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<A MODEL FOR MANDATORY JOB SAFETY ANALYSIS EMBEDDED IN THE PREMIT-TO-WORK SYSTEM >

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ABSTRACT

Permit to Work (PTW) systems is defined as "a formal documented system used to control the certain types of work that are potentially hazardous". Generally, PTW system should be designed to specify the work to be done safely and the precaution to be taken as well as approval, responsibility, permissions of work. For this reason, PTW is regarded as one of the most important safety management system to control the risk of maintenance that causes 30% of the accident in chemical industries.

In the early days, PTW was based on paper based system. But recently has continued to evolve into a computer based system. And these advanced systems has been applied to 80% of oil industry in North Sea and upgraded with providing the hazard information as well as supporting documentation.

Usually, the hazard information is provided in the form of hazard checklist or attached risk assessment report such as JSA sheet. But when we consider the various types of work, place and environment, all the potential work related hazard cannot be reviewed in the form of prescribed checklist or certain attachment. To review the potential hazard perfectly, the work permit should be supported by Job Safety Analysis (JSA). But it has rarely been seen that company have a rule to require the mandatory JSA whenever permit to work is accomplished. Despite a relatively simple analysis structure, it is time-consuming and person-consuming methodology to complete all the procedure.

In this paper, the model for maximizing effectiveness and efficiency of mandatory JSA in PTW system is presented. This model represents the relationships of JSA in conjunction with PTW and safety management system without sacrificing the effectiveness of JSA. Through this model, JSA can be done effectively by overcoming the limitations that can occur when off-line JSA is performed.

The features of model can be divided into two kinds. The first is configuration of task hazard and registered JSA sheet inventory to be used in the performance of JSA. The basic principle of JSA is that potential hazard should be identified with a variety of experts through inherent knowledge and brainstorming. So if the hazard information is accumulated and referenced in some systematical management, fast and meaningful JSA can be performed even if the mandatory JSA is charged in permit to work.

The second feature of the model is configuration of maintaining the value of the inventory data. This is for maintaining solidity of inventory and safety management.

Based on this model, practical and empirical JSA module embedded in PTW system was developed for improving the safety of maintenance in South Korea LNG industry. The result shows the possibility of mandatory JSA application in an effective and efficient way for more robust safety of work. In the future, similar computer based PTW system in other hazardous industries can easily be transformed into having practical JSA module based on the suggested model for more robust safety.

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1. INTRODUCTION

The safety management of inspection, maintenance, and other works is important for ensurin the safety of workers and plant in the hazardous industries. The Piper Alpha incident in 1988 which was the worst disaster ever in the offshore oil industry was caused by an incomplete blind flanging in an inadequate PTW system [1]. The Bhopal gas leakage in 1984 which is recorded as the largest chemical industrial incident was also started by an omission of an important work process [2]. The HSE report [3] disclosed that about 700 (33%) of 2,146 incidents notified in the chemical industries during the years 1982-1985 were associated with maintenance and workers were injured in 66% of them.

As wrong work can cause immediate injuries to workers or lie dormant before causing a large incident, they must be controlled through the PTW system which is a key program of the Safety Management System (SMS). Basically, the PTW system systematically sets forth the responsibilities and tasks of workers, managers, and supervisors and the preparations for safe work performance so as to prevent accidents. Therefore, how well pre-work potential hazards are identified and presented is the important criterion for determining the effectiveness of the PTW system. Usually, the hazard information is provided in the form of hazard checklist or attached risk assessment report such as JSA sheet. But when we consider the various types of work, place and environment, all the potential work related hazard cannot be reviewed in the form of prescribed checklist or certain attachment. Thus, such a pre-specified hazard scheme cannot sufficiently examine the various hazards before the start of work. Ideally, it is most appropriate to obligate the JSA for every work. But it has rarely been seen that company have a rule to require the mandatory JSA whenever permit to work is accomplished. Despite a relatively simple analysis structure, it is time and person consuming methodology to complete all the procedure.

On this background, this paper presents a practical, effective conceptual model for performing mandatory JSA for each work permit with a computer-based PTW system. This model is characterized by categorization of hazards into task-level hazards and job-level hazards and the safety management system-linked structure for sound data management. Based on this model, practical and empirical JSA module embedded in PTW system was developed for improving the safety of maintenance in South Korea LNG industry. The result shows the possibility of mandatory JSA application in an effective and efficient way for more robust safety of work. In the future, a similar hazardous process industry can introduce mandatory JSA embedded in the PTW system as referencing the model and empirical results presented here.

2. USES OF JSA TECHNIQUE IN PERMIT TO WORK

The most basic step in risk management is to identify, assess risk, and control. JSA is a technique for identifying hazards by focusing on the relation of workers with their tasks, tools, and

work environment by each task [4]. This technique is also called JHA (job hazard analysis) or THA (task hazard analysis). As shown in Figure 1, its general process is to select the job to be analyzed and describe the step-by-step tasks of the job to be analyzed.

JSA is carried out by a team of workers, safety managers, and supervisors and every job can be an object of JSA. Although JSA is a relatively easy analysis method, it is highly effective in productivity as well as safety and has high value as a training tool [4]. Furthermore, JSA is also useful for the preparation of clear work procedures and the investigation of causes of accidents [5, 6] and effective for job planning [7]. Even though JSA is such an effective tool, its biggest shortcomings are the need for the investment of much time and effort and the need for continuous improvement. These shortcomings also affect its acceptance in PTW which is targeted at jobs with negative effects on safety, environment, and assets [8, 9]. Furthermore, as most jobs in the plant site are practically subject to PTW, it is difficult to apply JSA obligatorily because of awareness of resistance that JSA is unnecessarily done and the possibility that it could increase inefficiency of work due to heavy workload. Thus, it is difficult to obligate JSA. Nevertheless, JSA is clearly a very effective risk management tool for securing safety in consideration of the work properties that vary widely in their nature.

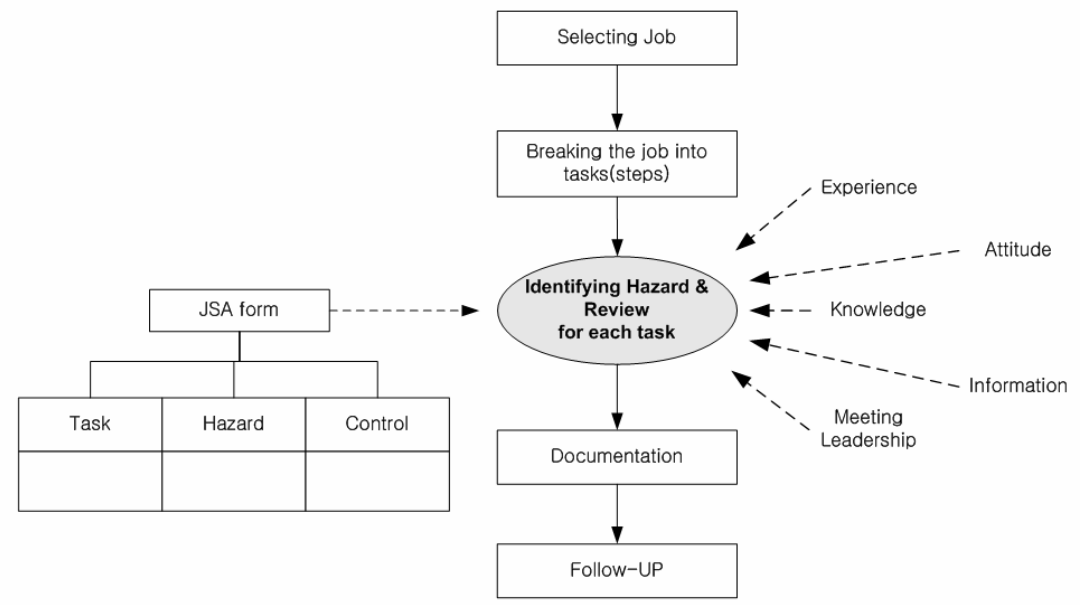

Figure 1 Typical Job Safety Analysis Procedures

3. CONFIGURATION OF HAZARD INVENTORY

The principle of JSA is to identify potential hazards for each task through inherent knowledge of worker and brainstorm for solving problems. Therefore, the existing JSA results of pre-studies is very valuable information that must be conveyed to workers and continuously improved [5], and can be a job hazard inventory by itself. And if the inherent knowledge, i.e. job inventory is used as references for identifying hazard and brainstorming, the data will be more valuable. However, the

structure for utilizing this worksheet is insufficient as a subsidiary tool for JSA in the PTW system because of non suitability and inefficiency in identifying the hazard of task level. Thus, we need a new approach for mandatory JSA and it is the establishment and reference of a task-based hazard inventory. What is important here is how the details on task hazard information must be constructed for supporting JSA and safety management of work. Regarding this, as shown in Figure 2, ease of input and search, hazard informativeness, and JSA utilization were considered, and JSA experts including safety managers, workers, and supervisors examined them.

This is based on the basic JSA items such as task, hazard, control, and risk, but there are largely three differences: the hazard information gives specific and possible consequence; PPE is separately indicated; and the pre-control risk information is put.

The hazard information is divided into hazards and consequence to provide clearer hazard information and to raise awareness of safety. Pre-risk is a different concept from the conventional risk, which was derived for JSA results to play the role of function for hazard checklist. Risk is a measure of combining severity and likelihood including possibility of unsuccessful controls. However, because this concept is made on the assumption that the controls are applied, it has a room to cause confusion on check of the primary task in terms of safety. Thus, if risks are provided considering the likelihood of accident in the situation of no control measures, they would be very useful for workers and supervisors in checking and focusing the primary safety management task before starting work. PPE was separated from control measures to connect with the PTW system through coding and provide the effect of information separability.

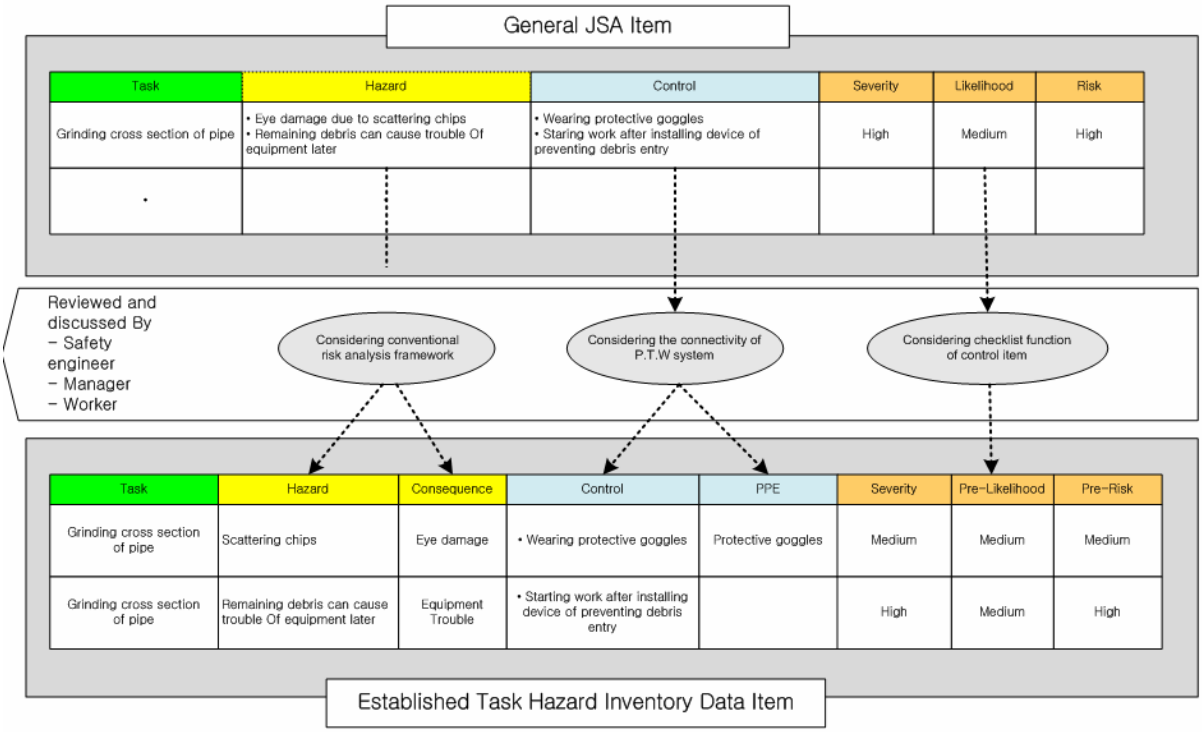

Figure 2 Major Items for Task based Hazard Inventory and Summary Example

When a task level hazard inventory is established as described above, this could be used to construct JSA data for any specific job, which will be a JSA worksheet at the job level, or a job hazard inventory. Job hazard inventory-applicable jobs can be selected as per the safety management policy of the company, which will allow JSA to be used rapidly in the mandatory JSA system.

4. MODEL OF MANAGEMENT FOR HAZARD INVENTORY & UTILIZATION

To maintain the reliability of inventory, the data must be proposed, reviewed, approved and accumulated at the safety management level. This prevents the negative effects of indiscriminate data accumulation and improves the effectiveness of search. Task hazards can be deduced from the JSA or voluntary safety activities. The dotted lines of Figure 3 signify that the task hazards must be examined by safety manager before final storage. The job hazard inventory has been named as registered JSA worksheet. Its targets could be determined by the company's safety management policy and they are also created by the JSA module. The JSA worksheets to be registered are reviewed, modified, and approved by safety managers. These accumulated registered JSA worksheets could be permitted for searching and referencing either by manager's authority or for specific job types by policy at the time of permit-to-work. This registered JSA inventory systems, these properties of performing JSA quickly whthout examinng the hazard in a rigorous way, is essential for minimizing the resistance of employees against the requirement for mandatory JSA and reducing the inefficiency of excessive PTW workload.

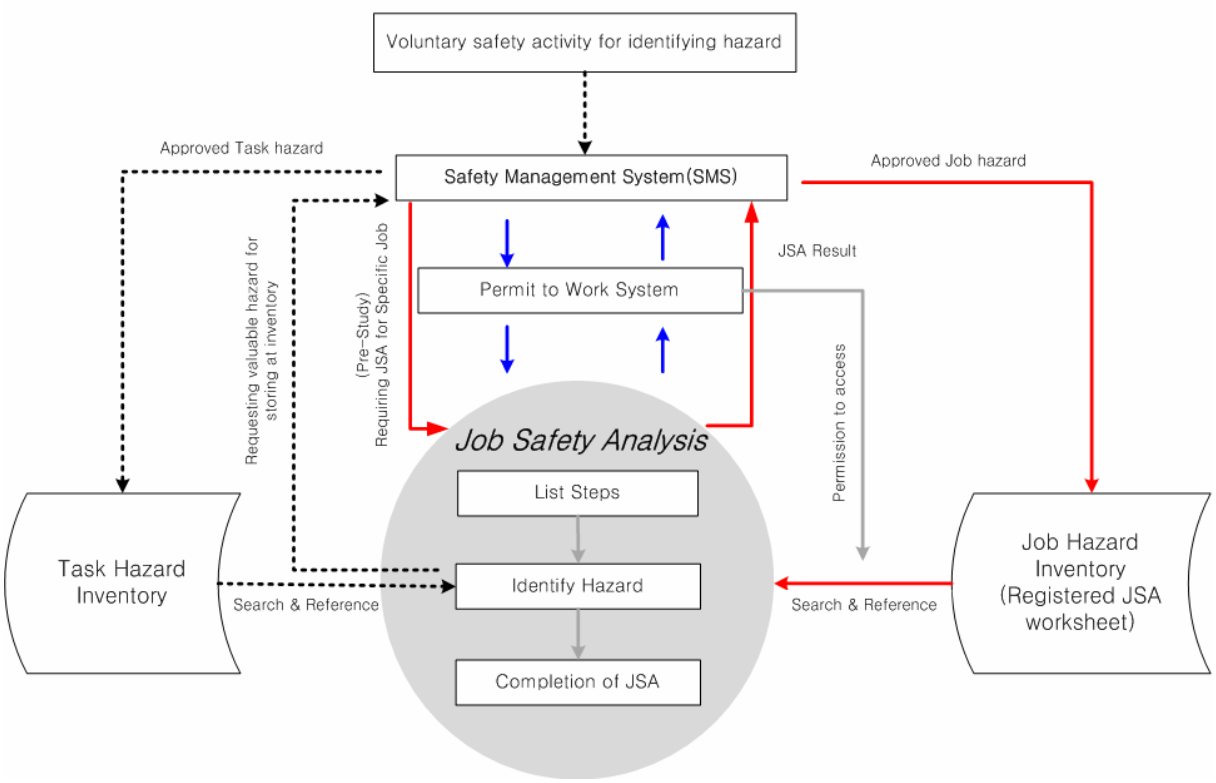

Figure 3 Conceptual Model of Mandatory JSA in PTW System

5. APPLICATION FOR KOREA LNG INDUSTRY

South Korea is the world's second largest importer of LNG. KOGAS has monopoly on LNG import to Korea and KOGAS is the largest company in the world as a single importer [10]. In Korea, LNG has been used since 1986 for power generation and city gas. LNG usage is growing at 18% annually on average. LNG usage in 2008 was about 1,200 billion cubic feet, accounting for 14% of total energy consumption.

In KOGAS, every job requires a permit and JSA except for daily operation of equipment and simple jobs that do not involve the operation of equipment such as visual inspection. The results of JSA are summarized as Word and Excel files and uploaded to the PTW system. The number of PTWs in 2009 was about 16,000 and several tens of thousands of PTWs are generated every year. This system revealed a few problems:

- As there are a large number of PTWs, they do not perform brainstorming which is the basic principle of JSA but just refer to the past JSA data for similar jobs. Sometimes they just submit the copied files. This cannot be regarded as JSA that considers the diversity of jobs.

- Usually supervisors read and write JSA but the JSA results vary by the level of supervisor.

- Repeated JSA requests for general jobs and even for dangerous jobs that have been performed with no accidents arouse resistance from workers on site and generate continuous disputes on efficient safety management which has negative effect on company operations.

Ultimately, the core of this problem is the trade-off between the conservative safety management that requires mandatory JSA and the efficiency of management, which is a long-time fundamental issue of safety. Thus, the model proposed in this paper was applied to the PTW system of KOGAS, a Korean LNG company, to verify the effectiveness of this model in maximizing safety of jobs and efficiency of works.

- **Building Task Hazards and Registered JSA Inventory**

For the proposed model to be immediately applied to the actual operations of KOGAS, it requires an initial hazard inventory database, which was built largely by two jobs shown below.

1) To build a task hazard inventory, 954 JSA worksheet files which were stored in the PTW system for the past 1 calendar year (2008) by KOGAS were extracted. Each JSA worksheet was analyzed and summarized using Excel. About 6,000 tasks were summed up. They were classified in line with the hazard inventory items in Table 2 as shown in Figure 4, and the results and PPE information were separately summarized for coding. The hazard inventory after deletion of duplicate data consisted of about 4,000 entries. The pre-risk of each task hazard was calculated through double-check by workers, managers, and safety experts in a workshop. The final summary data were converted into a database.

2) It was decided to apply the registered JSA to relatively simple preventive check jobs in accordance with the safety policy of KOGAS. 248 related jobs were deduced and JSA was performed for each of these jobs. During the performance of JSA, the task hazard extracted from the results in

step 1) was also referenced, and newly identified task hazards were added to the inventory. The completed registered JSA was reviewed and converted to the final database.

- **Developing System of Hazard Inventory & JSA Module**

The Hazard Inventory Module was implemented in the EHS system under the ERP system of KOGAS, and the JSA module inside the PTW system linked to it was built as shown in Figure 4. The KOGAS ERP (Enterprise Resource Planning) system was SAP which used the ABAP (Advanced Business Application Programming) language. Thus, the two systems were built using this language. ABAP is a high-level programming language created by the German software company SAP. It is one of the many application-specific fourth-generation languages (4GLs) first developed in the 1980s.

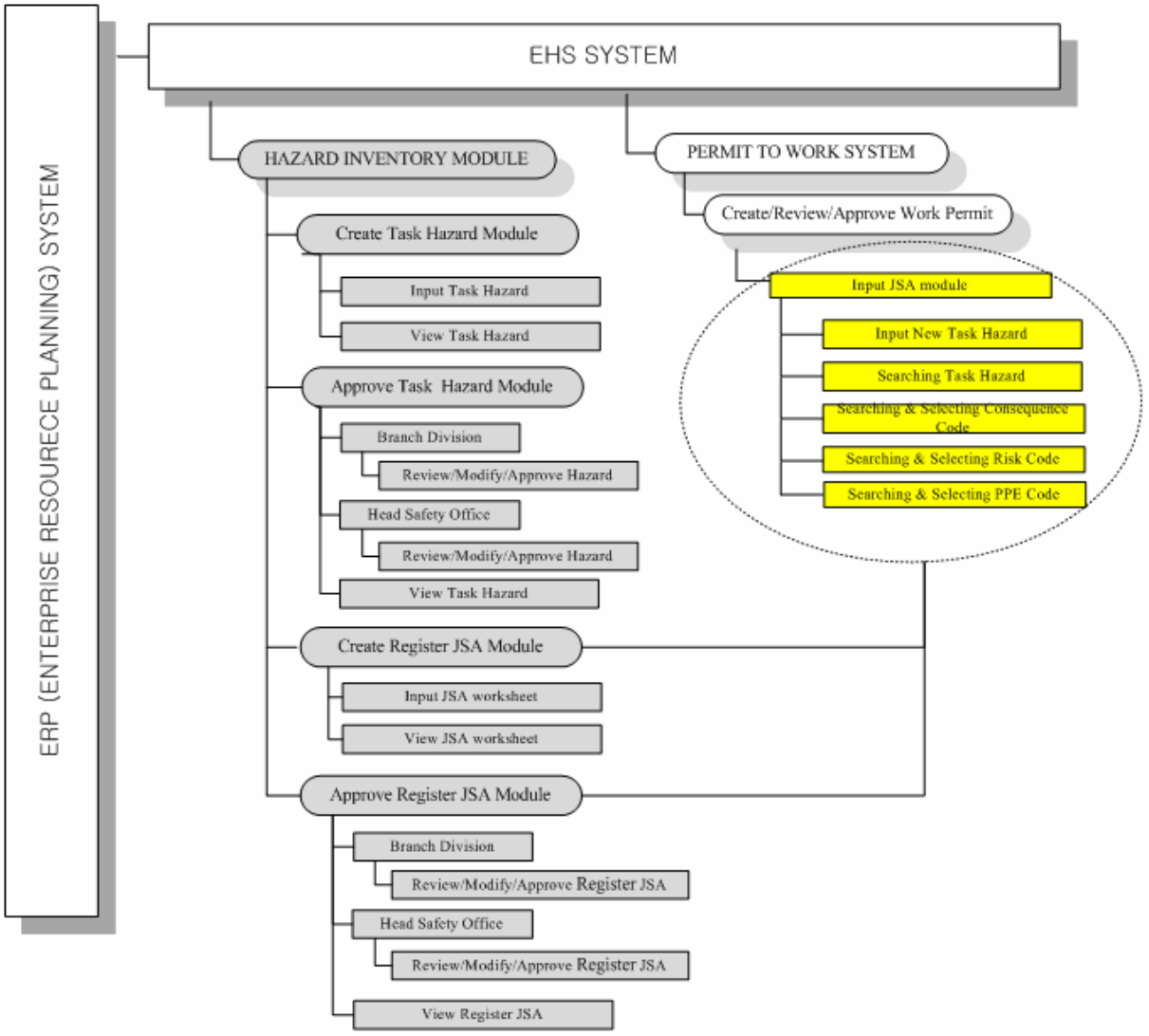

Figure 4 Architecture of Hazard Inventory & JSA Module in KOGAS PTW System

HAZARD INVENTORY MODULE

This module consists of 4 sub-modules: Create Task Hazard Module, Approve Task Hazard Module, Create Registered JSA Module, and Approve Registered JSA Module. In the Create Task

Hazard Module, you can create or view new hazards. The Approve Task Hazard Module is divided into Branch Division and Head Safety Office functions. First, the branch division can review, modify, approve, or return hazards, and the head safety office can review, modify, approve, or return the hazards that have been approved by the branch division. In the Create Registered JSA Module, you can create new JSA worksheets or view the existing worksheets. In the Approve Registered JSA Module, just as the Approve Task Hazard Module, the branch division and the head safety office can review, modify, approve, or return Registered JSA worksheets.

JOB SAFETY ANALYSIS MODULE

The JSA module linked to the existing PTW system was built as shown in Figure 5. In this module, analysts perform JSA in accordance with the procedure in Figure 1. Under the KOGAS PTW system, a policy is established so that the registered JSA worksheets can be used in preventive check jobs. Thus, in the PTW step, if the job type is preventive check, the registered JSA worksheets can be searched and collectively inserted to the job worksheet, and they can be modified as well. For a PTW that cannot use a registered JSA worksheet, the JSA is performed in accordance with the conventional way of identifying the hazard and brainstorming solution. The Task hazard inventory can be searched during the analysis process, the selected data can be inserted into the line and the analysis information can be modified by referencing the data. The consequence, PPE, and risk are selected from the presented codes. However, this part can be modified as well. Task hazards that analysts think have a sharing value during or after analysis can be input to the new inventory input windows, and their approval is requested.

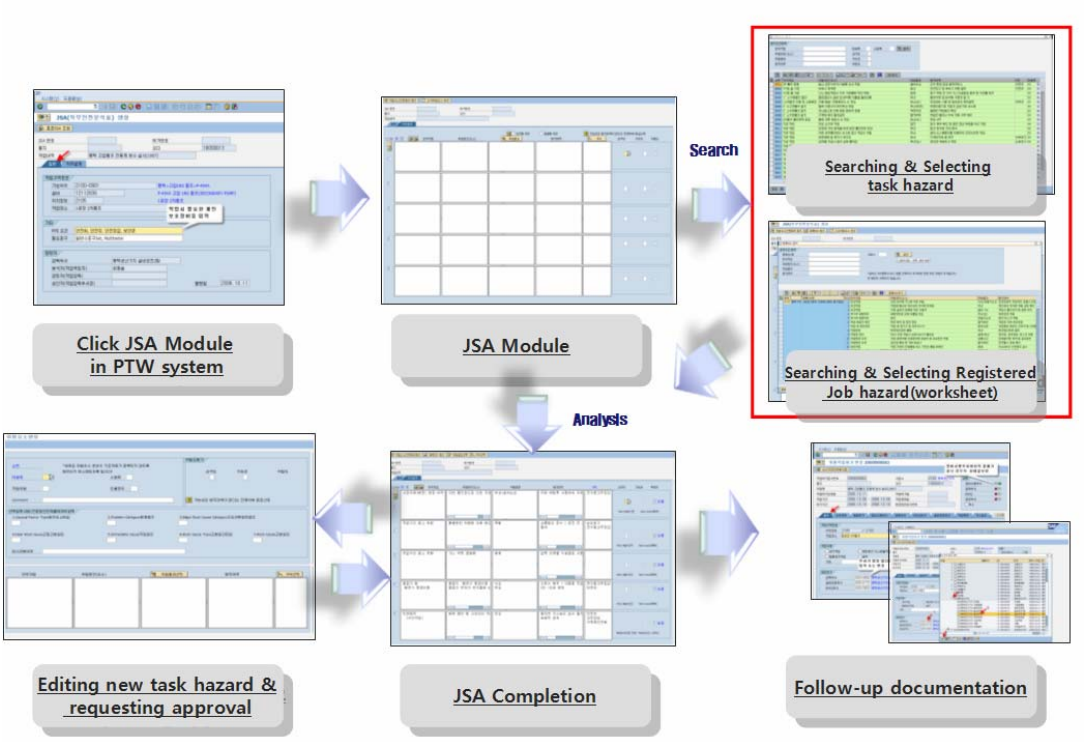

Figure 5 Main User Interface Related to JSA Performance

6. EFFECTS OF SYSTEM APPLICATION AND DISCUSSION

This hazard inventory system, which was built for linking the KOGAS PTW/SMS system, has been applied to actual management. At 6 months after starting to use the system, a secret survey was conducted to ask several supervisors who were familiar with JSA about the effects. They evaluated the effects from largely two aspects of safety and business performance, with 4 and 3 detail items. For each item, the respondents were asked to check very high (yes), high (yes), same (average), low (no), or very low (no) for the effect compared to the conventional method or for the effect from the independent perspective. The results are summarized in Table 1. For the derivability of hazards, 78% of the respondents answered that the effect of the new system was very high and 22% responded that it was high compared to the existing way. They responded that the clarification of consequence had the highest effect. The idea to present Pre-Risk for each task so that the JSA results would play the role of checklist also received a favorable evaluation. Although using the registered JSA worksheets for preventive check jobs received a lower evaluation than other items from the safety aspect, it was still a positive evaluation and it received a high evaluation from the business aspect. From the software aspect of the developed system, they answered that the working speed improved compared to inputting with the Word application. Besides, they recognized the hazard inventory itself as an effective means of delivering the hazard knowledge of workers (means of education) and acknowledged that it had a high utility value as a JSA system related to the operation of process in the future.

Table 1 Results of Survey about the Effects of the Developed System

Questions	Responses				
	Very High (Yes)	High (Yes)	Same (Average)	Low (No)	Very Low (No)
Safety Aspect					
- Is it effective for hazard identification?	78%	22%	0%	0%	0%
- Is the presentation of pre-risk level effective for checking and focusing the important task?	44%	56%	0%	0%	0%
- Is the consequence clarification effective for safety management?	89%	11%	0%	0%	0%
- Is the registered JSA system for preventive check jobs effective for safety management?	10%	90%	0%	0%	0%
Business Performance Aspect					
- Has the JSA performance speed improved?	44%	56%	0%	0%	0%
- Has the work efficiency improved due to the registered JSA?	44%	56%	0%	0%	0%
- How convenient was the software?	56%	44%	0%	0%	0%

7. CONCLUSIONS

Various accident reports and databases reveal that mistakes in inspection, maintenance and work in gas and petrochemical industries are the main cause of incidents that cause losses to plants as well as deaths of workers and neighboring residents. Thus, a permit-to-work (PTW) system that guarantees work safety plays a key role in preventing incidents. The most important function of the PTW system is to present various pre-work potential hazards and utilize them for safety management by workers and managers. And JSA is a perfect tool for this role. However, as JSA requires a lot of analysis time and many human resources, it is practically difficult for companies to make it mandatory. To address this problem, this paper presented detailed configuration of hazard inventory and a conceptual model for supporting the mandatory JSA in PTW, applied it to an actual industrial site and presented the results. This model is characterized by categorization of hazards into task-level hazards and job-level hazards and the safety management system-linked structure for sound data management to enable companies implement the mandatory JSA. This model was actually applied as a sub-model of the KOGAS SMS/PTW system in Korea, and the process and results were presented. The supervisors who used this system rated very highly the identification or deduction of hazards and responded that the pre-risk and consequence presentation scheme was more effective in safety improvement than the conventional system. The registered JSA system also received a favorable evaluation from the safety aspect, and also from the business performance aspect as it removed the potential resistance to the conventional mandatory JSA.

Based on these findings, the model proposed in this study, its application process and results will provide useful reference for searching practical and easily applicable modularization when you want to apply mandatory JSA in the PTW system in similar hazardous industries.

REFERENCES

1. Paté-Cornell, M. E. (1993). Learning from the Piper Alpha Accident: A Postmortem Analysis of Technical and Organizational Factors, Risk Analysis, 13: 215-223

2. Eckerman, I. (2005). The Bhopal SAGA Causes and Consequence of the world's largest industrial disaster, Universities Press(India), hyderabad, India

3. Grossel, S. S. (1991). Book Review Dangerous maintenance: A study of maintenance accidents in the chemical industry and how to prevent them. J. Loss Prev. Process Ind., 4: 132-133

4. Chao, E.L., Henshaw, J.L. (2002). Job Hazard Analysis. OSHA Publication 3071 2002(Revised). Occupational Safety and Health Administration, US Department of Labor, Washington

5. Roughton, J. E., Crutchfield, N. (2008). Job Hazard Analysis – A guide for voluntary compliance and beyond. Elsevier Inc

6. Roughton, J. E., Mercurio, J. J. (2002). Developing an Effective Safety Culture : A leadership approach. Butterworth-Heinemann

7. Holt, A.S.J. (2001). Principles of Construction Safety. Blackwell Science, London

8. Health and Safety Executive. (2005). Guidance on permit-to-work systems. HSE
9. International Association of oil & gas producers. (1994). Guideline on permit to work(P.T.W) systems
10. Energy Information Administration. (2010). Official Energy Statistics from the US Government, /http://www.eia.doe.gov/emeu/cabs/index.htmlS.

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