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A loss control management system for the petrochemical industry

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Abstract−This study was performed to develop a system that can be used to manage safety and environmental issues efficiently in the petrochemical industry. The main objective of this study is to reduce loss in petrochemical industries using a loss control system (LCMCI; The Loss Control Management System for Continuous Improvement of the Petrochemical Industry), which can be used to improve safety and environmental management continuously in the petrochemical industries. To prevent loss by accident in this study, firstly, causes of accidents were analyzed according to frequency and severity of accidents that have occurred in domestic petrochemical industries for 30 years. Secondly, the requirements of several kinds of systems (PSM, RC, OHSAS18001, ISO14001, etc.) which were applied mandatorily/optionally in petrochemical industries were analyzed and, also, the merits/demerits of each system were compared. Thirdly, the best practices which were recommended basically as a loss control management system in the world were modified in accordance with the situation of domestic petrochemical industries. Lastly, the requirements of loss management were defined in accordance with a management structure and then LCMCI was developed by using distribution of scores as result of this study.

Key words: LCIPI, PSM, Petrochemical Industry, Accidents Analysis

INTRODUCTION

The difficulties confronted in the globalization era are factors in which domestic industries can only be lagging behind in the competition with foreign industries that have experienced several years of loss management within the aspect of efficient management. Fortunately, domestic industries play a substantial role in the planned and scientific management of the systematic management system (ISO9000, ISO14001, etc.) of the International Organization for Standardization (ISO), yet-standardized OHSAS1800 and the Process Safety Management (PSM) selected by the Center for Chemical Process Safety (CCPS) - a subsidiary of the American Institute of Chemical Engineers (AIChE), and Responsible Care implemented at chemical industries. From the perspectives of domestic industries desiring sustainable development in order to leap forward as global industries, since no further specification or guideline to enhance the loss management system is, however, available, it is challenging to realize the hard work, despite the fact that domestic industries endeavor to increase the efficiency of management by way of producing ideals, by industries or bench-marking domestic or international industries. Accordingly, standardization was necessary to sustainably develop the loss management of petrochemical industries, whose effort has produced substantial results in foreign nations. Hence, this paper analyzes fundamental factors as well as sustainable factors for the development in each system implemented at petrochemical industries, and suggests a model (LCMCI) that can help them take off toward world-class industries.

LOSS CONTROL MANAGEMENT

This paper analyzed the CCPS-selected Process Safety Management (PSM), OHSAS18001, the International Environment Standardization (ISO14000), and Responsible Care, and compared with analogous foreign systems, among which the most widely-adopted DNV's PROSPER and Rhone-Poulenc Group's SIMSERP (System Integrating Management of Safety and Environment at Rhone-Poulenc) were chosen as the basic experimental targets.

1. PROSPER

The DNV as a professional affiliation has only developed and supplied the rating system, and currently operates ISRS (International Safety Rating System), IERS (International Environment Rat-

Table 1. Structure of the PROSPER

Elements	Score
1. General policy	281
2. Loss control planning	399
3. Loss exposure identification and evaluation	1337
4. Regulations and permits to operate	580
5. Design or products and services	828
6. Organizational structure and responsibility	849
7. Training	1512
8. Communications and promotion	1517
9. Documentation and records	1066
10. Operations control	2534
11. Inspection and testing	1537
12. Rules and work permits	1458
13. Logistics and contractor management	948
14. Emergency preparedness	1471
15. Monitoring and assessment	1681
16. Incident investigation	1080
17. System audits and management review	522
Total possible score	19600

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ing System), and IQRS (International Quality Rating System). The protocol has been used at numerous industries in the world, and PROSPER was developed by integrating the safety-environment-quality system in 1998. PROSPER consists of a total of 17 elements, as shown in Table 1, and has applied the PDCA (Plan-Do-Check-Action) cycle of the management system. The system is the world's first loss management system integrating safety-environment-quality and has the merit of universal applicability to all industries. A disadvantage is, however, that the system has not reflected the particularity of petrochemical industries, in order to be fully applicable without adjustment.

Table 2. Structure of the SIMSERP

Elements	Score	Integrate
1. HSE leadership & administration	1620	HSE
2. Leadership training	700	HSE
3. Planned inspections & maintenance	690	HSE
4. Critical tasks analysis & procedures	650	HSE
5. Accidents & incident investigation	605	HSE
6. Task observation	450	HSE
7. Emergency preparedness	700	HSE
8. Rules & work permits	615	HSE
9. Accident/incidents analysis	365	HSE
10. Knowledge & skill training	700	HSE
11. Personal protective equipment	380	HS
12. Health & hygiene control	700	HS
13. HSE management system evaluation	700	HSE
14. Risk assessment & change mgt.	640	HSE
15. Personal communications	405	HSE
16. Group communications	375	HSE
17. General promotion	315	HSE
18. Hiring & placement	365	HSE
19. Materials & services management	585	HSE
20. Off-the-Job HSE	240	HSE
21. Environmental issue identification	655	E
22. Performance monitoring & assessment	635	E
23. Product stewardship	455	HSE
24. Relations with external parties	455	HSE
Total possible score	14000	

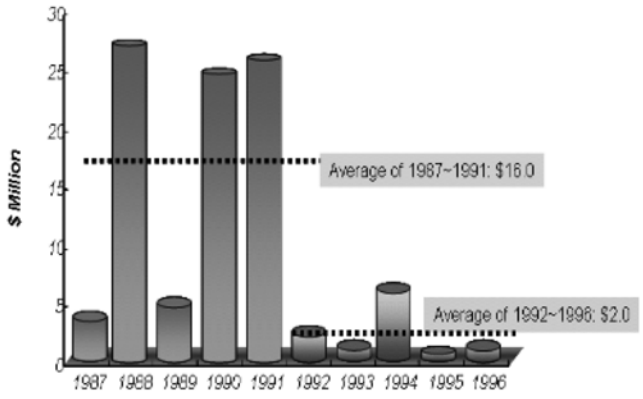

Fig. 1. Case of loss prevention (rhone-poulenc).

2. SIMSERP

Rhone-Poulenc Group, which has found a market in 170 nations in the world, started to develop and implement SIMSERP in 1992 to its subsidiaries. SIMSERP integrated the Safety Environment Management System while openly developing all factors; hence, it does not include the concept of PDCA management system. Most factors of SIMSERP, as shown in Table 2, comprise 24 elements and are integrated based on HSE (Health, Safety and Environment).

Rhone-Poulenc Group has eight-fold reduced loss since the first implementation of the system since 1992, as shown in Fig. 1, which depicts the fact that the investment to manage the loss in an organization can produce profitable industrial management.

THE LOSS CONTROL MANAGEMENT FOR CONTINUOUS IMPROVEMENT (LCMCI)

1. Basic Concept of Improving Management System

LCMCI is a tool for driving continuous improvement in an organization's Safety and Environment management system performance. This model enables an organization to take a comprehensive approach to the integration of Health, Safety and Environment into one management system. The approach to improve the performance of a management system can be represented by a series of step changes interspersed with periods of consolidation. The improvement is most effective when structured through, and identified in, a strategic long range plan. Each step change itself will consist of three stages (Fig. 2).

To improve the management system performance, the first stage is to indetify the need for change. The next stage is to actually develop and make the change, and the last stage will be to stabilize the situation by embedding the change within the organization. LCMCI is a tool to assist performance improvement in each of these three stages.

2. Assess

The process of assessing the need for change typically consists of three steps:

(A) Identification of the present situation (where you are)

(B) Identification of the desired situation (where you would like to be)

(C) Identification of the need for change (gap between the present and desired situation)

LCMCI can quantify the activities of an organization's HSE management system to determine the extent and quality of management

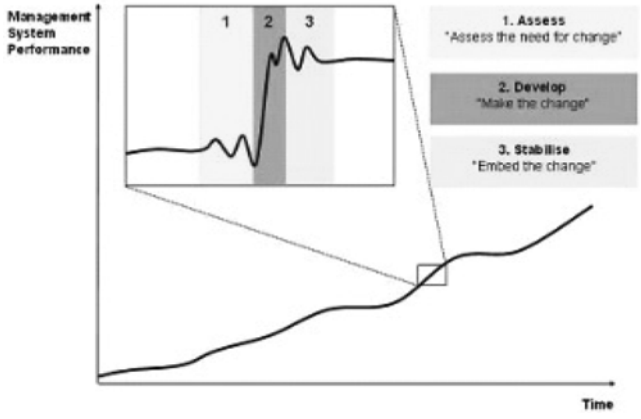

Fig. 2. Management system performance improvement.

control. This is achieved by assessing the organization's management system against specific and detailed questions on key HSE management activities. Management can then determine if the system performance is in line with its expectations. Areas that do not meet the expected level can then be targeted as improvement areas. Similarly, those activities that meet or exceed expectation can be reinforced. LCMCI can assist management to obtain better control of their unintended losses, i.e., injuries, illnesses, environmental losses, property damage and process losses.

3. Develop

Development consists of making the changes necessary to improve the performance of the management system. The process of making these changes includes

(1) Development of an action plan for change (who does what when)

(2) Facilitation of the change (allocate time, funds, commitment and expertise)

(3) Monitoring of the progress of change (evaluate what has been done)

LCMCI is a resource book describing good management practices for the control of loss. Management can use these blueprints as a guide to identify, implement and improve HSE management systems and operational practices in accordance with the assessed need.

4. Stabilize

The last stage of the change process is to embed the newly changed activity with the organization's management system and culture. Change can be fleeting. Activities are required to prevent the organization from reverting to its old habits. This can easily be observed from the behavior of individuals and groups. Typically, participants during training sessions develop new concepts and understanding and then revert immediately to their old habits when they are back in the home environment if that environment does not support the new point of view.

5. Accidents Analysis

A basic purpose of LCMCI is reducing loss cost and the number of accidents. Therefore, all requirements of LCMCI were decided from analyzing accident frequency and severity. Many accidents that occurred at petrochemical companies were analyzed to decide the weight value of LCMCI. The analysis was made from 918 accidents reported at companies located in Ulsan and Yechon petrochemical complex for 30 years (Fig. 3).

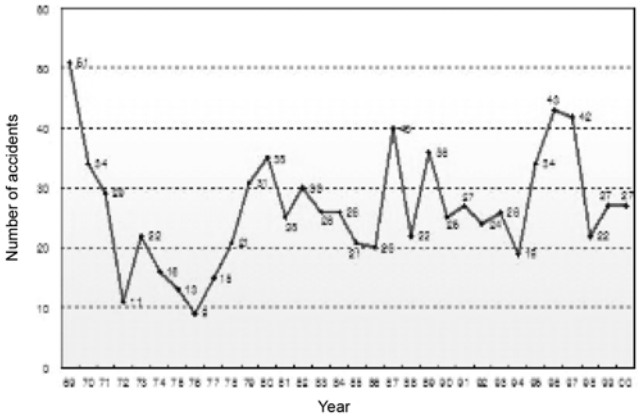

Fig. 3. The number of accidents used for the analysis.

6. Analyze Weight Value for Each Element

The results that are analyzed in order to calculate the score weight of LCMCI are the same as in Table 3. The result of weight value was from calculation through many steps.

7. Structure of LCMCI

The number of questions for each element by level is in Table 4. Because LCMCI level is decided according to the results of minimum average score and minimum on any element, logical error doesn't occur when a company wants to upgrade the LCMCI level.

Score distribution by level about each element is in Table 5. The score for every question is all added up by each element and then converted to a percentage. The sum total points of each element means a score for questions except for "not applicable (N/A)."

Table 3. Result of analysis for accidents

Element	Number of causes (including duplication)	Number of causes (excluding duplication)	Severity	Score (1st)	Score (10,000)	Percentage (%)
1. HSE Policy	19	7	4.40	31	122	1.2
2. Hazard identification and risk assessment	104	32	5.27	169	666	6.7
3. Legal and other requirements	49	18	4.65	84	330	3.3
4. HSE objectives and planning	63	20	4.62	92	365	3.7
5. Structure and responsibility	45	16	6.73	108	425	4.3
6. Training	113	41	6.43	264	1,040	10.4
7. Consultation and communication	112	35	5.90	207	815	8.2
8. Documentation	45	16	6.49	104	410	4.1
9. Document and data control	21	6	5.15	31	122	1.2
10. Operational control	349	111	5.53	614	2,424	24.2
11. Emergency preparedness and response	140	51	5.31	271	1,069	10.7
12. Performance measurement and monitoring	171	58	5.76	334	1,320	13.2
13. Accident investigation and corrective action	79	28	5.31	149	587	5.9
14. Records and records management	15	3	6.80	20	80	0.8
15. System audit and management review	45	14	4.07	57	225	2.3
Total	1,370	456		2,533	10,000	100

Table 4. The number of questions for each element

LCMCI Elements	1	2	3	4	5	6	7	8	9	10
1. HSE Policy	20	30	40	52	102	122	122	122	122	122
2. Hazard identification and risk assessment	30	90	177	252	322	456	561	561	561	666
3. Legal and other requirements	0	0	70	90	200	280	280	280	310	330
4. HSE objectives and planning	0	30	50	50	135	285	340	340	340	365
5. Structure and responsibility	50	80	120	225	255	355	395	425	425	425
6. Training	30	30	90	275	315	555	695	875	955	1040
7. Consultation and communication	70	70	140	180	220	370	450	610	690	815
8. Documentation	30	50	240	240	330	350	370	410	410	410
9. Document and data control	10	10	10	10	10	62	102	122	122	122
10. Operational control	453	783	1013	1144	1394	1614	1849	2139	2309	2424
11. Emergency preparedness and response	60	80	304	334	384	474	744	849	989	1069
12. Performance measurement and monitoring	180	293	435	603	623	688	790	1065	1240	1320
13. Accident investigation and corrective action	67	172	207	232	232	272	317	527	572	587
14. Records and records management	0	0	0	50	50	65	80	80	80	80
15. System audit and management review	40	50	50	70	175	195	215	215	225	225
Total questions required	1040	1766	2946	3807	4747	6143	7310	8620	9350	10000

Table 5. The score of each level

LCMCI Elements	1	2	3	4	5	6	7	8	9	10
1. HSE policy	1	2	3	4	6	7	7	7	7	7
2. Hazard identification and risk assessment	1	5	10	14	18	23	28	28	28	32
3. Legal and other requirements	0	0	4	5	11	16	16	16	17	18
4. HSE objectives and planning	0	3	5	5	10	16	19	19	19	20
5. Structure and responsibility	2	4	5	9	10	14	15	16	16	16
6. Training	1	1	4	10	12	21	27	35	38	41
7. Consultation and communication	3	3	7	9	11	18	21	27	30	35
8. Documentation	2	4	9	9	12	13	14	16	16	16
9. Document and data control	1	1	1	1	1	3	5	6	6	6
10. Operational control	18	31	44	51	63	76	88	100	107	111
11. Emergency preparedness and response	4	5	11	14	18	23	34	40	47	51
12. Performance measurement and monitoring	6	10	16	21	22	26	32	45	53	58
13. Accident investigation and corrective action	3	7	8	10	10	12	15	24	27	28
14. Records and records management	0	0	0	1	1	2	3	3	3	3
15. System audit and management review	2	3	3	5	11	12	13	13	14	14
Total questions required	40	79	130	168	216	282	337	395	428	456
Minimum average score	35%	40%	45%	50%	55%	60%	65%	70%	80%	90%
Minimum on any element	20%	25%	30%	35%	40%	45%	50%	55%	60%	70%

8. Statistics of LCMCI

The statistical structure of LCMCI is the same as in Fig. 4. The percentage for each level is "LCMCI Process" and number of questions and score for each level is "question categories."

The distributions for type of question and number of questions at international standards can be confirmed at "analysis of scoring type" and "international standard."

APPLICATION OF LCMCI FOR THREE YEARS AT A PETROCHEMICAL COMPANY

1. Result of Application

LCMCI finished development in 2002, and then was directly evaluated at a company. That company implemented LCMCI for three years, and the company improved continuously because every question of the LCMCI was at a designated level. The implementation results are same as Table 4 for three years.

2. Loss Decrease of the Applied Company

The applied company had 7-9 process accidents every year from 1999 to 2000, and in case of Non-loss Time Accidents had 3-5 accidents for the same period.

Loss Time Accidents were 3-4 accidents, and in the case of emergency shutdown, the accident average was 69-89 days.

However, the accidents decreased as follows when LCMCI was

LCMCI processes

Element	Score	%
1	122	1.2 %
2	888	8.7 %
3	880	8.8 %
4	865	8.7 %
5	425	4.2 %
6	1,041	10.4 %
7	015	0.1 %
8	410	4.1 %
9	122	1.2 %
10	2,424	24.2 %
11	1,069	10.7 %
12	1,820	18.2 %
13	507	5.8 %
14	00	0.0 %
15	225	2.3 %
Total	10,000	100.0 %

Question categories

Question category	Number of questions	Score
L1	44	1,040
L2	30	742
L3	51	1,173
L4	30	862
L5	47	815
L6	88	1,3585
L7	58	1,187
L8	58	1,210
L9	33	720
L10	28	655
Total	456	10,000

Analysis of scoring types

Type of scoring	Number of questions
Yes/No	250
누설/충진	119
%	16
AU	54
Ueq	17
Total questions	456

International standards

International Standard	Number of questions
ISO 14001	128
KRCC	128
OHSAS 18001	165
QS 9000	119
PSM	71

Fig. 4. Statistics of LCMC.

Table 6. Evaluation result for three years

LCMCI elements	2002, (35.2%, Level 1)	2003, (35.2%, Level 1)	2004, (35.2%, Level 1)	2005, (35.2%, Level 1)
1. HSE policy	32.8	65.6	70.5	71.9
2. Hazard identification and risk assessment	27.8	33.8	45.9	48.7
3. Legal and other requirements	40.0	47.3	53.3	57.1
4. HSE objectives and planning	49.0	49.0	60.0	61.8
5. Structure and responsibility	24.2	40.7	50.1	53.1
6. Training	27.9	42.3	41.3	46.7
7. Consultation and communication	25.8	35.0	42.3	47.8
8. Documentation	22.0	72.0	76.8	78.4
9. Document and data control	34.4	34.4	42.6	48.2
10. Operational control	37.9	51.7	48.8	55.1
11. Emergency preparedness and response	36.1	36.1	52.0	54.6
12. Performance measurement and monitoring	39.0	42.2	44.1	49.8
13. Accident investigation and corrective action	39.9	62.9	68.0	70.0
14. Records and records management	43.8	33.8	56.3	58.5
15. System audit and management review	71.1	62.2	80.0	81.6
Total questions required	35.2	46.1	50.9	58.9

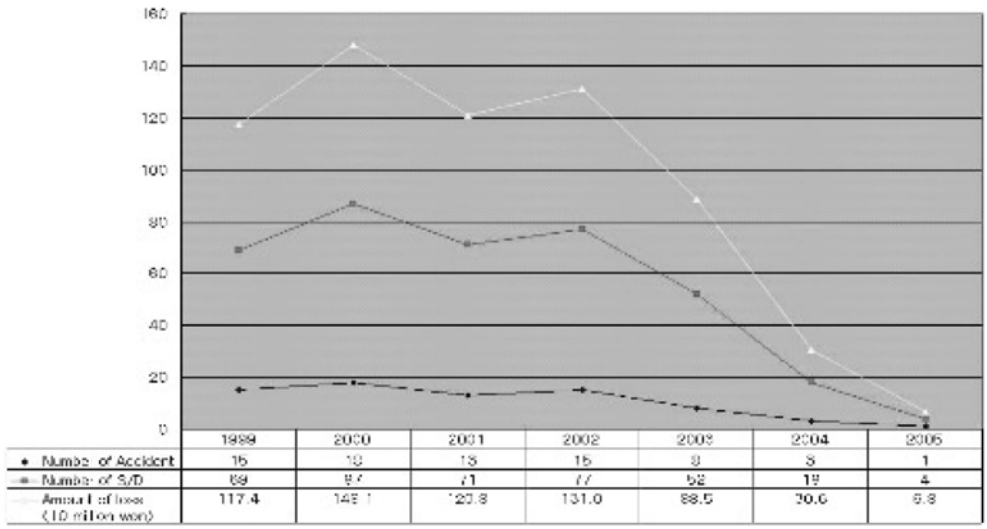

Fig. 5. The trend of reducing loss for 7 years.

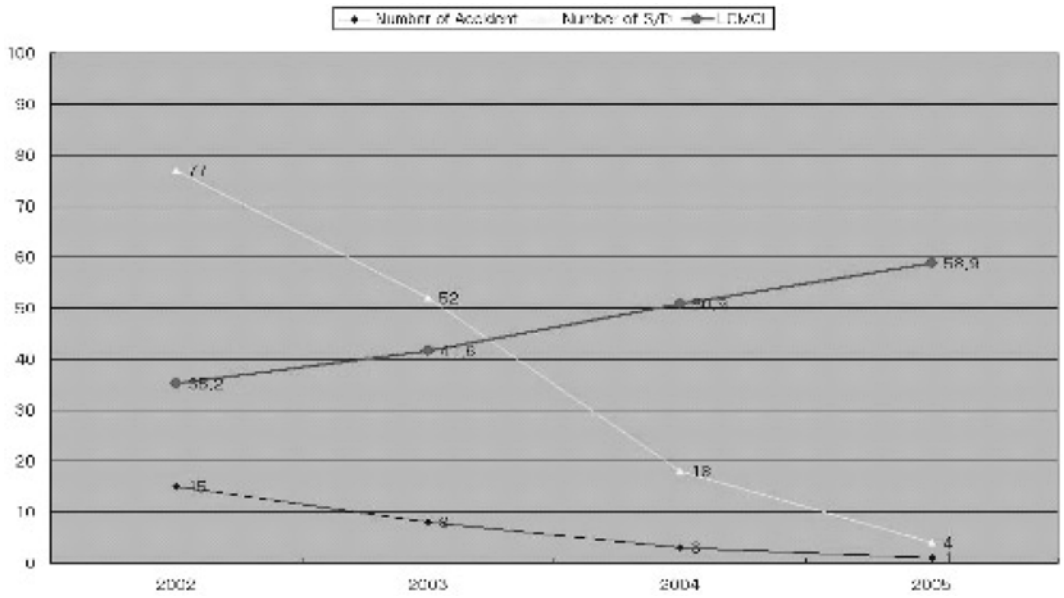

Fig. 6. Upgrading of LCMCI vs reducing of loss.

started to be applied from 2003.

(1) Number of process accidents : from 5 to 1
(2) Number of non-loss time accidents : from 2 to 0
(3) Number of loss time accidents : from 1 to 0
(4) days of emergency shutdown : from 52 to 4

CONCLUSION

This LCMCI has been applied at a petrochemical plant in Ulsan for 3 years and the results are as follows (Fig. 6):

(1) Comparing accidents for 3 years after LCMCI was applied with accidents for 4 years before it had not been applied (1999-2002), the number of accidents decreased 3.75 times.

(2) The loss cost of unintentional accidents (injury, process interruption and property damage etc.) has decreased approximately 3 times per year on the average. This is an important result to make a company's management state very healthy. On the other hand, productivity was improved extremely due to the decrease of an emergency shutdown of the plant from76 days to 25 days per year on the average.

From the above result, this LCMCI developed in this study was verified to reduce loss continuously in the petrochemical industy as a improvement tool of a company's competitiveness, satisfying the requirements of most kinds of systems which are applied in the petrochemical industy (PSM, RC, OHSAS18001, ISO14001 etc.).

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