THE MANUAL FOR RISK MANAGEMENT SYSTEM FOR USE DURING PLANT DISASTERS AND SPECIFIC RISK MANAGEMENT METHODS

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ABSTRACT

Countermeasures taken in recent years in response to accident that have occurred in high pressure gas production plants in Japan were analyzed from the perspective of risk management, revealing an increase in the number of cases where measures were delayed because of defects in disaster protection system manuals. The following are examples of such defects. (1) Disaster protection system manuals do not hypothesize evacuation flow lines according to the scale of the disaster and they are not widely distributed, so they are difficult to use in an unpredicted emergency. (2) When actual accidents occur, the manual does not act effectively, because in many cases, a training scenario is prepared and action taken in accordance with the scenario. (3) Because manuals are focused on the accident emergency liaison network system but do not clearly indicate responsibility for accidents, personnel on the scene of an accident that has occurred often contact the responsible manager and then wait for instructions concerning the action they will take. (4) Organizations including nearby organizations that will cooperate when an accident has occurred are listed in manuals, but because the specific details of the cooperation, in other words, the scope of the work each performs, are not indicated, this information is often useless.

In an effort to resolve this problem, this company that is an important energy base on the Japan Sea, has, regardless of the fact that it has never had an accident, reviewed the present disaster protection system manual from the perspective of risk management and has begun to prepare a manual for risk management system that includes an initial response system that can be applied flexibly when an accident has occurred. The specific steps taken were specifying facilities at high degree of risk of causing a disaster at the Niigata LNG Terminal and hypothesizing disasters at these facilities in order to prepare appropriate disaster protection action procedures by establishing evacuation flow lines. In particular, performing a risk evaluation of trouble records (trouble reports) at the terminal's facilities since it began operating in order to evaluate the possibility of a malfunction of each facility during present maintenance and operations in order to specify facilities that could possibly cause a disaster in order to specify facilities at high degree of risk of causing a disaster can be described as a characteristic of the preparation process. The foundations for this risk evaluation complied with the RBI standards of the ASME and API, but the data base construction method that was not included in the standards incorporated an overall risk management techniques. Our future goal is to not only enact this manual but to guarantee that it can be used for maintenance and operation management by creating this database.

We are presenting this conference with this manual for risk management system that includes an initial response system that can be applied flexibly when a disaster has occurred, assuming that it is applicable to similar terminals, and in expectation that they will use this manual and that it can contribute to disaster protection maintenance at terminals provided for public use.

1. Risk Management Data Base that is the foundation of the Manual for Risk Management System

1-1. Definition of the Risk Management Data Base

Methods of predicting plant damage caused by a disaster to include (1) an empirical rule based approach and (2) a disaster prediction evaluation approach. Examples of the first are [1] Process/System Checklist and [2] Safety Review. Examples of the second are [1] Relative ranking, [2] Preliminary Hazard Analysis, [3] "What if" analysis, [4] HAZOP, [5] FMECA, [6] FTA, [7] ETA, [8] Cause-Consequence Analysis, and [9] Human Error Analysis. With both approaches, the radiant heat, blast pressure, and gas diffusion that would be caused by a disaster affecting each type of equipment are calculated based on the degree of danger of each unit of a plant to prepare data to be used to make emergency shutdown judgments. Another is the RBM (Risk Base Maintenance) that has been stipulated by the API (American Petroleum Institute) [*1*2] and the ASME (American Society of Mechanical Engineers)[*3], etc. These methods are used as a tool to optimize a maintenance plan including inspections and repair of the constituent equipment of plants from an objective perspective. RBI (Risk Base Inspection) in the RBM defined by API-RP580 in particular was prepared by collecting the causes of losses caused by 170 serious accidents that occurred in the petroleum and petrochemical industries in the United States over three decades from 1961 to 1991. Approximately 40% of all serious losses caused by accidents were the result of mechanical damage to equipment, and approximately 80% of these 40% were the result of damage to pressure resistant parts, in other words, pipes, drums, towers, reactor vessels, tanks, pumps, heat exchangers and so on.

In order to identify equipment that is high degree of risk of causing a disaster, a working group consisting of representatives of maintenance departments, operations departments, and security departments was formed. From the above methods, the working group selected the ASME and API standards, began its work by first selecting plants that had been in operation for several decades, and then collecting and analyzing reports on trouble with all the equipment at these plants from the time they started operating till the present, as a method of supplementing ASME and API standards, because they suspected that according to the state of design and construction when they were constructed and the maintenance methods employed since that time, not only the state of gas leaks from their equipment, but the degree of deterioration and aging is likely to have varied from plant to plant. The data they obtained in this way were named the Risk Management Data. The Risk Management Data Base was prepared by supplementing the Risk Management Data with evaluation methods as such as risk categorization, degree of risk, risk avoidance, degree of risk monitor, and risk avoidance training and education, as shown in Table 1-1. The Data Base is not only applied to enact the Manual for Risk Management System, but to also perform future maintenance and operating management.

Table 1-1 The ingredients of evaluation

R code	Evaluation items	The ingredients of evaluation	
R1	Risk Categorization	● Natural disaster ● Maintenance, deterioration, aging ● Interface	● Design mistake, quality control / a guarantee of quality ● Human error
R2	Degree of risk	● A trouble of being simple part ● Influence degree to the main body machinery / facility ● Influence degree to machinery / facility of the main body circumference	● Influence degree to machinery / facility of the whole plant ● Influence degree to regional people
R3	Risk Avoidance	● The spot restoration ● Part exchange ● A leak / a fire	● The human body disaster ● Operation stop with damage
R4	Degree of risk monitor	● Nothing ● Once ● Each inspection	● Several times ● Prosperity
R5	Risk avoidance training and education	● On-the-job training ● Education / training ● Study only	● Circulation of a report ● Nothing

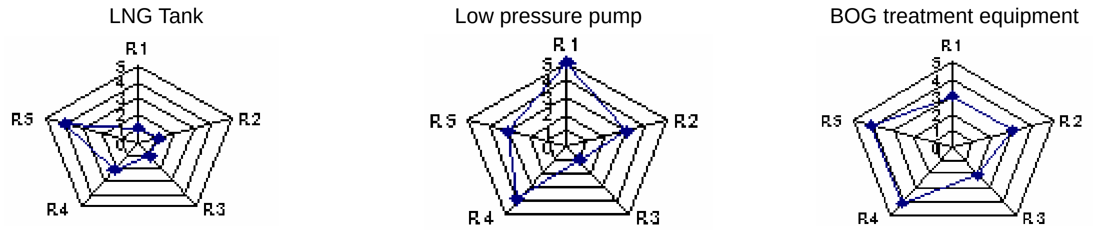
1-2 Risk Management Data Base preparation step

The Working Group performed its task according to the steps shown in Table 1-2, confirmed objective empirical rules and records of various kinds regarding both maintenance and operations, and interviewed persons involved in the trouble cases to perform risk evaluations for

Table 1-2 Specification of equipments at high degree of risk of causing a disaster

STEP	Enforcement contents
STEP1	Risk management data base depending upon trouble report
STEP2	Risk evaluation on each trouble report (risk categorization, degree of risk, risk avoidance, degree of risk monitor, risk avoidance training and education)
STEP3	Total risk evaluation
STEP4	Risk evaluation on burst repair by leaking of LNG and NG
STEP5	Risk evaluation on each equipment (possibility of trouble)
STEP6	Specification of equipments at high degree of risk of causing a disaster

each trouble case and overall evaluations of all types of equipment. Figure 1-1 shows the results of these risk evaluations of representative equipment.



Note） R1: risk categorization R2: degree of risk R3: risk avoidance R4: degree of risk monitor
R5: risk avoidance training and education

Figure1-1 Risk evaluation result of typical equipment

The trouble reports deal with four systems: operating systems, maintenance systems, electrical systems, and mechanical systems. Reports of operating system trouble are prepared mainly by personnel on duty at the time of the trouble. These accounted for more than half of the total of 800 trouble reports. Trouble during operation is discovered by patrols, alarms, or by checks performed during start-up and other operations. The content recorded in the trouble reports were not predicted or discovered during inspections regardless of the fact that periodic maintenance inspections were performed. The operations of maintenance systems are managed separately by the sections responsible for instrumentation systems, electrical systems, mechanical systems, and civil engineering systems etc. Instrumentation systems include instrumentation of transmitters installed in the plant and devices and computers used for control in the central control room. Many of the trouble reports deal with these instruments, because a malfunction of any one of them directly causes gas pressure fluctuations (disturbances) in gas transport systems. Because electrical systems consist of many unified standard parts, and because breaker malfunctions do not cause any loss of the reliability of electric power supply, even types of equipment that do not obstruct the transmission of gas are mentioned in many reports in relation to major equipment. Many types of equipment in mechanical systems are managed and maintained using the manufacturer’s inspection records in order to replace parts or perform work according to the description of the malfunction. These trouble reports include many cases where the cause was human error. Although departments that prepare trouble reports use descriptive methods with varying degrees of detail, it can be stated that their content is adequate to evaluate the risk to all the equipment at a plant. The effective cases to be evaluated were established as shown in Table 1-3 as a result of analyzing the trouble reports to prepare the Risk Management Data Base.

Table 1-3 Rearranging result of the trouble report

Item	The number	A summary
Total number	795	157 number (repetition 86, facility update / removal)
The effective number	637	Risk fixed 570, risk estimate 29, unknown factor 38

Note) Trouble report contains a slight record as trouble memo

2. Risk evaluation results and the identification of highly dangerous equipment that can cause disasters

The Risk Management Data Base prepared as described in part 2 has revealed that the highly dangerous types of equipment that can cause disasters are low pressure LNG pumps and their auxiliary equipment, BOG treatment systems and their auxiliary equipment, LNG shipping systems and their auxiliary equipment, cryogenic power generation systems and their auxiliary equipment, and piping systems. Of these systems, cryogenic power generation systems and piping systems were omitted from highly dangerous equipment that can cause disasters. The former were trouble cases caused not by mechanical damage to the equipment nor for reasons related to the technical ease or difficulty of maintenance: but rather by human error. The latter were caused by exterior surface corrosion and by the way the gaskets or packing were handled, and it was determined that these could be prevented by measures based on normal inspections. Therefore, because in addition to the factors mentioned above, there are risk factors such as those in (1) and (2) below, the low pressure LNG pumps and their auxiliary equipment and BOG treatment systems and their auxiliary equipment were identified as highly dangerous systems that can cause disasters.

(1) Low pressure LNG pumps and their auxiliary equipment

a. They are inside storage tank dikes where it is difficult to see white smoke or hear the sound of leaking gas.

b. Because it is known that the air inside a storage tank dike tends to move in a vortex and cannot be uniformly analyzed, and because experiments have shown that the wind speed is strong in the winter, it is unlikely that leaks can be unfailingly detected with a gas sensor.

c. The risk evaluation has shown that its deterioration is more advanced than that of an LNG pump with the same structure, LNG gas leaks from the connections with the auxiliary equipment, and the auxiliary instrumentation is highly likely to be seriously deteriorated.

(2) BOG treatment systems and their auxiliary equipment

a. Gas leaks almost every year. There are cases where it is discovered by abnormal means such as by gas sensors used by contractors or by patrols, but not by gas detection alarms.

b. In the first floor of a BOG compressor room, the compressor pipes are complexly installed in narrow spaces and there are open spaces in the building, so it is difficult to clarify behavior during a gas leak. Because the piping outside the building is also in small spaces, it is impossible to patrol easily, with the result that it is difficult to discover leaks.

3. The Manual for Risk Management System and Disaster Protection Training

3-1 The Manual for Risk Management System

The Preparation of the Manual for Risk Management System began, as shown in Figure 3-1, with the calculation of the scale of damage accounting for the wind direction when LNG leaks from low pressure LNG pumps and their auxiliary equipment or from BOG treatment systems and their auxiliary equipment: types of equipment that are highly dangerous and can cause disasters that were identified by the Risk Management Data Base. The scale of damage caused by the diffusion of leaking LNG was calculated by obtaining the diffusion concentration based on DEGRDIS recommended by the EPA (Environmental Protection Agency, U.S.A) to evaluate whether or not damage would spread according to the presence/absence of a nearby ignition point. Two evacuation flow lines of motion were established and an emergency system command network was completed based on the results. Establishing two nearly realistic evacuation flow lines of motion permitted the in-plant disaster protection team, regional disaster protection team, and emergency rescue team to share roles and created detailed linkages between these three teams. Preliminary consultations with the regional disaster protection team and the rescue team were carried out and reflected in the manual in order to gain their understanding of the significant change in the access routes so that these teams can perform unobstructed fire extinguishing activity and rescue operations.

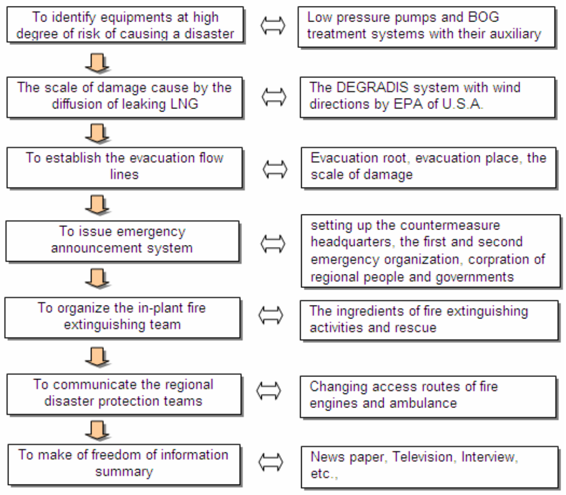


Figure 3-1 The manual for risk management system flow

3-2 Disaster protection training

Disaster protection training is performed periodically in order that in an emergency situation, rescue activities conducted cooperatively with the region and fire extinguishing activities can be carried out smoothly. At many enterprises, scenarios are prepared in advance and fire extinguishing activities, rescue activities and guidance to safe access routes performed in flow line with these scenarios in order to provide disaster protection training that conforms to reality. This disaster protection training (on November 17, 2003) was not normal habitual disaster protection training, but rather, training performed in accordance with the Manual for Risk Management System.

The following are examples of major differences between it and conventional disaster protection training;

(1) The equipment that caused the disaster was an LNG pressurized pump.
(2) The countermeasure headquarters (consisting of the top managers) decided to issue an emergency announcement according to the wind direction at the time the disaster protection training started and the hypothetical scale of the damage.
(3) The evacuation flow lines of motion were selected according the wind direction at the time

the disaster protection training started and the hypothetical scale of the damage.

(4) The location of the in-plant fire extinguishing activities team command center was determined according to the wind direction and hypothetical scale of the damage.

(5) The access routes for the regional disaster protection teams (fire engines and ambulances) were determined according to the wind direction and hypothetical scale of the damage.

(6) Divisions of roles that did not conform to work authority were prepared.

(7) Thorough rules that can be visually confirmed were created.

The switch-over from the former Disaster Protection System Manual to the Manual for Risk Management System has permitted training in conformity with actual circumstances at each plant and the reduction of the time from the start of training to its completion by about 15 minutes from the hypothetical time for conventional training. Photographs 3-1 to 3-4 show views of the disaster protection training.

Photograph 3-1 The location of in-plant fire extinguishing activities

Photograph 3-2 Aspect of fire extinguishing activities

Photograph 3-3 Aspect of rescue activities(ambulance)

Photograph 3-4 Aspect of evacuation

4. Conclusion

In the previous Disaster Protection System Manual, it was assumed that the highly dangerous equipment likely to cause disasters were LNG tanks or vaporizers, and the evacuation flow lines of motion were almost all planned for cases where LNG leaked from one of these types of equipment. It can be concluded that identifying the highly dangerous equipment likely to cause disasters from the Risk Management Data Base that is one of the features of the new Manual for Risk Management System has permitted calculation of a scale of damage that conforms with reality, guaranteed two evacuation flow lines of motion, and contributed to more efficient issuing of emergency announcements. And the Risk Management Data Base that has been established by carefully analyzing reports on trouble at plants from the time they started operating to perform risk evaluations has provided a large quantity of information concerning human error, the state of aging and of deterioration of equipment, and the effectiveness of education and training that are needed to guarantee the safety of plants. In the future, we want to analyze these kinds of information more quantitatively to complete the Manual for Risk Management System and to propose more effective maintenance methods.

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*2 American Petroleum Institute : Risk-Based Inspection Base resource API Publication 581 (2000.5)

*3 ASME : Risk-Based Inspection-Development of Guidelines Vol.3 Fossil-Fired Electric Power Generating Station Application CRTD-Vol.20-3 (1994)