Management of Risk

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by:-

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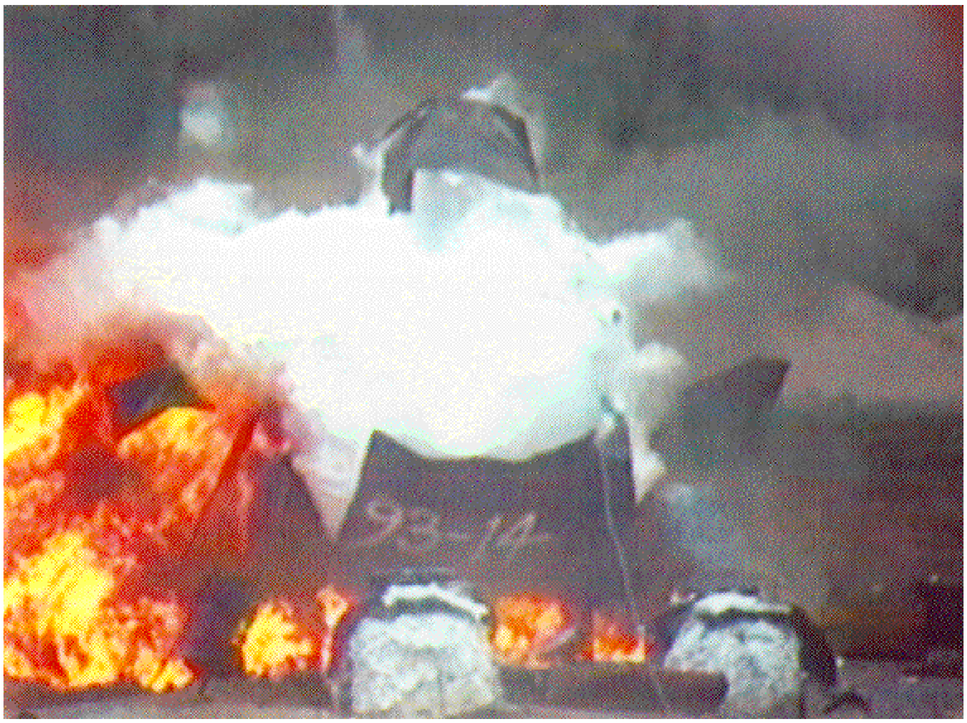
1. Consequences of Risk

An optimist could always consider that Risk Management is having an up-to-date all-risks insurance policy. But is good Risk Management more than assigning all perceived risk to your insurers? Before answering this question here is some food for thought:-

Feysin Refinery in France in 1966

However, as a result of a Propane leak there was a BLEVE – **B**oiling **L**iquid **E**xpanding **V**apour **E**xplosion which caused overall damage to the refinery estimated at US$ 87 million (indexed to 1997).

Feysin Refinery, Propane storage sphere after:-



Prior to the 6th July 1988 Piper Alpha was an Occidental oil production platform successfully operating in the British sector of the North Sea, as in the photograph below:-

However after a serious fire the platform was a total loss – an event insurers thought would never happen with a PD loss of US$ 1,860 million & BI loss of US$ 8,850 million (both 1997 basis). In both Feysin and Piper Alpha together with other major catastrophes worldwide such as Flixborough Cyclohexane VCE in the UK (1974) resulting in a loss of US$ 636 million (1997 basis), the Philips Pasadena Iso-butane explosion in the USA (1989) with a combined PD & BI loss of some US$ million (1995 basis).

The physical consequences of the Piper Alpha fire and Flixborough VCE are shown in the photographs below:-


FILXBOROUGH, 01.06.1974,
UK


FLIXBOROUGH, 01.06.1974
Section 25A
R 2525
Hydrogen plant

What this presentation seeks to illustrate is that the consequences of risk cannot always be managed or predicted and certainly cannot always be completely covered for by the insurers. Management of Risk is a corporate responsibility.

2. **Risk Assessment & Management**

Hazard Identification is an important part of any site risk assessment and management. Risk has two components – *Consequence* & *Frequency* and the "Risk Profile" is the distribution of total risk across a business with Risk Management the process for using all of the above for risk control.

3. Quantification of Risk

> *"When you can measure what you are speaking about and express it in numbers, you know something about it."*
>
> Lord Kelvin

> *"Errors using inadequate data are much less than those using no data at all."*
>
> Charles Babbage

Frequency is inherently a numerical measure with units of rate/unit time. *Consequences* can be of differing kinds but have to be measured and prioritised, usually numerically as money.

Conventionally, *Risk* is normally expressed as the mathematical multiple of consequences and frequency:-

$$\mathbf{R = f \times c}$$

4. Risk Ranking

Frequency - In ranking, or assessing, relative risk the frequency is often *qualitatively* and *quantitatively* defined as in the following table:-

Severity Category	Qualitative Definition	Quantitative Definition (Occurrences per annum)
A	Likely to occur in the next year.	1
B	Possible but not likely in next year.	0.01
C	Unlikely in next year.	0.001
D	Very unlikely to occur in the next year.	0.0001
E	Remote possibility of occurring in the next year.	0.00001

Note that the ***quantitative*** risk frequency is decreasing by a factor of 100 between A to B and 10 between B to C, C to D and D to E whereas the ***qualitative*** definition is vague or open to interpretation.

Consequence – Obviously, consequence can be vary from company-to-company, country-to-country, culture-to-culture. A US$ 50 million loss may be “acceptable“ to a large multinational oil company but even a minor severity incident could easily bankrupt a small single-site company. The table below lists conventional ***qualitative*** and ***quantitative*** definitions used within industry.

Severity Category	Qualitative Definition	Quantitative Definition	
		Injury	***Cost***
1	Catastrophic	Multiple fatalities	$ 50 M
2	Major	Single fatality, multiple injuries	$ 5 M
3	Very Serious	Permanent Injury	$ 500 K
4	Serious	Serious injury, full recovery	$ 50 K
5	Minor	LTA, short absence from work	$ 5 K

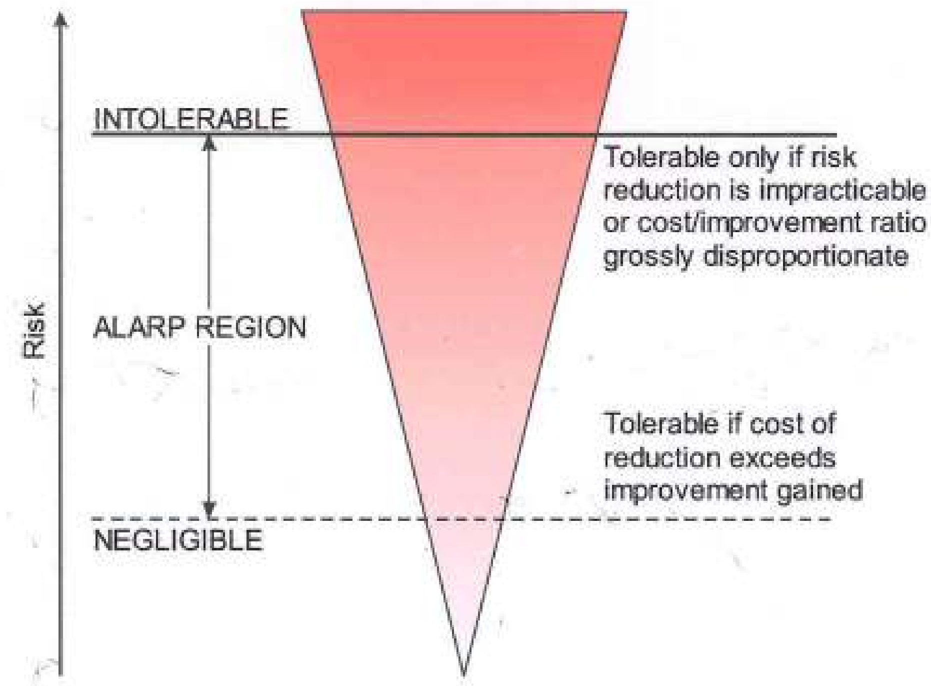
Inflation obviously would affect the quantitative $ amounts which should be regularly revised upwards. Although fatalities are always regrettable, the consequence of physical plant damage may be greater to a company or corporation than injuries and fatalities. However, in countries with highly "developed" legal systems lawsuits initiated by bereaved relatives could result in significant monetary damage awards. Contrast this with the relatively minor payments made to the victims (over 2,000 fatalities) of the Bhopal incident in India in 1984 following the release of Methyl Isocyanate to the atmosphere. Also Chernobyl in 1986 where fewer than 100 were killed by radiation but tens of thousands affected by stress, worsening a range of diseases ranging from high blood pressure, heart disease, stomach disorders, depression together with ongoing annual incidence of childhood thyroid cancer, many in Belarus and the Russian Federation.

The above highlights that "consequences" can be extremely diverse and often never even contemplated or understood when process plants are designed and located and can affect more than the physical assets or the bottom line! This is the value of good physical data and initial hazard assessment and good on-going corporate and local risk management.

5. "Acceptable" Risk

Many West European countries and companies have developed the concept of, so-called, acceptable, or tolerable, risk for a specific production process or facility. This has been defined as **ALARP** or **A**s **L**ow **A**s **R**easonably **P**ossible or **P**ractical.

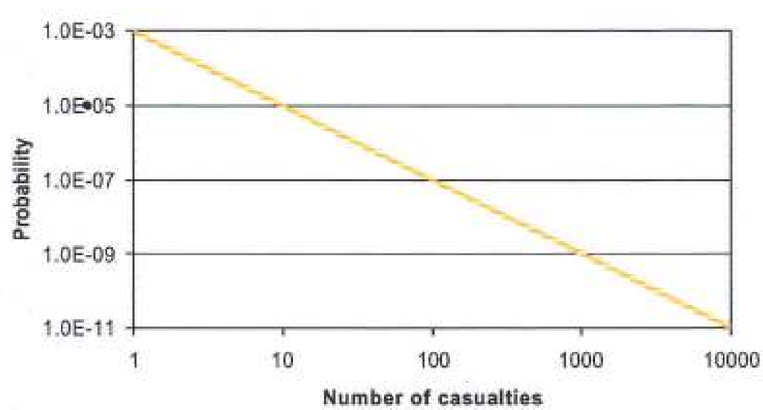
The ALARP principle is shown diagrammatically below, sometimes called the "risk carrot".



Probability of a Fatal Accident - ALARP Risk Level

The maximum "acceptable" or "tolerable" risk level has been defined using two probabilities:-

- ***Individual Risk*** – the probability of a fatal accident equivalent to 10^{-6} [/year];
- ***Societal Risk*** – probability of ≥ N casualties = $10^{-3}/N^2$. This is clarified in the graph below:-



For comparison of probabilities, some activities are listed in the table below, along with their associated annual likelihood of earlier fatality than would be the case if these activities were not carried out. It should be noted that these are only order of magnitude of figures and would vary slightly from country to country and location to location.

Annual Likelihood	**Activity**
10^{-4} to 10^{-3}	All accidents
10^{-4} to 10^{-3}	Traffic accidents
10^{-5} to 10^{-4}	***Industrial Work***
10^{-5}	Drowning
10^{-5}	Air Travel
10^{-5}	Drinking 5 litres of wine
10^{-6}	Smoking 3 cigarettes
10^{-6} to 10^{-5}	Natural Disasters
$<10^{-7}$	Lightning, hurricanes

6. Risk Reduction

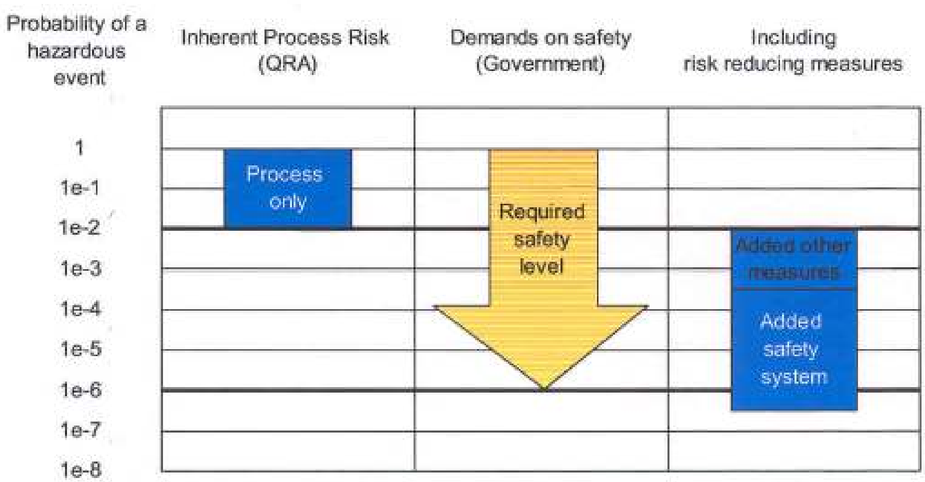
The inherent risk associated with operating an oil refinery or process units is often higher than the “acceptable” risk level, for example the Hydrofluoric Acid catalysed Alkylation of Butenes. Minimum levels of risk reduction will usually be then required to meet government or European Economic Community regulatory requirements. This can often be satisfactorily achieved by having a site “safety system” in place. This usually will usually have to include specific measures such as:-

- Site Evacuation Plans and Emergency Procedures;
- Mechanical safety devices such as relief valves and machinery trip systems;
- Comprehensive and on-going staff job and safety training;
- Free supply and use of personal protective clothing and equipment;
- Written Permit-to-Work system;
- Defined safe separation distances between process plant, fired heaters and LPG storage;
- Site fire brigade;
- Monitoring and recording of accidents and incidents;

- VHF Radio and other communication systems;
- Tank bunds etc.

Risk Reduction Requirements

There can be a number of requirements on a particular site to reduce the probability of a hazardous event or dangerous occurrence, as illustrated in the figure below:-

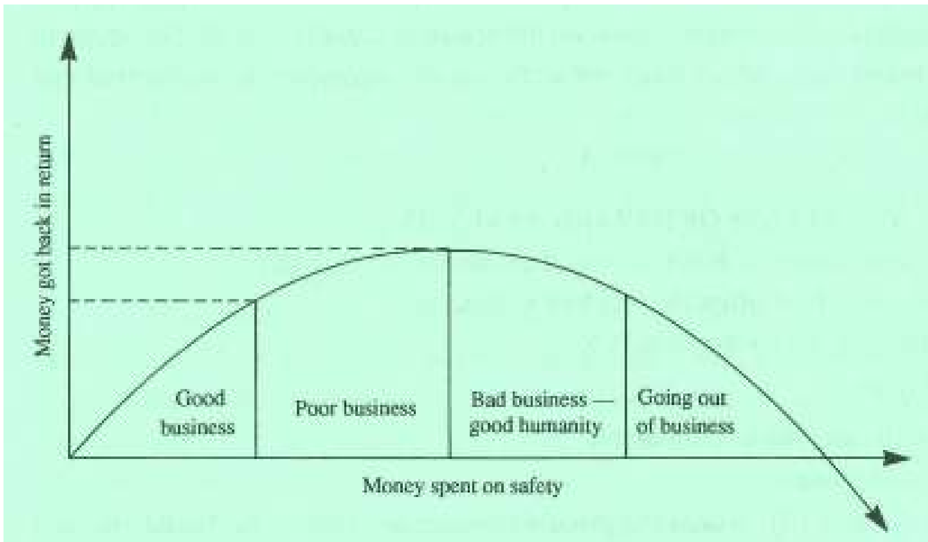


In the real world, there can be many reasons for risk reduction and management, sometimes not related to the "actual" risk but the "perceived" risk as a result of political or media pressure, previous incidents etc. The normal reasons for risk reduction and risk management are:-

- **To satisfy** – the local community, laws & regulations;
- **To protect** - people, environment & investment (equipment);
- **To lower** - plant risk profile (insurance premiums), protect the Corporate or Company image.

Although good levels of safety and risk management inevitably requires on-going financial expenditure and resources, there is a break-even point above which increasing expenditure on risk reduction may not actually produce any reduction in LTAs or losses. Companies still have to make a profit at the end of the day and unstructured or ill-defined risk management and nonconsideration of costs versus benefits could result in negative effects as shown diagrammatically below.

Whatever money is made available for safety should be spent in such a way that it produces the maximum benefit.



Risk Reduction Principles

Based on the conventional **R = f x c** formula, risk reduction measures are based on two principles:-

1. Reduction of the *consequences* of harmful events;

2. Reduction of the *probability* of harmful events.

An Example of Balancing Probabilities and Consequences

The risk of injury or damage depends on the size and probability of a hazardous chemical leak. Is it more effective to reduce the size of the leak or reduce the probability? Hazard analysis may help to answer this question.

If the inventory in a refinery process plant or storage area is reduced the maximum size of a leak will be less and so the consequences will be less but the probability of a leak will not be changed. Reducing the number of leak points such as valves, drains, pumps, etc, may be more effective than reducing the inventory in the existing equipment. If, however, it is possible to take a vessel out of service then there will be fewer places from which leaks can occur and both the probability and maximum size of a leak will be lower.

Risk Reduction Approach

The following approach to risk reduction is used in practice to apply available measures (in order of preference):-

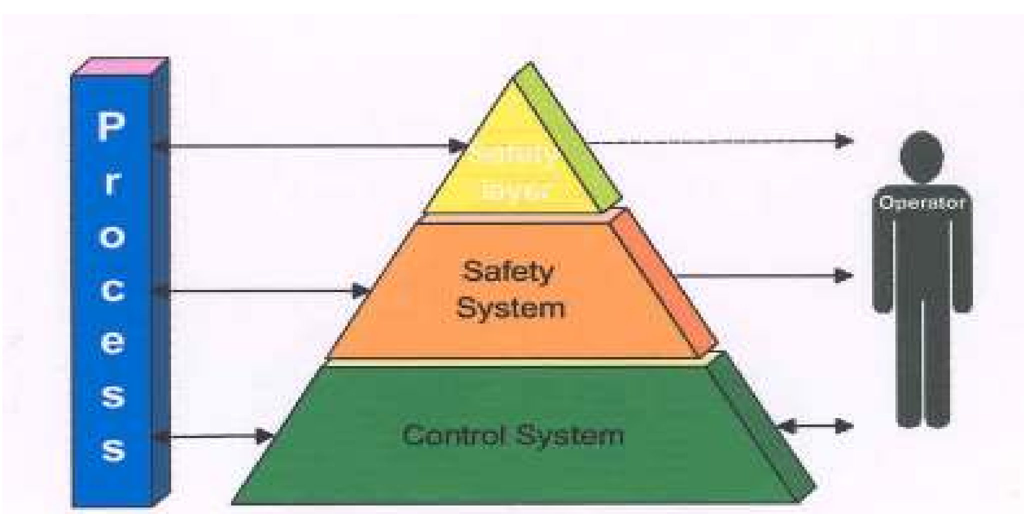
1. Use an inherently safe process if available;

2. Use mechanical safety devices (i.e. rupture disks & trip systems);

3. Use safety systems (to reduce frequency of demands on mechanical safety devices);

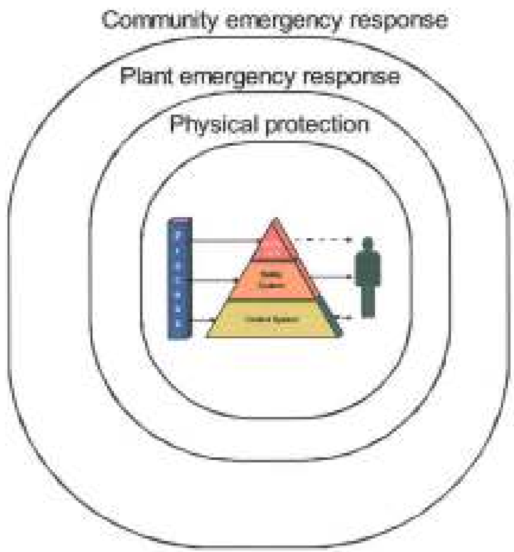
Process Industry Safety Layers

Conventionally for any particular process plant or integrated oil refinery there are the three "technical" safety layers as shown diagrammatically below:-



Theoretically, even if the operator or control system does not function as intended theoretically the two safety layers over-riding the control system should ensure that plant integrity is maintained and no unplanned loss of containment is experienced.

All risk reduction measures together form the so-called "layers of protection" concept, like the rings of an onion, as follows:-



7. Identifying the Hazards & Managing the Risk

An effective management system should be in place to systematically identify, assess & control potential risks that may arise from site activities and materials in use.

This system should be applied to all existing and new activities and facilities and should include potential impacts on people, assets, environment, business interruption and the Company/Corporate reputation.

This should cover full life cycle of a facility from inception, design, construction and commissioning to termination, including decommissioning and abandonment.

Risk Management - Performance Objectives

- Corporate risk acceptance criteria is established and Risk Management policy agreed;
- Hazard identification & risk management procedures are documented, communicated and understood;
- The hazard identification & risk assessment programme is developed and agreed and programme is implemented;
- The program is monitored and reviewed to ensure its effectiveness;
- Identified risk reduction measures are implemented;
- Employees are trained in hazard identification and risk assessment;
- Organisation system identifying responsibilities for undertaking and reviewing hazard identification and risk assessment is in place;
- Responsibilities for decision making and implementation of recommended risk reduction measures is identified and agreed;
- A follow-up system is established and implemented.

The above Performance Objectives are achieved by:-

- Developing hazard identification and risk assessment programme. This will cover projected facilities and existing facilities and activities;
- Identifying and agreeing priorities;
- Implementing the programme in the allocated timeframes;
- Allocating resources (manpower & funds) for programme development, implementation monitoring & review;

- Developing and agreeing a system for implementation of risk reduction recommendations and follow-up;

- Developing and maintaining procedures for hazard identification & risk evaluation;

- Verifying emergency response and evacuation management against the identified potential hazards and validating the site emergency response plan against the calculate risks;

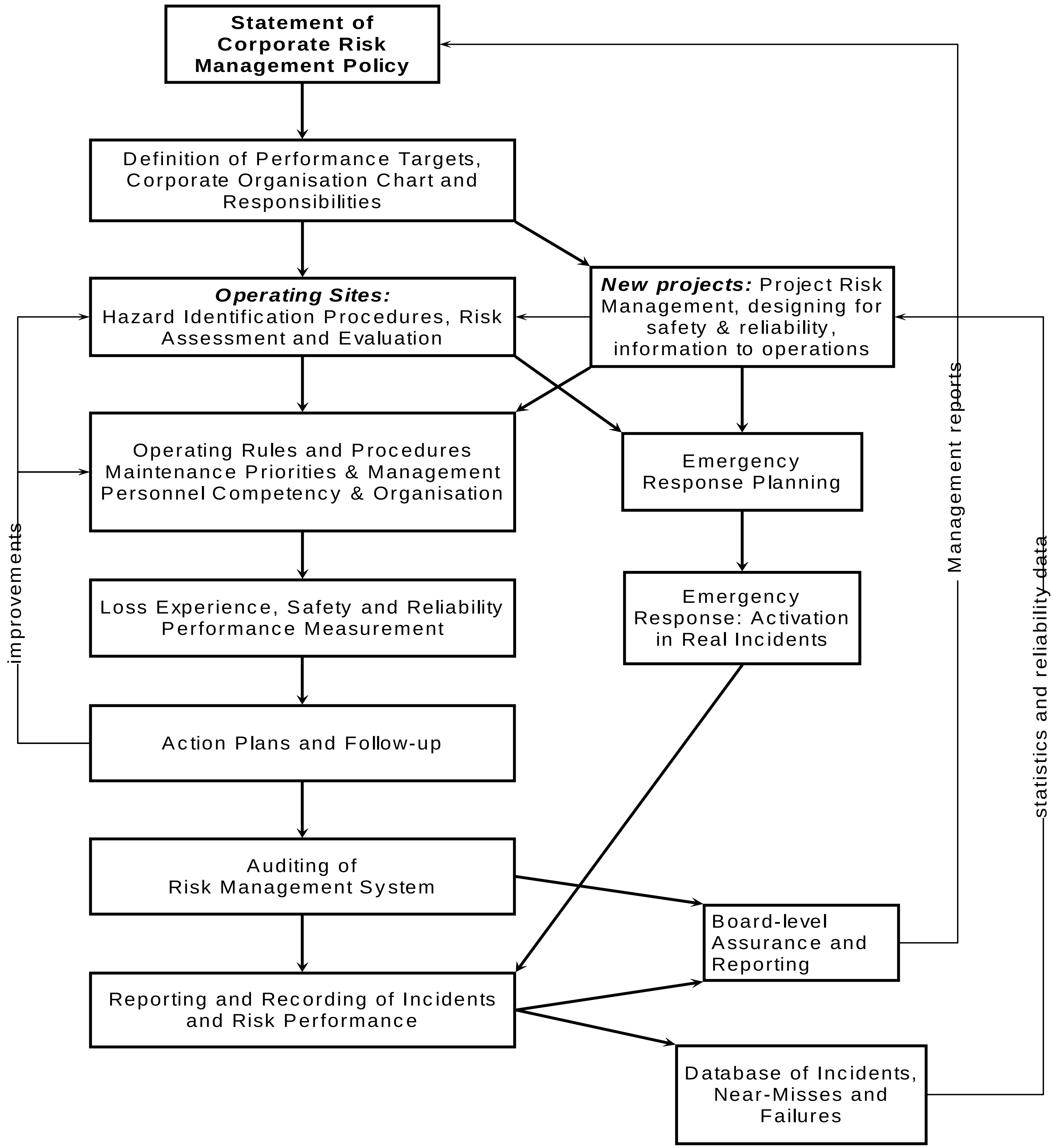
- Developing and maintaining management procedures, dealing with risks that remain after implementation of risk reduction measures.

8. Risk Management Systems

Throughout the world there are a many types and variations of effective Risk or Safety Management systems – some are called HSE Management Systems others Safety & Loss Control Systems. Some are sold commercially like the American International Loss Control Institute’s “Total Loss Control” system and are then tailored in scope, extent and content to meet specific national and cultural requirements.

Many are Corporate or company-wide systems, others covering only one site. They also vary significantly in scope and extent.

A typical Risk Management system structure is as follows:-



Statement of Corporate Risk Management Policy
Definition of Performance Targets, Corporate Organisation Chart and Responsibilities
Operating Sites: Hazard Identification Procedures, Risk Assessment and Evaluation
New projects: Project Risk Management, designing for safety & reliability, information to operations
Operating Rules and Procedures Maintenance Priorities & Management Personnel Competency & Organisation
Emergency Response Planning
Loss Experience, Safety and Reliability Performance Measurement
Emergency Response: Activation in Real Incidents
Action Plans and Follow-up
Auditing of Risk Management System
Board-level Assurance and Reporting
Reporting and Recording of Incidents and Risk Performance
Database of Incidents, Near-Misses and Failures
improvements
Management reports
statistics and reliability data

Risk Management System - Conclusions:-

1. An effective Risk Management system should ***identify, assess & control*** potential risks.

2. The choice of a particular strategy should ideally be made at an **early stage** when it is still possible to optimise plant design, minimise the inherent process hazards and take due credit for these features before committing expenditure on extensive protection. This approach will achieve full integration of ***prevention, protection & mitigation*** of fire hazards.

Possible strategies are:-

- **Fire prevention;**
- **Fire containment and minimisation;**
- **Acceptance of any consequential damage.**

Each chosen strategy requires provision of measures to manage the hazard and at each stage cost effectiveness must be considered.

The chosen strategies shall aim to reduce the risks to personnel to as low as reasonably possible (ALARP) and should prevent escalation to a major environmental incident.

They should – ***as a minimum*** *- meet Corporate and national targets for individual risk and major accident frequency.*

Risks versus Benefits

All human activities, including oil refining and insurance, involve some risk. It can be reduced but never completely eliminated.