a supplement to the HSE plan.

Case four: for operational activities with short cycle and relatively fixed location (e.g., production auxiliary operations, refinery temporary inspection, and maintenance), carry out hazard identification activities and fill in the risk management sheet before operation.

4.2.2.2 The compilation and application of HSE plan

The compilation of the HSE plan should be led by the major principals (team leader and project manager) of grassroots organizations. First, before the start of a project,

Code	No.			
Location (well number, job number)				
Name of the HSE plan				
1	Identification of additional hazards (including descriptions of changes in personnel, environment, process, technology, equipment, and facilities)			
2	Main risks warning (including main risks mentioned in the HSE guidance)			
3	Risk mitigation and control measures			
4	Emergency treatment			
Compiled by	MM/DD/YY	Project Supervisor	MM/DD/YY	
Audited by	MM/DD/YY	Project Manager	MM/DD/YY	
Relevant personnel notification records				
S/N	Name	Post (title)	Signature	Date
				Date
				Date
				Date
Completed on	MM/DD/YY	Accepted by	MM/DD/YY	
Remarks:				
1. This table is an attachment to the HSE plan				
2. This table shall be filled in according to the requirements specified in the HSE plan				
3. An attached page may be added to this table if necessary				

Table 2.
Risk management sheet (sample).

relevant personnel are organized to carry out site survey and data collection to identify hazardous factors that are to be managed but not included in the HSE guidance through risk assessment, and then develop appropriate measures. The compilation of the HSE plan should be completed jointly by technicians, squad leader, key position staff, and safety officers. The finished HSE plan should be submitted to the appropriate competent department for approval according to the project risk severity. Then the approved HSE plan should be communicated to all the stakeholders and the employees taking part in the project before the commencement of the project, so as to have all the personnel involved in the project understand the project's potential unconventional risks and characteristics thereof as well as appropriate control measures. Since the HSE plan is relatively short in content, it is practical for grassroots organizations to complete the compilation and education process before the project starts.

4.2.3 The HSE checklist

4.2.3.1 Content of HSE checklist

Compilation of the HSE checklist should be based on the principle of territorial management. The territorial scope of different positions should be divided, and the territorial management categories of tools, machines, equipment, and facilities should be defined. The key components, critical parts, and vulnerable parts should be highlighted according to the relevant inspection standards.

Compared with HSE guide and HSE plan, HSE checklist is quite simple. Just like the HSE guide, HSE checklist is prepared according to different work posts. The

worker should be responsible for the condition of hardware (machinery, equipment, tools) he/she uses or manages; the items need to be checked will be listed in his/her HSE checklist in order to facilitate his/her inspection; special attention should be given to the critical parts or vulnerable components of facilities. It is a form designed according to a scientifically reasonable route (order) to prompt inspection personnel to do his/her check efficiently.

4.2.3.2 Compilation and application of HSE checklist

For worksites of different natures, the ways to compile the HSE checklist are different. For example, the checklist for the standardized and customized worksites of drilling and other operations can be compiled together with the HSE guidance due to the relative fixed placement of equipment and facilities and remains relatively fixed. Different checklists should be developed according to the placement of field equipment and facilities for construction and other worksites where the placement of equipment and facilities is not fixed.

The HSE checklist is a form designed to cover all the abovementioned inspection contents according to a scientifically reasonable route (order). During shift changes or patrol inspections, relevant personnel may pay more attention to the equipment, facilities, tools, and machines under their control and be referring to the checklist, especially the critical parts of the equipment and facilities, so as to improve the efficiency of discovering hazards and ensure that the hardware facilities are in a safe condition. Although the HSE checklist is relatively simple compared with “two documents,” it focuses on the inspection on the safety state of objects, which is not included in the HSE case.

5. HSE-TDOC works as project risk management mode

In the HSE-TDOC risk management mode, the HSE guidance can be used to control conventional operational risks; the HSE plan can be used to prevent unconventional operational risks, i.e., the “two documents” are to regulate human behavior; and the HSE checklist, i.e., “one checklist,” can be used to inspect the state of objects. HSE-TDOC not only can be used for the risk control of mobile projects but also for the safety management of fixed workplaces. Besides, HSE-TDOC not only can be used for safety management in normal conditions but also for emergency response. Therefore, HSE-TDOC could serve as a HSE risk management mode to manage HSE risks arising from daily production and operation activities in grassroots organizations. Till now, HSE-TDOC as project risk management mode has been successfully applied in the frontline organizations of China National Petroleum Corporation (CNPC) for more than 20 years [11].

5.1 HSE guidance for conventional operational risk management

Conventional risks are the risks arising from conventional operational activities. As the content and environment of conventional operational activities are relatively fixed, the pre-established operating procedures and technical specifications such as standard operating procedures (SOP) are usually adopted for this kind of risk management. To give play to the role of risk prevention of such operating procedures and technical specifications, education for employees is required. Only through education, behavior of employees can be regulated. In order to have employees to grasp the position-specific operating procedures, the pre-established operating

procedures and technical specifications are put into the HSE guidance. Through educating with the HSE guidance in daily training, the knowledge including the operating procedures can be grasped by employees, and the operating procedures can only be obeyed by them on the basis of their knowing, otherwise if they know little of the operating procedures, let alone obey them.

At present, although many enterprises have paid great attention to staff education/training, the training effect is not satisfying due to single method, disorganized contents, and lack of continuity [12–16]. To a certain extent, the HSE guidance has solved problems relating to staff technical skill training. As the HSE guidance contains all the information that should be grasped by employees such as position-specific operating procedures and emergency response procedures, it is a collection of technical skills that should be grasped by employees for a specific position. Through continuous education of the HSE guidance, employees will grasp all the knowledge required by the position and hence improve their skills to prevent risks.

5.2 HSE plan for unconventional operational risk management

The HSE plan is a document developed to prevent unconventional risks of a project that are not included in the HSE guidance. Unconventional risks not only include risks arising from a variety of unconventional activities which cannot be normalized by the pre-established operating procedures and technical specifications due to the changes such as the content or environment of the operational activities but also risks arising from various changes. It should be clear that if the risk has been already managed by either PTW (the risks arising from excavation, hot work, work at height, temporary electricity, entry into confined space, etc.) or MOC or other management tools, there is no need to mention in the HSE plan. The HSE plan is designed to manage the risks that have not been controlled by either HSE guidance or PWT or MOC or other management tools that have not been managed yet due to various reasons.

Due to the reason that the management of unconventional risks of a project is not included in the HSE guidance which is about the management of conventional risks, they can be basically managed by means of the combined use of HSE plan, PTW, and MOC. Therefore, all the identified risks (conventional risks + unconventional risks) can be managed through the combined use of HSE guidance and HSE plan.

5.3 HSE checklist for management of objects (equipment, facilities, etc.)

Based on the principle of territorial management, HSE checklist is a form designed according to a scientifically reasonable route (order) to prompt inspection personnel to pay more attention to critical parts or vulnerable components of field hardware facilities that are used or managed by employees on each position, such as tools and machines, equipment, etc., in order to improve the efficiency of discovering hidden dangers. Each position is provided with a HSE checklist. Through the combined use of the HSE checklists of all positions, full inspection on all the hardware equipment, facilities, tools, and devices can be achieved.

Based on the characteristics of each position, it is necessary to conduct an inspection on hardware equipment and facilities used or managed by the position before shifts or during working hours (whichever is applicable), to ensure that the hardware facilities are in a safe condition. Through the use of position-specific HSE checklist, unsafe state of objects will be fully inspected and effectively controlled, thereby improving the efficiency of safety check.

6. The discussion

According to the above analysis, the key problem of HSE case is it has too much content, which makes both its compilation and implementation too difficult to carry out. The main objective is to reduce its content and to make the document of HSE case a bit simple in order to play its role effectively.

On basis of the fact that the content of the HSE case is too much, we adapt the HSE case for the two documents, i.e., the HSE guidance and the HSE plan; the main problem to restrict HSE case to play its role is solved effectively. As the HSE guidance is to manage conventional risks, which has much content but is relatively stable, therefore, the HSE guidance is no deadline for completion and can be used for a long time once completed. On the contrary, the HSE plan is to manage changeable unconventional risks, for each project may have different unconventional risks; therefore, the HSE plan should be developed for each project; fortunately, its content is not so much as the conventional risks, the HSE plan is quite simple, and it can be compiled in a short time just before the start of a project [7, 17].

In this way, the greatest problem to restrict the HSE case from playing its role is solved. We can see that unconventional risks of a project that are not included in the HSE guidance can be basically managed by means of the combined use of HSE plan, PTW, and MOC. In addition, as the HSE guidance is to manage conventional risks, all the identified risks (conventional risks + unconventional risks) can be managed through the combined use of HSE guidance and HSE plan. In addition, the checklist is designed to verify whether the condition of the workplace, such as machines, equipment, tools, and so on, is safe or not. The application of “two documents and one checklist” in first-line organizations ensures that not only workers operate according to standard procedure but also that the workplace is kept in safe condition. By eliminating the causes of accidents, namely, unsafe action of workers and unsafe condition of the workplace, the model is quite effective in accident prevention.

7. The conclusion

The accident-causing theory tells us that accidents happen either because of unsafe human acts or unsafe state of objects or their combination. In the HSE-TDOC risk management mode, “two documents” are to regulate the human acts, among which the HSE guidance is to control risks arising from conventional operational activities and the HSE plan is to control risks arising from unconventional operational activities; and “one checklist” is to check the state of objects. Therefore, the HSE-TDOC risk management mode can be implemented effectively to prevent various accidents.

What is more, the HSE-TDOC risk management mode overcomes the problems of HSE case and becomes quite simple to understand and quite easy to carry out, so it is quite effective in the HSE risk management of frontline organizations for construction projects and is welcomed by our frontline organizations.

Due to the constraints of the tutorial length, the introduction of the HSE-TDOC risk management mode for construction project mentioned here may be narrow unavoidably. A systematic and detailed version has already been published by a Germany press [18] and was also introduced in textbook [19].

Acknowledgements

First of all, I must make it clear that the “2 + 1” project was officially launched by HSE Department of China National Petroleum Cooperation (CNPC), and I have

been the leader and backbone of this project from the beginning to the present. Therefore, in view of the successful implementation of the project in our company and the recognition abroad, I am pleased to acknowledge all the personnel in the HSE Department of CNPC and other relevant persons, especially those who participated in the project; without their support and participation, there will be no such project, let alone its success.

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