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Korean Experience of Risk Management in Chemical Industries

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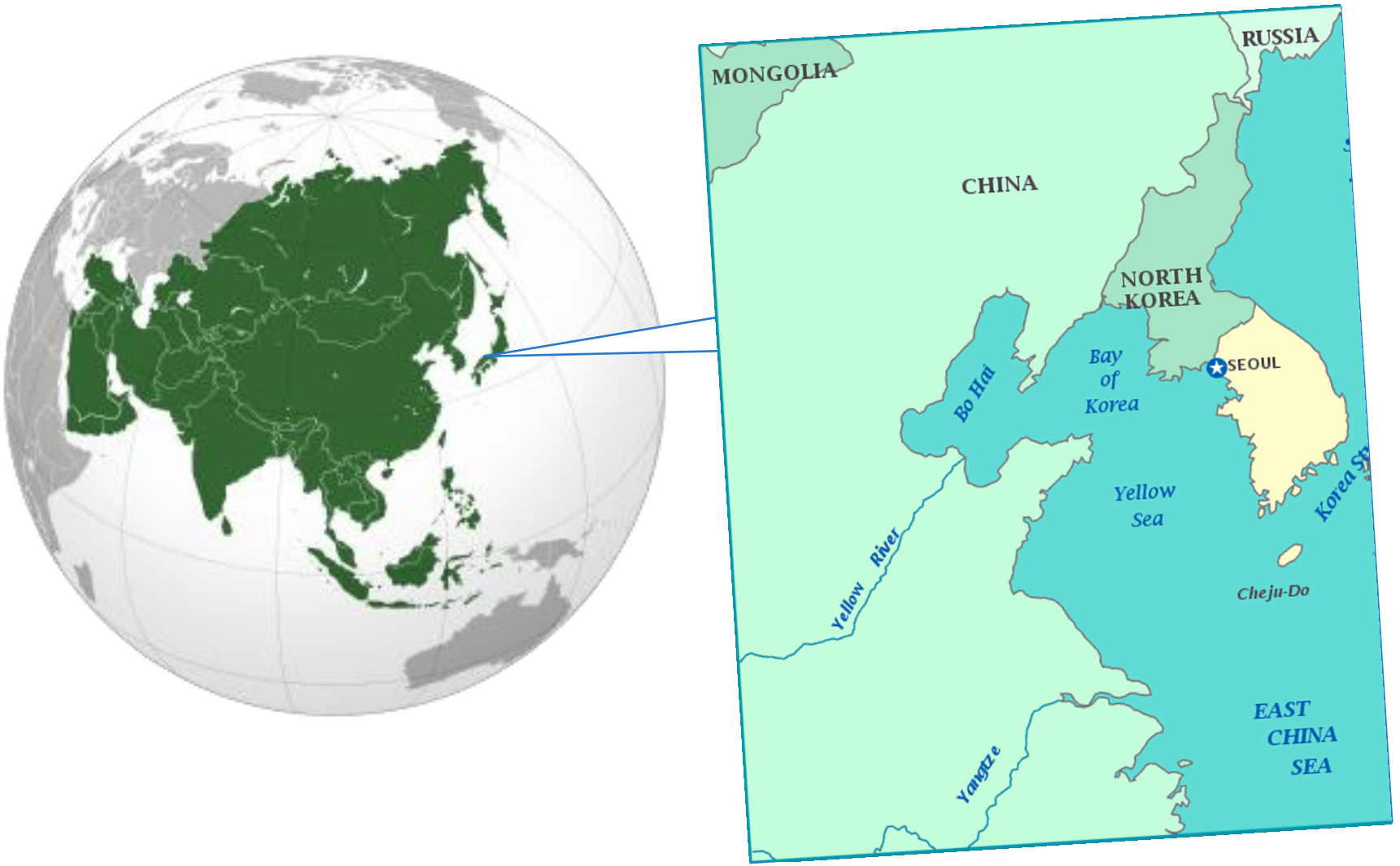
Location of Korea



Geography & Demographics (2016)

- Official Name **:** The Republic of Korea
- Language : Korean
- Area : 99,720km^2

  Source : The World Factbook(CIA, 2013)
- Population : 51million(2015)
- Population Growth Rate : 0.45%
- Life Expectancy : 82.40years(2014)

  Male 78.99, Female 85.48

  Source : KOSIS(Korean Statistical Information Service)

Economy (2016)

- GDP : US $ 1,392 trillion
- Per-Capita GNI : US $ 27,513
- Economic Growth Rate : 2.2%(2015)
- Trade Balance : US $7,067.6 million
- Consumer Price Increase : 1.0%
- Major Industry

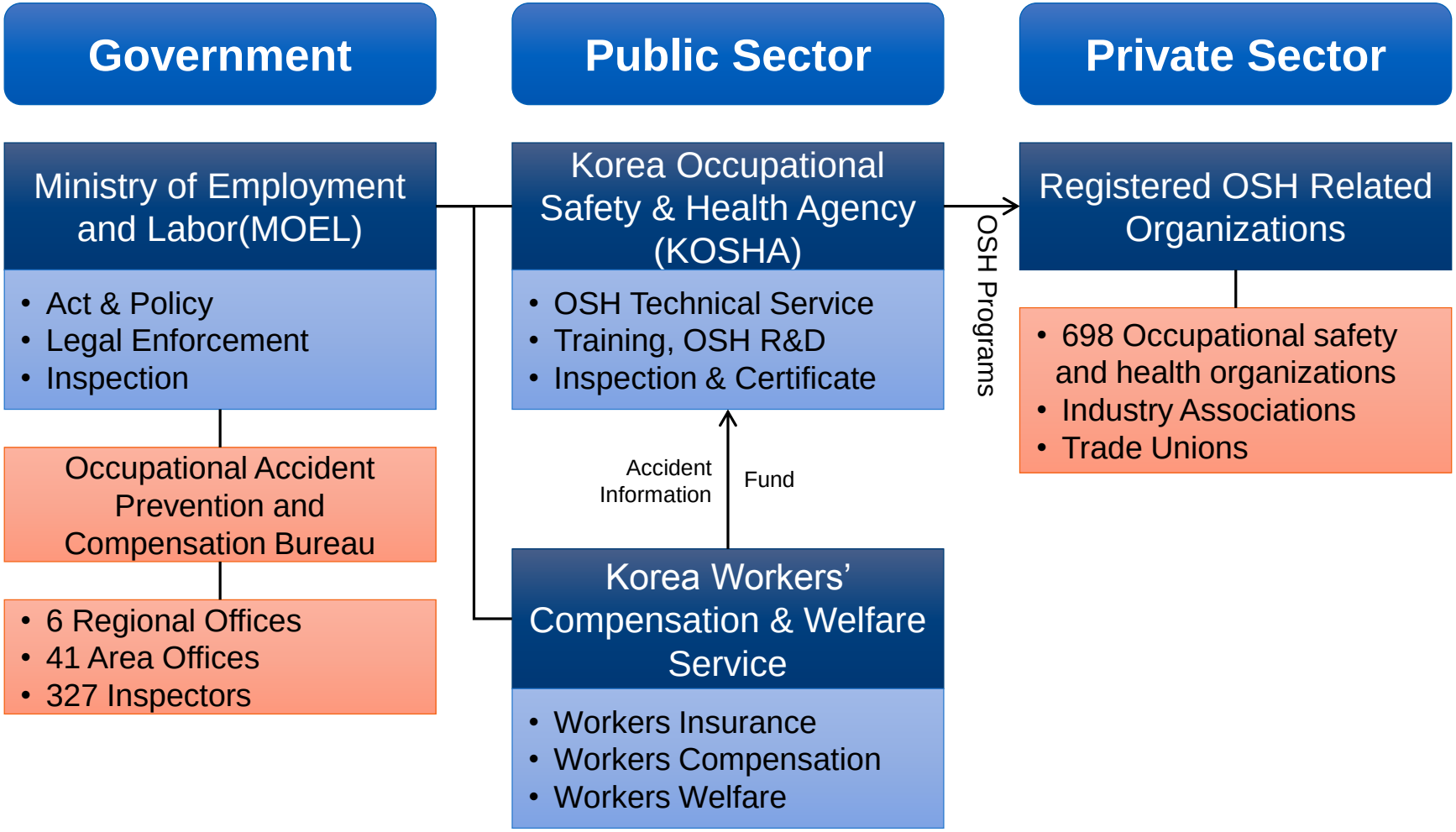
  Electronic Products, Semiconductors, Mobile Products, Automobile, Chemicals, Ship building

Major Labor Indicators (2015)

- Economically Active Population : 26.99 million
- Employed by Industry

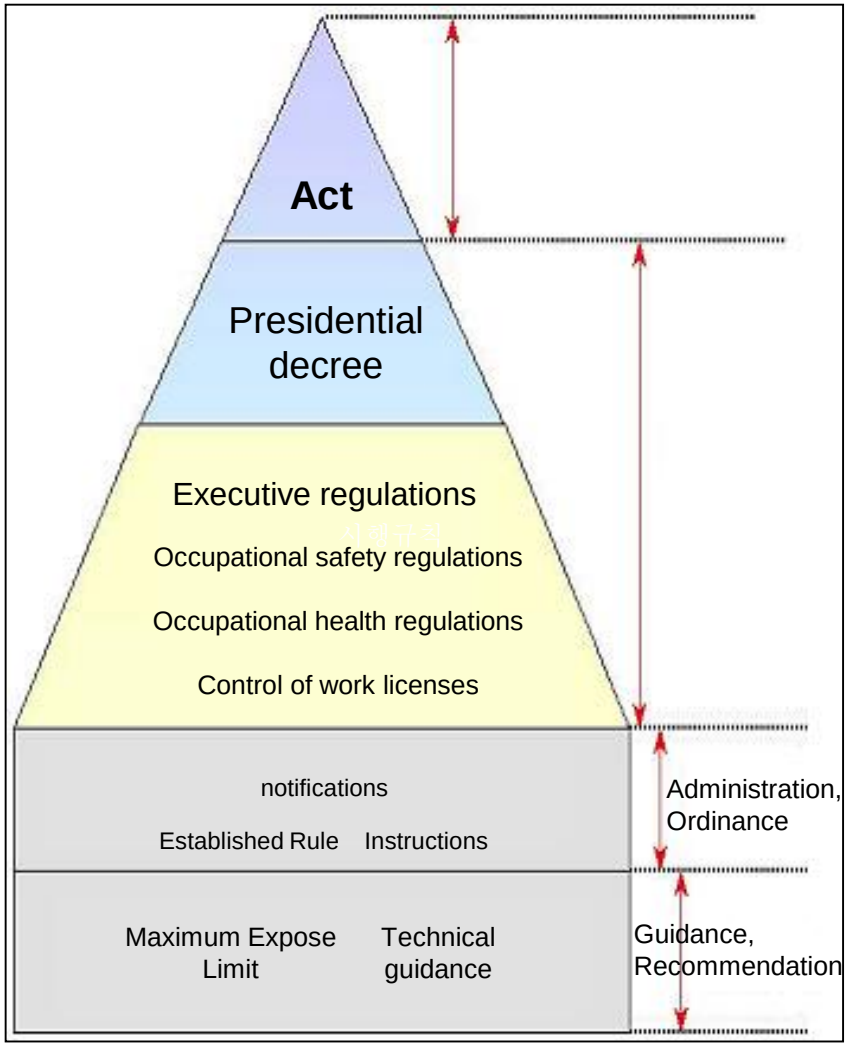
  Services (77.1%), Industry (17.1%), Agriculture (5%)
- Participation Rate : 60.3%
- Unemployment Rate : 3.6%
- Num. of Trade Unions : 5,305 (2015)
- Fatality Rate per 10,000workers : 0.53‰ (2015)

OSH organization system



OSH Legal system

OHS Act was promulgated in 1980, an entire revision in 1987 and then 33 times revisions have been to cope with OSH circumstances



Occupational safety and health Act(1980) last Amended 2013
Presidential decree
Occupational safety standard (Ministerial decree)
Occupational health standard (Ministerial decree)
Notification and guidelines (59 sort)
Technical guidance (KOSHA code)

Start from the Scratch (1953~1980)

- **Basic regulations on OSH enacted and parts of supervisory function adopted on the basis of economic development as the primary goal**

  ~ However, proper OSH regulation failed to be established and its impact on site was marginal

- **As economy grew, so did awareness and political demand on OSH**

- **In 1953, 10 OSH-related Chapters were included in the Labor Standards Act to impose responsibilities of employers for safety and health action**

  ~ However, in reality, they were not implemented due to lack of subsections responsible for defining specific standards

  → **In 1961 and 62, regulations on occupational safety as well as occupational health were enacted respectively and began to be applied in reality**

- **In 1963, Industrial Accident Compensation Insurance Act enacted and entered into force**

Start from the Scratch (1953~1980)

- **In 1966, Occupational Safety Department in the Labor Office was newly established in order to play a role as an exclusive unit for OSH**
- **With rapid industrialization, as industrial accidents increased, social awareness on OSH escalated as well**

産業災害 부쩍늘고 大型化

産業多樣化에 安全施設못따라

◇연도별 산업재해

	75	76	77
재해자	81,641	97,716	118,316
사망자	875	909	1,167
1천명당재해율	44.5	43.1	46.7
재산피해	51,901	63,354	107,690

<단위 : 백만원>

작년死亡·負傷11萬여명

財産損失만도 千76億원

Article from Dong-A Daily (1978)

› **Industrial Accident: increased and enlarged**

- lack of safety facilities comparing to industrial diversification

In 1990s, suffering from normal-hexane and benzene poisoning in shoes-manufacturing factories was highlighted as social issues

Victims of poisoning

In 1975: 81,641 → In 1977: 119,316

Stabilization of Safety (1981~)

- **With continuous economic growth, awareness on OSH increases**
  - OSH related laws and regulations were modified and units for supervision were arranged

- **In 1981, Occupational Safety and Health Act enacted**
- **In 1987, Korea Occupational Safety and Health Agency established**
- **In 1989, Occupational Safety Bureau inaugurated in the Ministry of Labor**

Stabilization of Safety (1981~)

- **Establishment & implementation of medium and long-term policy for accident prevention at the government level**

  → **Safety was on the rails with accident rate reduction**

- **Medium and long-term policy establishment and implementation:**
  - the 1st 6-year-plan of Industrial accident prevention (1991)
  - 3-year-plan of occupational safety advancement (1997)
  - the 1st-3rd 5-year-plan of industrial accident prevention (2000~2010)

- **A signature-seeking campaign for zero-accident from 10 million people for enhancement of people's awareness on safety**

- **Dramatic decrease of accidents rate**

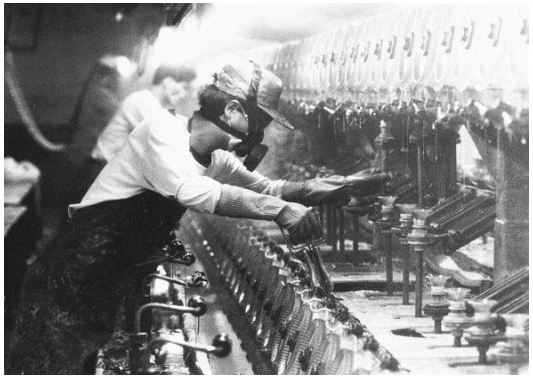
  In 1981 (the year of the law enactment): 3.41%
  → in 1987 (the year of KOSHA establishment): 2.66%
  → **in 2009: 0.7%**

Occupational Health takes root (1991~)

- **CS2 poisoning in a rayon manufacturing factory triggered tremendous awareness on occupational diseases; policy on occupational health began in earnest**

< The Won-jin Rayon CS_2 Accident >

- **About 1,000 workers exposed to CS2 and poisoned at a rayon manufacturing factory from 1988 to 1991 claiming about 170 lives.**
- **The factory shut down in 1993 and relocated to China**



Occupational Health takes root (1991~)

- **Establishment & implementation of comprehensive measures for occupational diseases prevention (1991)**

  - set up a system for workplace health management:
    widening the standard of health manager
  - improve medical checkup system
  - adopt a handling permit system against occupational diseases-causing materials such as asbestos
  - conduct Work Environment Monitoring every 5 years
  - improve the system of work environment measurement
  - institute Occupational Safety and Health Research Institute (OSHRI)

- **Persistent health issues came to the surface: leukemia in semi-conductor manufacturer, asbestos management, emotionally stressed workers**

Crisis of OSH (1997~2000)

- **1997 Asian financial crisis (IMF) and consequential deregulations**
  - Deregulations in OSH as well
    (easing the designation standard of safety and health managers)

- **Hiring Industrial physicians: compulsory → voluntary**

- **Loosen the hiring standard of safety manager and health manager and allow concurrent positions**

- **Alleviate the standard of mandatory training and education for OSH-interested parties**

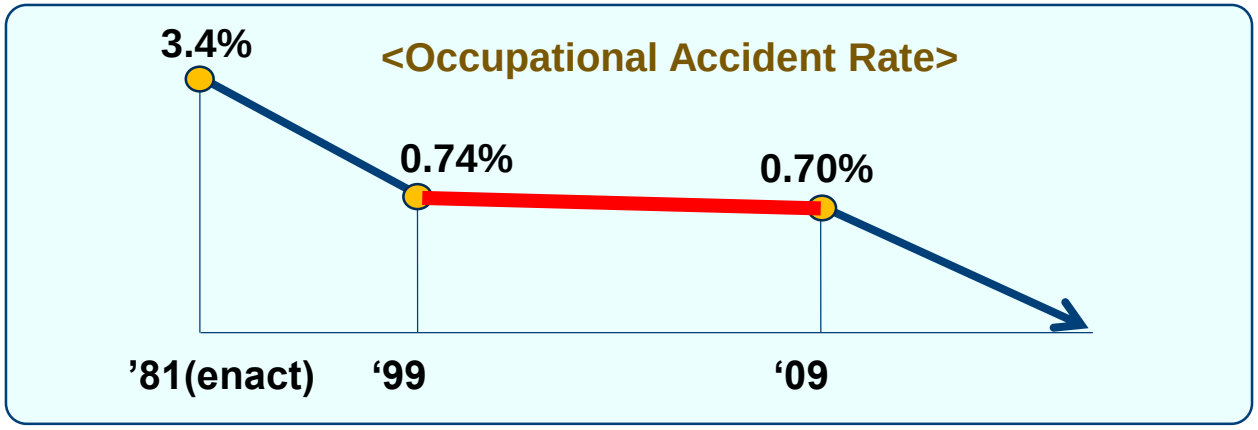
Crisis of OSH (1997~2000)

- **Abolition of regular inspection on Press and Lift**

- **Abolition of mandatory submission and examination of harm and hazard prevention plan in the manufacturing industry**

➡ **consider safety and health regulation as part of economic regulations leading to regression of safety culture**

➡ **stagnant industrial accident rate for 10 years at the 0.7%**



Rebound of OSH… (2000~)

- **Recognize safety as prerequisite to overcome an economic crisis and join the ranks of advanced countries**

  - increase safety needs of people in accordance with the increase of national income
  - adopt Risk Assessment system and Accident Prevention Rating System
  - Financial support for small-scale business, funding for occupational accident prevention facility
  - institute TF for accident prevention in service industry under MOEL and KOSHA

Rebound of OSH… (2000~)

- **In 2013, accident rate reached 0.59% by way of promoting omnidirectional policy with the aim of establishing safe and pleasant workplace**

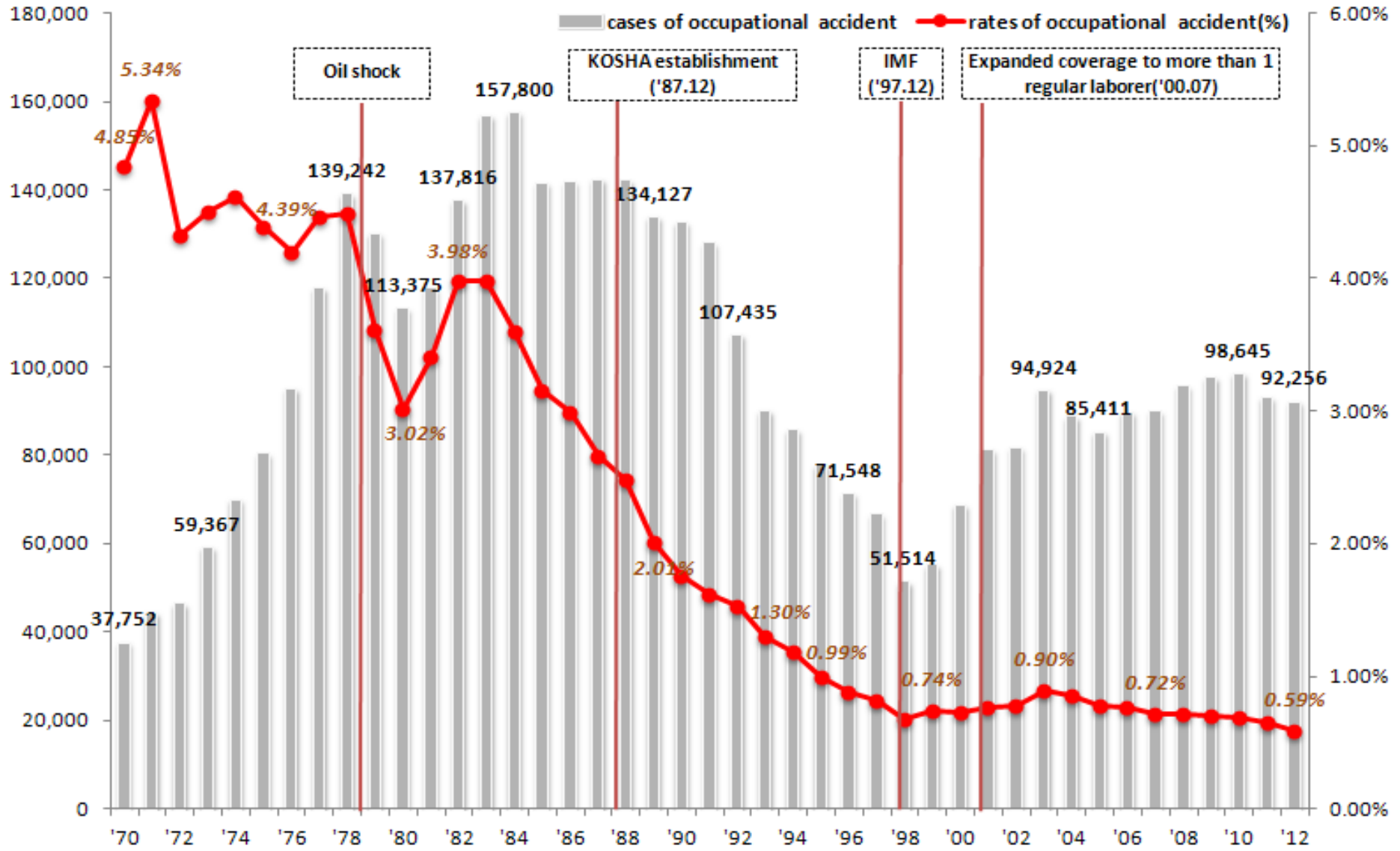
- **Measures for the vulnerable (aging and foreign workers)**

- **Expansion of OSH infra by fostering private accident prevention organizations and activating safety and health market**

Accident rate and Fatality rate per 10,000 workers have hit historic lows

- Nonetheless, persistent major accidents such as chemical explosion accidents and emotionally stressed workers
→ **rising social issues**

No. of Victims & Occupational Accidents Rates



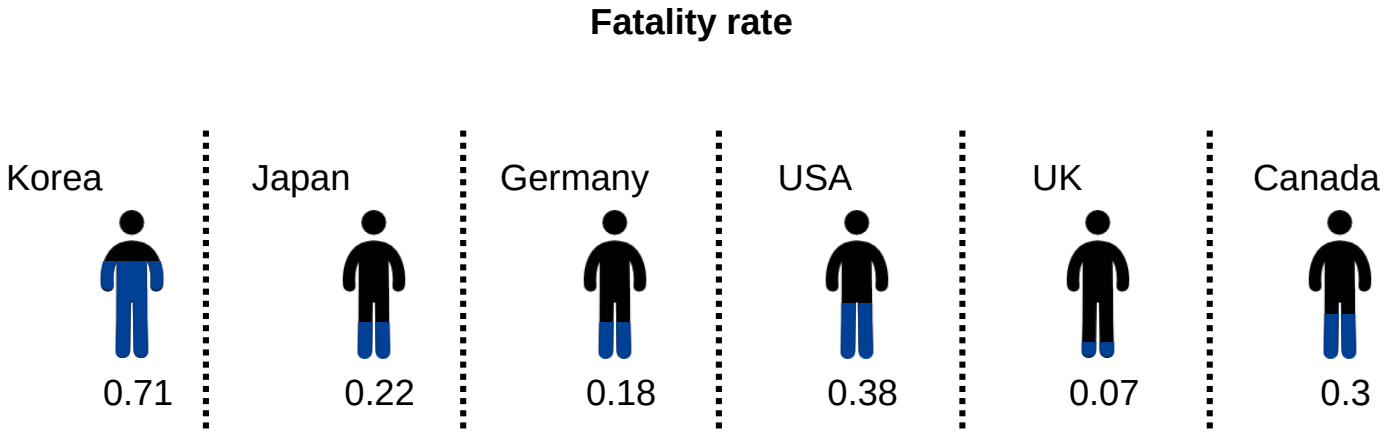
OSH Statistics

- OSH Statistics (year 2015)
  - No. of Enterprises : Manu. 15.5%, Const. 14%, Service 64.4%
  - No. of Employees : Manu. 24.2%, Const. 14.9%, Service 50.5%

(unit: establishment, person)

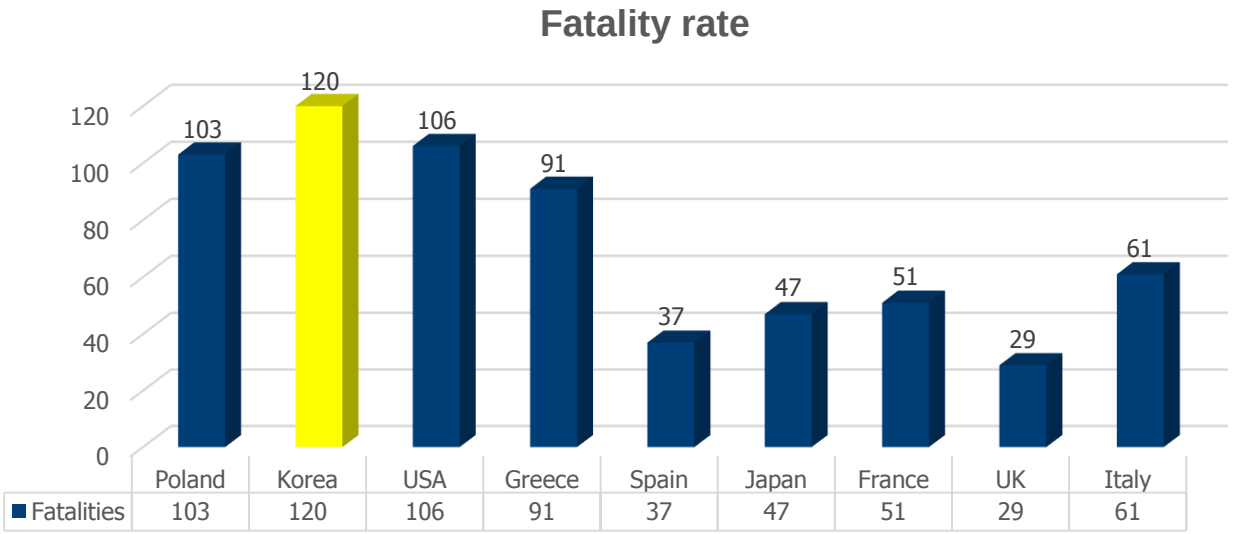
Economic Sector	Total	Service	Manufacture	Construction	Others
Number of Enterprises	2,326,677	1,499,541	362,702	326,792	464,434
Number of Employees	17,157,657	8,665,358	4,162,029	2,568,800	1,761,470
Number of Occupational Accidents	90,129	29,734	27,011	25,132	8,252

Fatality rate of Industrial accidents (per 10 thousands)



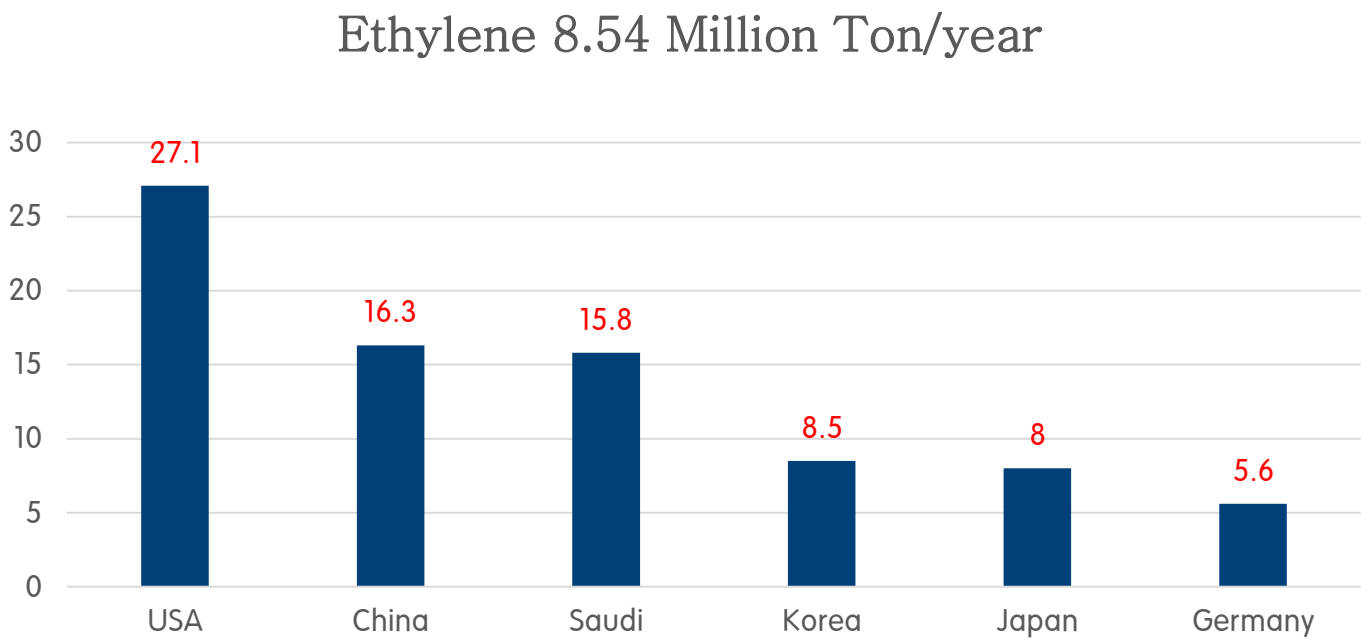
Source : The International Labour organization (ILO)

Fatality rate of traffic accidents (Per million population)



Source : World Health Organization(WHO)

Korean Chemical Industry



- **Ethylene market share : 1.9%('90) → 5.4%('12)**
- **3.4% of total chemical market(7th in the World)** :

  USD 144.4bil.('13)

Economical situation of Chemical Industry

- **Big contribution to welfare improvement**
- **70% of human body is water, 70% of what we wear**

  (Clothes, shoes and bags, etc) is chemical product

Societal Level of Chemical Industry

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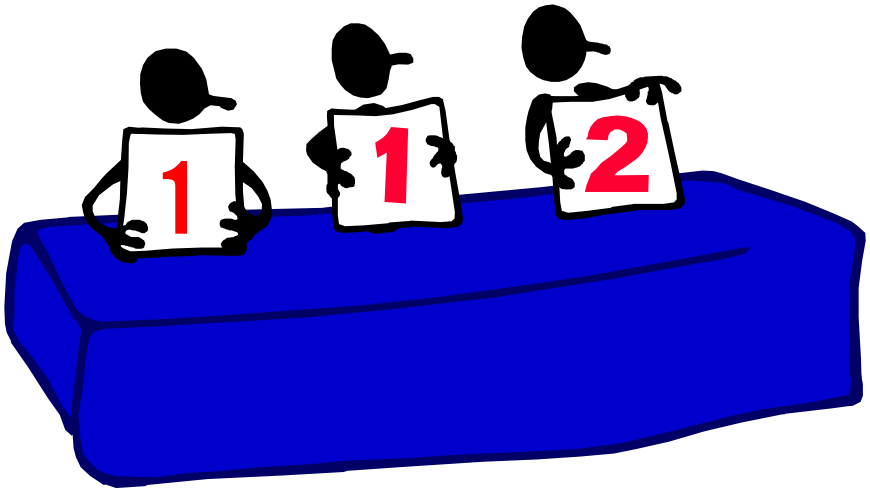
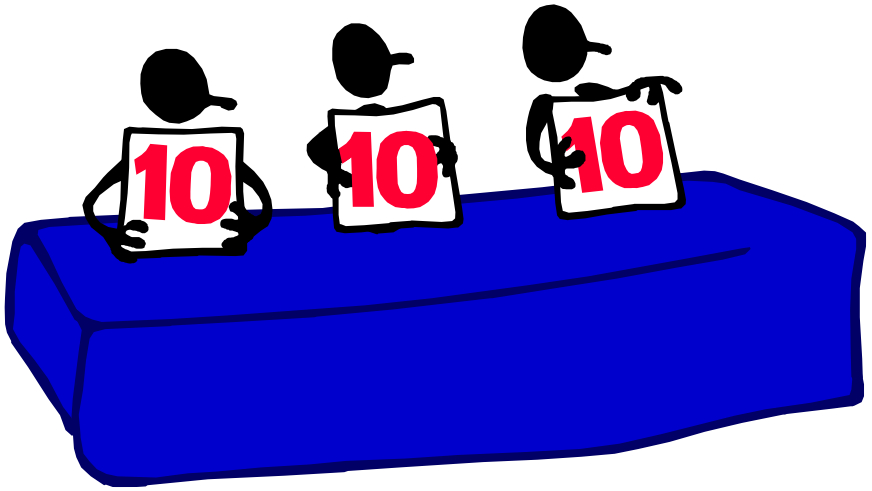
Community opinion of global Chemical Industry



- Only slightly better than tobacco
- Not responsible members of community
- Responsible for Safety & environmental problems

Vision of Chemical Safety



This
is
the vision of
Chemical
Safety

Accident Prevention

Major Chemical Accident

- Fire, Explosion and Toxic Release
- Loss of Personnel & Economics
- Impact to Residence & Environment
- Small Accident → Plant Shut Down
- Affect to Other Industry
- Special Directives in OECD, UNEP, ILO

Major Chemical Accident

-ILO Convention No. 174-

The term" major accident" means a sudden occurrence such as a major emission, fire or explosion in the course of an activity within a major hazard installation, involving one or more Hazardous substances and leading to a serious danger to workers, the public or the environment, whether immediate or delayed.

LPG accident

블랙스완

0.1%의 가능성이 모든 것을 바꾼다

나심 니콜라스 탈레브 지음 | 차익종 옮김

Black Swan

Crude oil Accident

Crude Tank Oil Leak Accident (2014. 4.)

- **Design Capacity: 750,000 bbl**
- **At the time of accident : 570,000 bbl (90,573㎘)**
- **Tank Size : D 84.75m × H 21.945m (F.R.T)**
- **Installed: 2011. 1.**
- **Leak Qt'y : 150,000 bbl**

  ※ 20t tank lorry 1,225 truck quantity

Side Mixer Destroyed

Side Mixer Destroyed

Side Mixer

Blade damage->Vibration-> Mixer Breakaway

Onsan Petrochemical Complex

To consider

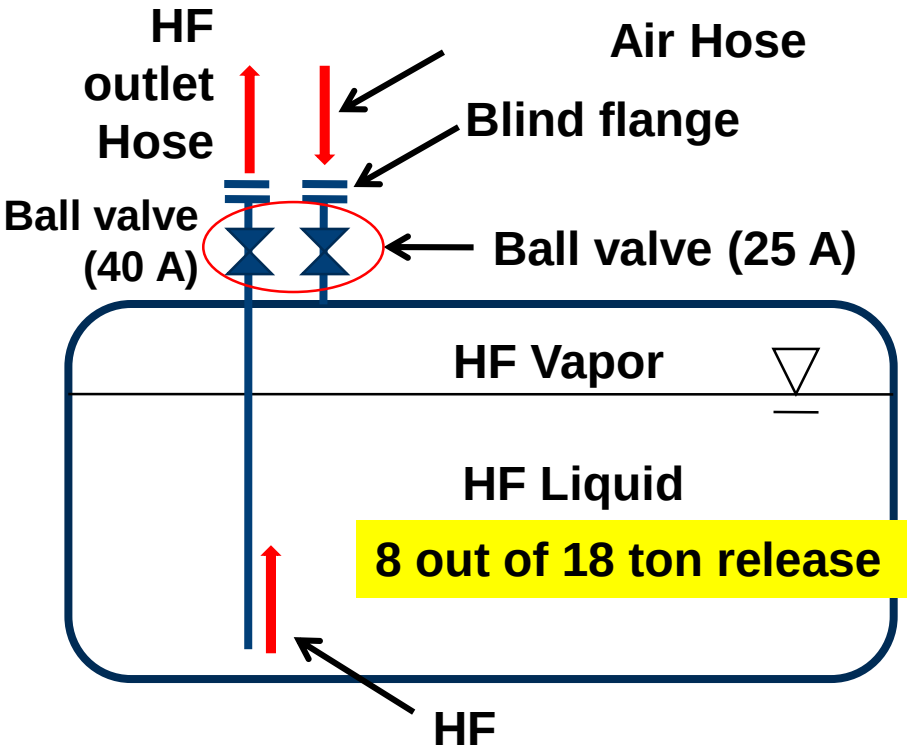
1. Black Swan type Accident

2. Complex Emergency Planning

- Fire water, Foam, etc
- Quick transportation of crude oil inside tank in case of similar accident
- Emergency response jointly in the complex

HF Release

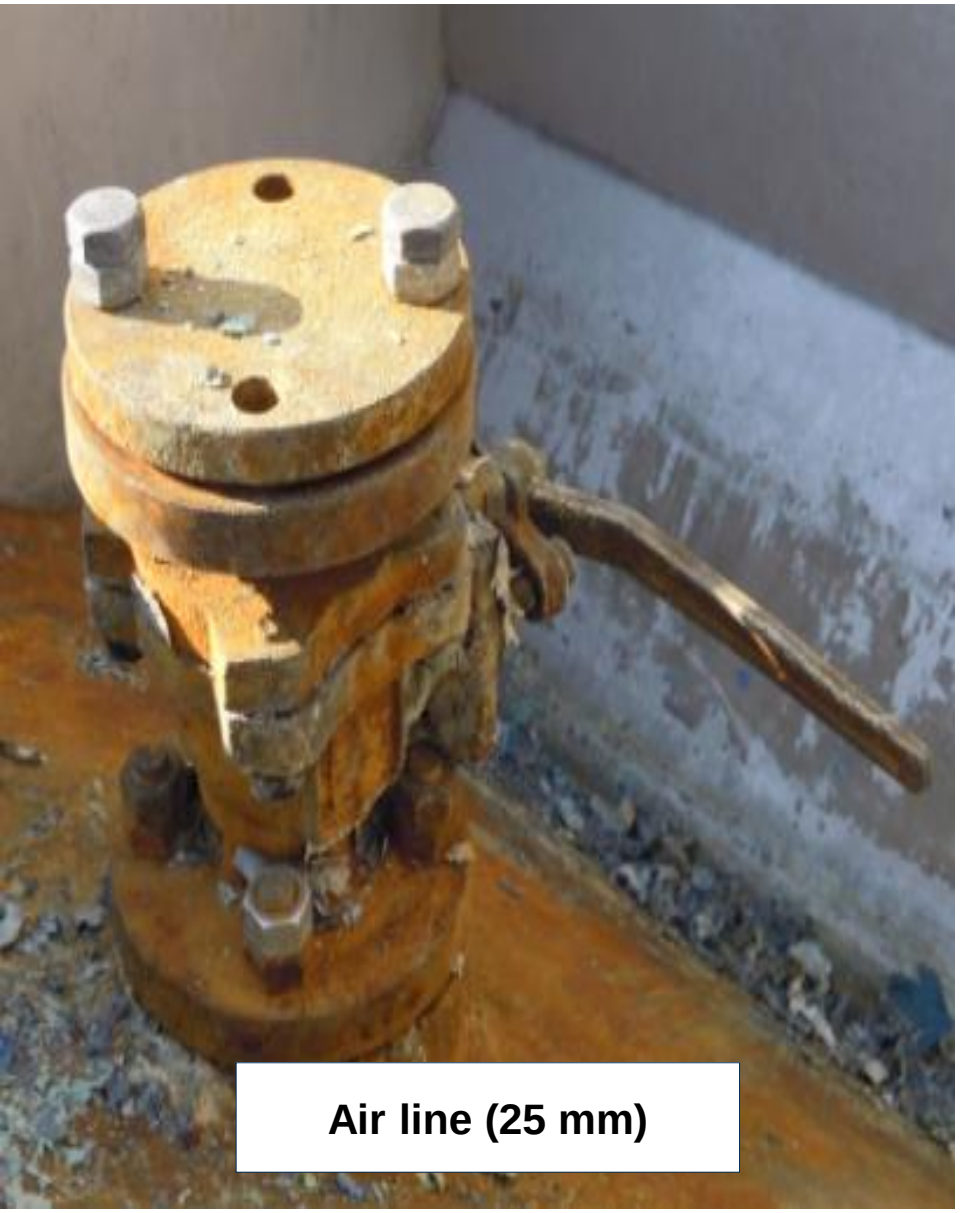
2012.9.27 HF Release, 5 workers dead, Thousand resident people medical treated, Environment severely damaged.

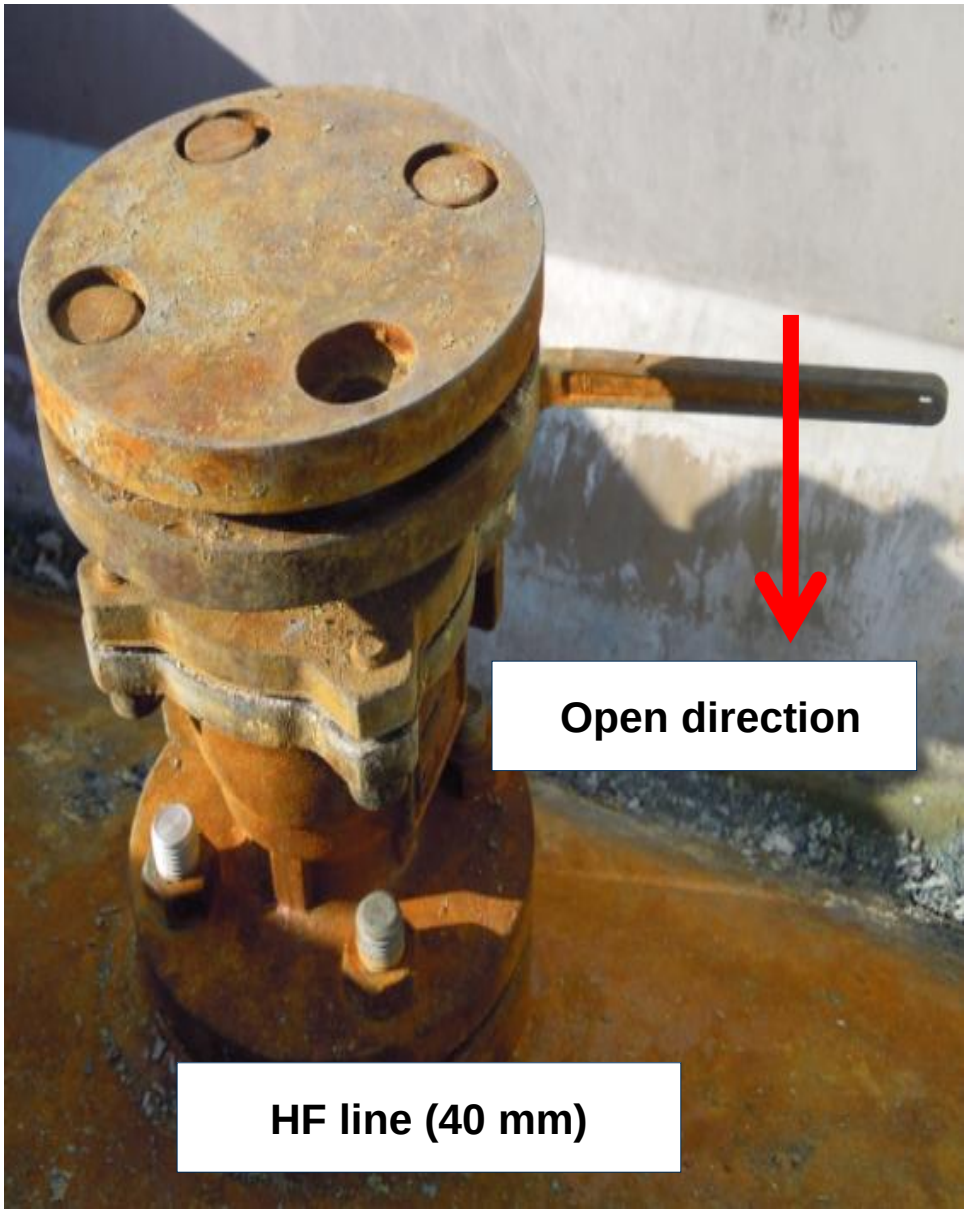


HF Accident

HF Tank Container

HF Tank Roof





HF Tank Roof

2 sec
Two worker access
rubber glove(2), general mask(1)

19 sec
Two worker operation

47 sec
(Release occurred)

48 sec
(Release spread)

50 sec
(Release spread)

Enforcement of the Chemical Control Act in 2015

- **Enforcement rules which contain detailed guidelines**

  - safety management in facility, penalty to violation
  - immediate reporting of chemical accident
  - off-site consequence analysis prior to location
  - risk management plan to special chemicals
  - investigation of environmental and human health effect

RMP (Risk Management Plan)

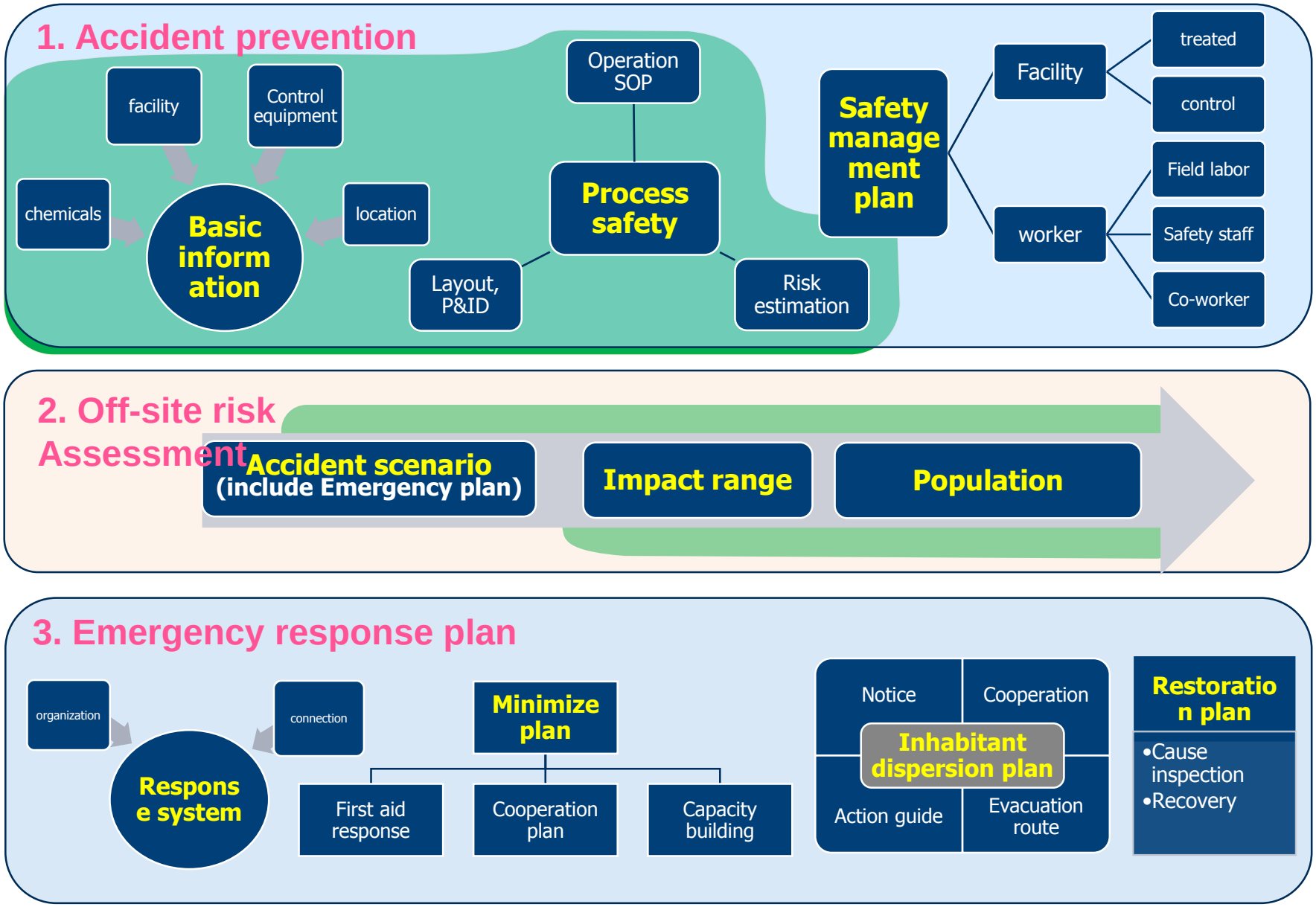
- **RMP should be submitted and be known to neighboring resident**

- management of 69 Precautionary Chemicals of Accidents(PCAs)

- containing spill scenario, emergency response

- emergency evacuation etc.

Main component of RMP



Main component of RMP

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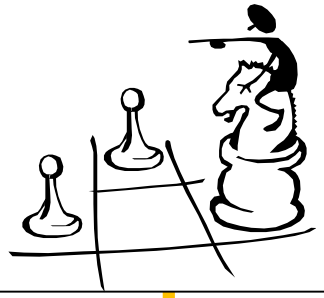
Process Safety Information

Process Hazards Analysis (Site Preview)

Safety Plan for Operation

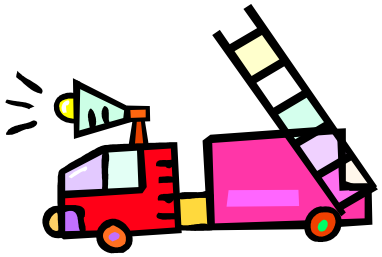


PSM Strength

Chemical Accidents Management System

RMP Strength

Emergency Preparedness, Response



Community Awareness, Clean up

PSM + RMP

Compliance audit

Chemical Accident Prevention (PSM in Korea)

- Introduction of PSM Regulation by amendment of Industrial Safety and Health Law: Jan 5, ’95

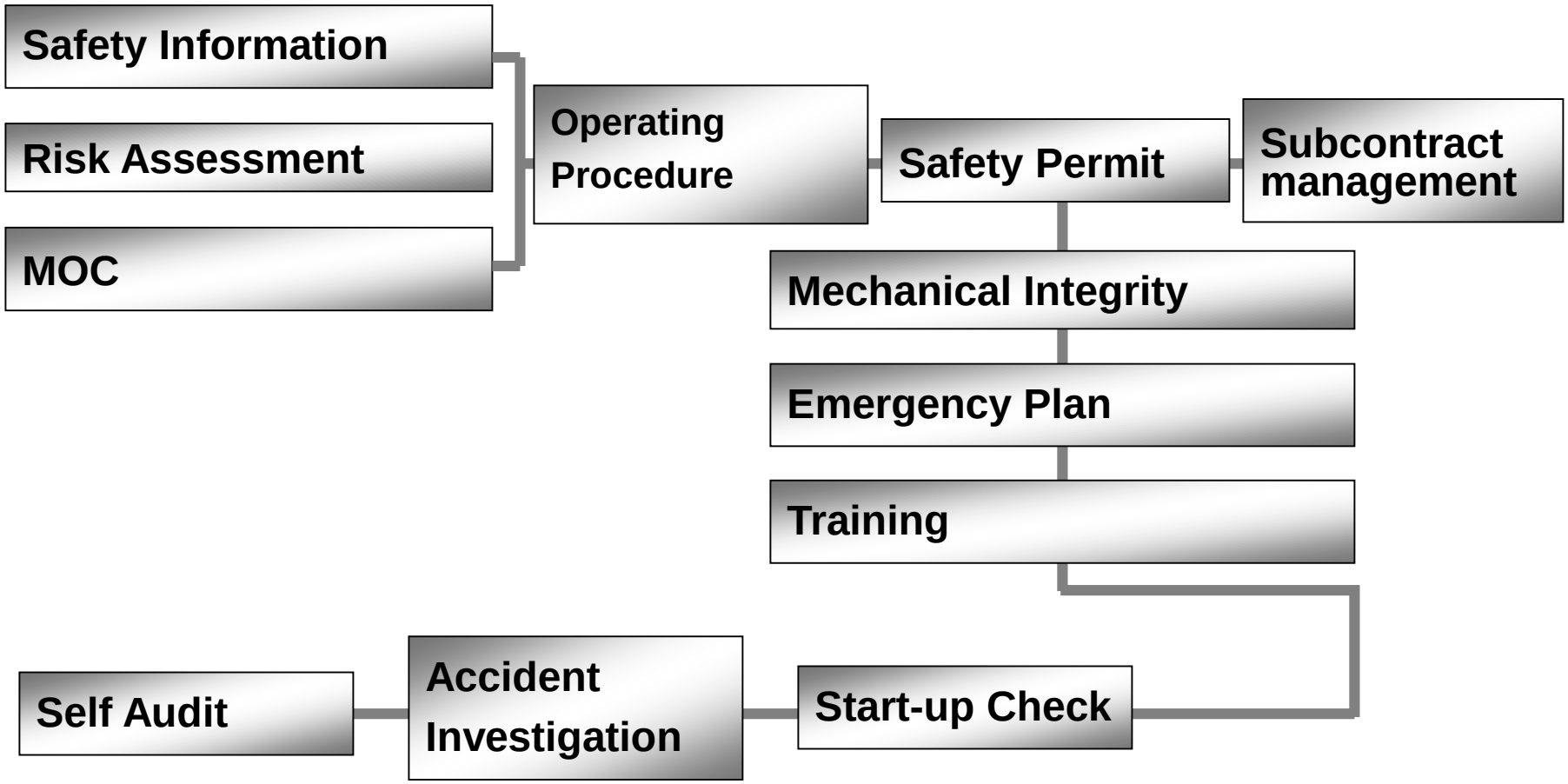
  ※ Referenced by US PSM & EU SEVESO Directive

- Effected on Jan. 1st,`96
- Assessment of Safety Report, Site confirmation, Performance based inspection
- PSM site : 1,865 Sites(2015)

Application of PSM

- **Business category**
  - Oil Refineries
  - Petrochemical Industries
  - Organic Composite Material & Synthetic resin
  - Fertilizer Industries
  - Pesticide Industries
  - Explosive Industrial
- **Installations associated with hazardous chemicals over threshold quantity (51 Materials such as Chlorine, Ammonia, etc)**
- **Nuclear, Military Installations excluded**

Process Safety Management System Elements



1. Content of PSM Report

- Process safety information

- Hazard analysis and assessment report

- Procedure and planning for safe operations for installations

- Emergency planning and response

2. Risk Assessment Report

- Purpose of process hazard analysis

- Hazard characteristics

- Potential measures of incident as a result of hazard analysis

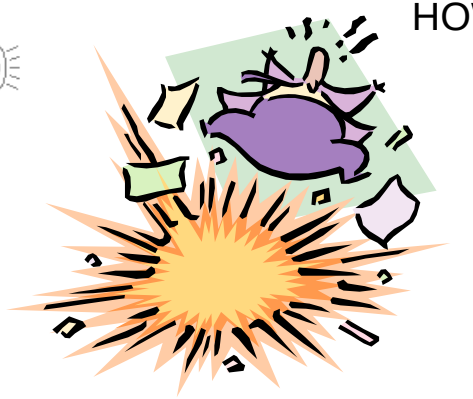
- Mitigation measures of incident as a result of hazard analysis

- Hazard analysis

Risk Concept

HOW BIG??

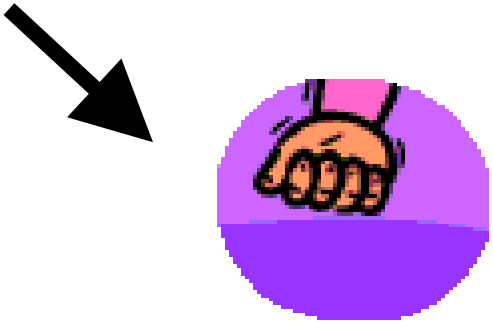
HOW OFTEN?



RISK

CONSEQUENCES

FREQUENCIES



ACCEPTABILITY CRITERIA

Risk related Works

Area	Detailed Work	Remark
Risk Identification	▪ HAZID/ENVID ▪ HAZOP ▪ FMEA	Risk Qualification
Risk Quantification	▪ Likelihood (ETA / FTA) ▪ Consequence Analysis ▪ Toxic dispersion/ Fire / Explosion	Risk Quantification
Risk Mitigation	▪ F&G ▪ Active Fire Fighting / Clean agent system ▪ Passive Fire Proofing ▪ Emergency Escape	Risk mitigation & control
Risk Management	▪ Design HSE Plan ▪ HSE Management System ▪ MOC (Management Of Change) Plan	Risk management
O&M RAM/RBI/RCM	▪ RAM (Reliability, Availability and Maintainability) ▪ RBI (Risk Based Inspection) ▪ RCM (Risk Centered Maintenance) ▪ Operation Assurance	Operation & Maintenance Risk assessment
SIL, Human & Environment	▪ Safety Integrity Level (SIL) ▪ HFE (Human Factor Engineering) ▪ EIA (Environmental Impact Analysis)	SIL, HFE, EIA

QRA Status in Chemical Industries

- **Consequence analysis**

  - ✓ ALOHA [EPA]
  - ✓ K-CARM[KOSHA]
  - ✓ KORA [EPA, Korea]
  - ✓ PHAST [DNV]
  - ✓ SuperChems [iOiQ]

  - CFD model
  - ✓ FLACS [Gexcon]
  - ✓ KFX [ComputIT]

QRA Status in Chemical Industries

- **Frequency analysis**
  - **Fault Tree Analysis[FTA], Event Tree Analysis[ETA] Software developed by KOSHA are AVAILABLE**
  - **But, Reliability database(RDB) such as OREDA[Offshore and Onshore Reliability Data], CCPS[Guidelines for Process Equipment Reliability Data], [IEEE Reliability Data] and [OGP Process Release Frequencies] are being used**

- **Making Korean RDB for Chemical Industries**

2014/2015

→ **Review of Current status regarding RDB**

→ **Gathering & Analyzing sample data and making plan of building Korean RDB**

2016

→ **Gathering Reliability Data for machineries and instruments**

→ **Design RDB algorithm**

2018

→ **Making prototype of Korean RDB**

3. Safety Procedure

- Procedure and manual for safe operation

- Procedure and specification for mechanical integrity

- Procedure for hot work permit

- Safety control procedure for contractor’s work

- Education and training plan

- Procedure for management of change

- Procedure for pre-startup

- Audit procedure

4. Emergency Procedure

- Resources(manpower, equipment. Etc) for emergency response
- Emergency communication system
- Emergency procedure and the role of each organization
- Education and training plan for emergency response
- Public relations for emergency planning and response
- Others related to emergency planning

Performance Based Inspection

Performance Based Inspection

- Preparation of grade classification and management standard for the spontaneous PSM implementation
- Self implementation for Good Company, concentrated check and control for Bad Company

Need for the Performance Based Inspection

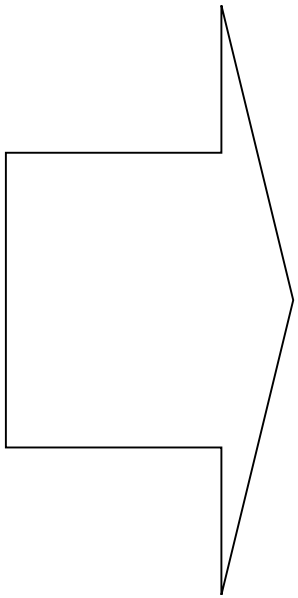
- 1995, 1 PSM Implementation
- PSM activity weakened due to deregulation, Major industrial accident increased
- Needs for the Performance based Inspection
- Manpower limited to manage whole PSM sites in a same way
- Self regulating qualification to Good Performance company

Classification of PSM Performance

P
(Progressive)

S
(Stagnant)

M^+ , M^-
(Mismanagement)



Different company
Management through
The Classification

Classification Criteria of the PSM enterprise

P (Progressive)	: Performance record over 90%
S (Stagnant)	: Performance record between 80% and 90%
M^+ , M^- (Mismanagement)	: Performance record less than 80%

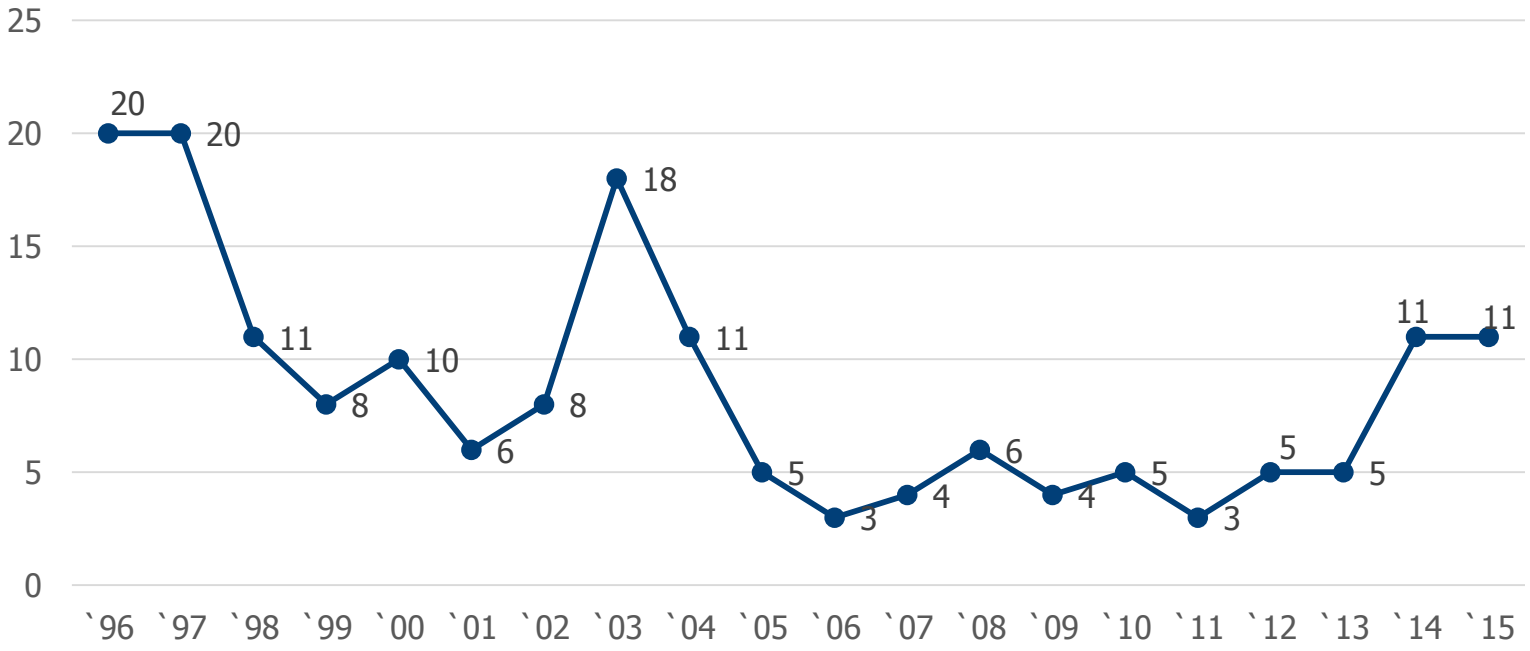
Performance Based Inspection Criteria

P (Progressive)	: PSM Self implementation
S (Stagnant)	: Check of PSM implementation status, more than once than per year
M^+ , M^- (Mismanagement)	: Check of PSM implementation, more than twice per year Technical advice for the checked item, PSM training every 6 months

Accident Trend

- **Accident Trend: 5ea('12)→5ea('13) → 11ea('14) → 11ea('15ea)**

※ In 2014, Chemicals regulated by PSM was expanded and Definition of major accident also widen.



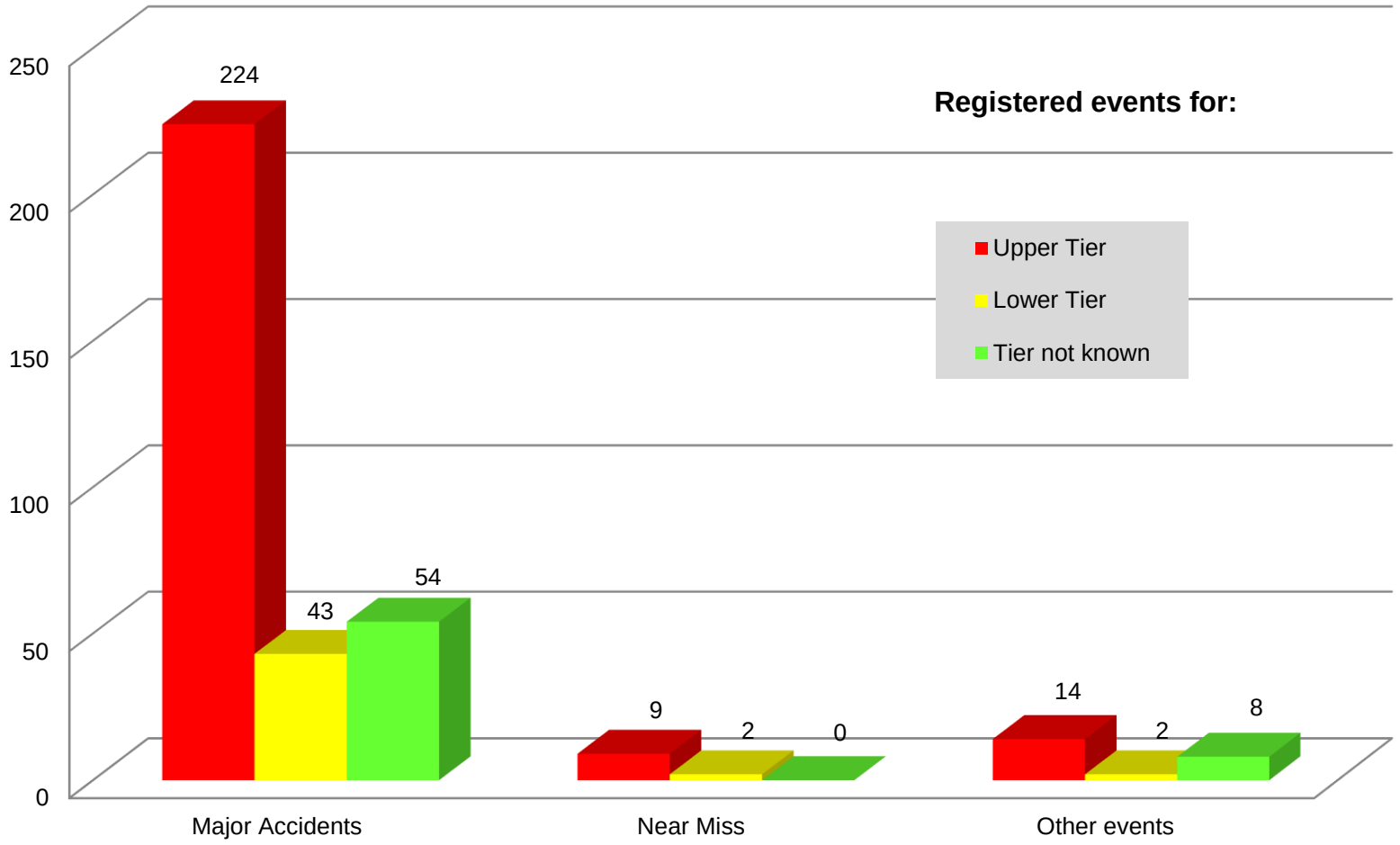
* Source : MOEL

PSM Effectiveness

- **Fatality , Injury , Near Miss Decreased**
- **Decrease of Emergency Shut Down**
- **Quality & Productivity Improved**
  - P&ID, HAZOP, Operating Procedure
  - Product Quality : 96.3%, Productivity : 98.2%

Process Safety Leadership

Total number eMARS reported events in the 27 eu countries (2000-2011)



Interview with TOTAL VP

"함께하는 공정사회! 더 큰 희망 대한민국"

안전보건공단

보 도 자 료

"조심조심 코리아 – 위험을 보는 것이 안전의 시작입니다"

▸ 배포일시:

▸ 총 3쪽

▶ 담 당 : 산업안전보건연구원 정책제도연구팀 안상헌 과장
- TEL : 052 - 7030 - 838

※ 참조 : 안전문화홍보실 배준호 과장
- TEL : 052 - 7030 - 722

"안전은 무엇보다 우선, Accidents zero를 위하여!"

구미 불산사고 2주기, 산업안전보건연구원장의 TOTAL社 인터뷰

○ 권혁면 산업안전보건연구원장은 '휴브글로벌 불산 누출사고 2주기 포럼'에서 안전분야 리더 기업인 TOTAL社의 안전부사장(Pol HOORELBEKE)을 상대로 구미 불산사고와 같은 사고의 재발방지 방향에 대한 인터뷰를 진행하였다.

○ '휴브글로벌 불산 누출사고 2주기 안전보건 포럼은 지난 9월 27일(목) (사)한국위험물학회가 연세대학교에서 휴브글로벌 불산 누출사고 2주기를 맞이하여 다국적기업인 TOTAL사의 불산 취급 기술을 공유하기 위해 3명의 TOTAL사 전문가를 초청 개최한 포럼이다.

○ 다음 내용은 휴브글로벌 불산사고 2주기 포럼에서 한국위험물학회 부회장인 권혁면 연구원장이 인터뷰한 1문 1답이다.(Q 권혁면 원장, A: Pol HOORELBEKE)

- Q. 불산사고 2주기 포럼에 참석하게 된 동기는?

A. TOTAL사는 대산에 있는 삼성토탈의 주주중 하나이다. 난 약 10년 동안 이 공장을 안전한 작업장으로 만들기 위해 한국인 동료들과 함께 일해왔다. 10년 동안의 산업 안전분야의 경험과 지식을 한국의 동료들과 함께 공유하고자 한다. 토탈사는 안전 운전 분야에서 리더이고 우리의 경험을 주고받는 것이 우리가 우리의 산업을 안전하게 만들고 유지하는데 공헌하는 부분이기 때문이다.

[Interview with TOTAL VP]

Hube Global HF Accident
2nd Memorial Forum

Zero Risk? Zero Accident!

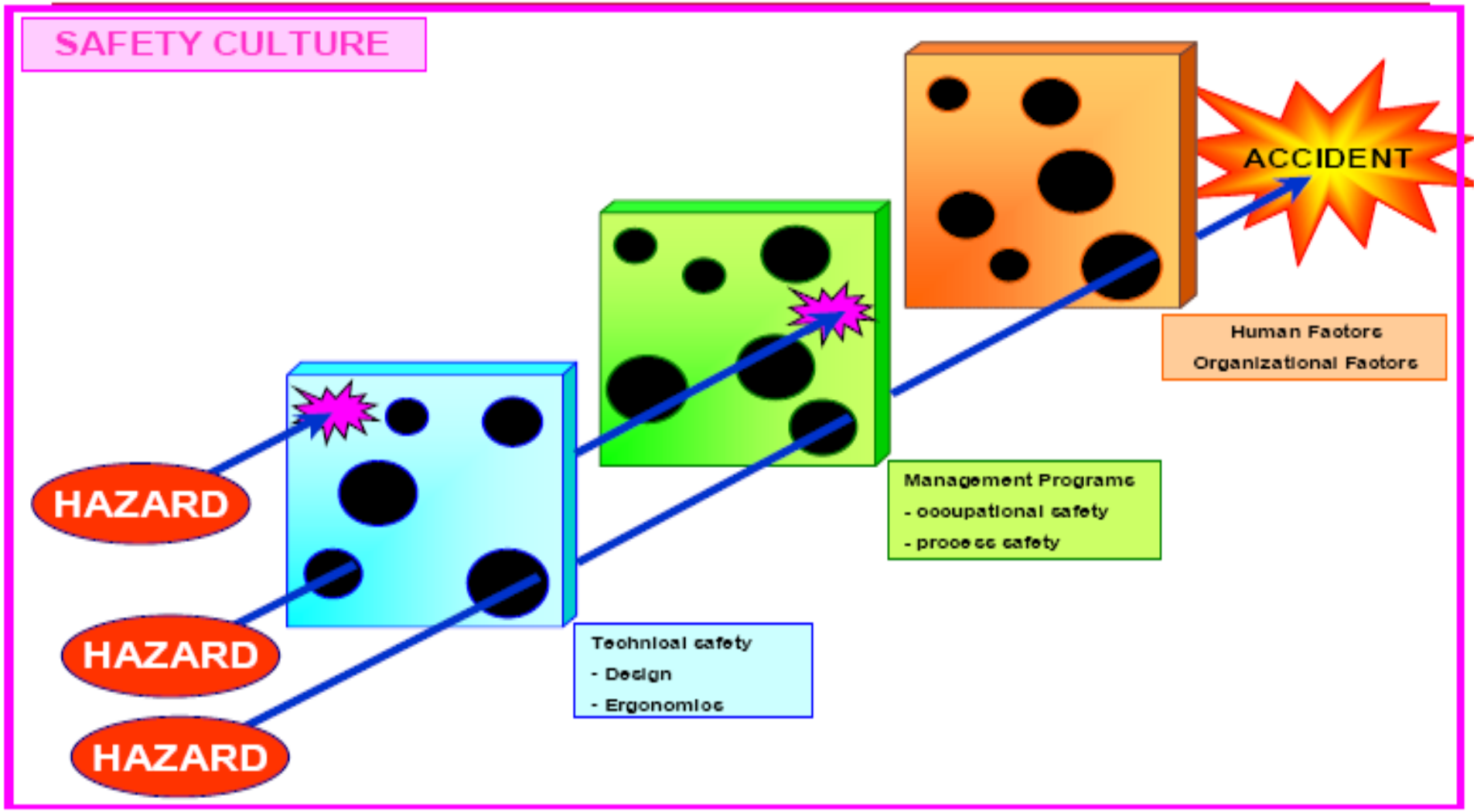
- Interview with TOTAL Vice President(HF Accident)

  - In terms of accident prevention there is no Magic Solution

- HAZARD always exist every where.

  - Our goal is how to manage hazards well not to be activated to the Accidents.

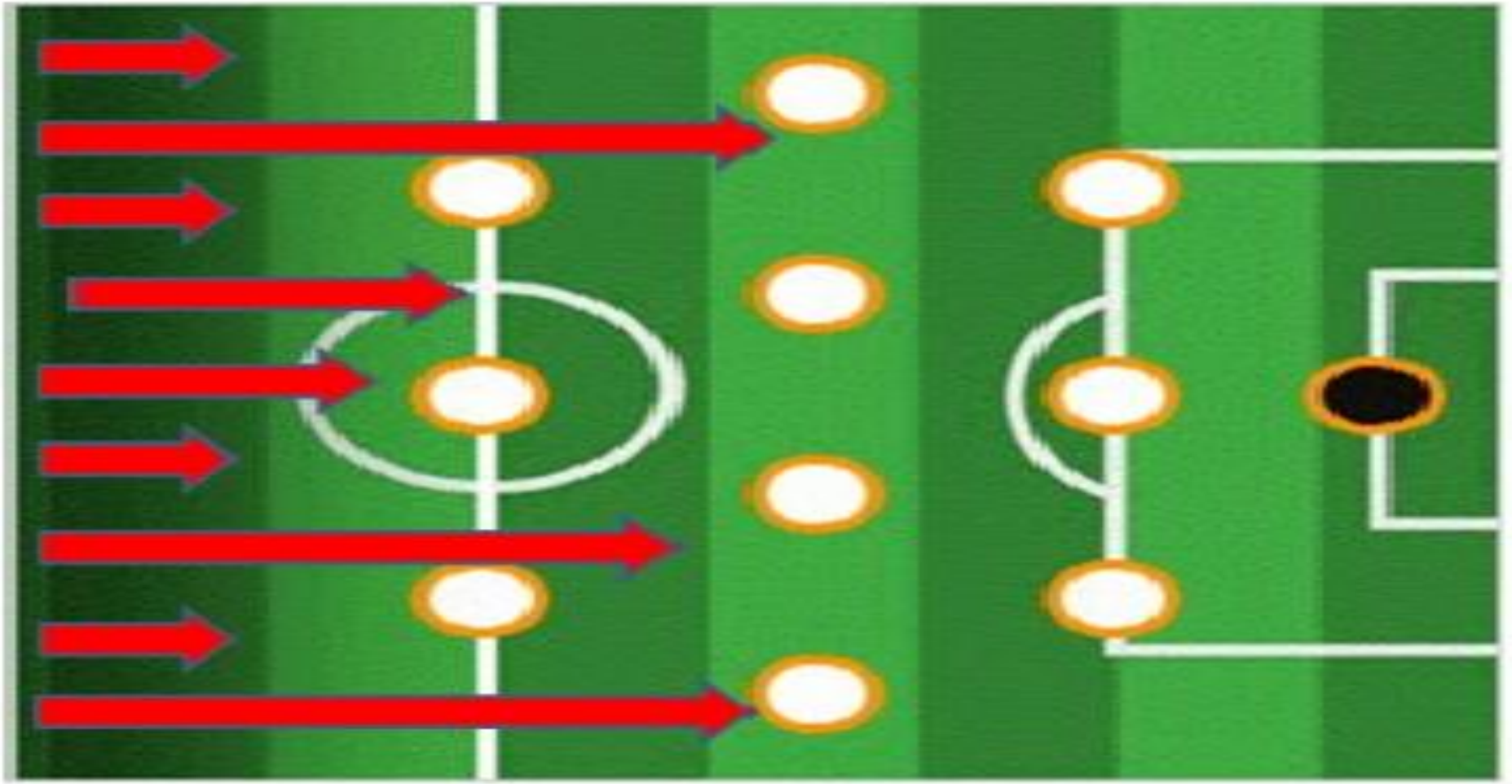
Protection of Layers



Soccer game vs Accident prevention

YONSEI UNIVERSITY

축구 경기의 수비와 안전사고 예방활동의 공통점?

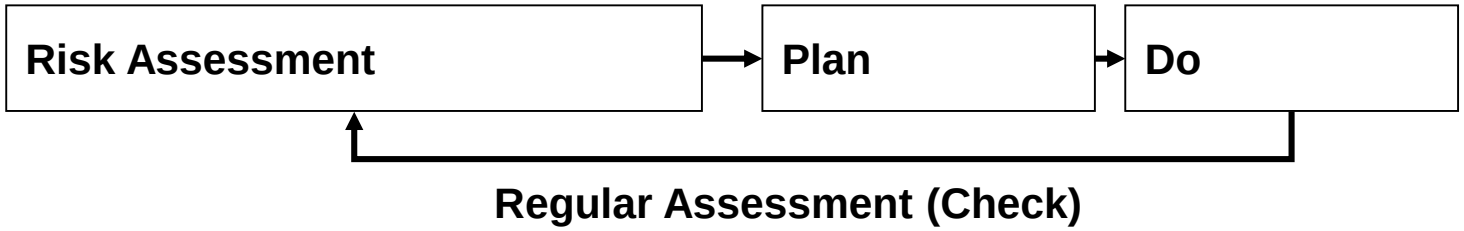


Goal and Accident

- **Soccer game**
  - 500 times offensive pass each team per game
  - 20~30 valid pass to the goal post
  - 1~2 goal made
- **Accident prevention**
  - Heinrich law 1: 29: 300

Solution

- **Various Risks**
  - Fire, explosion, release, constriction, overturn, fall, collision, fall of objects, electric shock
- **Numerous Work Procedures**
  - Operation procedure
  - Maintenance procedure, etc.
- **Voluntary Safety and Health Management System**



How to keep working safe?

- ☐ 표준작업절차서(SOP): 작업단계별 진행 절차 위주, 일부의 위험성 포함
- ☐ 작업안전분석(JSA): 작업 수행 전에 실시, 작업 단계별 위험성파악/대책 수립
- ☐ 안전작업허가서(SWP): 작업을 수행해도 좋다는 개념, 작업 자체의 수행방법의 적합성을 일부만 다룸
- ☐ 작업전 안전대화(Safety talk): 작업 직전에 JSA 결과(시트)를 사용하여 대화, 작업 장소 및 도구, 방법 등의 내용을 포함함.
- ☐ 행동기반안전(BBS): 작업자의 행동을 관찰하여 피드백하는 프로그램 (안전한 행동은 칭찬, 불안전한 행동은 긍정적인 대화기술로 개선 유도)
- ☐ 현장순찰/감독: 일반적으로 사업장에서 적용하는 일반적인 방법

How to keep working safe?

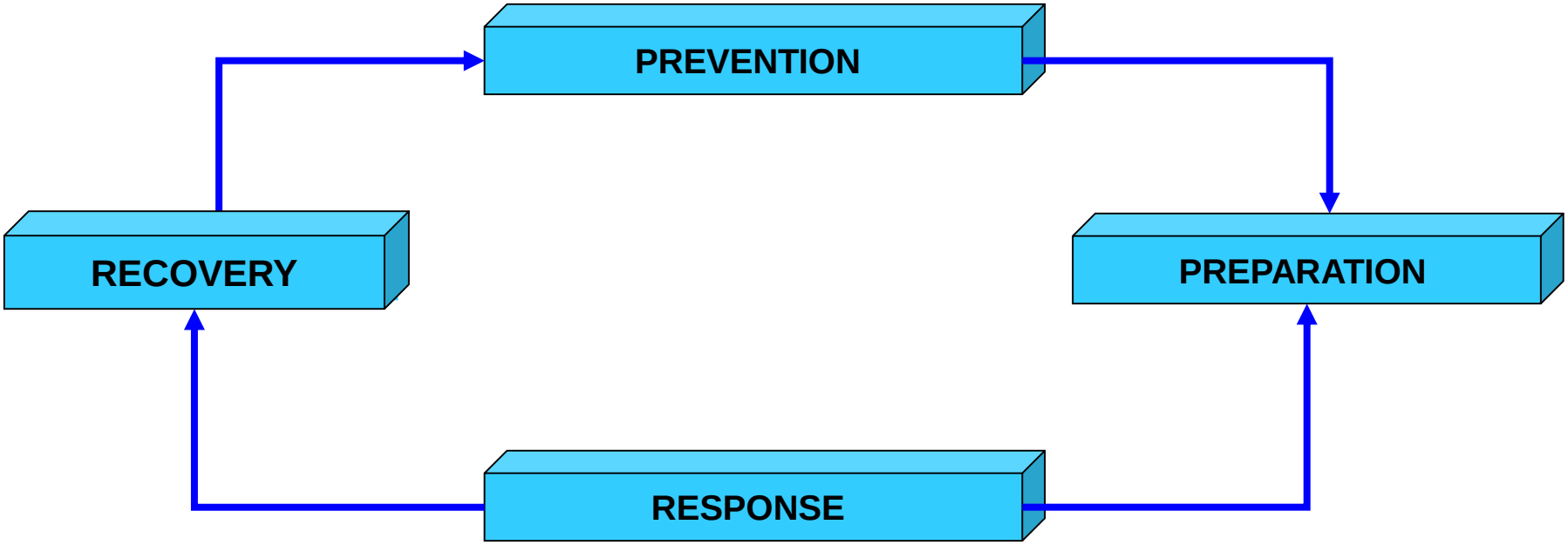
- **HSE, UK:**
  - Level of OSH is determined by the CEO regardless of company size
  - High level of OSH cannot be achieved without active participation of Management group.
  - Walk & Talk

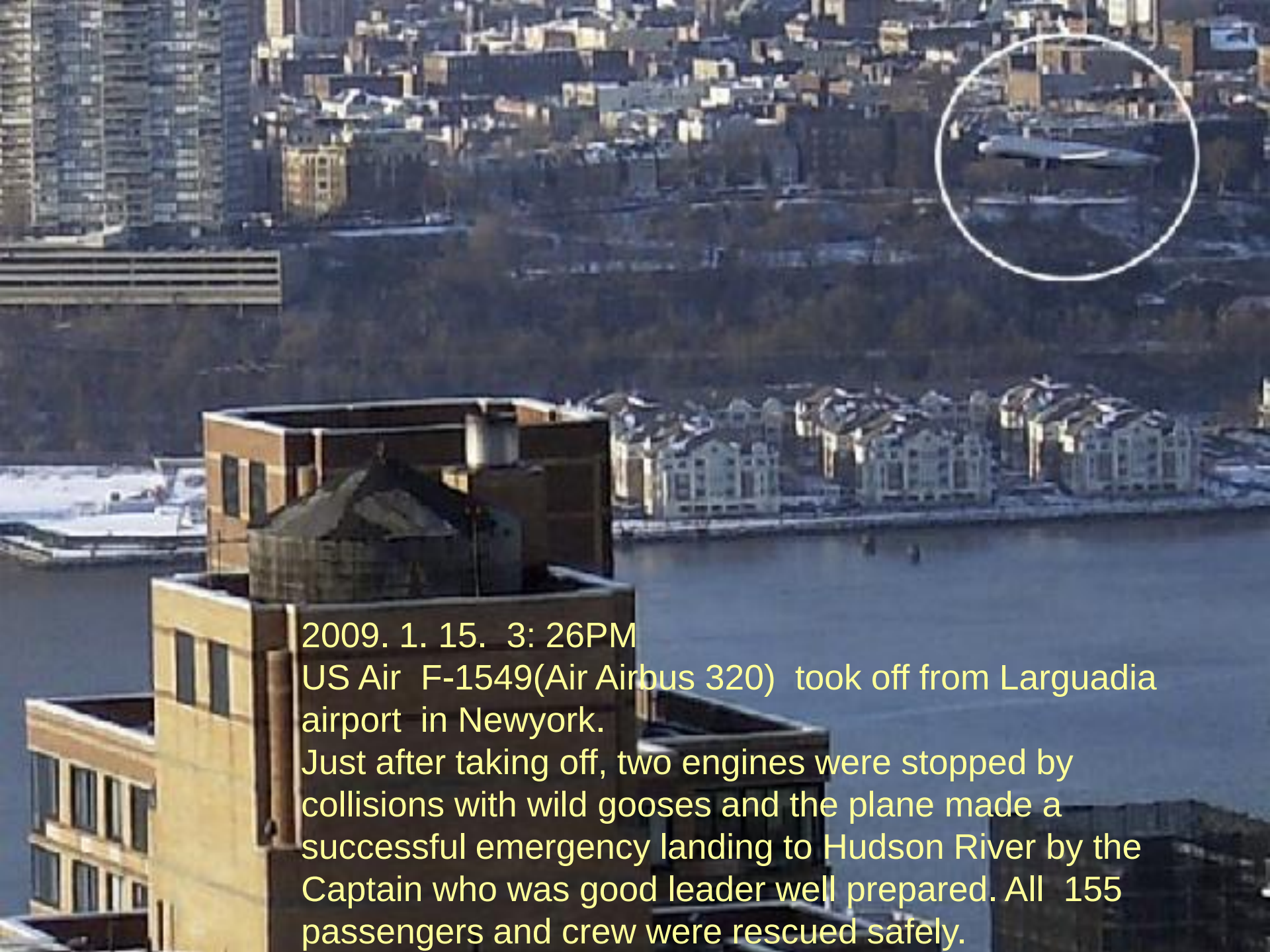
- **Ministry of Welfare and Labor, Japan:**
  - When they check the company of high accident rate, it is found that CEO is not leading OSH issues
  - CEO does not understand the resources such as people, experience and budgets, and etc.

Process Safety Leadership Group

Emergency Management

4Phases of Emergency Managements

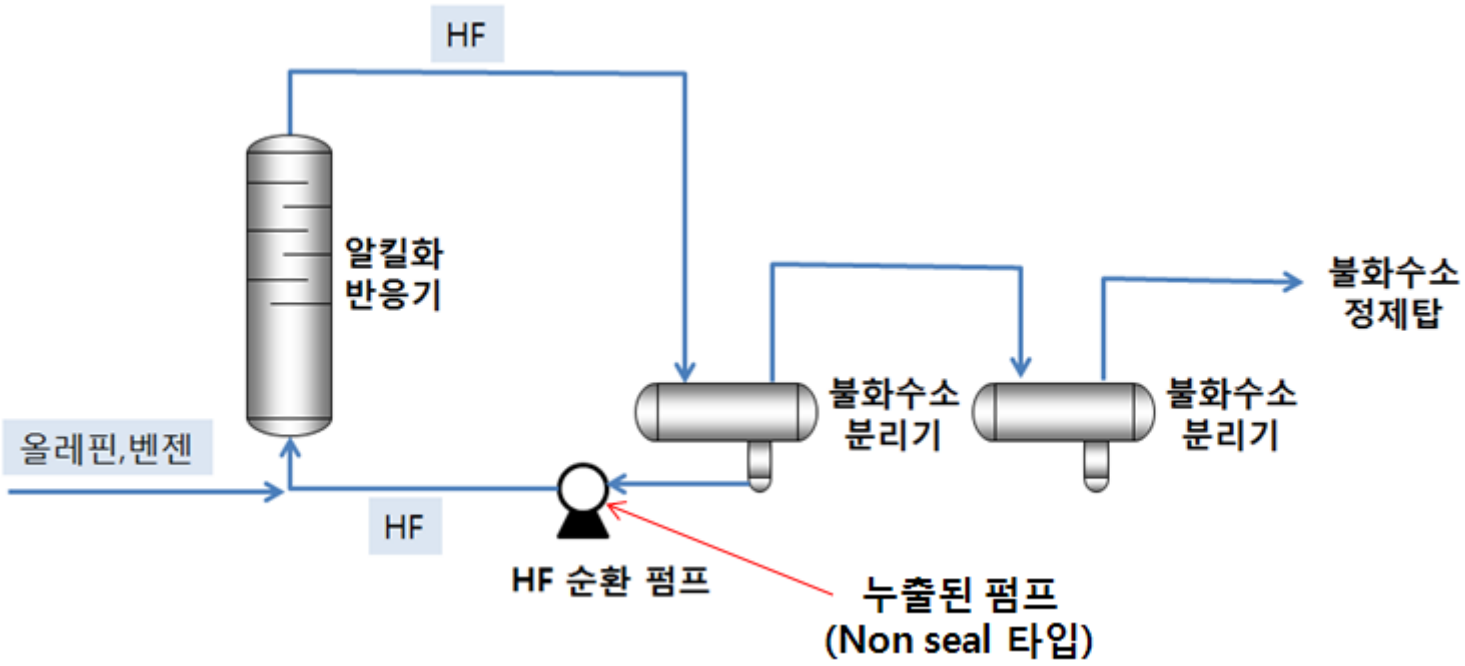




2009. 1. 15. 3: 26PM
US Air F-1549(Air Airbus 320) took off from Larguadia airport in Newyork.
Just after taking off, two engines were stopped by collisions with wild gooses and the plane made a successful emergency landing to Hudson River by the Captain who was good leader well prepared. All 155 passengers and crew were rescued safely.


여객기 A320의 이륙에서 허드슨강 불시착까지의 과정
0
5Km
뉴 저 지
티터보로 공항
관제소에서
안내한 비상항로
허드슨강
3:28 pm
Emergency Landing
Request
3:27 pm
Bird Strike
3:40 pm
Landing safely to the
river
브롱크스
센트럴파크
맨해튼
이스트강
퀸스
뉴 욕
러과디아
공항
브루클린
3:26 pm
Take-off
사고기
구조선
비행기 날개 위에서
구조를 기다리는
승객들
허드슨강
비상 탈출구
미국
뉴욕시

HF Release


HF
알킬화
반응기
올레핀,벤젠
HF
HF 순환 펌프
불화수소
분리기
불화수소
분리기
불화수소
정제탑
누출된 펌프
(Non seal 타입)

Emergency Response

◆ 내용

- 1. 일시 : 2014년 2월 25일 14시 28분경

◆ 2. 장소 : 이수화학(주) 울산공장 No.1 연성알킬벤젠공정

3. 사고설비 및 내용

펌프 (HF Circulation) 내부 부품 파손에 의한 HF+PF(Total 100L, 각50L)

4. 대처사항

1) 누출로 비상대응조직 출동시킴 @ 14:28

2) 소화전 방수하여 Water 중화시킴 @ 14:30

3) 운전원 전신가압복 착용후 펌프 Suction & Discharge V/V 차단 @ 14:33

4) 이동식 스크러버 설치하여 HF Vapor 중화처리함 @ 14:35

5) 공정 Down @ 14:35

6) 펌프 Leak 부위 상황 종료 @ 14:48

7) 인근사 비상연락 통보(TO 한주)

5. 피해상황 : 없음

신속한 대응으로 확산 방지 조치

Portable (Transferable) Scrubber

Conclusion

- **Prevention of chemical accidents**
  - PSM system is VERY Good Tool
  - But, it must works 24 hrs with voluntary management system
  - Regulatory approach is not sufficient to cope with diverse and varied hazards
- **Emergency management**
  - Prepare a good emergency management plan
  - Make the plan workable through repeated drills and exercises

  * Successful emergency management case of Flight 1549 & HF Release
- **Who can make their company safe?**
  - CEO's effective/substantive leadership on PPRR is deciding the destiny of their company

Anna Karenina

세계문학전집 219

안나 카레니나 1

Анна Каренина

레프 톨스토이 연진희 옮김

민음사

Anna Karenina Rule in the Safety

세바시: 세상을 바꾸는 시간 15분 강연

YONSEI UNIVERSITY

Thank You

Contact

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