Handbook on Process Safety Integrity for Utility Operators

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Preface

This handbook is intended for utility operators to explain the process safety integrity issues with the focus on maintaining the long term sustainability, efficiency and effectiveness of the utility assets. It is hoped this handbook provides the basis of the essentials for managers and key engineers responsible for the ownership , operation and maintenance of assets in the utility sector

Many thanks Farooq Janjua, Riyadh, KSA , July 2014

Nothing is so important that we cannot take the time to do it safely and properly

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SECTION 1 : INTRODUCTION

1.1 Introduction

At the onset the challenges faced by common process operators is to lower Operational Risk and improve Production Efficiency or…is the Key to better optimize how we manage operation and maintenance workload against a developed risk management policy

The aim of this book is to provide an overview of the holistic understanding of assessing and understanding operational risks and the need for standardization & systematization of working practices for prioritization of safety related and production critical work

In connection with link between management of assets , safety and risks which is the theme of this book the common link is the need for a process plant to maintain safe and reliable sustainable operational performance

The challenge for example in operating ageing assets as a common issue amongst utility operators is the need for **dependable equipment, competent personnel and effective systems**. Some quotations regarding ageing equipment from the UK Regulator

"Ageing is not about how old the equipment is. It's about what is known about its condition, and how that's changing over time" HSE Research Report RR509 - 'The plant ageing guide'

"Ageing is…where a component suffers deterioration and damage (usually, but not necessarily, associated with time in service) with an increasing likelihood of failure…. HSE Research Report RR823 - 'Plant Ageing Study'

The underlying theme of this book therefore is a set of ten common themes towards a sustainable plan for asset and process integrity

1. Conduct an analysis with an approved asset management integrity performance instrument (Data & KPI Collection)
2. Develop a Management Control Reporting System (MCRS)
3. Define the system, processes, people and entities evolved programs
4. Development of documentation/process standards
5. Design and agree a verification program/process
6. Identification of Safety Critical Equipment and processes (Safety Case, Bow-Tie, Hazid/op)
7. Define maintenance, testing, monitoring, inspections, and operations involvement
8. Risk management assured through QA/QC (development of performance standards, assurance standards and maintenance strategies)
9. Integration of standards and specifications with tools and reporting
10. Training & Coaching program - (KEY TO SUSTAINABILITY !)

Some examples of some typical general challenges in achieving this may be as follows :

Dependable equipment : Equipment projected as not fit for purpose ,Increased congestion of equipment and removal of redundant equipment ,replacement of obsolete equipment ,operation outside original design or lack of turn down capacity , reducing equipment and key system reliability , need to upgrade to meet latest HSE standards

Effective systems : Lack of clarity for ownership of knowledge between operator and sub-contractors , low implementation of documentation systems ,Compliance with current and future environmental legislation

Competent personnel : Flexible and changing workforce, leaner organisations with increased reliance on sub-contractors

1.2 Organisation and Responsibilities towards safety

Before we examine the role of Operation and maintenance and assets in the overall process / risk assessment let us start with the theme of safety

As part of the importance of an organization in developing and implementing safety management systems which are well described in many publications and books , so is not described here , it is important that in developing n operational organization should also understands that its employees at all levels must play their part in ensuring safety.

Improvements to the working environment take time and money, therefore everyone must realise that the process of improvement is a continuous one. An operational organization should consult with its employees to identify the most effective ways to make the improvements necessary

This is clear and in terms of an organization it is typically expected that all employees at all levels are responsible for:

- Being aware of the Company Health and Safety Policy
- Being aware of and following the organisation's systems and procedures for safe working
- Taking an active role in continual improvement by identifying to their line manager any shortcomings in the safe systems/procedures
- Caring for their own health and safety and that of anyone affected by their work
- Reporting anything that is unsafe or a risk to health

It is important to realize that as a typical statement that an organization should understand that health and safety at work depends upon the inherent safety of the working environment.

An operational organization should therefore provide:

- Safe plant and systems of work
- Safe means of using, handling, storage and transportation of articles and substances
- Safety information, instruction, training and supervision
- Safe place of work with safe access and egress
- Safety for people not employed but affected by its undertaking

so far as is reasonably practicable. Where the working environment falls short of the above standards, the organization should strive to improve conditions until they meet the standards.

In addition to these universal responsibilities, setting an organization within the company should ensure the clear roles and responsibilities of the managers and supervisors towards safety – Example of the typical responsibilities as follows:

Managing Director

An organisation's managing director is ultimately responsible for all health and safety matters in respect of the organisation's activities

His responsibilities can for example typically include the following :

- Ensuring that the other Directors are provided with adequate resources and assistance to enable him to fulfill their duties.
- Reviewing the Directors monthly reports on health and safety performance.
- Typically for example reporting health and safety performance to the Board at regular intervals (eg every six months or as required depending upon the type , activity and size of the organization)

Other Directors

Other directors within an operational organization are typically responsible to the Managing Director for all health and safety matters in respect of the organisation's activities.

They are responsible for the implementation of the Company Policy in accordance with the current policy statement.

They are assisted by both the External Health and Safety Adviser and the OHS Manager. Their responsibilities typically can include the following:

- Reporting Health and Safety performance to the representative director every 3 months
- Accepting and reviewing the monthly Health and Safety performance reports provided by their reports
- Keeping the Health and Safety Policy under review and recommending necessary or desirable modifications to the Managing Director
- Monitoring the implementation of the Company Policy and taking such action as is necessary to maintain its effective functioning
- Being alert and encouraging others to be alert to detect hazards, particularly those arising from changed circumstances, and arranging for appropriate precautions to be taken
- Arranging that their reports have adequate training, information, instruction, supervision and resources to undertake their responsibilities
- Authorising such expert advice from outside the Company as they judge necessary or desirable
- Chairing safety committee meetings
- Taking all reasonable opportunities to consult employees on health and safety matters and encouraging suggestions for improvements
- Keeping abreast of the health and safety aspects of statutory employment requirements and taking action to maintain the Company's compliance
- Setting a personal example at all times

Human Resource Director

The HR Department Director in an organization is typically responsible for:

- Reporting Health and Safety training performance to the project manager every month
- Managing the Health and Safety Training Team (when set up)
- Maintaining a database of training requests from all business units using the Training Team administrative resource
- Scheduling and delivery of training to all business units using the Training Team administrative resource
- Ensuring that the Training Team are adequately resourced, trained and competent
- Arranging for expert advice and guidance for the training team, including preparation of training plans, manuals and codes of practice
- Attending safety committee meetings
- Setting a personal example at all times

Safety Manager

The Safety Manager is typically responsible in an organization for:

- Reporting Health and Safety performance to the Managing Director every month
- Keeping the Company Policy under review and recommending necessary or desirable modifications to the Project Manager
- Monitoring the implementation of the Company Policy and taking such action as is necessary to maintain its effective functioning
- Arranging safety audits and safety inspections as required
- Being alert and encouraging others to be alert to detect hazards, particularly those arising from changed circumstances, and arranging for appropriate precautions to be taken
- Keeping abreast of the health and safety aspects of statutory employment requirements and taking action to maintain the Company's compliance
- Arranging and attending safety committee meetings
- Arranging that Health Safety and Welfare appears as a standard item on the agenda for Monthly Staff Meetings

- Taking all reasonable opportunities to consult employees on health and safety matters and encouraging suggestions for improvements
- Organising and managing an annual Training Plan for all Operational and Maintenance staff
- Organising and arranging for any training required by Safety Representatives
- Providing advice on all health safety and welfare matters to all the organisations staff
- Investigation of all accidents, near misses or ill health, and reporting any findings to the Project Manager and taking appropriate action
- Setting a personal example at all times

Senior Managers in the Organisation

The organisation's senior managers are typically responsible for:

- Reporting Health and Safety performance to their Directors every month
- Liaising with the OHS Manager over the implementation of the Company Policy and taking such action as is necessary to maintain its effective functioning
- Ensuring that all hazards are assessed and appropriate safe methods of working adopted
- Being alert and encouraging others to be alert to detect hazards, particularly those arising from changed circumstances, and arranging for appropriate precautions to be taken
- Liaising with the OHS Manager over the preparation of an annual Training Plan for all Operational and Maintenance staff
- Taking all reasonable opportunities to consult employees on health and safety matters and encouraging suggestions for improvements
- Attending safety committee meetings
- Setting a personal example at all times

Site Managers

The Site Managers within the organization are typically responsible for:

- Reporting Health and Safety performance to their Manager every month
- Maintaining a working environment that, so far as is reasonably practicable, is without risk to the health and safety of anyone affected
- Being aware of the Company Heath and Safety Policy, and assisting in the implementation thereof, and taking such action as is necessary to maintain its effective functioning
- Liaising with the OHS Team over the implementation of the Company Policy
- Liaising with the OHS Team over the preparation of an annual Training Plan for all Finance, Administration and Personnel staff
- Taking all reasonable opportunities to consult employees on health and safety matters and encouraging suggestions for improvements
- Setting a personal example at all times

Operational or Maintenance Supervisor

An organisation's Operational or Maintenance Supervisor is typically responsible for:

- Consulting with the operational or maintenance teams and preparing a monthly Health and Safety performance report for the Plant Manager
- Maintaining a working environment that, so far as is reasonably practicable, is without risk to the health and safety of anyone affected
- Identifying any shortfall in the training needs of operatives and advising the plant manager
- Being aware of the Company Heath and Safety Policy, assisting in the implementation thereof and taking such action as is necessary to maintain its effective functioning
- Being alert and encouraging others to be alert to detect hazards, particularly those arising from changed circumstances, and arranging for appropriate precautions to be taken
- Attending safety committee meetings
- Setting a personal example at all times

Safety representatives

Safety representatives may be appointed from any level within the company to represent the interests of the workforce with regards to health and safety at work. Whilst carrying out their Safety representative functions they do not sit within the management structure and should not feel constrained by their normal operational role.

The functions of a safety representative are to:

- Take reasonably practical steps to keep informed of:
    - The legal requirements relating to the health and safety of people at work, particularly the group of people they directly represent
    - The particular workplace hazards and the measures necessary to eliminate or minimise the risks deriving from these hazards
    - The Health and Safety Policy
- Encourage co-operation between the employer and his employees in promoting and developing essential measures to ensure the health and safety of the workforce and in checking the effectiveness of these measures
- Investigate, normally in co-operation with the Co-ordinating Supervisor/Safety Adviser:
- Hazards and accidents in the workplace
    - Employee complaints relating to health, safety or welfare
- Carry out inspections in the workplace
- Alert the employer, in writing, to any unsafe or unhealthy working practices or conditions, or unsatisfactory arrangements for welfare at work
- Represent the employees to whom he/she has been appointed in consultation with Inspectors from any external enforcing safety authority
- Receive information from any external enforcing safety authority
- Attend Safety Committee meetings

1.3 Planning and Implementation

It is important that an organisation develops and maintain a plan for continuous improvement of the working environment and the health and safety competency of its employees. The start point for this plan is the condition survey report which identifies the majority of defects on individual larger sites and common defects at well sites. The plan will be a “living document” that continuously develops as new defects and training needs emerge. The plan will also include a list of high risk activities and environments that require specific procedures to keep people safe.

Each site owner will contribute to the plan by confirming or otherwise the defects identified for their site, and by identifying further defects as they become apparent. The site owner will also identify the high risk activities and environments on his/her site.

Each line manager will contribute to the plan by identifying the existing level of safety training for their direct reports, and by identifying the training needs of individuals in relation to the work they do.

The plan will identify the estimated cost for improvements to the physical environment and will include a budget for implementing the improvements over a period of time. Wherever practical, the budget will be based on a cost benefit analysis so that the maximum risk reduction can be achieved at the lowest cost.

The plan will identify the estimated cost of providing training throughout the company and will include a budget for initial and refresher training over time. The budget will be based on a risk benefit analysis so that those employees most at risk from their work activities will be trained first.

The organisation should ensure that they will implement the plan for physical improvements by allocating tasks and targets to each line manager and each site owner as resources become available. Some tasks will be undertaken in-house, and some tasks will be delivered by external contractors. Each task and target completed will be reported to the plan owner, together with a feedback form to record whether implementation achieves the desired effect or not. Where a task or target does not achieve the desired effect it will be investigated to find potential improvements so that, if repeated elsewhere, it will be increasingly successful

The organization should also wherever practicable, implement the plan for safety training by integrating the safety and operational features of any task so that the training improves safety and operational performance at the same time.

It is also essential that the organization provide a Health and Safety Handbook to each employee. The handbook will provide information and guidance on controlling high risk activities and environments. Each employee is expected to read the handbook and sign a receipt for it. The handbook will be reviewed at least annually, and revisions made where necessary. The handbook will identify activities that require additional training, enabling the employee to identify their own training needs

1.4 Monitoring Performance

Performance will be monitored for physical improvements and for training, with each part for example typically being allocated 50% of the total performance report.

Normal Reports ;

Performance against a plan is typically expected to be continuously monitored using the monthly report mechanism. A standard monthly report form will be used that records tasks and targets allocated and training planned. The reporter will state the percentage achievement for each item. The project manager will typically collate the reports and provide an overall report to the Director every 3 months.

It is usual that the director will collate the 3 monthly reports and provide a summary report to the Board say every 6 months.

Exception Reports :

Occasionally an incident may occur or a site may fail significantly to meet its targets. Should this happen, a reporter at any level may raise or pass on an exception report for immediate transmission to the next level of management. The report will provide details of the event and reasons for its occurrence. Where possible the report should also include suggestions for improvement

Accident / Incident Reports :

Any accident/incident investigation report relating to a reportable event shall be treated as an exception report and will always be transmitted to the Project Manager. Reportable events are defined within the accident/incident investigation protocol.

Internal Audit Reporting :

It can be expected that say a safety advisor will carry out a number of internal audits each month in consultation with the site managers. These reports will be used to verify the quality of the monthly reporting mechanism.

1.5 International Best Practice

International best practice is now seen as “goal setting” rather than prescriptive.
This requires managers at all levels to achieve an appropriate level of risk reduction, based on the circumstances of the hazards faced in the specific work environment and the cost of reducing that risk. The factors used to assess the risk and the risk reduction are:

- The severity of an incident
- The likelihood of an incident
- The frequency of the activity
- The number of people engaged in the activity
- The cost of reducing or eliminating the hazard

For example, if there are damaged handrails in two similar locations, one of which is used regularly, and the other used rarely, priority must be given to the location in regular use. The UK produces “goal setting” Regulations based on the requirements of European directives on Health and Safety at Work. These Regulations are generally seen as setting world-wide best practice and have been adopted either directly or

with small changes to suit local conditions by many countries across the world. The UK Regulations have the benefit of being specific to the typical hazard, for example, the
Confined Spaces Regulations, the Lifting Operations and Lifting Equipment Regulations, the Manual Handling Regulations etc.

1.6 Prioritised Reporting

Each site owner / network manager is required to identify defects on their site, using the Guidance Note to assist in the process. To avoid overloading the data collection process, which would in turn overload the prioritisation process, only one or two subject headings should be tackled at a time.

A single defects sheet contains space for 5 defects to be identified. At one sheet per week, some 250 defects could be identified each year on each site. As there are physical and financial limits on what could be done on a site, it is expected that no more than 1 or 2 sheets per week should be returned. This constraint will also encourage site owners to concentrate on their known safety priorities.

1.7 Data Collation and Reporting

A defects sheet should typically be completed and returned to the asset management team. The team will enter the data into a database, assign priorities, and arrange for the work to be processed ether via the site owner, or via a term or maintenance contract.

The database shall meet the needs of the asset management team for the purposes of safety and operations.

The database will contain the raw information, and further fields for priority, work ordered, progress, completion etc. Reports shall be produced showing progress against identified priority defects and against all defects recorded

Concerning a Safety Deficiencies Guidance Note this can be described as a prime working document for site owners, which can be adopted as a means of identifying safety and operational deficiencies. Further information is provided in section 5 and 6 dealing with asset assessments and asset safety condition surveys Typically also the Asset Management Team can also construct the database for collation of the information, such that the database serves all the needs of asset management, including safety deficiencies. Typically , also this work is carried out in-house by the maintenance teams where practical and a term contract be established with teams of specialists to carry out the remaining specialised necessary repairs and improvements identified and prioritised by the Asset Management Team

Example : Safety Deficiencies Data Collection Form

Site Name :	Date :	Site Owner :
Example shown below in shaded area		
Building or area: Chlorinator Room	Equipment Identifier/ Asset No: CC1, CC2, CC3	Equipment description: Electrical cabinets
Location of Defect: Doors	Safety Defect: ☐ Operational Defect: ☐ Both: ☐ Estimated Priority (1 to 5, 1 = urgent): 4	
Description of defect: Old style electrical cabinet doors cannot be locked to prevent unauthorized access.		
Building or area:	Equipment Identifier/ Asset No:	Equipment description:
Location of Defect:	Safety Defect: ☐ Operational Defect: ☐ Both: ☐ Estimated Priority (1 to 5, 1 = urgent):	
Description of defect:		
Building or area:	Equipment Identifier/ Asset No:	Equipment description:
Location of Defect:	Safety Defect: ☐ Operational Defect: ☐ Both: ☐ Estimated Priority (1 to 5, 1 = urgent):	
Description of defect:		

Building or area:	Equipment Identifier/ Asset No:	Equipment description:
Location of Defect:	Safety Defect: □ Operational Defect: □ Both: □ Estimated Priority (1 to 5, 1 = urgent):	
Description of defect:		

Appendix : Example of Safety Deficiencies Guidance

Note : Below is a typical/ example only which needs to be developed on site specific basis

Physical Hazard	Identification	Controls
Chlorine	What to look for. • Unsupported cylinders. • Corroded pigtails. • Lack of replacement washers for connections. • Sensors out of date. • Alarm systems not functioning correctly. • Ventilation system not linked to sensors and alarms. • Damaged or very stiff valves. • Missing warning signs • Drum lifting beam not present. • Scales not calibrated, missing, damaged. • Drums not marked as full, empty, duty, standby. • Chlorguard system, if fitted, not functioning. • Emergency repair kits not available. • Drum rollers not free to move. • Ammonia leak detector bottle not available or empty.	What to do. • Support all cylinders in the upright position, including those not in use. • Replace corroded pigtails, and replace at least annually. • Ensure a minimum of 3 months supply of washers is available. • Out of date sensors to be replaced immediately. • Ensure sensors and alarm system are calibrated and checked annually, or immediately upon indication of failure. • Ensure that the ventilation system operates and shuts down at the correct sensor points. • Cylinders or drums with damaged or very stiff valves to be rejected and the supplier to collect at own expense. • All chlorine rooms to be fitted with warning signs • Chlorine drums are only to be lifted with a proper drum lifting beam. • Scales for weighing chlorine are to be calibrated annually, or after any damage. • All drums to be clearly marked full, empty, duty or standby. • Chlorguard systems must be checked at least monthly for correct operation and where supplied, must be fitted and used. • Emergency repair kits suitable for cylinders or drums to be supplied and kept on site for ready use. • Drum rollers to be checked for free movement and maintained/repaired as necessary. • Ensure ammonia leak detector bottle is available and ready for use.
Confined spaces	What to look for. • Confined spaces, such as inspection chambers, pits, tanks, silos, chemical stores, chlorine stores, generator housings etc. • Means of controlling access to confined spaces (doors, covers etc.)	What to do. • Place a sign on the site entrance stating “Treat all inspection chambers, pits, tanks, silos, chemical stores, chlorine stores, generator housings etc. as confined spaces – entry by authorised persons only” • Mark all above ground confined spaces with a warning sign and ensure all confined

	• Inadequate ventilation of confined spaces entered regularly	spaces have an adequate barrier to access. • Repair/maintain or install adequate permanent ventilation and clean any filters as necessary
Electricity	What to look for. • Open or unlocked panels. • Isolating panels without lock-off facilities. • Loose cables. • Improper cable connections (chocolate block, bare wire etc.) • Live conductors in panels without shrouding. • Sagging overhead cables. • Cables on walkways • Unfenced high voltage transformers. • Note: detailed electrical safety inspections must be carried out by competent electricians.	What to do. • Close and lock all panels not being worked on. • Ensure isolating panels can be locked off. • Secure loose cables to cable trays or similar. • Remove all improper cable connections from site. • Accessible live conductors must be made inaccessible by shrouding or similar. • Ensure overhead cables are properly supported and place warning signs if a high vehicle hazard remains. • Re-route cables away from walkways. • Fence or otherwise protect all high voltage transformers, and place warning signs. • Arrange for a competent electrician to inspect the site.
Fire Safety	What to look for. • Adequate numbers of fire extinguishers. • Extinguishers in date and correctly mounted. • High risk areas (oil, grease and fuel storage, packaging, stores). • Fire hose reels in good condition.	What to do. • Provide additional extinguishers as necessary. • Arrange a central contract for inspection and replacement of extinguishers. • Place warning signs for high risk areas. • Check fire hose reel operation and arrange for maintenance if necessary
Lifting equipment	What to look for. • Current certification. • All equipment in good condition, • Lifting accessories marked with safe working load.	What to do. • Arrange for certification of the equipment. Annual for all lifting equipment and 6 monthly for accessories. • Destroy or scrap all accessories in poor condition, arrange repair or maintenance of lifting equipment. • Accessories not marked with safe working load to be scrapped.
Chemicals	What to look for. • Chemicals stored in unmarked containers. • Acids and alkalis stored together. • Excessive storage of chemicals in containers rather than in bulk tanks. • Spills of chemicals. • Old containers of paint, oils, greases etc. in workshops. • Waste oils in transport workshops.	What to do. • Remove and dispose of all unmarked containers. Where necessary, arrange for disposal as hazardous waste. • Acids and alkalis must be stored separately. Where both are needed in a closed environment then store each type in trays or bunds to limit the possibility of mixing. • Limit orders of chemicals to manageable amounts, do not order more than can be used in a month, or consider changing to bulk storage. • Chemical spills to be mopped up with absorbent material or diluted with water (if

		safe) and washed away. • Old containers of paint, oils and greases should be disposed of as hazardous waste. • Waste oils produced during vehicle maintenance should be stored in flameproof containers and collected from site weekly
Slip, trip or fall from height	What to look for. • Uncovered and unprotected openings into chambers, tanks etc. • Coverings to walkways, tanks etc. in poor condition or not properly secured. • Loose, damaged or missing handrails or toe-boards to elevated walkways. • Fixed ladders in poor condition, corroded or loose. • Portable ladders in poor condition, damaged or painted. • Scaffolding platforms constructed without adequate handrails, toeboards or scaffold boards.	What to do. • Replace covers to openings where practical, and place barriers around openings where the cover cannot be replaced immediately. • Identify covers in poor condition or not properly secured and schedule them for maintenance or replacement/repair. • Identify missing handrails and schedule them for immediate replacement/repair. Loose or damaged handrails and toe-boards must also be scheduled for maintenance or repair as a second priority. Overall priority must be given to areas in frequent use. • Fixed ladders in a dangerous condition must be marked with a warning sign and repaired or replaced as a high priority. • Remove from site all ladders in poor condition, damaged or painted. • All scaffolding must be inspected on first construction and each week thereafter. Any scaffold that does not meet acceptable standards must be marked with a “do not use” sign until faults have been corrected.
Pressure systems	What to look for. • Pressure vessels out of inspection date. • Corroded or damaged pressure vessels. • Safety devices not functioning or not tested. • Pressure vessels without a manufacturer’s plate. • Pressure lines subject to damage or unprotected. • Jubilee clip type fixings on pressure lines.	What to do. • Arrange inspection and certification. • Arrange repair or replacement, if badly corroded take out of service. • Check safety devices regularly (pressure relief valves, pressure gauges etc.) • If no plate is present, can the vessel be identified in the O&M manual. If so, mark the pressure vessel and provide details nearby. • Pressure lines to be moved to a safe location and protected as necessary. • Jubilee clip type fixings to be replaced with correct fixings (may need special crimping tool).
Mobile plant	What to look for. • Keys left in. • Plant in poor condition. • Plant not needed. • Plant used by unauthorised people. • Passengers riding on plant.	What to do. • Keys of all plant to be kept in a key press when not in use. • Arrange for repair/maintenance of plant in poor condition. • Consider relocation of redundant plant. • Do not permit unauthorised persons to use plant. • Do not permit passengers to ride on plant

		unless correctly seated.
Machinery	What to look for. • Unguarded moving parts of machinery. • Machinery that may start automatically. • Potentially hazardous machinery without an emergency stop. • Machinery capable of being reenergized directly from an emergency stop • Machinery incapable of being isolated and locked off.	What to do. • Provide guards to all moving parts of machinery on a risk based priority. • Mark machinery with “warning – may start automatically” as appropriate. • Fit emergency stops to potentially dangerous machinery that does not already have one. • Check that resetting the emergency stop does not reenergize the equipment directly. If it does then place a warning sign and arrange for re-wiring. • Ensure that machinery can be isolated and locked off where necessary for safety when carrying out maintenance or repair.
Deep water or sewage	What to look for. • Open tanks or pits without barriers. • Unguarded lagoons/reservoirs. • Missing lifebuoys and lifebuoy ropes. • No warning signs. • Access to the public.	What to do. • Place barriers around all high risk tanks and pits. • Place warning signs on each side of lagoons “warning – deep water” • Ensure lifebuoys are replaced, with a 10 m cord attached to each one. • Place warning signs on all other tanks and pits where there is a risk of drowning. • Prevent public access to reservoirs, lagoons or similar. If this is not practical ensure that adequate signage is placed.
Site security	What to look for. • Site fencing damaged or missing Site gates damaged or missing. • Locks missing or inoperative. • Sites not security signed. • Inadequate fencing i.e. not high enough. • Boundary walls in poor repair	What to do. • Schedule replacement/repair of fencing on a priority basis. • Replace or repair gates. • Ensure locks are present, functioning and in use when the site is left. • Place security signs on all gates and on fences and boundary walls where appropriate. • Review security need and replace inadequate fencing. • Repair boundary walls.
Cutting and grinding equipment	What to look for. • Cutting disk machines without guards or with unsecured guards. • Damaged disks • Badly stored disks. • Grind wheels with missing or badly set guards. • Worn grind wheels.	What to do. • Replace/secure guards or take out of service until guards can be replaced. • Dispose of any damaged disks. • Check storage of disks (vertical on pegs) • Replace/secure guards or take out of service until guards can be replaced. • Worn grinding wheels to be replaced or dressed.
Manual handling hazards	What to look for. • Heavy covers. • Heavy chemical drums. • Valves etc. in difficult or awkward	What to do. • Provide simple lifting equipment to aid handling. • Chemical drums and similar to be carried

	locations.	on pallets. • Review the position of valves etc. and change them during maintenance.
Hot surfaces	What to look for. • Compressors with exposed pistons. • Air lines leading from compressors to pressure vessels. • Combustion engines with exposed exhausts. • High temperature lights in accessible places.	What to do. • Compressor pistons should be shielded from contact using steel mesh or similar. • Air lines should be placed out of reach or be otherwise shielded from contact. • All engine exhausts should be shielded from contact by mesh guards or by being out of reach. • High temperature lights (for example halogen work lights) must be protected with a mesh cover preventing contact with the lamp itself.
Lighting	What to look for. • Lamps not functioning. • Dirty lamp covers. • Inaccessible lights. • Inadequate lighting.	What to do. • Replace the lamps if accessible. • Arrange a cleaning programme for accessible lamp covers. • Consider moving inaccessible lamps to an accessible point. • Provide additional lighting at an accessible level.
Fragile materials	What to look for. • Roof coverings with skylights and asbestos cement roofs	What to do. • Mark the edges of the roof with warning signs saying fragile roof.
Slip, trip or fall on the level	What to look for. • Waste materials on or near walkways. • Pipes, conduits and cables crossing walkways. • Leaking water, particularly onto hard or tiled surfaces. • Oil or diesel spills on hard or tiles surfaces. • Changes in level, slope or surface	What to do. • Remove existing waste material, clean up before and after any maintenance or operation activity. • Where practical, re-route pipes, conduits and cables away from walkways. Alternatively, provide steps and platforms over the trip hazard. • Identify leaks for repair and schedule the work on a priority basis. • Clean up oil and diesel spills immediately using an absorbent material, or use sand if nothing else is available. • Identify and mark changes in level or slope that represent a trip hazard.
Noise	What to look for. • Any environment where you cannot hold a conversation at 2 metres. Of which the following are examples: - Areas where very loud noises occur regularly. - Generator rooms or containers. - Rooms where a loud single note is	What to do. • Check for damaged or defective equipment making more noise than it should and schedule it for repair/maintenance. Provide warning signs and hearing protection. Where a single note noise is produced, select the hearing protection to suit the noise. Limit or control entry to high

	produced such as blower rooms and pump halls. - Damaged or missing exhaust systems from combustion engines.	noise environments.
Asbestos	Asbestos cement roof or shade. • Damaged or broken asbestos cement sheets. (normally in roofs or shades) and broken pieces of asbestos cement in walkways or roadways.	Asbestos management plan as per local regulations
Traffic on site	What to look for. • Traffic routes causing problems with access or delivery. • Parking areas not adequate. • Dangerous corners. • Uneven or damaged roadways. • No separation between vehicle routes and pedestrian routes.	What to do. • If practical, re-route access and delivery routes to reduce or eliminate the problems. • Review parking needs and provide more if necessary. • Place sightline mirrors at dangerous corners. • Repair damaged or uneven roadways. • Separate vehicle and pedestrian routes with bollards or with painted hatched walkways.

1.8 Training

It is strongly recommended that the organization develops guidance note for training as the prime working document for site owners and line managers. This is based upon Training Needs Assessment process for identifying training needs for individual employees and an established database for collation of the information and scheduling training.
It can also be noted that design of courses and delivery of "Train the Trainer" courses, required the initial delivery of training be contracted out to a competent qualified person and also training validation is also required over a period of time to confirm the appropriateness of the training and the quality of delivery.
As example regarding the provision of personal protection it is only personal protective equipment such as head protection, foot protection and reflective vests do not require training. The following table lists equipment with its essential training requirements

Description	Essential training
Half face respirator – provides protection against dust and limited protection against chemicals	Selection of correct filter Face fit test to ensure no leaks Maintenance and cleaning of the respirator Changing filters and filter life Emergency responses
Full face respirator Protection as above but additional eye protection	As above plus cleaning the view piece.
Harness – can provide fall protection and can also be used during vertical winched access	Correct fit and adjustment of harness Selection of correct anchor point for multi-point harnesses Maximum duration of use in suspension mode
Tripod – used to provide safe entry and exit into shafts, chambers, wet wells, manholes, etc. Where no fixed access can be provided	Setting up the tripod Ground conditions and making safe Adjusting the legs for uneven ground Anchoring the legs when necessary Physical checks of lifting and attachment points
Winch – used for lowering and lifting persons into restricted access sites and used for emergency evacuation of injured persons from confined spaces	Attachment to tripod Checking the cable and cable attachment to drum Operation of the tripod under load Physical checks of lifting and attachment points

Safety line – used to prevent or limit falls during access to confined spaces or when working over openings into tanks etc.	Tying off the safety line (use of standard knots) Selection of anchor points Correct position of snatch lock Operation of the snatch lock during a descent Difference between fall prevention and fall arrest
Fall arrester- can limit a fall to less than 2m, can also be used to restrict the likelihood of a fall	When to use a fall arrestor How to secure it What happens to it after use
Gas detector – used to identify hazardous atmospheres	Turning it on and checking function, including sensors, self calibration, battery life Understanding the readings and hazard levels Peak and average readings and their meanings.

Example of Occupational Health and Safety Training Guidance Note

The below is example which needs to be developed for site specific and organization requirements. This gives an outline indication only of the type of requirements for an organisation to identify a training need, and to assign a priority to it for operations and maintenance personnel

Training subject	Duration and Essential Content	Target group
Health & Safety Essentials	½ day Company safety culture H&S Policy statement and meaning Commitment to safety Company and individual responsibilities H&S Handbook contents Common hazards Accident/incident reporting	All personnel
Confined spaces	2 days initial, 1 day refresher. Major hazards – O2, H2S, CH4, Heat, Drowning. Risk reduction – isolation, lock-off, ventilation, access. Equipment – gas detector, tripod, winch, harness, safety line, escape BA, (full BA). Team work – size of team, responsibilities. Emergencies – rescue and recovery. Practical exercises.	All operations personnel
Chlorine operations	2 days initial, 1 day refresher. Major hazards – effects of chlorine, off-site risk. Drum and cylinder handling – lifting equipment, weighing contents. Secure storage – securing cylinders, securing drums. Leak detection – ammonia bottles, detectors, alarm systems. Chlorguard system – connection and operation. Safe operations – full BA, half face masks, chemical suit. Emergency control – dealing with leaks,	Applicable only in the case of water and waste water operation - in this case for all operations and maintenance personnel dealing with chlorine (see note below)

	chlorine emergency repair kit.	
Lifting operations	1 day initial, 1 day refresher Checking equipment – safe working load, equipment condition, slings, shackles etc. Lifting pumps – connections to pumps, isolation and lock-off, lifting procedure, safe set-up, cleaning pumps for inspection. Lifting other equipment – slinging, centre of gravity, securing slings, tag lines and control, hand signals	Maintenance and operations personnel carrying out lifting operations
Work equipment	½ day initial, ½ day refresher Work equipment general hazards – electrical, cutting equipment, fire hazards, guards, safe operation. Fault finding and reporting – daily checks, taking out of service etc. Safe use – location, other persons, noise, public etc.	Operations and maintenance personnel
Manual Handling	1 day Human body – capabilities, strength, weaknesses, age effects Handling loads – general lifting, pushing, pulling Inspection chamber covers – problems and solutions, lifting techniques, two person lifting, key length	Operations and maintenance personnel
Fire fighting	½ day Causes of fire – air, ignition, fuel, electrical. Hazards from fire – burns, asphyxiation, property damage. Types of fire extinguishers – water, CO_2, powder, foam, checks to be carried out. Use of extinguishers - practical	Operations and maintenance personnel + 10% of office staff.
Emergency first aid	½ day Accidents – types and seriousness Dealing with an injured person Responses Breathing Airway Circulation Resuscitation	Operations and maintenance personnel + 10% of office staff.
Permit writing	½ day Types of permit – permit to enter, permit to work, permit to dig. Responsibilities of permit writer Practical exercises	Selected operations and maintenance personnel
Electrical safety	2 days Basic electrical safety Isolation procedures	Electricians

	Locking off procedures Safety checks Test equipment Sanction to test Permit and permit writing Working lock-off	
Construction safety	2 days Excavations Scaffolding and ladders cranes plant and machinery traffic management concreting site wiring power tools cutting and welding operability of finished work stores management waste materials welfare facilities	Construction supervisors/foremen
COSHH	½ day Handling chemicals Storage of chemicals Protective clothing Managing incidents and spills Effects of chemicals First aid for chemicals	Laboratory staff and personnel handling chemicals

Examples of Contents from Safety Manuals – Chlorine Safety

Table of contents

- Preface
- Objective
- Responsibilities
- Natural & Chemical Features
- Synonyms
- Classification
- Usage Of Chlorine
- Chlorine Cylinders & Containers
- Chlorine Hazards
- Relation Between The Size Of Gas & Liquid
- Interaction With Water
- Fire
- Chemical Interaction
- Hygienic Effects
- Provisions Of General Erection & Building
- Design & Erection
- Exhaust & Ventilation Fans
- Gas Anti Leakage System
- Heating Temperature
- Electric Systems
- Fife Fighting Systems
- Security Measures
- Components Of Chlorine Dozing Room
- Preventive Operation Procedures

• Preventive Handling Procedures
• Preventive Procedures To Replace The Containers
• Emergency Procedures In Case Of Leakage
• Emergency Procedures In Case Of Fire
• Area Clearance In Case Of Leakage
• Leakage Treatment Tools
• Emergency Tools
• Security Containers
• Personal Protection Tools
• Eye Protection
• Skin Protection
• Respiratory System Protection
• Personal Protection From Chlorine Gas
• First Aid
• Chlorine Inhale
• Chlorine In Contact With The Skin
• Chlorine In Contact With The Eye
• Training
• Appendices
• Official Rules
• References

Examples of Contents from Safe Operation of Fork Lifts

Table of contents

Chapter One : Definitions
• Types Of Forklifts
• Components Of Fork Lifts
• Gauges
• Control Systems
• Data Board
• Types Of Wheels
• Lifting System
Chapter Two : Physical Work Of Fork Lift
• Direction By Rear Wheels
• Center Of Load Gravity
• Capacity
• Load Equation (Inch – Pound)
• Load Center
Chapter Three : Fork Lift Operation
• Speed
• Circulation
• Eight Inches Rule
• In Case Of Vision Hide
• Be Sure Of Upper Obstacles
• Lose Chains
• Un Fixed Loads
• Wide & Long Loads
• Operation At Slopes
• Operation At Rough Surfaces
• Elevators
• Loading Bases
• Fork Lift Parking
Chapter Four : Safety In Fork Lift Operation
• Dangerous Parts At The Fork Lift
• Right Sitting Position Of The Operator

• Fall Down
• Cross Roads
• Standing Under The Raised Forks
• Persons Transportation
• Lifting Persons
• Allowing Others To Operate The Fork Lift
• Safety Measures
• Seat Belt
• Horn
• Reverse Horn
• Turn Flashers
• General Safety Rules

Chapter Five : Maintenance

• Check Up The Safety Equipment
• Check Up The Steering Unit
• Check Up The Brakes
• Check Up The Hydraulic System
• Check Up The Wheels & Tires
• Check Up The Mileage
• Leakages
• General Check Ups
• Daily Check Ups
• Daily Report

Chapter Six : Fueling

• Supply Fuel
• Charge Batteries
• Change Batteries

Examples of Contents from Industrial Security Training Programme

Table of contents

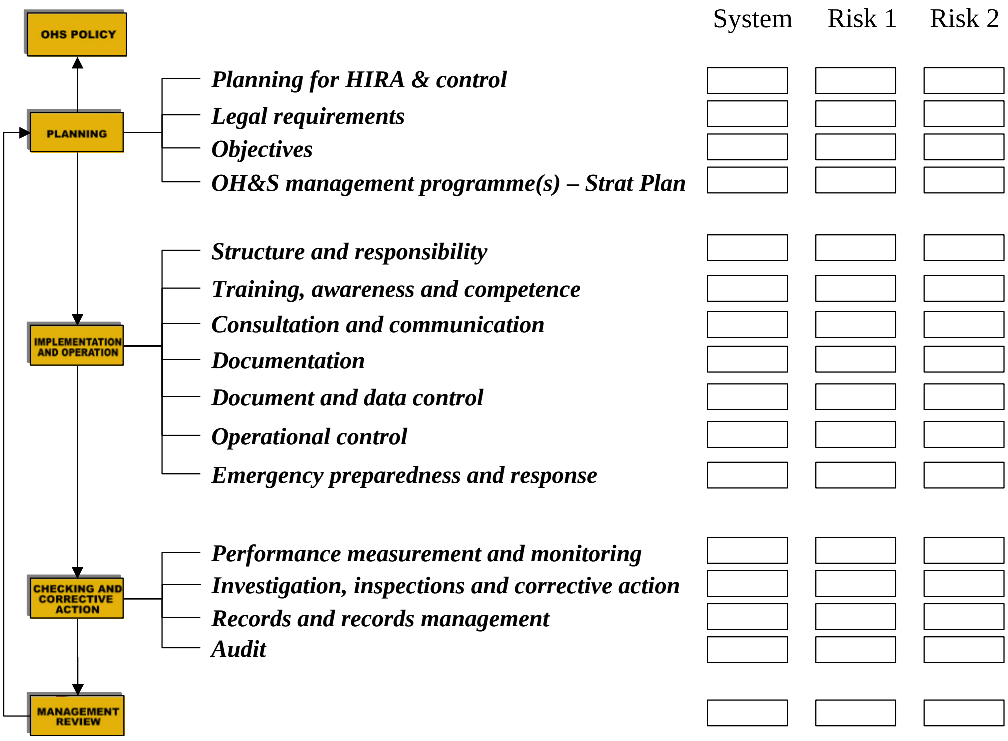
• Preface
• General Principles
• Schedule Of Training Programs
• Candidate Forms
• First Aid
• Vocational Protection Principles
• Personal Protection Tools
• Dealing With Poisonous Gases And Dangerous Chemicals
• Fires And Protection Principles
• Industrial Security Principles
• Safety Measures In Using Fork Lifts
• Traffic Guidance At The Job Sites
• Outline of Safety Measures In the site
• Emergency Plans And Crisis Administration
• Higher Administration Of Safety & Security
• Consultants & Contractors Safety At The Projects
• Training Locations

Annex : Health, Safety & Environment (HSE) Management System Framework

There is a wide pleuthoria of information available on developing HSE Management systems , in line with recognised international standards. Due to this reason we have not delved into this issue in this book and only give the outline of typical framework of system.
This would also be in line with the quality process for continual improvements

<u>1 Example of Safety Management System</u>

1. HSE policy



2. Planning for hazard identification & risk assessment (HIRA) & control:

   2.1 Integrated enterprise-wide risk management system

   - Catastrophic risk management (headline risks) – standards/procedures/controls requiring monitoring

2.2 Action management (link with hazard register)

2.3 Risk management - qualitative and quantitative techniques:

JSA	(Job Safety Analysis) – to help develop standard operating procedure
FTA	(Fault Tree Analysis) – detailed analysis of contributors to major unwanted events, using quantitative risk analysis methods
ETA	(Event Tree Analysis) – detailed analysis of the development of major unwanted events, using quantitative methods
HAZOP	(Hazard and Operability Study) – systematic identification of hazards in process plant design
SCHIRP	(Systematic, Comprehensive Hazard Identification & Risk Profiling) - baseline
FMECA	(Failure Modes, Effects & Criticality Analysis) – general to detailed analysis of hardware component reliability risks
CTA	(Critical Task Analysis) – to help develop standard operating procedures
SWIFT	(Structured What If Technique)

2.4 Risk & hazard register:

- Pre-emptive (e.g. projects, changes)
- Baseline
- Issue-based (e.g. post event or one requiring quantitative technique)
- Continuous (e.g. inspections, observations etc)
  (work area, occupation & activity based)

2.5 Hazard management standards / fatal risk control protocols / major hazard installations
2.6 Workplace risk ratings (based on inspections & audits – linked with hazard register)
2.7 Hazard & near-hit reporting – hazard of the month

3. Legal requirements:

- Safety regulations
- Corporate legal advice and from Industrial Security & Government Affairs

4. Objectives:

Targets & objectives – defined on scorecard & in business / operating plan

5. Safety management program:

5.1 HSE strategic, business & operating plans
5.2 Behavior & Mindset Modification Processes:
- Critical behavior observations
- Visible, felt leadership
- Cardinal / golden safety rules (zero tolerance)
- Recognition & reinforcement system e.g. scratchies / safety suggestions, focus on positive, safe behavior

5.3 Contractor system (including sub-contractors) – includes 3rd party equipment safety
5.4 Equipment selection & certification
5.5 National insurance requirements
5.6 Off-the-job safety

6. Structure & responsibility:

6.1 Leadership structure & accountability
6.2 H&S management committee
6.3 Accountabilities defined:

- Board / President/CEO
- Vice President: Planning & Business Development
- Plant Managers
- HSE Director
- HSE department staff
- H&S representatives, rep. committee chairman & committee members
- Superintendents / supervisors
- General employees
- Contractors / sub-contractors
- Visitors

7. Training, awareness & competence:

7.1 Competency-based training, fit-for-purpose

TOPICS:

7.2 Induction:

- Visitors
- Contractors, consultants
- General area orientation & local area orientation
- Employees (booklet to be handed out as well)

7.3 Ergonomics – work with Original Equipment Manufacturers (OEM)

- Reduce back pain in driver & machine operators
- Reduce repetitive strain injury, musculoskeletal injury (man-machine interface) / equipment design, safe method of work
- Materials / manual handling

7.3 Hazard, risk management & behavior / mindset processes
7.4 Specialist training of H&S staff and contractor management
7.5 Employee recruitment, selection, competency & training – screening & verifying stated skills & past history
7.6 Buddy system – mentorship – old hands mentor new hands
7.7 Awareness:

- Hazard of the month
- Communication of industry hazard alerts & incidents
- Company specific site safety alerts / notices
- Internal / international / HCIS
- Safety publications
- Safety incentives
- Safety promotion & campaigns
- HSE employee awards program – recognizing excellence – issued by President/Vice President: Planning & Business Development
- Toolbox early (pre-shift) meetings
- Internet information reference sources:
  - www.myosh.com (Safety solutions site)
  - www.cdc.gov/niosh/ (National Institute for Occupational Safety & Health – Centers for Disease Control & Prevention)
  - www.bsi-global.com (British Standards Institute - OHSAS 18001 System Standard)
  - www.who.int (World Health Organization)

8. Consultation & communication:

8.1 Crew & group safety & toolbox meetings (with action management)
8.2 Sector and national associations:

8.3 Exchange leading / best practice within industry, sharing & learning between the organisation & other companies

8.4 HSE quarterly workshops / seminars for leadership team

9. Documentation

9.1 System to reviewed periodically, update where necessary

9.2 Reporting:

- Internal / corporate
- Insurer – national requirements / broker

9.3 Hazardous materials management – includes Material Safety Data Sheets (MSDS)

9.4 Registers:

- Hoists
- Wire ropes
- Chains
- Fire extinguishers
- Breathing apparatus
- Height rescue equipment
- Training records
- First aid equipment

10. Document & data control

Electronic business management system (EBMS) – Document management, or via intranet

11. Operational control

11.1 Purchasing – safety specifications – products

11.2 Tagging, lock-out & (energy isolation)

11.3 Safety cones & signs, notices & barricades

11.4 Underground:

- Mobile equipment
- Fixed plant & machine guarding
- Cranes & lifting equipment
- Scaffolding
- Working at height (fall prevention)
- Unsupported ground (underground & surface ground control)
- Unventilated areas, confined space & hot work
- Remote loading
- Conveyors
- Boilers / pressure vessels system
- Dust suppression
- Barricades, notices & signage
- Tag board
- Gas detectors

11.4 PPE & clothing, including safety harnesses / other fall arrest devices

11.5 Vehicles & traffic safety

11.5 Workshop safety

11.6 Equipment license register

11.7 Pre-use inspections

11.8 Access control

11.9 Visitor controls

11.10 Underground & surface fire prevention

11.11 Chemical / hazardous substances management

11.12 Change management

11.13 Standards – e.g. electrical testing

11.14 Safe work procedures – for safe systems of work

11.15 Standard operating procedures

11.16 Job safety analyses & pre-emptive risk assessment - forms part of change management – technical, HR, emergency response, procedural, management & operational nature

11.17 Task analysis forms

11.18 Machine guarding

11.19 Permit System:

- Hot work
- Dig
- Access pit mining area
- Confined space entry
- Working at heights
- Electrical safety - high voltage
- Ionizing radiation
- Blasting
- Isolation from stored mechanical energy

11.20 Emergency preparedness & response:

- First aid
- Site evacuation drills
- Fire risk plan
- Crisis management plans / contingency plans, emergency action plan communication on crisis
- Dealing with media / public
- Plant evacuation siren & PA
- Flooding
- Cyanide
- Power failure, gas leak
- Explosive device or bomb threat

12. Performance measurement & monitoring

12.1 Information system for HSE, risk management, document control and action management

12.2 Statistical analyses, using HSE information system

12.3 Performance management

Lagging (trailing) indicators – LTIFR, NLTIFR, AIR, severity ratio, damage incidents etc (contractors + employees)

12.4 Leading (proactive) Indicators – hazards, near-hits, observations, audits, % safe behavior etc

13. Investigations, inspections & corrective action

13.1 Incident/accident reporting & investigation

13.2 Pre-use checklist - operational

13.3 Safety inspections

13.4 Incident reporting, investigation/analysis (using systematic root cause analysis) & management

14. Records & records management:

Statistics & scorecard

15. Audits

15.1 Internal audits (with protocols/checklists) – GOSI, regulations, hazardous substances, contractor safety management

15.2 3rd Party System Audits – CAP

15.3 OHSAS 18001– 3rd party audits or internal

15.4 Insurance brokers

15.5 Housekeeping

15.6 Corporate safety audits

15.7 PPE compliance

16. Management review

- Weekly senior management meetings
- Weekly site operational review
- Internal HSE management review
- Hazard register review
- Regulatory compliance review
- Performance management reviews
- Post-accident review
- H&S management committee

2. Example of a Typical Health Management System

1. Wellness, fitness, diet program (lifestyle)
2. Pre-placement fitness for duty medicals (employees & contractors)
3. On-site primary healthcare (reduce absenteeism, e.g. flu vaccinations)
4. Occupational healthcare – periodic medical surveillance & biological monitoring
5. Occupational hygiene monitoring
6. Emergency medical preparedness & response
7. First aid training
8. Health regulatory compliance
9. Rehabilitation
10. Health scorecard: % reduction in people potentially exposed above the OEL / BEI, reduction in occupational illness rate
11. Off-the-job health
12. Occupational hygiene stressor register – H.E.G.s e.g. dust, noise, temperature, chemicals etc
13. Identification, evaluation, control & monitoring of workplace health hazards and exposures
14. Instrument calibration
15. Fatigue (shift work), including comfort
16. Employee assistance program – psycho-social services
17. Health education & training
18. Working in extreme temperatures
19. Health risk register
20. Smoking policy
21. Sanitation & personal hygiene
22. International travel health related risks
23. Hearing conservation program
24. Ergonomics (repetitive trauma resulting in musculoskeletal disorders), noise-induced hearing loss
25. Lung disease, vision impairment - drivers, poisoning (absorption, inhalation, digestion)
26. Stress & asthma management
27. Dermatitis
28. Company health & emergency response audits
29. Regional healthcare & emergency medical service providers' assessments

3. Typical example of Environment Management System

1. Commitment & policy
   - 1.1 HSE policy – environmental stewardship
   - 1.2 Environmental responsibility included in the terms of reference governing the role of the board
   - 1.3 Code of ethics
2. Planning:
   - 2.1 Environmental aspects & impacts (risk assessment):
     - Aspects identification and register
     - Impacts identification and register
     - Assessments of environmental impact for license applications – including hydro-geological assessments
     - Risk assessment – register and reviews, qualitative and quantitative
     - Contingency plans to address residual risk, reviewed by experts
     - Reviewed by stakeholders
     - Risk assessment completed prior to closure, to identify ongoing liabilities
     - Key aspects to address (within specified timeframes) – CO_2 / greenhouse, ozone depleting substances, suppliers
     - Project management – design, construction & commissioning – input at planning stage
3. Legal & other requirements:
   - General Regulations on the Environment + Rules for Implementation
   - Industry Investment Codes
   - ISO 14001 environmental management standard
4. Objectives & targets:
   - Site specific
   - Internal performance criteria – internal standards where there are no government or external standards or where they are not applicable – e.g. diesel emissions, contractors
   - Values - minimum impact in day-to-day activities / reduce environmental footprint
5. Environmental management programs:
   - 5.1 Flora & fauna
   - 5.2 Cultural heritage (including archaeological) - avoiding disturbance of artifacts of significance
   - 5.3 Visual impact / landscape
   - 5.4 Water (including conservation & treatment, groundwater, surface water, sediment control & in-stream biological monitoring)
   - 5.5 Air quality:
     - Dust and other emissions
     - Climate change – Kyoto protocol / ozone-depleting substances
   - 5.6 Waste – rock, non-process waste (e.g. reduce, recycle, reuse)- cleaner production, safe disposal of residual wastes & process residues, removal of asbestos / PCBs in transformer oil
   - 5.7 Recycling and re-use – used oil, grease, scrap metal, batteries, paper, cardboard, gloves & aluminium cans
   - 5.8 Contaminated sites management
   - 5.9 Chemicals management
   - 5.10 Wastewater management
   - 5.11 Conservation management – biodiversity, native species propagation and planting, endangered species management, wildlife habitat plantings / conservation, weed / pest (predator) eradication
   - 5.12 Energy conservation
   - 5.13 Vibration / noise

5.14 Hydrocarbon management
5.15 Land management plan – future use
5.16 Rehabilitation (through mining life cycle, concurrent reclamation, alternative productive land use, returning land to previous or better use, re-contouring)
5.17 Revegetation studies / research
5.18 Bonding / closure plans – provide additional security to stakeholders
5.19 Contractor environmental management (incl. sub-contractors), including suppliers / customers - environmentally-focused supplier program
5.20 Hazardous materials management
5.21 Exploration – environmental guidelines

5.22 Spill prevention
5.23 Benchmarking & addressing changing external expectations
5.24 R&D (developing better practices & innovating technologies) - with specialists

6. Implementation & operation:

6.1 Structure, accountability and responsibility:
Resources:
- Management / leaders
- General employees
- HSE department staff
- Training
- Financial

6.2 Training, awareness & competence:
- Induction, including contractors
- Legal responsibilities
- Regulatory training, include competencies
- HSE dept skills (qualifications)
- General environmental awareness and motivation
- Knowledge and skill assessment
- Integration into business management systems – required for contractors / new employees etc
- HSE employee awards program – recognizing excellence – issued by President / VP: Planning & Business Development
- Internet information reference sources:
  www.un.org/rights (United Nations Universal Declaration of Human Rights)
  www.iucn.org (World Conservation Union)
  www.globalreporting.org (Global Reporting Initiative)
  www.iso.org (International Management System Standards)
  www.standards.com.au (ISO 14001)
  www.cepaa.org (SA 8000 Social Accountability Standard)
  www.unep-wcmc.org (United Nations Environment Program)
  www.unglobalcompact.org (United National Global Compact)
  www.wbsd.ch (World Business Council for Sustainable Development)

6.3 Communication, consultation & reporting:

6.3.1 Stakeholder identification (industry associations, indigenous communities, investment community, community organizations)
6.3.2 Stakeholder communication (including our own employees)
6.3.3 Internal communication regarding operating requirements
6.3.4 Government organizations:

6.3.5 Non-government organizations
6.3.5 Annual public reporting / community report (accessible to public via internet & some posted), feedback from
stakeholders sought prior to publication – comments incorporated
6.3.6 Consult communities on environmental consequences of activities – completed at licensing phase
6.3.7 Complaints register – feedback and response
6.3.8 Community liaison

7. Environmental management system documentation:

Manual

8. Document control:

- Environment information system
- Records
- Reviewed periodically, updated where necessary

9. Operational control:

- Procedures – storage of chemicals, waste disposal
- Standards
- Environment management applications (between HSE & Ops) – ensuring conformance with internal and external requirements
- Plant / equipment operation, maintenance & testing
- License checklists
- Monitor progress / leading edge / keeping abreast of changes – strategic management of changing requirements

10. Emergency preparedness & response:

- Emergency response / contingency planning
- Impoundment emergency action plans
- Response drills e.g. hazardous material spill
- Clean-up & remediation strategies
- Community involvement in developing & reviewing response plans

11. Measurement & evaluation:

11.1 Monitoring & measurement:
11.1.1 Monitoring standards and procedures
11.1.2 Monitoring (includes stakeholder involvement):
  - Creek / river flow
  - Rainfall
  - Pit water quality
  - Silt pond discharge
  - Compliance boreholes
  - Surface water quality
  - Water storage dam
  - Conductivity
  - Aquatic biological monitoring
  - Phreatic Surface (water table)
  - Rehabilitation
  - Air discharges:
    - Depositional dust fall

        - Total suspended particulates
        - Respirable particulates
        - Meteorological conditions
    - Post-closure monitoring programs
    - Quarterly monitoring reports
    - Trend analyses / statistics

12. Non-conformance and corrective / preventive action:

    - Incident reports, notification, procedure and register
    - Incident response
    - Investigation (using root cause analysis technique)
    - Classification system for incidents
    - Procedure for non-compliance

13. Records:

    - Registers
    - Library
    - Databases

14. Environment system audits:

    - Internal & external license audits
    - Waste audit
    - Insurance audit
    - Bond calculation audit
    - ISO14001 standard audit
    - Report in terms of Global Reporting Initiative Sustainability Reporting Guidelines
    - Company corporate HSE audit
    - Encouraging external involvement in monitoring, reviewing & verifying environmental performance
    - Interviews with external stakeholders (local community, NGOs, regulators, media representatives & government officials)

15. Review & improvement:

    - Management review
    - Management system review
    - Continual improvement

SUSTAINABLE DEVELOPMENT CONSIDERATIONS – LINKS WITH HSE

1. Social impact assessments (for new developments & mine closure)
2. Human rights – endorse Universal Declaration of Human Rights
3. Local community investment – regional economic growth (supply chain management)
4. Indigenous employment & business support
5. Local employment & business support
6. Management of heritage sites
7. External permitting & permissions
8. Government relations
9. Media relations
10. Indigenous affairs – traditional rights of indigenous peoples, including indigenous employment
11. SA 8000 standard – social
12. Staff & contractor behavior
13. Management of culturally significant & religious sites
14. Scorecard – community contributions (expressed as % of pre-tax profit), community relations plan
15. Business ethics & conduct – compliance line, confidential, anonymous reporting
16. System for community donations by employees

SECTION 2 : HAZARD IDENTIFICATION ANALYSIS

2.1 Introduction

In this chapter we go through the various phases of Hazard Identification Analysis (HAZID) for which the objectives are to identify main hazards, to review the effectiveness of selected safety measures and, where required, to expand the safety measures in order to achieve a tolerable residual risk.
By means of the HAZID analysis the primary process, but also non-process, hazards as well as their possible escalations can be identified due to the structured manner of the procedure. Employees can be advised of the relevant hazards concerning their working area

HAZID analyses are usually to be revised when considerable modifications, upgrades or re-design of existing facilities are carried out or if events like accidents, critical situations or near misses call for this. In this context a change, upgrade or re-design is to be considered as essential if process modifications associated with consequences for safety or safety related equipment are involved. This also applies for utilities including buildings, machinery, equipment etc. that do not necessarily contribute to the primary operating objective but which are associated with the process facilities in terms of layout or operation and that are safety relevant. Those being in charge of operations and maintenance and those working in the facilities should have the initial HAZIDs at the start of the project and then thereafter to go through the formal process for possible changes. In principle operators are expected to repeat the analyses at least every few years (3 to 5 years as example) in order to maintain the residual risk as low as reasonable practical

Process Hazard Analysis (PHA) which are a well structured approach, and according to recognised and international best practice and standards. These follows specific requirements as example of which :

- EPSC, IChemE & Chemical Industries Association, 2000, "HAZOP – Guide to Best practice for the process and chemical industries".
- IEC 61882:2001 - Hazard and Operability studies (HAZOP Studies) - Application Guide
- F.P. Lees, 1996, “Loss Prevention in the Process Industries”, Butterworth-Heinnemann, 2nd edition.
- Chemical Industries Association (CIA), 1977, "A Guide to Hazard and Operability Studies".
- AIChE Center for Chemical Process Safety (CCPS), 1992, "Guidelines for Hazard Evaluation Procedures", USA, 2nd edition.
- Wells, G., 1996, "Hazard Identification and Risk Assessment", IChemE, UK.
- ISO-17776:2000, "Guidelines on tools and techniques for Hazard Identification and Risk Assessment"

PHA is mandated by regulations in many countries, for example:

- USA: OSHA Process Safety Management (PSM) programs under 26 CFR 1910.119
- USA: EPA Risk Management Plan under 40 CFR 68.67
- European Union: Seveso II Directive
- UK: Control of Major Accident Hazards (COMAH)

The above regulations themselves and associated guidelines provide valuable information on best practices for PHA. In particular, the US regulations go into considerable detail on what a PHA should contain and how it should be conducted.

The Center for Process Studies (CCPS) of the American Institute of Chemical Engineers (AIChE)has published several documents containing guidelines on PHA, including "Guidelines for Hazard Evaluation Procedures" and "RevalidatingProcess HazardAnalyses".

The CCPS has described procedures for12 methods of performing a PHA. The six most commonly used are said to be:

1. What-If

2. Checklist
3. What-If/Checklist
4. Hazard and Operability Study (HAZOP)
5. Failure Mode and Effects Analysis (FMEA)
6. Fault Tree Analysis (FTA)

The OSHA and EPA regulations permit the same six methods as listed above but allow any other functionally equivalent method to be used. Combinations of methods may also be used.

According to AIChE, the range of applicability of the above six methods is as shown in Table.

The CCPS publications and the OSHA and EPA regulations are perhaps the most useful source of general information on PHA. For specific PHA methods, other more detailed standards are sometimes available.

For HAZOP, an important reference is IEC 61882 "Hazard and operability studies (HAZOP studies). Application guide (British Standard)".

For FMEA, an important standardisIEC-60812 "Analysis Techniques for System Reliability - Procedure for Failure Mode and Effects Analysis (FMEA)". Useful information is also available in the standards of the automotive industry, which uses FMEA extensively; e.g. AIAG's "FMEA" Standard and SAE-J-1739" Potential Failure Mode & Effects Analysis in Design".

For FTA, IEC 61025 "Fault Tree Analysis" is available.

Numerous books and articles have also been written describing best practices for PHA.

Table: Applicability of PHA techniques

Table 1: Applicability of PHA Techniques (ref: AIChE)

Particular Phases in Process Design and Operation	Checklist	What-if	What-if/ Checklist	HAZOP	FMEA	FTA
R&D		✓				
Design	✓	✓	✓			
Pilot Plant Operation	✓	✓	✓	✓	✓	✓
Detailed Engineering	✓	✓	✓	✓	✓	✓
Construction/Startup	✓	✓	✓			
Routine Operation	✓	✓	✓	✓	✓	✓
Modification	✓	✓	✓	✓	✓	✓
Incident Investigation		✓		✓	✓	✓
Decommissioning	✓	✓	✓			

Basically PHAs are structured analysis of the Process Deviations potentially triggering Hazardous scenarios and problems in safely operating the plant. The form of PHA most widely utilized in modern industry is HAZOP (Hazard and Operability Study), which is by far the most structured and useful form of qualitative Hazard Identification for Process. HAZID analysis can be applied as well and example checklists are provided in this chapter which also , providing an hazard identification more aimed to events external to the process, and entering into process hazards in a less systematic way.

Application of Reliability Improvement Program are not normally part of the PHA Review, however during PHA Review these will need to interface with these parallel activities, and one of the final useful outputs of the Review will be the identification of the gaps to be fulfilled for aligning the PHAs to a suitable level sufficient to input in systems specifications, design and IPF analysis (e.g. during SIL - Safety Integrity Level assessment and verification, although this is obviously excluded from present proposal).

2.2 Methodology

Appendix 1 provides a simplified review of the hazard identification exercise as ' high level review ' For Activities of a review specific for the process or activity this will be developed according to the following plan :

Phase 1 : Process Hazard Analysis Initiation

1. Kick-Off Meeting (KoM) : this activity will involve an initial kick-off meeting for the high-level coordination and contacts needed to carry out the job. As part of this, the specialists from our project Team will interface with the relevant specialists from engineering – operation / maintenance and asset teams and they will define jointly the priorities for the PHA Review;
2. Data Collection: this activity will be developed sequentially with the KoM, exploiting the same business trip. It will involve collection of all existing PHAs, and all the applicable reference material from the Project Management. to this end, a suitable interface shall be set-up, from both sides, At the end of data collection a register of documentation (PHAs and supporting documents) will be prepared and circulated for approval. This list of PHAs will represent the agreed scope of work for the initial reviews.
3. PHAs Reviews (Core Activity): A series of Reviews will be developed by the Project Team to verify the compliance as previously described. The Team will comprise, as a minimum, a Senior HAZOP/HAZID and SIL Specialist (with experience of Chairmanship, follow-up, reliability verifications), co-teamed as needed by a Senior Process Specialist and a Senior Instrument Specialist, available on call as needed. For each existing PHA, the necessary verifications will be carried out, by either using appropriate checklists and by engineering expertise. Each PHA will be critically examined producing a Review Report, which will state: *(1) Level of Compliance with Best Practice, (2) Quality of the PHA, (3) identified GAPs and Omissions, (4) further recommendations and actions to be taken, and (5) high level Priority Plan for suitable integration to acceptable levels*. This activity is a Table-Top task and it is expected to be carried out at our premises in Italy. Meetings to discuss specific issues can be convened if necessary, and a final review meeting where the results of the PHA review are presented and discussed to the O &N M and asset specialists and Managers will be convened.
4. Following completion of all PHAs review, the full list of actions and the priority plans produced will be harmonized and consistently collected in an Overall Plan, inclusive of the estimated costs and planning for implementation (which can be used to start the subsequent PHASE 2).

Phase 2 - PHA analysis and gap closure activity approach

PHA Analyses to be integrated, improved, or carried out from scratch, resulting from the findings of PHASE 1, will be offered for in such way to properly answer the NWC needs and expectations.

The detailed development of the PHAs will be aligned with the international standards and best practice previously mentioned (see below section), and it will be essentially carried out as a structured brainstorming, thus requiring a Team Work.

Activities are expected to be carried out for the most part at NWC premises in KSA (although they can be also held at our premises in Italy, if more appropriate), as described below.

The PHA review comprises the following:

- preparation of the PHA sessions (table-top activity to be carried out at the individual sites);
- provision of PHA Chairman for the sessions;
- provision of a suitable PHA recording software for the duration of the sessions (e.g. PHA Works by Primatech, or equivalent)
- provision of a Process Expert for the Project
- provision of an Instrumentation/technical expert for the Project
- Reporting in English language for PHA

The studies will be carried out on the most updated available sets of P&IDs and C&E Matrixes, plus the other additional supporting documentation (PFDs, Plot Plants, etc.). The Role of each Technical Team Member is briefly explained in the following:

- PHA CHAIRMAN:
  He is an experienced, independent technical specialist. He is responsible for dividing the P&IDs and the systems into suitable nodes, leading the study with appropriate guidewords, establishing the detailed work schedule, ensuring that the correct procedure is followed and that notes and results of the study are properly recorded without omissions. He will also resolve any conflicts that may arise during the study, ensuring that the team works toward a common goal by utilizing all team members expertise, and checking on progress of the study. The Chairman is also responsible for issuing the PHA Report, after completion of the review.
- PROCESS AND INSTRUMENTATION EXPERTS:
  They are experienced technical personnel with extensive background in the Process, Technical and Instrumentation discipline, and their role is to support and assist the NWC Team in the analysis, by adding expertise, coaching the team in their respective fields of expertise, and by adding value to the analysis with their knowledge of engineering.
- O & M / ASSETS TECHNICAL GROUP:
  Members of the Technical Group are responsible for providing comments and answers based on their knowledge and experience of the plants, for resolving issues emerged during the study. General rule is that total number of Team members should not exceed 6-8 people to avoid disorganized sessions. The O & M / assets project team should comprise as a minimum the following experts:
  - Process Specialist;
  - HSE Specialist;
  - Instrument Specialist;
  - Other discipline experts (mechanical, electrical, maintenance etc.): available on call.

The PHA technique is a systematic analysis that uses a guide word structured approach to identify deviations from intended process design. The most commonly applied form of PHA to assess safety of process systems is HAZOP, and basically all PHAs of PHASE 2, for being comprehensive, will be structured as a HAZOP. The primary goal of PHA is the identification of Process Safety Hazards and Operability Problems. The main type of document for the application of the PHA procedure is the Piping and Instrumentation Diagram (P&ID), therefore it is fundamental to rely on the most updated issue of the Project P&IDs and to complete the appropriate internal reviews prior to the start of the Activities.

The analysis is based on a number of discrete systems (nodes) in which each P&ID is appropriately divided. In this way the team can focus close attention on a single circuit and then produce recommendations for each system.

Each node will be reviewed by examining which deviations for normal operation can lead to undesired outcomes, and exploring the details of these outcomes. All applicable deviations will be examined combining appropriate guidewords to the relevant process parameters. Standard guidewords, parameters and applicable deviations for a continuous process are listed in the below table

Each deviation will be analyzed identifying the primary potential cause, including, but not limited to:

- Malfunction of process control systems;
- Blockages;
- Operational Error (e.g. opening wrong valve);
- Faulty maintenance activities;
- Failure of power supply, cooling water, instrument air or other utilities.

For each realistic deviation/cause identified, the session will continue analyzing the consequences associated to the deviation/cause and assessing whether these consequences can cause a hazard (where the term "hazard" is intended from a safety or operational point of view, such as fire, explosion, release of flammable or toxic material, off-spec. products, loss of production, etc).

Where a deviation will be found to be credible and the consequence, examined without considering the existing safeguard, will show the potential for a hazard, the Team will consider what mitigating features might exist (e.g. relief valves, shutdown systems, alarms, etc) and whether they could be considered sufficient or not, depending upon the severity of the expected outcomes.

All discussion will be recorded on the spreadsheet, and for each node a complete digression of all relevant parameters/guidewords and related deviations will be compiled under the Chairman and the Team supervision. The complete record of the whole PHA Sessions will be reported in the PHA Report for easy reference during the Follow-up process.

When considered necessary, remedial measures will be required depending on the expected (qualitative) likelihood of the event and its consequence; These measures will be recorded in the worksheets in the form of recommendations aimed at identifying actions to be subsequently followed-up by the project team. Each Recommendation/Action will be identified via a unique reference number.

Each Node discussed during the meeting will be marked in colour in the Master Copy of the P&IDs, to ensure no items is missed and to facilitate the explanations during the sessions. The marked-up P&IDs representing the PHA Master Documents will be eventually attached to the Report for easy reference.

PARAMETERS	**GUIDEWORDS**	**DEVIATIONS**
FLOW	more / less / none / reverse / other than	high flow / low flow / no flow / reverse flow / loss of containment
PRESSURE	more / less / none	high pressure / low pressure / vacuum
TEMPERATURE	more / less / as well as	high temperature / low temperature / cryogenic
LEVEL	more / less / none	high level / low level / no level
STATE/ COMPOSITION	more / less / reverse / part of / as well as / other than	additional phase / loss of phase / change of state / off-spec composition / contaminants / corrosive concentration
CORROSION/EROSION	more	Increase of corrosive condition (e.g. contamination, intermittent wet/dry operation , excessive velocity, wet H_2S, etc)
REACTION	more / as well as / other than	runaway reaction / side reaction / explosion
UTILITY: power, air, steam, nitrogen, cooling water	No	loss of …
UNSTEADY OPERATION: startup, shutdown, maintenance, testing, sampling, drainage	as well as / other than	difficult … / hazardous …
DOCUMENTATION	part of / as well as / other than	incomplete documentation / unclear documentation / incorrect documentation

Table Typical PHA/HAZOP Guidewords/Parameters and Related Deviations for Continuous Processes (only applicable Parameters shall be analyzed)

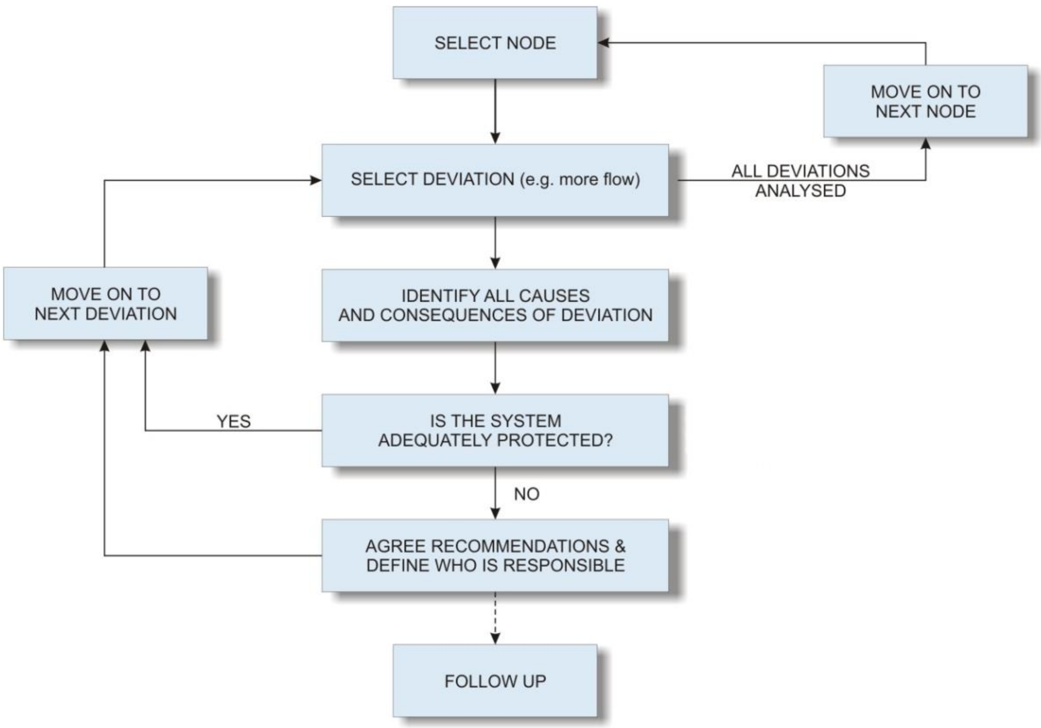


Figure - PHA/HAZOP Standard Flow Scheme

The main steps involved in the PHA study process which was discussed above are schematically indicated in the flow chart of the above figure and are summarized here below in a step-by-step list:

- selection of a Node which contains the specific section of the plant and definition of Node's design intent and process conditions;
- Selection of a relevant Parameter and selection of a Deviation applying a suitable Guide Word to the Parameter (the GW, Parameters and Deviation not applicable for the specific cases will be normally skipped without further analysis);
- identification by brainstorming of potential and credible Causes associated with the deviation and assessment of the possible Consequences associated with each cause (Team work);
- identification of the Safeguards included in the design to protect the System (by preventing the hazard and/or mitigating the consequences);
- agreement on suitable Recommendation(s) for action if the existing safeguards are considered to be inadequate based on the Team judgment. If an immediate solution is available and acceptable to the team, the proposed solution is recorded in the Worksheet to facilitate the follow-up. Where solutions are unlikely to be found without a more detailed technical evaluation, the Chairman will record the problem for a separate later assessment. All recommendations shall be appropriately evaluated during the follow-up activity, which is NOT part of the PHA;
- repetition of the above procedures until all relevant GWs have been applied to all Parameters within each Node of the process system until the complete system within the scope has been examined by the Team.

A typical format of the Working sheets is shown in the figure below and includes General Information, Node description, Parameter, possible deviation (parameter and guide word), deviation causes, consequences, existing safeguards, recommendations, responsible party (action owner) and possible comments. The appearance of the Worksheet and the Columns can be customized.

Facility: Test Facility

Session: (1) 11/01/2007 Revision: (0)
Node: (1) Description of Node 1 (e.g. Fractionator Column Bottom including pumps, etc)
Drawings: P&ID XYZ...
P&ID XYW...
Parameter: Flow

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY
No	1. No Flow from Fractionator Bottom	1.1. Operating Error closing EBV-201 during normal operation	1.1.1. Damages to P-013A or B seals leading to potential leak and fire (temperature is above AIT)	1.1.1.1. Operating Procedures and Operators Training Programme 1.1.1.2. Ergonomic design to prevent accidental activation 1.1.1.3. FAL-204	:	
		1.2. Pump P-013A stop	1.2.1. High level in fractionator bottom potentially sealing-off the Scrubber from the SV-208A/B/C/D causing overpressure	1.2.1.1. FAL-204 1.2.1.2. LAH-206 1.2.1.3. Steam Driven stand-by Pump P-013B is available	1. Provide an automatic Start-up of Spare Pump P-013B/A on low pressure at discharge, including the relevant instrumentation	Action Owner
			1.2.2. Coking of the Scrubber Grid leading to potential partial plug	1.2.2.1. See Above		
	2. No flow back to fractionator Bottom	2.1. Malfunction of FIC-203 closing FCV-203	2.1.1. Increase of Temperature in Fractionator Bottom due to loss of cooling by E-010 with consequent closure of TCV-211 by TIC-211. Overheating of Wash Oil Strainers F-008A/B and Steam Generator E-010. Coke formation in the bottom of Fractionator which will transfer to Scrubber Grid.	2.1.1.1. FALL-xxx generating ESD	2. Increase Design Temperature of Pumps P-013A/B, Wash Oil Strainers F-008A/B, Steam Generator E-010 (tube side) and relevant piping up to 415°C (operating Temperature of the liquid coming from the bottom of the Fractionator Grid)	Action Owner
More	3. More Flow from Fractionator Bottom	3.1. Both Pumps P-013A and B running at the same time (e.g. Transmitter failure, local IA failure, operator error)	3.1.1. No significant problems			
	4. More flow back to	4.1. Malfunction of FIC-203 fully	4.1.1. Minor process upset with	4.1.1.1. FAL-204	:	

Figure - PHA/HAZOP Typical Worksheet

Sessions Organization

The Work is organized in daily sessions of the approximate duration of 6-7 hours, with short breaks. Typically, considering the normal development, the following tasks are scheduled for each PHA session:

- First day: Introductory Part:
  - Formal Opening of the Session,
  - Overview of the Project,
  - Overview of the PHA process;
- First day to Last day: Perform the PHA (core activity);
  - The HAZOP leader will introduce the study, setting out objectives, the HAZOP process for team members, and roles.
  - The design engineer will give a brief description of the operation of the system under study, outlining the major issues he has had to address in the design, and the key design parameters and conditions.
  - The leader will select a line diagram and mark up the first section of pipework and equipment that is to be studied (the node) . He will use the list of guidewords to determine possible deviations from the design intent, the likely causes and the consequences. The team should consider to what extent alarms, trips and ultimate protections such as the design envelope mitigate the effects of the deviation.
  - If the deviation from the design intent is considered to be serious and any mitigations do not ameliorate the situation adequately, the team should consider if there is an obvious solution. If this solution cannot be found quickly, the team should define the problem as a simple action for resolution outside the study session.

- The cause, the consequence, the safeguards (eg protective systems), any proposed actions and the person nominated to resolve the problem should be recorded on a worksheet (Appendix 2 shows a typical worksheet).
- Each page of the worksheet should be clearly identified by means of the P&ID number, the node number being studied and a continuation number.
- The review process will proceed from one guideword to the next, iterating steps (c) to (e).
- It is the task of the team leader to draw from his experience to prompt the team to consider all potential hazards appropriate to the area under study, if necessary by him making reference to check list 3 .
- As the examination each line or piece of equipment (the node) is completed, it will be colour coded on the P&ID to indicate it has been studied. The study then moves on to the next node. Depending upon the complexity of the P+ID's and the intent of the HAZOP, there can be a number of nodes on each P+ID or alternatively a single node could extend across several P+ID's.
- When each P&ID has been studied, it should be checked for lines or equipment that have not been colour coded. Lines that have not been colour coded must be HAZOP'd using the procedure defined above unless those parts of the P+ID's are excluded from the scope of the HAZOP. The breakpoints between the excluded scope and the study scope must be clearly marked. The parts of a P+ID not HAZOP'd should be labelled accordingly.

- Last day: Closure of activities:
  - Review main findings of the PHA,
    - The team at the first opportunity will review recorded actions - ideally at the next meeting and the agreed actions passed to the client at the earliest stage.
    - Some clients require the HAZOP worksheet is projected on to a screen in the meeting whilst it is being created. This method allows consensus over what is recorded on the worksheet to be seen to be achieved. However it significantly prolongs the review process since time can be spent debating semantic issues which distract from consideration of the technical ones the team has been assembled to deal with.
    - The most expedient method is for the team leader/secretary to edit the draft minutes and provide a hardcopy for review the next day by team members. If time and cost are not a consideration and the layout of the HAZOP room permits it, then projecting the worksheet onto a screen in the meeting room should be considered.
    - If agreed in advance the HAZOP Secretary will provide the client with a copy of all the worksheets generated in the meeting and a recommendations summary list before the HAZOP team demobilises. Depending upon the recording software being used and the needs of the client, copies of the action response sheets can be passed on before the team demobilises. Where the client requires the generation of action response sheets, the normal arrangement will be for these to be submitted whilst the final report is being drafted.
  - Formal Close-out of session.

    A final written report will be prepared. It will typically include some the following, depending upon the intent of the HAZOP and the needs of the operator:

    - A summary
    - An introduction
    - The terms of reference and scope
    - The methodology
    - A presentation of the main findings
    - A list of recommended actions
    - A list of HAZOP attendees, as an appendix

- All worksheets, as an appendix
- A list of HAZOP drawings, as an appendix
- A3 sized P+ID's marked up with HAZOP nodes, as an appendix

At the end of all PHAs a Recommendations Register will be produced, including all recommendations aroused from the PHAs executed in Phase 2.

FOLLOW-UP and verification activities

At the end of Phase 2 PHAs, a series of recommendations will be produced and listed for Follow-Up and project implementation. The follow-up activity is aimed at documenting the actions taken to address all the recommendations. The Person/Dept. identified in the (Action) "by" column of the Worksheets (see below) is responsible for a timely implementation of the Actions arisen from the Review.

Check List (1) Piping

Change in Quantity	High/Low Flow No Flow Reverse Flow
Change in Physical Condition	High/Low Pressure High/Low Temperature Hydrate/Ice/Slush Change in Viscosity/Wax Froth/Foam/Slugs
Change in Composition	Change in Chemical Gomposition/DensityfMW/$C0_2$/H_2S Changes in Water/Oil Cut Debris/Solids/Sludge/Scale Cross Contamination Too much/too little additive
Operation	Change in Mode of Operation Isolation/Maintenance/Purge
Start-up/Shut-down	Testing Commissioning Maintaining / Modifying
Emergency	Service Failure
Effluent	Compatibility
Effect on Downstream Systems	Knock-on Communication

Check List (2) - Equipment

Vessels	**Pump**	**Heat Exchangers**
Pressure deviations	Isolation/Draining/Flushing	Temperature deviations
Level deviations/bunding	Loss of Seal/Seal Flush	Pressure deviations
Temperature deviations	Increased Solids	Contamination
Vortex	Increased Specific Gravity	Fouling
More/Less Mixing	Minimum Flow	Leakage
More/Less Layering	Others	Drainage
Increased velocity	Cavitation	Flushing
Sediment	Incorrect NPSH	
Start-up/Shut-down/Purging	Purging	
Fouling	Dead head	
Capacity		
Dip Legs		

Compressors	**Filter** **Pig Launcher/Receiver**	**Vents/Drains**
Blowdown Temperature	Isolation	Isolation
Change in Pass out/Pass in (See Surge)	Depressurising/Draining	Cross Flow/Reverse Flow
Horse Power Limitation (See MW)	Purging	Pressure Rise/Restriction/Choke
Local Power Failure (See Segregated Operation)	Filling/Pressuring	High Back Pressure in Vent Line (Choose own valve)
Lutes in Piping	Broken Flow	Flashing/Cooling
MW (Molecular Weight) Change	Regeneration	Elevation Change
Seals/Bearings/Rundown/Blowdown		Sequence in the Vent/Drain header
Segregated Operation (See Local Power Failure)		Air Ingress
Start-up/Shut-down		+ Piping Check List
Stone Wall		Phase Flow
Surge (See MW)		
Vents/Drains		
Auxiliaries		
Contamination (Seal/Lube)		
Control		
Leak Of f		
<u>Reciprocating</u>		
Loading/Unloading		
Pressure Control		
Pulsation		

Check List (3) - General

Access
Area Classification
Auto Ignition
Blanketing
Carcinogen/Toxic Materials
Compatibility
Condensation/Heat Loss
Control
Corrosion
Cracking
Cyclic Loading
Drainage/Slope of line
Electric Shock
Electro Potential
Emergency Equipment Fixed/Portable
Erosion
Failure Mode
Fire
Foam
Frothing
Hammer
Impact
Inerts
Interlocks
Lightning
Metallurgy
Monitoring
Noise
pH
Pre Commissioning/Construction
Pulsation
Electro Magnetic
Radiation Thermal
Nuclear
Rain Water/Sea Water
Reaction (Chemical)
Reaction (Mechanical)
Sampling
Spading
Specification Change
Start/Stop
Static Electricity
Short Term Exposure Level/Threshold Limit
Value
Syphon
Time
Un-revealed fault
Vacuum
Vibration
Vortex
Winterising

Sheet No:
Date:
Line No / Tag No
Description:

Guideword	Deviation	Cause	Consequence	Mitigation	Ref Num	Recommendation	Action By

Appendix 1 : Example HAZID Worksheets as high level review

Section 1: Global issues

No.	Guide word	Potential Hazards and effects	Threats	Controls	Recommendations	Action
1.1 Natural and Environmental Hazards						
1.1.1	Climate Extremes	Temperature Wind Dust Sandstorms	Pipeline and associated facilities are exposed to extremes and may cause failure	Complete system is designed for worst possible climate extremes.	NI – design as per previous and based upon experience	None
1.1.1	Climate Extremes	Temperature Wind Dust Sandstorms	Pipeline and associated facilities are exposed to extremes and may cause failure	Complete system is designed for worst possible climate extremes.	NI – design as per previous and based upon experience	None
		Lightening	Thunderstorms	Lighting arrestor	Evaluate	Assess requirements, if any
		Earthquakes	None Identified (NI)			None
		Erosion	NI	Complete system is designed as per standards to prevent erosion		None
1.2 Created (Man Made) Hazards						
1.2.1	Security Hazards	Internal and external security .malicious threats	Malicious damage/sabotage	Limited access; Alarm in Control room if gate is opened	NI	NI
	Terrorist Activity	Riots, civil disturbance, strikes, military action, political unrest		No possibility	NI	NI
1.3 Health Hazards						

No.	Guide word	Potential Hazards and effects	Threats	Controls	Recommendations	Action
1.3.1	Disease Hazards	Endemic diseases, infection, malarial mosquitoes, hygiene - personal and/or catering, contaminated water or foodstuff	Personal Health issues	No possibility		None
1.3.2	Asphyxiation hazards	Asphyxiating atmospheres, failure to use appropriate PPE, vessel entry, working in confined spaces, smoke, exhaust	Same as above		PPE (Personal Protection Equipment) are required to be carried essentially	Operation manual should clearly include the usage of portable H2S detector and PPE by the personnel.
1.3.3	Toxic	Hazardous atmosphere, asphyxiating atmosphere, chemicals in use	Same as above	No possibility		None
1.3.4	Physical	Noise, radiation (ionising, e.g. radioactive scale or non-ionising, e.g. flares, UV, sunlight), ergonomics	Same as above	Noise expected to rise only during venting at the time of maintenance	Ear plugs are required for this operations	Operation and Maintenance manual should clearly include the usage of ear-plugs by the personnel
1.3.5	Mental	Shift patterns	Stress	Unmanned operation		None

No.	Guide word	Potential Hazards and effects	Threats	Controls	Recommendations	Action
1.3.6	Transport	Excessive journeys, extreme weather, quality of roads	Tiring	Limited distance; Travelling schedule is flexible		None
1.4 Contracting Strategy						
1.4.1	Prevailing influence	Stability and contractual conditions, contractor selection constraints	Using different standards make tracking of standard difficult and could cause problems	Rules and procedures	HSE rules and regulations should be adhered to	Ensure effective implementation
1.4.2	Legislation	Governmental contracting requirements			All the requirements should be fulfilled	
1.4.3	External Standards	Additional engineering and construction standards	Same as above	None		
1.4.4	External Environmental Constraints	Governmental environmental requirements			HSE rules and regulations should be adhered to	Ensure effective implementation
1.5 Hazards Recognition and Management						
1.5.1	Hazard Studies Environmental studies	HAZOP, QRA, HSEIA etc		Studies	Conduct HAZOP Qra and HSEIA as per Company guidelines	Implement HAZOP, QRA and HSEIA
1.5.2	Project Controls	Quality assurance (change control, interdepartmental involvement and interfaces)		NPCC Quality manual is available	HSE Quality manual should be adhered to	
1.6 Competency						

No.	Guide word	Potential Hazards and effects	Threats	Controls	Recommendations	Action
1.6.1	Level of Indigenous Training	Quality of local workforce and contractors	Maloperation	ATHEER have similar set-up existing and competency will be incorporated within corp. policies		NPCC to ensure that local workforce will be competent to execute the job as per HSE regulations to ensure minimisation of human error
1.6.2	Training Requirements		Same as above			
1.6.3	Level of Technology		Same as above			

Section 2: Process specific items

No.	Guide word	Potential Hazards and effects	Threats	Controls	Recommendations	Action
2. 1 Control Methods/Philosophy						
2.1.1.	Manning/operations Philosophy	Effect on design, effect on locality (Manned, unmanned, visited)		Only patrolling is planned as per existing stations	NI	
2.1.2	Operations Concept	Over simplification		Well established procedures as per existing systems	Ensure Standard Operating Procedures (SOP)	SOP to be implemented.
2.1.3	Maintenance Philosophy	Plant/train/equipment item, heavy lifting, access, override, bypass, commonality of equipment, transport		Preventative maintenance programme (PMP)	Ensure effective PMP to minimise downtime etc. Access and egress to be unhindered and allow safe working (e.g., collision free).	PMP and permit to work systems to be implemented.
2.1.4	Control Philosophy	Appropriate technology, (DCS/local panels)	Any Automatic operation?	Same as above	NI	
2.1.5	Manning Levels	Accommodation, travel, support requirements. Consistency with operations and maintenance, etc philosophies			NI	
2.1.6	Emergency Response	Isolation, ESD philosophy, blowdown, flaring requirements		Back-up systems	Loss of utilities to be managed via back up support	Ensure effective back up support and periodic checks taken.
2.1.7	Concurrent Operations	Production, maintenance requirements				
2.1.8	Start-up Shutdown	Modular or plant		Well established		

No.	Guide word	Potential Hazards and effects	Threats	Controls	Recommendations	Action
		wide		procedures as per existing systems		
2.2 Fire and Explosion Hazards						
2.2.1	Stored Flammables	Improper storage, operator error (release), defect, impact, fire (mitigation measures include: substitute non flammable, minimise and separate inventory)	NI			
2.2.2	Sources of Ignition	Electricity, flares, sparks, hot surfaces (mitigation measures include: identify, remove, separate)	NI			
2.2.3	Equipment Layout	Confinement, escalation following release of explosive or flammable fluid (operator error, defect, impact process control failure, corrosion), module layout/proximity, orientation of equipment, predominant wind direction	Congestion	Layout of parallel equipment (filters, pressure reduction and metering) to be reviewed with regard to jet fire and impingement effect.	Incorporate in QRA	QRA issue

No.	Guide word	Potential Hazards and effects	Threats	Controls	Recommendations	Action
		(mitigation measures include: reduce degree of confinement, spacing based on consequence assessment, escalation barriers)				
2.2.4	Fire Protection and Response	Active/passive insulation, fire/gas detection, blowdown/relief system philosophy, firefighting facilities			None specific (NS) other than generic action	Emergency response procedure to be addressed in HSEIA
2.2.5	Operator Protection	Means of escape, PPE, communications, emergency response, plant evacuation			NS	NI
2.3 Process Hazards						
2.3.1	Inventory	Excess hazardous material (mitigation measures include: minimise hazardous inventory, alternate processes and utility systems)			NS	NI
2.3.2	Release of inventory	Excessive process stress, impact (penetration by foreign object),		Refer to comment under impingement effect and QRA	QRA aspect	QRA issue

No.	Guide word	Potential Hazards and effects	Threats	Controls	Recommendations	Action
		process control failure, structural failure, erosion or corrosion (mitigation measures include: recognise and minimise process hazards during design, inherently safe plant, containment and recovery measures)				
2.3.3	Over Pressure	Offsite sources, process blockage, thermal expansion, connection of process to utility systems, chemical reaction	NI		NS	
2.3.4	Over/under Temperature	Atmospheric conditions, blowdown, fire, hot surfaces, chemical reaction	NI		NS	
2.3.5	Excess/zero Level	Overfill storage tanks, loss of function in separation vessels, blowby to downstream vessels				
2.3.6	Wrong Composition/Phase	Offsite contamination, failure of		Covered in HAZOP		

No.	Guide word	Potential Hazards and effects	Threats	Controls	Recommendations	Action
		separation process, build-up of wrong phase (sand, hydrates, etc), toxic substances				
2.4 Operational Hazards						
2.4.1.	Rupture of Adjacent pipeline in the corridor	Rupture may cause hazardous situation	Unsafe situation	Refer to comment under impingement effect and QRA	QRA aspect	QRA issue

Section 3: Site specific items

No.	Guide word	Potential Hazards and effects	Threats	Controls	Recommendations	Action
3.1 Effect of the Facility on the Surroundings						
3.1.1	Geographical - Infrastructure	Plant location, plant layout, pipeline routing, area minimisation	NI		NS	
3.1.2	Proximity to Population	Security		Refer to Global section	NS	
3.1.3	Adjacent Land Use	Crop burning, airfields, accommodation camps	NI		NS	
3.1.4	Proximity to Transport Corridors	Shipping lanes, air routes, roads, etc	NI		NS	
3.1.5	Environmental Issues	Previous land use, vulnerable fauna and flora, visual impact		HSEIA	Incorporate within HSEIA	HSEIA
3.1.6	Social Issues	Local population, local attitude, social/cultural areas of significance	NI		NS	
3.2 Infrastructure						
3.2.1	Normal Communications	Road links, air links, water links				
3.2.2	Communications for Contingency planning					
3.2.3	Supply Support	Consumables/spares holding				

3.3 Environmental Damage						
3.3.1	Continuous Plant Discharges to Air	Flares, vents, fugitive emissions, energy efficiency		HSEIA	To be addressed in HSEIA	HSEIA
3.3.2	Continuous Plant Discharges to Water	Target/legislative requirements, drainage facilities, oil/water separation		HSEIA	To be addressed in HSEIA	HSEIA
3.3.3	Continuous Plant Discharges to Soil	Drainage, chemical storage		HSEIA	To be addressed in HSEIA	HSEIA
3.3.4	Emergency/upset Discharges	Flares, vents, drainage		HSEIA	To be addressed in HSEIA	HSEIA
3.3.5	Contaminated Ground	Previous use or events		HSEIA	To be addressed in HSEIA	HSEIA
3.3.6	Facility Impact	Area minimisation, pipeline routing, environmental impact assessment				
3.3.7	Waste Disposal Options			HSEIA	To be addressed in HSEIA	HSEIA
3.3.8	Timing of Construction	Seasons, periods of environmental significance	NI		NS	
3.4 Utility Systems						
3.4.1	Firewater Systems		NI		NS	
3.4.2	Fuel Gas		NI		NS	
3.4.3	Inert Gas			Carried as and when required in controlled manner		
3.4.4	Diesel Fuel		NI		NS	
3.4.5	Power Supply	Loss of signal		Back-up power (UPS) for all signals	NS – refer to loss of utilities	None
3.4.6	Communication	Loss of information in Control room		Alarm is provided.		

No.	Guide word	Potential Hazards and effects	Threats	Controls	Recommendations	Action
3.4.7	Drains					
3.4.8	Inert Gas	Use of Nitrogen purging		Maintenance procedure	Ensure effective control and within SOP	Control and SOP
3.4.9	Waste Storage and Treatment		NI	NS		
3.4.10	Chemical/fuel Storage		NI	NS		
3.4.11	Potable Water		NI	NS		
3.4.12	Sewerage		NI	NS		
3.5 Maintenance Hazards						
3.5.1	Access Requirements	Refer to Process – Control Methods		Existing maintenance procedure to be followed		
3.5.2	Override Necessity					
3.5.3	Bypasses Required					
3.5.4	Commonality of Equipment					
3.5.5	Heavy Lifting Requirements					
3.5.6	Transport					
3.6 Construction/ Existing Facilities						
3.6.1	Tie-ins (shutdown requirements) Concurrent Operations	All aspects to be within SOP and executed under strict supervision. As above		NS Nothing further	Ensure hot tapping etc all conducted under controlled conditions.	Management and control
3.6.2	Reuse of Material	As Above		Nothing further		
3.6.3	Common Equipment Capacity	As Above		Nothing further		
3.6.4	Interface - Shutdown/blowdow	As above		Nothing further		

No.	Guide word	Potential Hazards and effects	Threats	Controls	Recommendations	Action
	n/ ESD					
3.6.5	Skid Dimensions (weight handling/equipment (congestion)	As above		Nothing further		
3.6.6	Soil Contamination (existing facilities)	As above		Nothing further		
3.6.7	Mobilisation/ Demobilisation	As above		Nothing further		
3.7 Contingency						
3.7.1	Geographical Infrastructure	Plant location, plant layout	NI		NS	
3.8 Planning						
3.8.1	Recovery Measures	Medical support, firefighting support, spill leak/clean-up support, security/military support, evacuation	NI		NS	

SECTION 3 : CRITICAL ASSET IDENTIFICATION

3.1 Introduction

The approach to the AIMS (asset integrity management systems) which is to be discussed in the next chapter will be explained as involve several technical, operational and organizational issues:

- Checking the identified integrity risks and if necessary update them (revision and comparison with equipment supplier standards and business expectations .
- Assessing the potential impact of loss of integrity and malfunctions on the business, people and the environment.
- Determine appropriate strategies for the integrity risk management (fit-for-service, residual life etc.).
- Establishing and implementing the policies, processes and procedures appropriate for the asset management.
- Revise and update Key Performance Targets (KPTs) and Indicators (KPIs) to monitor the effectiveness of processes and systems performance
- Reviewing , revising and updating the implementation of appropriate responsibilities within organization – this includes the providing the tool to estimate adequate resources in terms of time, budget, resources and information , maintain and ensuring skills (i.e. through specific training) and of course the systems to support communication, cooperation and change management.
- Effectiveness of failure and malfunction investigation

Although not part of the context of this book the role of the internal auditing to verify how best to optimize the asset life cycle can be achieved quite often without major capital expenditure by better planning, improved training and clear statement of performance standards in testing and maintenance routines

Particular issues that may need to be looked at , as general issues are

- Poor understanding of potential impact of degraded, non-safety-critical plant and utility systems on safety-critical elements in the event of accident.
- The need to strengthen the technical authority in the organization.
- Ensuring there is no over complication which may blur the understanding of the state of the plant – ie complexity of SCADA , categorizing and recording equipment which was overdue for maintenance (information delay)
- Ensuring there are no issues in cross organizational learning processes and mechanisms and lessons learnt , continuous improvement process.

The auditing process, which again , is not covered in this book involves the process of

- Interviews with operations and maintenance management personnel to understand the processes in place
- and implementation of standards and procedures
- Interviews with contractors and maintenance personnel to verify the competency
- Sampling of equipments records for completeness and compliance with procedures
- Observation of operation and maintenance work in progress for compliance with procedures

In this chapter we cover the system for critical identification of assets. It is noteworthy to point out that the the IIMM (International Infrastructure Management Manual, NAMS Limited, 2011) defines Maintenance as:
"All actions necessary for retaining an asset as near as practicable to its original condition, but excluding rehabilitation or renewal"
Maintenance does not increase the service potential of the asset or keep it in its original condition, it slows down deterioration and delays the time when rehabilitation or renewal is required. It is a mechanism to ensure that assets continue to deliver the required level of service.

Maintenance requirements and costs change over the life of the asset. They will sometimes be apparent early in the life ("cradle" failures) but more typically maintenance needs increase as the asset ages and deteriorates. Maintenance needs and priorities also depend on asset criticality, function, geography, environment and operating procedures.
Given the significant costs of maintenance over the asset life cycle and the importance of the service provided, it is vital that an approach to maintenance management based on world class practice is fostered within the organization.
Life cycle decision making involves making choices between different mixes of maintenance, rehabilitation and renewal activity across an asset portfolio. Typically, maintenance costs are regarded as operational or OPEX, with rehabilitation and renewal being replacement capital or CAPEX costs. Maintenance cannot be addressed in isolation, it must be linked to the rehabilitation or renewal strategies for the asset.
In situations where asset renewal is deferred, the condition of an asset will typically deteriorate increasing the maintenance need. On the other hand, an asset which is regularly rehabilitated or replaced would be expected to have a lower maintenance demand.

The Anatomy of Asset Management states: "*Organizations from a wide range of industries are quoting 20%, 40% or even 50% gains in business performance, while simultaneously controlling costs, risks and long term capability.*"(reference 1)
Chris Lloyd at al (including Australia's Dr Penny Burns, publisher of the AMQI (reference 2) writes: "*Economic and natural resources are finite, unlike the demands made on them. Organizations seeking to make best use of limited resources have hard choices to make. Choices which concern the reliability and availability of physical assets are particularly difficult*."(reference 3) Asset efficacy could be added to reliability and availability.
This contemporary thinking highlights the importance of ensuring that assets meet the required standards in respect of functionality, operability, durability, reliability, availability, maintainability, safety, risk management, effectiveness, and efficiency through the planned lifecycle of the asset. The primary objective is ensuring asset contribution to business outcomes continuity as well as stable, effective and efficient service delivery from assets to the required standard, founded on optimum asset performance

The Institute of Asset Management: An Anatomy of Asset Management: Issue 1.0, December 2011 advocates that: "*Most organizations that are dependent on assets (owners and operators), face growing pressure to reduce cost, capital investment and operational budgets!*" and poses the following questions:
- *Are future business consequences understood?*
- *Is the risk profile associated with the asset portfolio, and how this may change over time, understood?*
- *Can planned asset expenditures be justified to external stakeholders?*
- *How effectively can project spend be prioritized when facing funding or cash flow constraints?*
- *Is the appropriate asset data and information to support AM decision-making easily available?*"8
This contemporary thinking goes on: "*As organizations are coming under increasing pressure to deliver more for less, it is imperative that these types of questions can be answered. Where these decisions impact on assets, asset performance, risk or net value realization, it is the Asset Management communities' responsibility to articulate these implications and the adoption of a holistic Asset Management approach is essential to enable this. Organizations that have developed their capabilities in Asset Management to a relatively high level of maturity can answer these questions with a high degree of confidence. This helps enormously when dealing with shareholders, regulators, customers, investors or politicians who do not have the time or the skills to understand the long-term implications of the decisions they make.*"
Application of this approach, combined with an understanding of the critical aspects that can significantly impact the way asset management is applied in practice, can be achieved through the development of an Asset Management Framework. This is then rolled out through the various elements in a controlled, structured and prioritized way to ensure limited resources are applied to maximum efficacy.

World class organizations have a well defined asset management framework that they align their asset management practices with.
This includes a high level alignment between the organization's mission and vision and its asset management

policy and strategies. Maintenance protocols form an integral component of the overall approach to how the assets are managed and the maintenance policies, strategies and protocols should be guided by an all-encompassing an Asset Management Framework.
Best practice asset management practices, methodologies, tools, information systems and data structures will be used to make decisions that optimize the balance between levels of service, risk and life cycle cost for customers and stakeholders.
Asset management frameworks to be considered with respect to the *Asset Maintenance Strategy* and *Asset Maintenance Manual* are:

- PAS 55
- ISO 5500 Asset Management Standard
- The Institute of Asset Management (IAM)
- International Infrastructure Management Manual (IIMM)

The aim of this section is to describe the asset maintenance activities need to be prioritized as outage time and budget for the maintenance work that needs to be carried out are often limited.
With a finite quantum of time, resource and funding availability, it is critical for an organization to have a systematic, transparent and consistent process for identifying maintenance type and prioritizing maintenance activity. This framework is required for an organization to documents the rules, assumptions and logic to be used in selecting suitable maintenance types, and provides an organization's asset team a framework for the decision making process. This will assist also the organization to maximise the return on investment and minimise the risk under the constraints of time and budget.
In order to implement an optimized and prioritized maintenance regime, asset criticality and asset failure risks need to be assessed. This section describes the steps to be undertaken in carrying out risk and criticality assessment.

Regular gap analyses of appropriate and current practices of an organization or site's asset management strategy will help drive the ongoing identification of improvement actions. It is critical to evaluate and prioritize improvement actions in order to define the highest priority area that has the greatest impact on asset management outcomes.
The asset management improvement actions should be structured around the following areas:

- Processes improvements
- Systems improvements
- Data improvements
- Implementation improvements

Increasing the sophistication of maintenance strategy requires the optimization and balancing of technical levels of service, life cycle cost, and the criticality of each asset. Maintenance planning Improvement needs to be focussed on ongoing review and adjustment of levels of service and/or maintenance budget to achieve an optimized maintenance plan

An appropriate action plan as a general approach towards identifying problems and solutions is as follows. This is an underlying general working concept

Problem Solving Step	Deliverables	Tools & Tips
1. Define the problem	Write a problem statement and consequence of failure	Select one problem to begin (if there are several, explain their relationship with the one chosen) Include the metric this problem supports
2. Collect data and evidence	Quantify needs with metrics Collect & check data Establish current state Establish future state / goal	"Walk the process" and document using a process map (if applicable) Gather data to quantify the problem with the "as-is" process, ensure data accuracy Establish a target / improvement goal for project
3. Identify root causes	Make a list of inputs Prioritize the list of inputs	Ask "why, why, why?" to facilitate brainstorming Prioritize root causes by "voting" or by gathering data
4. Identify corrective actions	Generate solutions; either existing or new Prioritize solutions	Brainstorm multiple solutions to address each cause Apply "mistake-proofing" if possible; what can be done to ensure the process is done correctly each time Assess solutions and determine which best addresses the needs
5. Implement corrective action	Pilot & implement the selected solution(s)	Test the solution or process change
6. Review action	Review the effectiveness of the solution(s)	Validate that solution provides the expected benefits; identify other changes as needed to meet target
7. Observation to ensure efficiency	Validate the change	Gather data to determine if desired performance has been achieved over time
8. Document the result	Develop plan to monitor process	Monitor and document outputs & control inputs

3.2 Life Cycle Assessment Management

All assets must all be properly and efficiently managed in order for the system as a whole to function as intended, delivering continuous services to customers, minimising failure risk, and achieving optimum economic life-cycle costs over the life of all assets. This involves many different work activities, including inspections, operational activities, planned and unplanned maintenance, rehabilitation and asset replacement over the life of the assets. Lifecycle activities include operating, maintaining, repairing, refurbishing, replacing, expanding or improving assets, and possibly disposing of them altogether when no longer required. Throughout this cycle, there are three key principles that underpin the effective management of public assets:

- recognition of the economic value of assets, including economic consumption over time and delivering long
- term equity to stakeholders and customers who use the service (i.e. today's users are not financially penalised to benefit tomorrow's users)
- targeting economic efficiency using economic and risk-based analysis techniques to optimize asset expenditure over the asset's lifecycle (i.e. the right actions are taken at the right time to maximise value for money)

- the role of the business as a "steward" of the assets, a long-term role that can be quantified in performance terms (i.e. there is a sense of responsibility for the long term well-being or sustainability of the assets).

Even for commercial organizations, similar principles apply. Long term investment decisions in new and upgraded assets may also be driven by mandated standards, future service expectations, the price customers are prepared to pay for the service, and the level of risk.

3.3 Life Cycle Decisions

Asset management decisions involve selecting the most appropriate actions to take during the life-cycle of the asset. For example, do you do nothing, maintain, repair, refurbish, replace or upgrade an asset? Is preventive maintenance worthwhile on an asset?

Typically, there is some uncertainty as to the life an asset will achieve before it "fails", as shown by the two red curves, and the blue bell curve shows an expected distribution of asset lives amongst a group of similar assets. Intervention or management tactics will differ depending on the criticality of an asset, which in turn relates to the consequences of failure on the service outcome. For example, a sole pump serving an important plant would be regarded as critical. An intervention should be targeted earlier in the life-cycle of the asset in managing this risk. For assets for which failure is not critical, where there are minimal consequences and the asset can be readily repaired or replaced, then a "run-to-failure" strategy would be appropriate.

In making decisions targeting economic efficiency, the following need to be considered:

- Expected future stream of operating and maintenance costs over the lifecycle compared to the periodic costs of renewal or major treatments, using net present value (NPV) analysis. These represent direct costs to the agency and analysis should result in an internal economic efficiency outcome
- Economic impacts of risk, which can be considered solely internally or at society level. For example, if an asset failure results in closure of a facility for an extended period of time there will be an economic impact on customers who are adversely affected as well as any direct cost impacts to the agency. Economic impacts can be assessed using standard risk management techniques (consequence and likelihood), and converted into equivalent financial terms if appropriate.

The level of acceptable risk to the business as well as its customers also needs to be considered. For example, a significant investment to only marginally improve system reliability may be judged not worthwhile. Such consideration helps to determine the threshold for intervention.

In economic analysis of lifecycle costs and risk, different strategies are tested and an optimal solution determined which maximizes economic value. High value investments or significant risks should be assessed in this way. Routine, lower cost, lower impact decisions typically use simple qualitative risk analysis.

3.4 Maintenance Philosphy and Regimes

Maintenance Philosophy is the guiding protocol and determines the application of maintenance practice. Over the decades maintenance philosophy has evolved from wholly reactive to various protocols of scheduled maintenance including amongst others:

- Planned Preventative Maintenance (PPM)
- Reliability Centred Maintenance (RCM)
- Total Quality Maintenance (TQM)
- Total Productive Maintenance (TPM)
- Condition Based Maintenance (CBM)
- Failure Prediction Modelling
- Run to failure

Each of these approaches offers benefits, and the cost of each varies. Due to the potential broad nature of an organisation's asset base and the risk attached to asset failure, both direct and consequential, no single maintenance regime will offer the optimum maintenance solution. Leading maintenance practices involve a mixture, or combination of the maintenance regimes mentioned above, tailored to the performance requirement of the asset and how this can be met in the most economical fashion.

Undertaking unplanned maintenance root cause analysis is a structured process to help an organization or a site to improve the maintenance strategy by preventing the recurrence of asset failure. The analysis supports asset integrity management and reliability centred maintenance. It is a technique to help the asset team identify repetitive failures, providing corrective action that can keep undesirable events from occurring in future, reduce downtime, reduce cost of maintenance, and increase safety.

Reference 4 mentioned at the back of this section demonstrates the importance of performing maintenance at the optimum level and demonstrating that under-maintaining and over-maintaining can both have unfavourable outcomes

3.5 Maintenance Maturity

The IIMM includes an asset management maturity scale so organizations can assess their strengths and weaknesses within each functional area – such as levels of service, demand, risk management, operations, maintenance, capital projects, and financial management.
This recognizes the need for an organization to decide the level of maturity that is appropriate to the scale, complexity and level of risk associated with their infrastructure asset portfolio(s).

Typically, an organization would conduct a gap analysis to identify its current position, define its desired position, and then develop an improvement plan to enable it to progress to the desired level in a structure and prioritized manner.

There are also gap analysis tools that can be used to assess asset management practice and develop improvement plans.
Successful implementation of an *Maintenance Strategy* and *Asset Maintenance Manual* will help facilitate an organization to move to sophisticated techniques such as RCM and FMECA.

The quantum and timing of renewals work required depends on several factors, including:
Nature and age of the assets and their condition deterioration pattern, and whether a condition based failure has occurred or is likely to occur.

- Performance of the assets, where they fail to deliver the required service capacity. The monitoring of asset reliability, capacity and efficiency during planned maintenance inspections and operational activity can help identify non-performing assets.
- New asset expansions or other development that may dictate asset upgrade, replacement or removal.
- Criticality of the assets in terms of the degree of risk to service provision, including associated financial, environmental and social impacts.
- Economics. The cost of maintenance is deemed to be uneconomic when the annual cost exceeds the annualised cost of renewal. Economic factors may also come into consideration in order to co-ordinate renewals with other major works. Operating and maintenance histories are used to identify current and projected costs.

Unlike maintenance, historical renewals costs are not necessarily an indicator of future need other than on a broad whole of lifecycle basis.
As described in the IIMM, renewals programs are typically based on a combination of the following methods:

- Forward projections of historic expenditure, possibly combined with some level of judgment to make broad parametric adjustments.
- Broad estimates based on replacing the asset at the end of its useful life.
- Predictive modelling of varying degrees of complexity (from a forward works program based on staff judgment through to advanced mathematical techniques that have complex relationships between models).
- Bottom up approaches where needs are identified via observation of defects in the existing assets and compiled into work bank of projects. Projects within the work bank are prioritized and then funding allocated until the budget is reached.

Renewal planning requires consideration of a range of different options or lifecycle treatment strategies, The three generic strategies shown involve different patterns of repair, refurbishment or replacement. Lifecycle economics involves testing the timing and costs of different strategies, and requires good data on the costs of general maintenance for each.

3.6 Performance Measures

Contemporary asset management requires clearly defined performance measures, aligned with the Mission and spanning from the Mission to the operational activities conducted on the assets.
Performance measures provide information about achievement and trends that may affect the service in the future. The general descriptions on the right hand side of this diagram provide a basis for developing a set of performance measures at each level. The more important of these measures are typically known as KPIs (Key Performance Indicators), as together they provide a view of overall performance.

Performance measures for customer and technical levels of service (LoS) can be categorized as asset measures, financial measures, functional performance measures, and efficiency measures. These measures are typically known as KPIs (Key Performance Indicators) and overall performance can be illustrated as a performance dashboard or by an aggregation of measures.
Performance evaluation measures the ability of the organization's assets to deliver the required level of service. Technical level of service is the level at which maintenance achievements are to be assessed.
A performance measurement system can also be used for comparison and benchmarking purposes
The table below shows an example of a level of service and associated performance measures for response time to a particular failure type or fault. In this case, current performance and future targets are specified reflecting a desire or customer expectation for faster response than has occurred to date. It is important to note the cascade of information, from a level of service statement which can be communicated to a customer, using performance measures to establish a target.

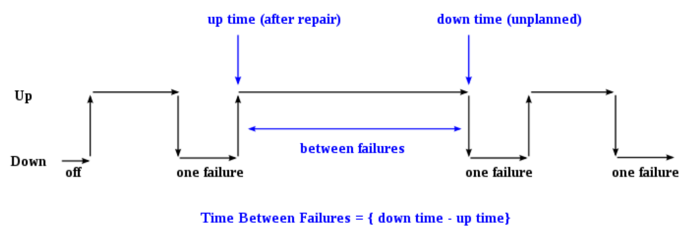
Level of Service and Performance Measures Example

Level of Service Statement	**Technical Performance Measures**	**Current Performance**	**Target Performance**			
			Year 1	Year 3	Year 5	Year 5 -10
Failures and service requests are responded to promptly	Average "x" & "y" hours to attend & restore an urgent fault in service respectively	x = 5 y = 10	x = 4 y = 9	x = 4 y = 8	x = 3 y = 7	x = 1 y = 4

Mean time to repair (**MTTR**) is a basic measure of the maintainability of repairable items. It represents the average time required to repair a failed component or device. Expressed mathematically, it is the total corrective maintenance time divided by the total number of corrective maintenance actions during a given period of time. MTTR are expected to be reported in internal and outsourced contracts where a system whose MTTR is 24 hours is generally more valuable than for one of 7 days if mean time between failures is equal, because its Operational Availability is higher.

However, in the context of a maintenance contract, it would be important to distinguish whether MTTR is meant to be a measure of the mean time between the point at which the failure is first discovered until the point at which the equipment returns to operation (usually termed "mean time to recovery"), or only a measure of the elapsed time between the point where repairs actually begin until the point at which the equipment returns to operation (usually termed "mean time to repair"). For example, a system with a service contract guaranteeing a mean time to REPAIR of 24 hours, but with additional part lead times, administrative delays, and technician transportation delays adding up to a mean of 6 days, would not be any more attractive than another system with a service contract guaranteeing a mean time to RECOVERY of 7 days.

Mean time between failures (MTBF) is the predicted elapsed time between inherent failures of a system during operation. MTBF can be calculated as the arithmetic mean (average) time between failures of a system. The MTBF is typically part of a model that assumes the failed system is immediately repaired (mean time to repair, or MTTR), as a part of a renewal process. This is in contrast to the mean time to failure (MTTF), which measures average time to failures with the modeling assumption that the failed system is not repaired (infinite repair rate).
The definition of MTBF depends on the definition of what is considered a system failure. For complex, repairable systems, failures are considered to be those out of design conditions which place the system out of service and into a state for repair. Failures which occur that can be left or maintained in an unrepaired condition, and do not place the system out of service, are not considered failures under this definition. In addition, units that are taken down for routine scheduled maintenance or inventory control are not considered within the definition of failure.



Mean time to recovery (**MTTR**) is the average time that a device will take to recover from any failure. Examples of such devices range from self-resetting fuses (where the MTTR would be very short, probably seconds), up to whole systems which have to be repaired or replaced.
The MTTR would usually be part of a maintenance contract, where the user would pay more for a system MTTR of which was 24 hours, than for one of, say, 7 days. This does not mean the supplier is guaranteeing to have the system up and running again within 24 hours (or 7 days) of being notified of the failure. It does mean the average repair time will tend towards 24 hours (or 7 days). A more useful maintenance contract measure is the maximum time to recovery which can be easily measured and the supplier held accountable.

Equipment Availability – annual hours run of critical equipment / annual critical equipment hours availaibility planned * 100 (refer to criticality assessment)

Completion of scheduled maintenance activities = maintenance activities completed / scheduled maintenance activities * 100

Condition and Performance

Condition is used to describe the physical state of an asset, while performance describes its ability to deliver the required level of service. Most Customer and Technical Levels of Service should have either a condition or performance measure associated with them. Condition and performance are monitored at the operational level to facilitate maintenance, operational and renewal decisions.
All measurements of customer and technical levels of service should be recorded and displayed in charts that allow valid year-on-year comparisons of historic and projected performance to be made and readily understood

Intervention Standards and Work Triggers
Condition and performance should be used along with asset criticality and risk (see Section 9.0) in making decisions about when to intervene, typically with a planned maintenance or renewal activity. Figure 7-3 illustrates the concept of defining intervention levels in terms of condition. In this diagram, multiple performance measures for condition are illustrated. The top line is regarded as the “network” level KPI, an indicator that reflects the desired minimum standard of the whole network. Some assets will be in better condition, whilst others will be in worse condition.
The condition scale is typically reported on a 1 (excellent) to 5 (poor, or failed) scale. The curved line illustrates a typical condition deterioration profile.
The bottom line signals the condition at which a repair work trigger occurs, for example a localised pipe repair.
The middle line defines the average condition expectation for a specific length or node to node asset. The work program needs to be developed on an asset by asset basis to achieve this condition objective.
Detailed Maintenance and renewal / rehabilitation intervention levels would be described in an organisations' *Asset Maintenance Manual* using set condition ratings.

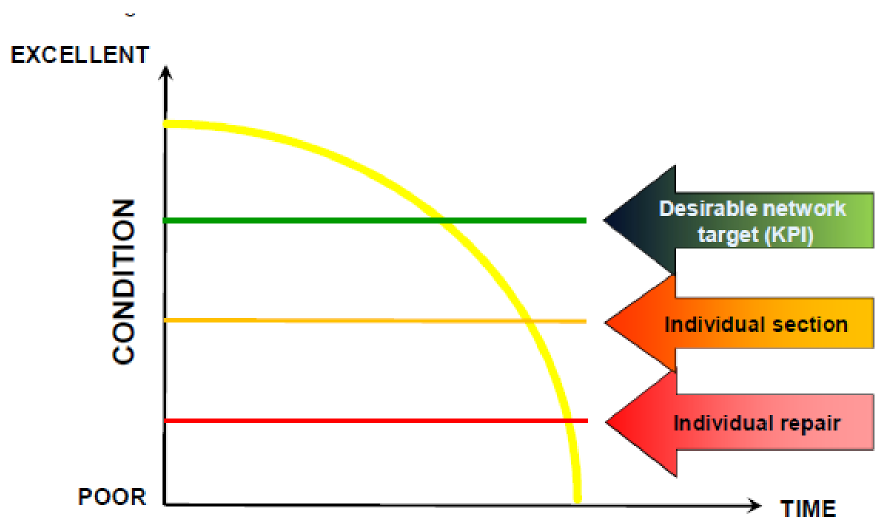


Figure – Condition based assessment

The shape of the condition curve is fundamental in predicting future condition or performance of the asset, and by extension the network.
Progressive capture of condition data, in a robust and consistent manner, will allow an organization to be able to associate condition with the asset's position in the life cycle – the horizontal axis in the diagram above.

3.7 Asset Criticality and Risk

Contemporary asset management also requires that asset managers understand and communicate the

relationship between performance, risk and life cycle costs at both the portfolio level and the asset level.
At the portfolio level, this means communicating with the Board, key stakeholders, funders and regulators about the overall performance of the asset system, its risk profile and its funding envelope needs, and how these are expected to change over the planning period – which should span at least 10 years, preferably 20 years.
At the asset level, technical staff need to perform analyses of asset criticality, condition, performance, failure risk, life cycle cost requirements, and to determine relative priorities for maintenance and capital renewal expenditure over the forward life of the asset. This requires the capture, not only of asset condition and performance data, but also maintenance cost histories by location at the equipment or component level.
This need to balance the three elements of risk, service and life cycle cost for the impacts of excessive risk on the left hand side (such as service disruptions, health and safety issues) against excessive spend on the right (such as waste and inefficiency).
Best practice asset management means the "right" level of service is being delivered, the costs are efficient, and the level of risk is acceptable to customers and stakeholders

Effective condition deterioration prediction underpins proactive asset management programs and enables whole life cycle costs to be optimized using economic analysis.
Current condition information along with knowledge of future service demand is an input to the prediction of the future state of the assets, thus facilitating multi-year financial analysis and long term planning and budget allocation.

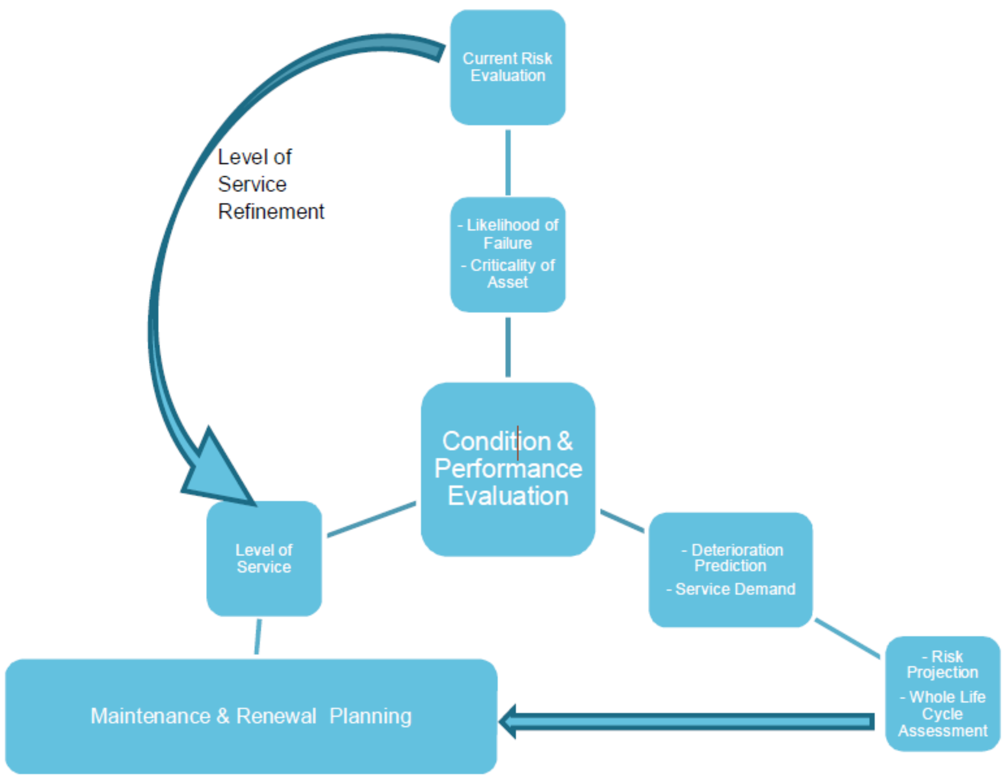


Figure : Relationship between Condition, Levels of Service and Risk in Optimizing Work programs

As will be discussed in section 4 on Condition and Performance Evaluation , The physical integrity of assets is measured by carrying out condition assessments throughout the asset's life cycle. The level of assessment depends on the type, scale and criticality of the asset to be inspected. Assessment types differ from simple visual inspections through detailed engineering testing.
The knowledge that needs to be acquired includes the likely physical failure mode of the asset and the likely time

for maintenance, rehabilitation or renewal
Inspection types, techniques, intervals and the recording process all need to be addressed.
A condition grading approach enables quantitative data consistency, as well as providing the capability to benchmark and compare assets among other units or authorities. For example, current practice for most water and wastewater agencies uses a mix of a 1 to 5 grading scale supplemented where appropriate by non destructive testing techniques such as CCTV or ultrasonic testing, and plant monitoring techniques such as vibration monitoring

A reliable forecasting methodology is to be used for long-term planning for maintenance and renewal and the allocation of OPEX and CAPEX budgets. Clearly, the expected asset condition decay curve affects the optimization of asset interventions.
Degradation patterns for condition and performance are key factors in establishing maintenance programs, upgrades, refurbishments and renewal planning for assets. There are several factors affecting the degradation process such as age, material, usage and environment exposure. The deterioration progression affects the likelihood of failure and interruption to service; and consequently, the risk evaluation of assets. A consistent condition inspection process will enable an organisation to determine decay curves for its assets over time. Markov Chain statistical modelling can then be performed to address the probabilistic nature of deterioration of the assets

Demand forecasts may affect infrastructure planning in various ways, and the resulting scenarios and options need to be evaluated. Forecasting demand also involves risk and uncertainty. Therefore, the risk related to demand prediction needs to be assessed and a sensitivity analysis performed to identify the essential factors and any variables that could affect the decision making process.

For prioritizing maintenance activity an organization s asset team needs to define the current condition, criticality rating, and risk rating of each asset and how these three factors influence the agreed level of service.
Maintenance prioritization is evaluated against three criteria, namely:
- Condition Rating
- Criticality Factor
- Asset Risk Factor
Typically, there is a relationship between condition and the risk of asset failure.
An approach to using these criteria in a “balancing” approach is described below.

Example of Weighting of Prioritization Criteria

Criteria	Weighting	Description
Condition Rating	30 %	This example assumes a condition rating scale of 1 to 6. This would depend upon an organization developing a condition assessment manual, so the condition rating definition would need to be updated using this information
Criticality Factor	20%	Each asset for example is classified in terms of three categories (3=Critical, 2=Medium, 1=Non-Critical), which dictate the importance of the asset to the service.
Asset Risk Factor	50%	After undertaking risk assessment, each asset is classified in terms of four risk categories (4=High, 3=Serious, 2=Medium, and 1=Low) which dictate the likelihood and consequence of failure.

An overall prioritization index can be determined to evaluate and prioritize maintenance activities, calculated using the following equation:

Condition Rating x 30% + Criticality Factor x 20% + Risk Factor x 50%

The table below illustrates this example for assets with a range of rating and factor scores. The overall prioritization index defines the priority levels for maintenance action on the assets.

Table Example of Calculation of Overall Prioritization Index

Asset Information	Condition and Criticality		**Combined Condition and Criticality Index**	**Risk**	**Overall Prioritization Index**
% of Contribution	30%	20%		**50%**	
Asset ID	Condition Rating	Criticality Factor		**Asset Risk Factor**	
Asset 1	**5**	**3**	**2.1**	**3**	**3.6**
Asset 2	**2**	**1**	**0.8**	**1**	**1.3**
Asset 3	**3**	**2**	**1.3**	**2**	**2.3**
Asset 4	**1**	**3**	**0.9**	**4**	**2.9**
Asset 5	**4**	**2**	**1.6**	**2**	**2.6**
Asset 6	**5**	**1**	**1.7**	**4**	**3.7**

Another factor to be considered in prioritizing maintenance is the packaging of tasks with similar requirements. It is essential to identify and group maintenance works that have a similar requirement such as isolation points, resources, skills, tools, machinery, as this is typically more efficient and cost effective than carrying out similar tasks separately.
Based on the overall priority index result, assets can be "ranked" for the purposes of establishing maintenance levels of service, as illustrated in the table below for response times.

Table Example of Response Times based on Priority Index

Priority Ranking	**Priority index range**	**Description**	**Response time**
3	Greater than 3.5	Emergencies	Within 4 hours
2	Between 2.5 and 3.5	Urgent	2 days from issue
1	Lesser than 2.5	Routine	7 days from issue

An alternative approach is to select the most critical assets first, then use the risk assessment process to identify the priorities for critical assets. This approach is particularly appropriate when funding levels are highly constrained, and there is only sufficient available to treat the most important assets.

An alternative structured evaluation methodology to identify critical equipment whether mechanical, electrical civil, or instrumentation, control or automation (ICA) can identify which equipment has the most serious potential consequences on the buisiness performance . If it fails for example consequences on the buisiness can include :

- Production throughput or equipment facility / utlisation
- Cost due to lost or reduced production
- Environmental issues
- Safety Issues
- Reduced customer satisfaction

Criticality is determined by integrating the probability and consequence of failure. Factors such as safety, environmental impact, risk to production loss, replacement cost and maintenance costs are included and consequence of failure can be weighted and used to determine the overall risk ranking. The following table shows a simplified assessment of assets covering operations, environment and safety impacts

	Severity			
Score	Production/ operations	Environment	Safety	Probability
1	Minor or no loss of output	No potential adverse impact on environment	No potential for an adverse effect on safety	Once in 10 years
2	Minor loss of critical unit < 6 hours	Minor environmental impact not reportable	Possibility of minor injury First aid only	Once in 1 year
3	Major loss of critical units > 6 hours	Significant environmental issues that could be managed	Possibility of medical treatment	Once in 3 months
4	Minor plant shut down < 6 hours	Major environmental incident. Reportable	Possibility of long term hospitilisation	Once a month or more
5	Major plant shutdown > 6 hours	Catastrophic environmental incident. Large impact on population. External communication	Possibility of death	Once a week or more

After assessing these four factors the criticality number is scored as follows
Criticality number = (Sum of production, environment, safety score) * probability

Criticality Number	**Criticality Description**
3-24	Low criticality
25-44	Medium criticality
45-75	High criticality

APPENDIX

Maintenance Management Best Practices – Reliability Centered Maintenance (RCM)

Reliability Centred Maintenance (RCM) is an industrial improvement approach focused on identifying and establishing the operational, maintenance and capital improvement policies that will manage the risks of equipment failure most effectively. RCM is an engineering framework that enables the definition of a complete maintenance regime. It regards maintenance as the means to maintain the functions a user may require of machinery in a defined operating context. As a discipline it enables machinery stakeholders to monitor, assess, predict and generally understand the working of their physical assets. This is embodied in the initial part of the RCM process which is to identify the operating context of the machinery and write a Failure Mode Effects and Criticality Analysis (FMECA). The second part of the analysis is to apply the RCM logic, which helps determine the appropriate maintenance tasks for the identified failure modes in the FMECA. Once the logic is complete for all elements in the FMECA, the resulting list of maintenance is packaged, so that the periodicities of the tasks are rationalised to be called up in works packages. Lastly, RCM is kept live throughout the in-service life of machinery, where the effectiveness of the maintenance is kept under constant review and adjusted in light of experience gained.

RCM can be used to create a cost effective maintenance strategy to address dominant causes of equipment failure. It is a systematic approach to defining a routine maintenance programme composed of cost effective tasks that preserve important functions.
The important functions of a piece of equipment to preserve with routine maintenance are identified, their dominant failure modes and causes determined and the consequences of failure ascertained. Levels of criticality are assigned to the consequences of failure. Some functions are not critical and are left to run to failure, while other functions must be preserved at all cost. Maintenance tasks are selected that address the dominant failure causes. This process directly addresses maintenance preventable failures.
Failures caused by unlikely events, non-predictable acts of nature, etc. will usually receive no action provided their risk (combination of severity and frequency) is trivial (or at least tolerable). When the risk of such failures is very high, RCM encourages (and sometimes mandates) the user to consider changing something which will reduce the risk to a tolerable level.

The result is a maintenance programme that focuses scarce economic resources on those items that would cause the most disruption if they were to fail.
RCM emphasises the use of Predictive Maintenance (PdM) techniques in addition to traditional preventive measures and recognises three principal risks from equipment failures, which are:

- Threats to safety
- Threats to operations
- Threats to the maintenance budget

Modern RCM gives threats to the environment as a separate classification, though most forms manage them in the same way as threats to safety.

RCM offers four principal options among the risk management strategies:

- ‘On-condition’ maintenance tasks
- Scheduled restoration or discard maintenance tasks
- Failure-finding maintenance tasks
- One-time changes to the system (changes to hardware design, to operations,
- or to other things)

RCM also offers specific criteria to use when selecting a risk management strategy for a system that presents a specific risk when it fails. Some are technical in nature (can the proposed task detect the condition it needs to detect (does the equipment actually wear out with use?). Others are goal oriented (is it reasonably likely that the proposed task and task frequency will reduce the risk to a tolerable level?). The criteria are often presented in the form of a decision logic diagram, though this is not intrinsic to the nature of the process.

Condition Based Maintenance (CBM)

Breakdowns in industrial manufacturing systems can have a significant impact on the performance of a business. Expensive equipment is made idle, labour is no longer optimised and the ratio of fixed costs to output is negatively affected. Rapid repair of 'down' equipment is critical to improving performance and the process of addressing equipment breakdowns after occurrence is known as Corrective Maintenance. However, when equipment does breakdown the problems and cost can go well beyond the period of repair. Often process lines, such as Water Treatment Plants, require significant run time after start-up to begin producing water of the correct quality and in the required quantities. Because of the impact both during and beyond the immediate equipment downtime, facilities have sought to prevent equipment breakdown by a process known as Preventive Maintenance

With preventive maintenance equipment is routinely inspected and serviced in an effort to prevent breakdowns from occurring. Such inspections are based on either calendar periods or equipment process time, and generally include recorded data that can be compared over time to determine if negative changes in performance indicate an imminent equipment problem.
The Corrective Maintenance and Preventive Maintenance approaches have been in use for decades, but each have some important drawbacks.

To try to maintain equipment at the right time, condition based maintenance is introduced. CBM is based on using real time data to prioritise and optimize maintenance resources. Observing the state of the system is known as condition monitoring. Such a system will determine the equipment's health, and act only when maintenance is actually necessary. Developments in recent years have allowed extensive instrumentation of equipment and together with better tools for analyzing condition data the maintenance personnel of today are able to decide the right time to perform maintenance on equipment. Ideally condition based maintenance will allow maintenance personnel to limit their interventions to carrying out only the required tasks at the right time thus minimising spare parts costs, system downtime and time spent on maintenance.

First and most important of all, starting to use CBM is costly partly because it requires improved instrumentation of the equipment. Often the cost of sufficient instrumentation can be quite large, especially if this has to be retro-fitted to equipment that is already installed. It is therefore important to decide whether the equipment is sufficiently important to justify the investment. A result of this is that the first generation of CBM usually focuses on vibration in heavy rotating equipment such as large pumps and motors.
Secondly, introducing CBM invokes a major change in how maintenance is performed, and potentially to the whole maintenance organisation in a company. Organisational changes can be difficult to implement.
Also, the technical side of it is not always as simple as would be hoped. Even if some types of equipment can easily be observed by measuring simple values as vibration (displacement or acceleration), temperature or pressure, it is not trivial to turn this measured data into actionable knowledge about the health of the equipment.

Value Potential of CBM

As operational systems get more expensive to install and maintain, and instrumentation and information systems tend to become less expensive and reliable, CBM becomes an important tool for managing plants in an optimal manner. Optimising operations will lead to lower production cost and reduced use of resources. Minimising the use of resources may be one of the most important differentiators in a future where environmental issues become more important by the day.

Failure Mode Effects and Critical Analysis (FMECA)

Introduction to FMECA

FMECA is an Analysis technique that facilitates the identification of potential design problems by examining the effects of lower level failures on system operation

FMECA is important because it:

- Provides a basis for identifying root failure causes and developing effective corrective actions
- Identifies reliability/safety critical components
- Facilitates investigation of design alternatives at all stages of the design
- Provides a foundation for other maintainability, safety, testability, and logistics analyses

Simple Example of a FMECA for a flashlight

Severity of failure
SEVERITY classifies the degree of injury, property damage, system damage, and service loss that could occur as the worst possible consequence of a failure. For a FMECA these are typically graded from I to IV in decreasing severity. The standard severity levels, defined in various national standards may be used or equipment specific severities may be defined. The latter of these is recommended to ensure applicability to the local environment.
For the flashlight example above the severity levels would be:

Part How can it fail? What is the effect?

Item	**Failure Mode**	**End Effect**
Bulb	Dim light	Flashlight output
	No light	No flashlight output
Switch	Stuck closed	Constant flashlight output
	Stuck open	No flashlight output
	Intermittent	Flashlight sometimes will not turn on
Contact	Poor contact	Flashlight output dim
	No contact	No flashlight output
	Intermittent	Flashlight sometimes will not turn on

Severity of failure

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Severity I Light stuck in the “on” condition
Severity II Light will not turn on
Severity III Degraded operation
Severity IV No effect

Item	Failure Mode	End Effect	Severity
Bulb	Dim light	Flashlight output dim	III
	No light	No flashlight output	II
Switch	Stuck closed	Constant flashlight output	I
	Stuck open	No flashlight output	II
	Intermittent	Flash light sometimes will not turn on	III
Contact	Poor contact	Constant flashlight output	III
	No contact	No flashlight output	II
	Intermittent	Flash light sometimes will not turn on	III
Battery	Low power	Flashlight output dim	III
	No power	No flashlight output	II

Criticality

CRITICALITY is a measure of the frequency of occurrence of an effect and may be Based on:

- qualitative judgment or
- failure rate data

Integrated FMECA

FMECAs are often used by other functions such as Operations, Health & Safety, and Logistics.
Coordinate your effort with other functions up front
Integrate as many other tasks into the FMECA as possible that make sense (Operations, Health & Safety, and Logistics, etc.)
Integrating in this way can save considerable cost over carrying out separate assessments and will usually produce a better product.
If possible, use the same analyst to accomplish these tasks for the same piece of hardware. This improves consistency of approach and can be a cheaper option.

FMECA Facts and Tips

FMECA's should begin as early as possible
This allows the analyst to affect the design before it is set unconfirmed.
If you start early (as you should) expect to have to redoportions of the FMECA as the design is modified.
FMECA's take a lot of time to complete.
FMECA's require considerable knowledge of system operation necessitating extensive discussions with software/hardware Design Engineering and System Engineering, Operations and Maintenance, Health & Safety.

Examples of Condition Based Maintenance Monitoring for rotating machinery such as pumps and electric motors

The most commonly used method for rotating machines is called vibration analysis. Measurements are taken on machine bearing casings with seismic or piezoelectricity transducers to measure the casing vibrations, and on the vast majority of critical machines, with 'eddy-current' transducers that directly observe the rotating shafts to measure the radial (and axial) vibration during normal operation.
The level of vibration can be compared with historic baseline values to measure the degree of degradation and identify the need for intervention in the form of adjustment, calibration or replacement of the whole unit or its some of its constituent parts. Interpreting the vibration signal obtained is a complex process that requires specialised training and experience. One commonly employed technique is to examine the individual frequencies present in the signal. These frequencies correspond to certain mechanical components (for example, the various pieces that make up a 'rolling-element' bearing) or certain malfunctions (such as shafts out of balance or misaligned). By examining these frequencies and their harmonics, the analyst can identify the location and type of problem, and sometimes even the root

Cause. For example, high vibration at the frequency corresponding to the speed of rotation is most often due to residual imbalance and is corrected by balancing the machine. As another example, a degrading rolling-element bearing will usually exhibit increasing vibration signals at specific frequencies as it wears. Special analysis instruments can detect this wear weeks or even months before failure, giving ample warning to schedule replacement before a failure which could cause a much longer
Down-time.

Other techniques

The most rudimentary form of condition monitoring is visual / audible inspection by experienced operators and maintenance engineers. Failure modes such as cracking, leaking, corrosion, abnormal noise levels etc can often be detected by inspection before failure is likely. This form of condition
Monitoring is generally the cheapest and is a vital part of workplace culture to give ownership of the equipment to the people that work with it. Consequently, other forms of condition monitoring should generally augment, rather than replace, visual inspection.

Slight temperature variations across a surface can be discovered with regular visual inspection and non-destructive with thermograph. Heat is indicative of failing components, especially degrading electrical contacts and terminations.

Thermograph can also be successfully applied to high-speed bearings, fluid couplings, conveyor rollers, and storage tank internal build-up.

Ultrasound can be used for high and low-speed mechanical applications and for high-pressure fluid situations. Digital ultrasonic meters measure high frequency signals from bearings and display the result as a dBuV (decibels per microvolt) value. This value is trended over time and used to predict increases in friction, rubbing, impacting, and other bearing defects. The dBuV value is also used to predict proper intervals for re-lubrication. Ultrasound monitoring, if done properly, proves out to be a great companion technology for vibration analysis.

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SECTION 4 : ASSET INTEGRITY ASSESSMENT

1 Introduction

Asset Integrity Management Systems (AIMS) can be defined as the ability of an asset to perform its required function effectively and efficiently whilst protecting health, safety and the environment and the means of ensuring that the people, systems, processes and resources that deliver integrity are in place, in use and will perform when required over the whole lifecycle of the asset and assist owners and operators safely, effectively, and efficiently manage the integrity and realize the maximum potential from their assets during its lifecycle without harm to people, environment, or business.

Asset Register

An asset register is a business statement showing the assets that are owned. It consists of clearly stated costs of assets both direct and incidental, the date of purchase, the suppliers name and address, serial number, internal reference number, and depreciation rate and method

Operations (POMS):

Any piece of equipment, operated as designed, will normally yield a safe and profitable life. This is addressed in the inclusion of Intranet based Plant Operations Manuals (POMS) that focus on the Facilities (Processes and Equipment)

Corrosion Management (CMS)

Each item of equipment and its system has defined "degradation" management strategies that are enforced by the materials of design and the operating conditions. These strategies encompass corrosion monitoring and control.

Corrosion Anomalies – POE (Probability of Exceedence)

PoE leak and rupture represent anomalies such as Leak and rupture . There is also a definition of Remaining life PoE Leak and Remaining life PoE Rupture The Remaining life PoE is normally based on when the individual anomaly will reach the user specified PoE confidence limit

Inspection Management (IMS)

Inspection and testing is a verification that predicted degradation mechanisms are correct and that less likely mechanisms are not increasing risks to an unacceptable level. The inspection process is covered in the Inspection Management System

Maintenance Management System (MMS)

Maintenance, in the context of AIMS (asset integrity management program) , is the routine work on the assets as defined by the manufacturers and designers. It is considered separate from corrosion management and inspection but as an integrity management process it is fully integrated with those processes

Pipeline Integrity Management System (PIMS)

Each phase in the life cycle of the pipeline is treated in PIMS software including design (route selection, material selection and corrosion protection), operations (routine pigging, intelligent pigging and condition monitoring) removal, planning and performance monitoring, QA/QC, corrosion management, . Additional procedures support mothballing, pipeline defect verification etc. The Emergency Pipeline Repair System (EPRS) is a subsystem of PIMS.

Structural Integrity Management System (SIMS)

Threats addressed in an SIMS include corrosion and fatigue and implementation plans such as risk based inspection methodologies, and protective coatings are also addressed. The Lifting Equipment Management System (LEMS) covers lifting equipment.

Pressure Equipment Management System (PEMS)

PEMS addresses boilers, pressure vessels, piping, and safety equipment. Requirements for risk based inspection; periodic inspection and first in-service inspection are addressed along with repair, mothballing and a summary of methods of inspection. PSV inspection and testing requirements are covered in a subsystem of PEMS. Pressure equipment such as pressure vessels and piping, including the testing and maintenance of pressure relief valves and fuel storage tanks are also included typically in a PEMS.

Instrumentation, controls & alarms (ICA)

ICA issues are typically encompassed in Reliability Centered Maintenance (RCM) for Electrical, Instrumental and Alarms like on line instrumentation , pressure gauges, gas sensors etc

In terms of the word ‘ integrity ‘ this can be subcategorized in the following :

<u>Design Integrity – “Assure design for safe operations”</u>
Assurance that facilities are designed in accordance with governing standards and meet specified operating requirements
<u>Technical Integrity – “Keep it in”</u>
Appropriate work processes for Maintenance & inspection systems and data mgt. to keep the operations available
<u>Operational Integrity – “Keep it Running”</u>
Appropriate knowledge, experience, manning, competence and decision making data to operate the plant as intended throughout its lifecycle

In the context of condition assessments therefore for an asset it is clear that an organization needs to follow the appropriate accounting basis and valuation methodologies for each category or types of assets which has been discussed and agreed with the management of organization . Condition data is typically used to determine the need and timing of some preventative or remedial action to prevent loss of service or economic loss. Understanding asset failure modes and risks leads to better asset management decision-making. Being aware of the failure modes allows effort to be focused on understanding the timing and consequences of the failure, and the expected expenditure patterns. The methodology use “**risk”** also helps to prioritize and manage the efforts of an asset integrity management program as an effective risk based program results in a reduced level of risk for a given level of inspection/management activity. In any operating plant, a relatively large percentage of the risk is usually associated with a small percentage of equipment. A Risk Based methodology permits the shift of inspection and maintenance resources to provide a higher level of coverage on the high risk items and an appropriate effort on lower risk equipment.

In terms of corrosion and the types of acid attack, pitting corrosion, hydrogen blistering and cracking, sulphide stress / corrosion cracking etc etc may occur without proper management when not expected or not initially expected; existing mitigation systems might not be effective (ie paints, overlay, plating, cathodic protection) and also the process may be different from what the original design intent.
For example in the wastewater services sector H_2S is a major contributor to environmental cracking such as Sulphide Stress Cracking (SSC). Assessing the integrity and risk rating of components in contact will include a delve into the issues such as H_2S partial pressure, in situ pH, Concentration of dissolved chloride, presence of elemental sulphur or other oxidant ,temperature ,galvanic effects ,mechanical stress ,time of exposure to contact ,predictivity corrosion, corrosion resistance, field assessments and supplier specific material selection details etc

An alternative example in the case of pipeline integrity assessments are the parameters of the results of conducting close-interval potential survey (CIS) (ie through survey procedure of correct interruption ratio) and identification of areas for additional survey or exploratory excavations and feedback of detailed surveys (for example involving DC voltage gradient ,pipeline current mapping, electromagnetic survey, soil resistivity surveys, drainage , topography and support/ welding reviews , CCTV feedback etc) and finally the results from any past fracture/ leakages and remedial actions

It is not the purpose of this book to go into such details which need to be looked at on specific basis – It is however noteworthy to mention that the general principle of undertaking the details assessment of the integrity and condition of assets can drive enterprise value , enable more intelligent decisions about the lifecycle of the asset and enable the synergy of information and efforts with the owners, contractors and sub contractors involved in the up keep of the assets
Plants will always have to perform some amount of routine, preventive, predictive or proactive maintenance Methods to determine the best cost scenario are still evolving. The questions are: how to predict an assets’ condition including integrating with the need for maintenance, and determination of the maintenance schedule proactively

Assessing the condition of assets need to consider the effectiveness of resources, skills, governance and implementation of the O & M procedures and reflect also the level of risk associated with the loss of integrity and/or malfunction of the assets and also in line with supplier performance specifications and good industry practice

The benefits of developing a more sophisticate and exact methodology for knowing the current condition and performance level of an asset are:

- Ability to plan for and manage the delivery of the required level of service.
- Avoidance of premature asset failure, leaving open the option of cost effective renovation.
- Risk management associated with asset failures, and mitigation of the consequences of failure.
- Accurate prediction of future expenditure requirements through understanding remaining asset life and capital investment needs.
- Refinement of maintenance and rehabilitation strategies

2. Financial Assessment of Assets

From a financial perspective estimates can be made of the Gross Modern Equivalent Asset Value (MEAV) as a vehicle for presenting asset condition information. The value is the current cost of replacing the asset concerned with one of a similar capability but to modern standards.

As an accounting base for example reference is made to the IFRS accounting standards dealing with individual assets – property, plant and equipment (fixed assets), capital work in progress and inventories

- IFRS – IAS 16 Property, Plant and Equipment.
- IFRS – IAS 2 Inventories.
- IAS 38 – Intangibles.
- IFRS 3 Business Combinations

The aim of this chapter is not to present a financial lesson in asset valuation as this is under a different subject and under a strict financial discipline where issues such as accounting books, statutory , tax and insurance requirements prevail. The objectives of this section for example do not cover financial issues which are under the realm of financial disciplines and not under the objectives of this book .

For example for issues such as following then the reader should note that examples as listed below are not covered or intended to be mentioned at all in this book :

- Methods for measurement and recording of costs for capitalization and depreciation.
- Methods for monitoring budgeted capital expenditure against actual expenditure or financial controls over the ownership of assets or their financial safeguarding
- Compliance with Accounting Standards as per regulatory requirements or assets register ,assets information systems and financial statements

The alternative objective of this section is to provide an overview from process risk perspective for assessing the condition of assets and putting a measurable and benchmarkable assessment

2. Condition and Serviceability Overview

Best practice use of condition or serviceability assessment is based upon having good knowledge, at an appropriate level, of the company's assets in terms of condition, performance and cost of ownership. This enables each component of the asset base to be assessed and categorised by its ability to deliver the service required of it at minimum whole-life cost. Such information is used to devise optimum capital maintenance strategies, that combined with operational maintenance standards, ensure the best service / cost balance.

Asset Condition reflects the physical state of the asset, which may or may not affect its performance. The performance of the asset is the ability to provide the required level of service to customers. Generally this can be measured in terms of reliability, availability, capacity, and meeting customer demands and needs. All of this is critical information for determining the remaining useful life of an asset and more importantly the timing for possible intervention steps to bring levels of service, provided by the asset, back to a desired standard
Other factors can also determine useful life. Factors such as:

- Technical advances which might make the existing asset obsolete.
- Changes in community expectations meaning that the asset no longer has the capacity to meet community standards.
- Growth impacts meaning that the asset's capacity falls short of the new demands.
- Compliance - changing standards mean the asset becomes non-compliant.
- Economic life - whereby the costs of continuing to operate the asset warrant it now being replaced.

It is critical that service organisations have a clear knowledge of the condition of their assets and how they are performing. All management decisions regarding maintenance, rehabilitation and renewal revolve around these two aspects.

Not knowing the current condition or performance of an asset may lead to the premature failure, which leaves the organisation with only one option - to replace the asset (generally the most expensive option!). The unforeseen failure of an asset can have major consequences that constitute a business risk or potential loss to the organisation.

This is the any organization s objective in this area but a number of enabling initiatives must be completed first:

• Asset inventory database with appropriate hierarchy and detail
• Works management system to capture maintenance activity on the networks
• Maintenance management system to capture maintenance activity and asset performance data
• Financial systems to capture and record costs accurately against assets and activities

The process of determining serviceability by best practice methods requires them being fully integrated into day-to-day operational activities for them to be effective.

Operational assets: are the assets acquired or used in the income generating of the business – in a water utility this applied to items such as water network, wastewater network, water plants, waste water plants, pumps, reservoirs, and wells etc

Real estate: is the land and anything fixed, immovable, or permanently attached to it such as buildings..
Based upon the Uniform Standards of Professional Appraisal Practice (USPAP) the following would be the approaches of land valuation:
Direct market comparison approach
Income approach
Cost approach

Non operational are the assets which not be used in the operations of a business such as equipment and machineries, motor vehicles, leasehold improvements, office equipments, furniture and fixtures, safety and security etc

2. 1.1 Physical Inspection Approaches

In a non quantifiable manner based upon detailed information from operation and maintenance databases , a broad view of condition would considers an asset's value to the business for delivering service to customers rather than simple physical condition; this principle takes account of best practice principles of serviceability

In other words an asset can be considered to be in good condition when the asset can perform its required task reliably and at optimum cost. It can be considered poor condition to be the opposite of this.

This approach enables us to identify assets that may appear to be in good physical condition but in practice cannot deliver the service required. A typical example of this would be a pump that is in perfectly good physical condition but has, for whatever reason, been designed or specified incorrectly and cannot meet its duty requirements at the required cost. We would record this as being in poor condition. Conversely a pump that may appear to be in poor condition on initial inspection but delivers reliable and adequate service would be considered in good condition providing maintenance costs were moderate.

In order to conduct asset surveys by physical inspections only it would be expected that typically a valuation team, comprised of professional engineers from the business would conduct an exercise of both physical inspections and interviews with those people responsible for maintenance and operation t and its associated ICA and SCADA/telemetry equipment. This for example would record data such as for example whether pumps are duty or standby , the date of the last major overhaul and obtain information on the level of historic maintenance.
In this assessment of the condition of these assets the objective would be not only to determine the remaining useful life of the assets , but also to some degree an understanding of whether the assets are being used efficiently - for example this may require hydraulic analyses to determine whether they are of adequate capacity, and operational information such as to interruptions in supply, plant breakdowns, preventive maintenance schedules and quality etc
The data and information needed to be collected would typically include:

- Design and as built drawings
- GIS maps
- Spreadsheet summaries of the system
- System information – for example , in case of pipelines this would include copies of risk assessments , engineering drawings , mechanical , civil and process information covering network age , operating and design conditions and function by material and diameter soil type, surface type, and failure history of pipelines, locations and details of control and monitoring – for example valves , flow meters etc
- Discussions with operational and maintenance staff on shortcomings of the systems

This would enable the team to build up a detailed assessment of condition and age at a component level. These results can then be aggregated on a criticality-weighted basis to provide effective age and condition at the valuation level of process stage.

This can be represented as:
N= R X f (A) x f(C)
Where:
N = Net Book Value
R = Replacement Cost (benchmarks)
A = Age (known or estimated)
C = Condition (1 to 5)

The replacement costs used for the valuation can be based on Modern Equivalent Values using benchmarks at process level. The below figure illustrates how the age and condition assessments made by our survey at detailed component level, are used as weighted averages and combined with modern equivalent prices to derive net asset values for the balance sheet.

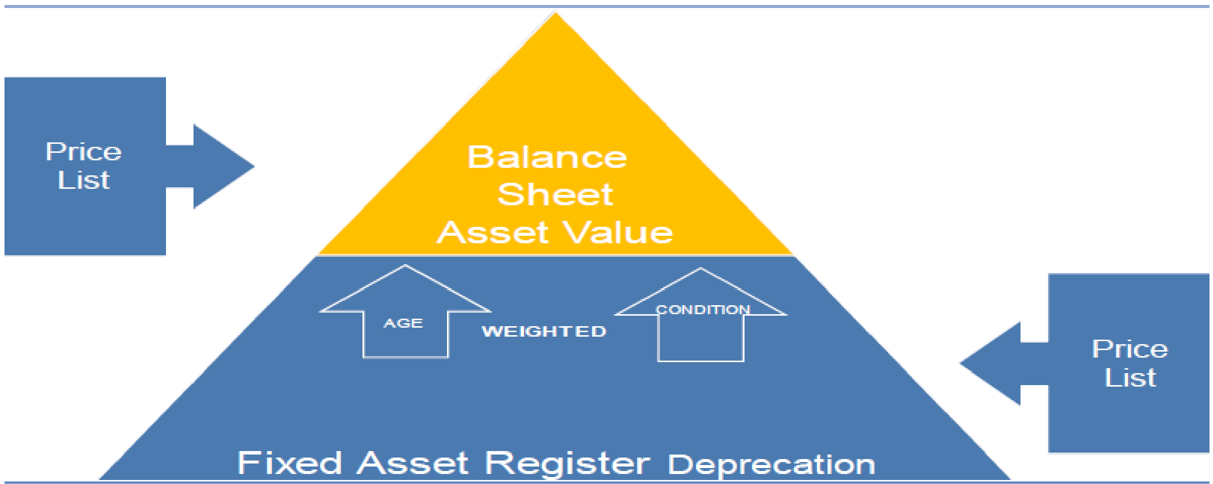


Figure Derivation of Net Asset Value

Using the above approach age assessment can be based on available records and knowledge of the Operation and Maintenance employees and other circumstantial evidence. Condition assessment can be based additionally on the surveying engineer's professional judgement. The method would involve identifying, counting and categorizing assets based upon either standardised level of counting or the classification of assets using an agreed assets grading system or as an optimum based upon the tagging / labelling of the assets based upon a pre-established asset management database and this would entail the logging and use of bar code scanners in the physical site visits

Condition of equipment comprising the assets would then be assessed typically on a scale of 1 to 5 using criteria appropriate to the types of asset. In general these grades reflected the following

a) Excellent – consistently capable of achieving full design performance
b) Good – minor defects at extreme performance levels
c) Adequate – minor defects at average performance levels
d) Poor – major shortcomings at average performance levels
e) Unsatisfactory – incapable of meeting average performance requirements

In normal accounting practice, the book value of an asset is derived from its original capitalized value less the amount of depreciation. The depreciation calculation is based on local accounting standards and tax regulations. In a simplified case of linear depreciation for example assumptions would be based upon operational assets falling into one of two categories; civil assets depreciated say over 40 years and Mechanical and Electrical assets say over 20 years . The useful lives of fixed assets should be re-examined on a periodic basis. If the estimate of the asset's life changes, the depreciation expense should be adjusted for the current and future periods.

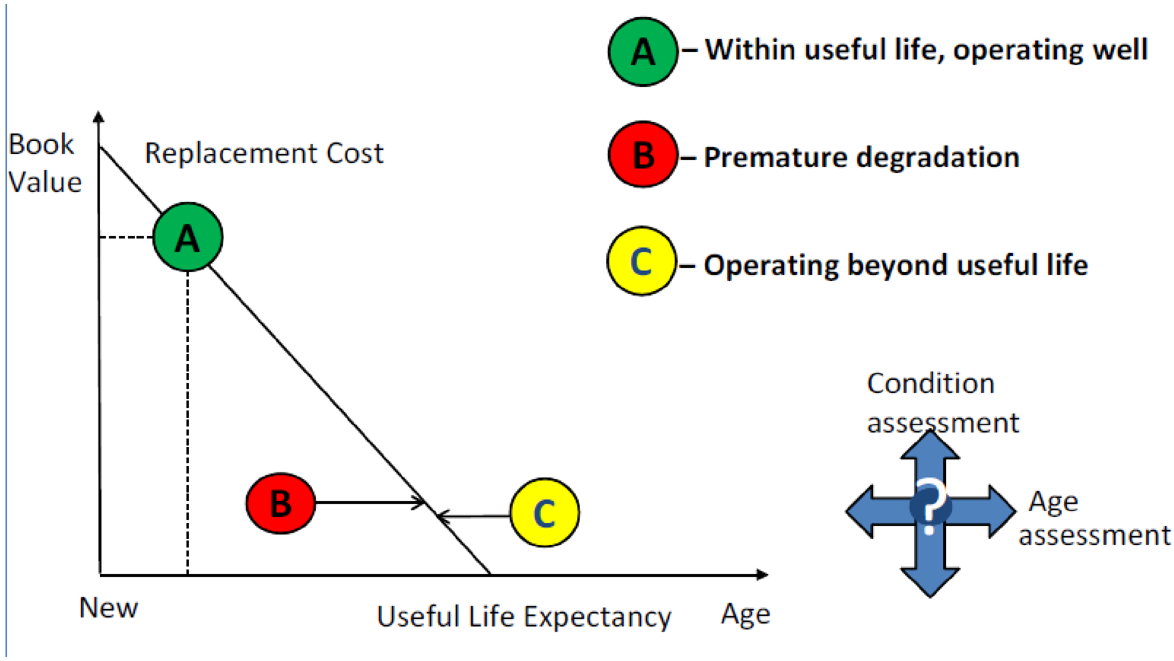


Figure – Depreciated Asset Value

The figure above shows a line of depreciation. "A" represents an asset which has been depreciated normally in the accounts. However, "B" and "C" represent possible points, which this valuation recognises, where neither age nor condition is consistent with the original depreciation line.

The reality of the valuation exercise is that the accounting history of the asset is not known or doesn't exist. The figure below shows what we would expect to have occurred to explain the cases of "B" and "C".
Where an asset is in poor condition for its age, as in example "B", this should have been reflected in the accounts as impairment, i.e. a premature right-off of asset value. Where an asset is still operating beyond its normal life expectancy, as in example "C", this is most likely to be reflected by additional investment during its life, i.e. the real life of the asset is less than it seems and the total capital cost being depreciated is greater.

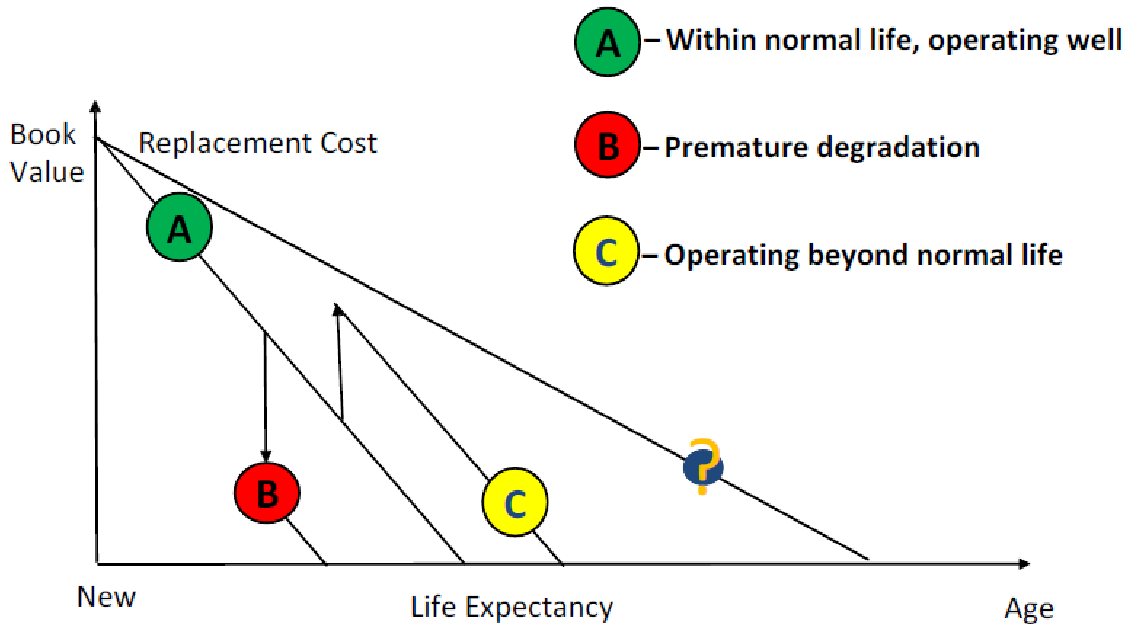


Figure – Impairment and Capital Addition

Based upon the above an algorithm would be used to combine age and condition to generate a discounting percentage to apply to the replacement cost and hence derive the net asset value.

For non-operational assets , primary valuation would be based on the underlying cost information which would typically be obtained from the suppliers contracts, assets invoices and purchase orders . In the absence of values in suppliers contracts, assets invoices and purchase order records, the benchmark market pricing approach would be used based upon cost information for similar assets, typically obtained from suppliers. Where the values are not available in the benchmark markets, the next best approach would be to estimated the asset values of nearest possible similar assets. The effectiveness of this approach depends on a number of factors such as :

- The extent and level of comparability of each property compared to the property under evaluation.
- Time of sale.
- Verification of sale data eg legal obligations or title deeds for the properties;.
- Lack of any conditions which may be affecting the sale.

The income approach considers the income that an asset will generate over its remaining useful life and estimates value through a capitalisation process. This process applies an appropriate yield, or discount rate, to the projected income stream to arrive at a capital value. The income stream may be derived under a contract or contracts, or be non-contractual, eg, the profit generated from either the use of or holding of the asset.
Two methods which may be used under the income approach are:

- Income capitalisation, where an all risks yield is applied to a fixed income stream, or
- Discounted cash flow where the cash flows for future periods are discounted to a present value.

A method for example which can be used to assess the value of the commercial properties using (the residual value) is based on the assumption of the best possible usage for the location and on the assumption that the construction was built with the highest quality and for the maximum generation of income for the land. The value of the real estate project is then derived by capitalizing the income through the use of the standard rates and requirements that are commonly used in the market and then the value of the building and the construction works are deducted from it to get the net value of the designated land.

The cost approach applies the basic economic principle that a buyer will pay no more for an asset than the cost to obtain an asset of equal utility, whether by purchase or by construction. Unless undue time, inconvenience, risk or other factors are involved, the price that a buyer would pay for the asset being valued would not be more than the cost to acquire or construct a modern equivalent. Often the asset being valued will be less attractive than the cost of a modern equivalent because of age or obsolescence; where this is the case, adjustments will need to be made to the cost of the modern equivalent. This adjusted figure is known as the depreciated replacement cost.
The cost approach analysis is defined as the "the method of which is derived the value of properties by introducing the asset replacement cost and deduction from the estimated depreciation rate". In order to determine the depreciation rate, the skills and expertise of the assessor is key to determine the depreciation factor. For example in the case of buildings the equation could be
Market Fair Value = Residual Life / Useful Life of the asset x Cost of the new asset

3. Summary of Condition Assessment Principles

Condition Assessment should not be carried out in isolation. Related issues need to be considered, such as:

- Risk Management.
- Maintenance Management Planning
- Data Collection Techniques eg Has the asset failed, or is it in the process of failing? , Is the proper process safety management (PSM) system in place and is it operating properly? , What is the reliability strategy? Does it need to be changed? , What is the implementation of O & M procedures in the site against the supplier initial recommendations and against optimal best practice work ?, Are there any constraints or barriers that inhibit the best practice? When will the asset fail again?, Can any additional opportunity costs be harvested?
- What is the software tools available and how they are used eg **PRIMAVERA** Project management **SIDAM 3** data field collection, inspection management **ANTEA** documentation management **RBI** Risk based inspection **SAP** asset costs, resource planning, financial **ADM** maintenance analysis, reliability data, EAM , enterprise asset management programmes ?
- What are the Key Performance Targets (KPTs) and Indicators (KPIs) to monitor the effectiveness of processes and systems performance ?

The objectives of systems to monitor asset condition and performance should be to:

- Identify those assets which are underperforming
- Predict when asset failure to deliver the required level of service is likely to occur
- Ascertain the reasons for performance deficiencies
- Determine what corrective action is required and when (maintenance, rehabilitation, renewal)
- Record asset failures for use in advanced AM techniques.

The development and continued use of condition assessment data will allow preparation of verifiable predictive decay curves for particular asset types and hence permit prediction of remaining life. By considering the current condition point on an assumed decay curve, the profile can predict the effective life (time) before failure. This failure time can be physical end of life, minimum level of acceptable service, or limit of capacity of the asset.
The Core approach focuses on data collection for managing risks associated with critical assets and monitoring key performance measures

For passive assets the extent and repetition of condition assessment will be influenced by:

- The type of the asset
- The criticality of the asset
- The relative age of the asset
- The rate of deterioration of the asset
- The economic value of the outcomes to the business.

We have made the distinction between two types of asset and the approach taken for the assessment of condition of these two groups is necessarily different:

Aboveground assets which are observable and can be readily inspected. The condition assessment can utilise physical inspection supported by investigation of operational experience and reports obtained from appropriate staff and business information systems. This class of assets comprises all assets within sites, including buried pipe-work, and will normally be recorded within the maintenance management system asset database. These assets have been split into two categories:

Civils works: For example, structures, buildings, ancillaries, pipe-work and fencing
M&E and Control : All mechanical & electrical and control equipment

Underground assets which are buried and cannot be easily inspected. Universal physical inspection is impossible or impracticable and can be severely restricted within a water utility organization to CCTV surveys of small diameter sewers so a condition assessment has been made based upon operational experience and reports obtained from business information systems. For the water utility sector this class of assets comprises entirely of pipes, fittings, manholes and hydraulic structures outside of operational sites. These assets are normally recorded in a GIS system.

3.1 Simple Approach

In the simple approach the use of condition grades to assign relative condition values to assets and in common with best practice regulatory principles is a 5-level system as used by regulatory authorities in the UK and Australia where:
• Grade 1 is equivalent to best possible condition
• Grade 5 represents worst condition

These grades would also be linked to a likely capital maintenance requirement in that grade 5 indicates immediate remedial action is necessary, grade 4 would mean actionin the short to medium term etc.
The grades and definitions are statements of general principle chosen to reflect a pragmatic assessment of an asset's ability to deliver the required service. In practical terms grades 4 and 5 indicate capital maintenance interventions are necessary while grade 3 indicates additional maintenance interventions are required

Rank	Description of Condition
1	Very Good Condition - Only normal maintenance required As New; designed and constructed to modern standards
2	Minor Defects Only - Minor maintenance required (5%) Old design with perhaps minor faults but performing well
3	Maintenance Required to Return to Accepted Level of Service - Significant maintenance required (10-20%) Visible faults and deterioration while performing adequately subject to appropriate maintenance
4	Requires Renewal : Significant renewal/upgrade required (20-40%) Significant faults and deterioration, performing poorly but not critically, replacement required in short to medium term
5	Asset Unserviceable : Over 50% of asset requires replacement Serious faults and deterioration preventing the delivery of basic service, immediate replacement required

Safety and Safety Grades

An approach to a high-level safety assessment at sites would be similar to that used for condition assessment as mentioned above where

• Grade 1 represents safety provision to modern international standards
• Grade 5 represents and absence of safety provision or where there is a source of serious hazard.

Safety of staff going about their work is of paramount importance and the grading reflects a high-level assessment of risk observed during the physical inspection of facilities. The grading is designed to highlight issues rather than provide detailed solutions and will be combined with detailed safety audits at representative sites to establish remedial programmes and implemented through an investment programe
The survey would consider what hazards were present and whether any provision has been made to mitigate the risks. The grading is presented below. The grade reflects the degree to which the risks have been mitigated so Grade 1 reflects that all reasonable measures have been taken to modern best practice standards while Grade five reflects absence of provision and serious hazard risk.

Safety Grade	**Safety Grade Definition**
1	Risk mitigation provided to modern standards
2	Risk mitigation provided to old standards but in good condition
3	Risk mitigation provided but with visible faults and deterioration
4	Risk mitigation compromised by unserviceable or faulty assets so unable to provide protection
5	An absence of any risk mitigation and/or clear source of serious hazard

This system of grading is aimed at identifying observable issues that can be addressed in detail within a Safety Plan. Issues that may not be observable such as the presence of unbound asbestos or PCBs will be addressed by specific studies undertaken in a Safety Plan developed specifically for the site or organisation. The following aspects of safety risk would be considered:
• Slips, trips and falls
• Machinery (moving parts, rotating equipment etc.)
• Electrical
• Asbestos
• Chemicals
• Lighting

3,2 Intermediate Approach

The approach shown in the below figure involves the enhancement of the organisation's ability to rank more effectively those assets that constitute a significant problem at condition levels 3, 4, and 5.

The intermediate condition rating approach is usually expanded to suit:

- asset types
- failure modes
- evidence of distress.

The simple and intermediate approaches allow development of predictive decay curves. The sophisticated approach using greater numbers of parameters, will generate more accurate curves and give greater certainty to the current condition of the asset.

Rank	Description of Condition	
3.0 3.4 3.8	Level of Service Maintenance	Minor
		Average
		Significant
4.0 4.2 4.4 4.6 4.8	Requires Major Upgrade	Minor
		Average
		Medium
		Substantial
		Significant
5.0 5.2 5.4 5.6 5.8	Asset Basically Unserviceable	Minor
		Average
		Medium
		Substantial
		Significant

3.3 The Sophisticated Approach

Although these sophisticated systems may allow the condition to be assessed on up to ten different parameters with condition scores between 0 and 1,000 they can still be broken down into the base scores of 1 to 5 if required.

The adoption of sophisticated condition ranking systems may not be justified for all assets. However, with the advancements being made in AM techniques and practices, it is likely that in the future most asset owners will employ sophisticated methods for all their assets

3.4. Inspection and Condition Grading Process

In general it would be necessary for survey teams would need to made prior appointments to visit sites to ensure access and the presence of appropriate staff from operations to explain the context of operation and to describe any operational issues that were relevant to condition and serviceability assessment. Surveys should be conducted, as far as possible, following the process stream through the site. In the simplified approach inspections will be visual; where access to asset sets are for example impractical or dangerous the knowledge of operations staff should be used as the sole basis for the grading; for example surveyors would not enter confined spaces, such as in the water utility industry - wet wells, chambers etc.

Where several similar assets made up an asset set within a functional unit, for example a pump-set within a pumping station or cells within a filter then the condition grade given for the set would normally reflect the condition of the worst component. If considerable disparity existed between components within a set, for example one pump may have been new, then a note would be made on the data collection forms and this would be taken into account at the moderation stage.

Photographic evidence is an important aspect of the process and can be used to illustrate grading decisions, illustrate safety hazards etc.

Questioning operations staff about the ability of the assets to deliver the required service is also a crucial aspect of the inspection process. For inspections, questions should be asked of suitably knowledgeable staff about the reliability of the asset and its ability to deliver the required service. The QA check for bias can for example be undertaken by sending teams to each others' sites to review and amend the condition grading taken as initial, if necessary.

4 Water and wastewater utility assets

Adopted best practice approach wherever possible is clearly the best methodology for any organization utilising the information existing within the business regarding the underground assets. However best practice approaches to reliably establish serviceability rely heavily upon the collection, collation and analysis of accurate condition and performance data over several calendar years. Where such information is not available to a utility, the best practice approach is to convene expert panels to consider what information is available and to make judgements Within the simplified 5-tier framework described earlier the approach necessarily adopted for assets that cannot be inspected was to utilise all available performance data and knowledge of asset capability.

The following are more specific condition grading standards for a range of infrastructure types namely: wastewater distribution systems, water mains

Table Example Condition Grading Criteria for Water Mains

Grade	**Definition**
1	Average failure rate up to 125/1,000km/annum (more than 1,600m between failures over 5-years)
2	Average failure rate greater than 125 up to 250 failures/1,000 km/annum (<1,600m but >800m between failures over 5 years)
3	Average failure rate greater than 250 up to 500 failures/1,000km/annum (<800m but>400m between failures over a 5-years)
4	Average failure rate greater than 500 up to 1,000/1,000 km/annum (<400m but >200m between failures over 5 years)
5	Average failure rate greater than 1,000/1,000 km/annum (less than 200m between failures over five years).

In cases data is not available for distinguishing pipe performance between pipe materials and diameters directly using mains failure data directly, condition can be prescribed by developing a guidelines given to materials and diameter categories of pipe – for example Concrete Cylinder Pipe water mains are normally of large diameter and therefore critical to network operations and service delivery in addition to pipes of Ductile iron water and Precast Concrete

Condition Rating for Water Pipes

Rating	Description
Excellent	No failures. Complies with engineering standards.
Good	Few failures. Few areas not complying with engineering standards.
Fair	Failures beginning to occur. Significant areas not complying with engineering standards.
Poor	Regular failures occurring and significant corrosion. Increases operating costs resulting. Many must be replaced.
Failing	Significant failures and should be substantially reconstructed.

(Source 1 http://www.municipal.gov.sk.ca/Assessment/Asset-Management/Grading-Standards)
Source 2 : Guide to Accounting for and Reporting Tangible Capital Assets.
(http://www.psab-ccsp.ca/other-non-authoritative-guidance/item14603.pdf)

Table – Example of Condition Grade Definitions for sewers

Condition Grade	Condition Grade Definition
1	No structural defects
2	Sewers with minor circumferential cracking or moderate joint defects.
3	Sewers with deformation 0-5% of diameter and cracked or fractured or longitudinal/multiple cracking or occasional fractures or severe joint defects or minor loss of level less than or equal to 10% of diameter or badly made connections.
4	Sewers with deformation 5-10% of diameter and cracked or fractured or broken or serious loss of level more than 10% of diameter.
5	Sewers already collapsed or deformation >10% and cracked or fractured or broken or extensive areas of missing fabric

For accurate performance and comprehensive survey data for sewer networks. , CCTV information would be required for representative survey Size banding of sewers can also be simplified to just two bands:
Band 1: Up to and including 700mm diameter
Band 2: Over 700mm diameter
It can be considered that the principal influence upon performance of sewerage network is material and age and in certain circumstances diameter within a material category. This is due to the progressive influence of hydrogen sulphide corrosion and to the fact that materials and construction practice has improved over time.

Water Supply, Storm water and Wastewater Condition Grading Standards: Civil Structures

Grade	Condition	Description
0	Non existant	Asset abandoned or no longer exists
1	Very good	Sound physical condition. Asset likely to perform adequately without major work for 25 years or more.
2	Good.	Acceptable physical condition; minimal short-term failure risk but potential for deterioration in long-term (10 years plus). Only minor work required (if any).
3	Fair	Significant deterioration evident; failure unlikely within next 2 years but further deterioration likely and major replacement likely within next 10 years. Minor components or isolated sections of the asset needs replacement or repair now but asset still functions safely at adequate level of service. Work required but asset is still serviceable.
4	Poor	Failure likely in short-term. Likely need to replace most or all of asset within 2 years. No immediate risk to health or safety but works required within 2 years to ensure asset remains safe. Substantial work required in short-term, asset barely serviceable.
5	Very poor	Failed or failure imminent. Immediate need to replace most or all of asset. Health and safety hazards exist which present a possible risk to public safety or asset cannot be serviced/operated without risk to personnel. Major work or replacement required urgently.

(source http://www.municipal.gov.sk.ca/Assessment/Asset-Management/Grading-Standards)

Water Supply, Storm water and Wastewater Condition Grading Standards: Mechanical and Electrical Assets

Grade	Condition	Description
0	Non existant	Asset abandoned or no longer exists
1	Very good	Plant in sound physical condition designed to meet current standards. Operable and well-maintained. Asset likely to perform adequately within routine maintenance for 10 years or more. No work required
2	Good.	Acceptable physical condition but not designed to current standards, or showing minor wear. Deterioration has minimal impact on asset performance. Minimal short-term failure risk but potential for deterioration or reduced performance in medium term (5 – 10 years). Only minor work required (if any).
3	Fair	Functionally sound plant and components, but showing some wear with minor failures and some diminished efficiency. Minor components or isolated sections of the asset need replacement or repair but asset still functions safely at adequate level of service. For example, bearing and gland wear becoming evident and some corrosion present. Deterioration beginning to be reflected in performance and higher attendance for maintenance. Failure unlikely within 2 years but further deterioration likely and major replacement required within next 5 years. Work required but asset is still serviceable.
4	Poor	Plant and components function but require a high level of maintenance to remain operational. Likely to cause a marked deterioration in performance in short-term. Likely need to replace most or all of assets within 2 years. No immediate risk to health or safety but work required within 2 years to ensure asset remains safe. Substantial work required in short-term, asset barely serviceable.
5	Very poor	Failed or failure imminent. Plant and component effective life exceeded and excessive maintenance costs incurred. A high risk of breakdown with a serious impact on performance. No life expectancy. Health and safety hazards exist which present a possible risk to public safety, or asset cannot be serviced/operated without risk to personnel. Major work or replacement required urgently.

(source 1 http://www.municipal.gov.sk.ca/Assessment/Asset-Management/Grading-Standards)
Source 2: International Infrastructure Management Manual – Version 3.0, 2006
(http://openlibrary.org/books/OL21245688M/International_infrastructure_management_manual)

SECTION 5 : EMERGENCY RESPONSE PLANNING

1 Introduction

The majority of organizations and businesses recognize the need to plan for the unexpected and there are few organizations that do not have some form of a plan to deal with the consequences of an unwanted incident or disaster. For example, This could be a hazardous materials spill that may necessitate evacuation or , a severe weather warning that leads to concern about flooding or infrastructure damage,

Organisations realize also to stay in business after a major incident requires careful pre-planning and this means taking action before an incident occurs, not after

An the outset it is necessary to define an “emergency” and relate the definition to other non-emergency events

Criticality can be considered as Assessment of a risk while crossing its likelihood and the seriousness of its consequences. Other criteria can be taken into account to evaluate the criticality, such as the ability to monitor or to tackle the risk.
Contingency plan can be considered as Set of actions to be undertaken to prevent the hazard from happening (Preventive Actions).
Emergency can be considered as a serious “incident”. and an **Emergency plan** can be considered as set of actions to be undertaken once the hazard has occurred (Corrective Actions). An emergency Response Plan provides “*A professional, strategic and tactical managed response protocols: (i) to mitigate the effect of an emergency upon the business; (ii) that are scaled to the severity of the emergency and (iii) which set out the relationships for response teams, within and outside the business.”*
Emergency Response Plan provides: “*professional, strategic and tactical managed response protocols: (i) to mitigate the effect of an emergency upon the business; (ii) that are scaled to the severity of the emergency and (iii) which set out the relationships for response teams, within and outside the business”*

Emergency Room – this is a location where the Strategic Response Leader and his team can plan the response and manage the situation. It is essential that the Emergency room remains a “quiet” area and not become a melee of people, thus only those appointed by the Strategic Response Leader as a part of the Strategic Response Team shall be permitted within the Emergency room.

This will be the central command post should have necessary equipment and supplies including:
Operational information:

1. maps of distribution system and city maps
2. engineering information
3. access to other system information
4. copies of standard operating procedures
5. human resources information (including contract information, copies of relevant legislation, training and certification information, and emergency contact information)
6. access to vital contact information (including – but not limited to - all relevant contact information for key staff, suppliers, contractors, and other individuals and organizations that will be needed to assist in emergency response.)
7. access to information about consumers including contact information
8. list of all chemicals stored at CBU sites and MSDS information
9. other vital records

Emergency Plans

10. copies of the Organisation’s Emergency Plan
11. copies of the City Emergency Plan (and appendices to this plan – including a city based Flood Plan and Crisis Communications Plan)
12. copies of the Water Security Emergency Plan
13. copies of the Wastewater Emergency Plan

14. copies of relevant legislation

Communications equipment and office equipment and supplies

15. communications equipment (fax, phone, email, cellular phones, City radios, satellite phone if other phone networks have been affected)
16. computers (laptops, desktops), printers, scanners, photocopiers, CD burners, USB memory sticks and other devices
17. overhead projector
18. laptop and LCD projector
19. tape recorder, tapes
20. TV (with cable access if possible) and VCR (with recordable tapes)
21. AM/FM radio
22. office furniture (tables/desks, chairs, lighting, bulletin boards, whiteboards)
23. office supplies (blank CDs, stationary, clipboards, binders, paper, pens, pencils, highlighters, staplers, staples, hole punches, paper cutters, thumbtacks, masking tape, duct tape, file folders, markers (including dry-erase), flip chart and extra paper etc.)

Integration with an organisation's IT systems

24. The Emergency Room should also be fully integrated with the organisation's IT system – for example in the case of a water utility this will include the GIS, SCADA and Hydraulic and network modelling . It is also important that a member of the IT services be on hand during the emergency in order to provide any advice and support as necessary.

Emergency Report, The emergency report contains normally the following information:

- Record of the names of the strategic reponse team members and their designated role, as well as any other person who enters the Emergency room and the Reason of their presence
- Record on the emergency situation itself : description of the situation, facilities concerned, casualties, property damages, equipment mobilised etc.
- Record all the actions taken and decisions made within the emergency room and by the tactical response team to show, as a minimum:
  - Time of the opening of the emergency room
  - Date and time of initiation of the emergency and the nature of the emergency and its level
  - A record of all messages
  - Records of communication with third parties
  - Records of all status reports received from the Emergency Tactical Response Leader
  - Time of the closure of the emergency situation and emergency room

The service concerned by the emergency analyse the causes and define corrective actions to be undertaken. The Final emergency report is normally sent also to the organisation's top management and for archiving in the emergency room.

Incident can be defined as: *"An unplanned event which has no significant affect on the service provided to business customers"* With regard to the definitions mentioned above for an incident , although this is undesirable because it is unplanned and possibly draws upon the business resources to resolve within an unplanned way and inefficient way, an incident is not necessarily an "emergency", which can be defined as: *"An incident of such significant risk as to affect the ability of the business to provide the required level of customer service or in some other way adversely affects the day to day business as normal activities of an organization '*

As an example, a failure of a pump at a pumping station is an "incident" which becomes an "emergency" if a stand-by pump is either unavailable or does not cut-in, causing impacts on the functional service of that pumping station

Risk can be considered as Effect of uncertainty on objectives (from ISO 31000 – Risk Management).

Hazard can be considered as Potential source of harm. Deviations from design or operational intent may constitute or produce a hazard. A single hazard could potentially lead to multiple forms of harm.

Harm can be considered ass the consequence of a hazard occurring and may take many forms: employee, contractor or customer injuries, environmental pollution, financial loss risks, brand image depreciation, legal prosecution, etc…

Performance Indicator The important criterion to be measured is the frequency of emergencies. A falling frequency over the period of the contract will indicate a number of favourable trends: a. Improved reliability and sustainability of the assets; b. The effectiveness of risk management in "designing" risk out of the system; c. Improved workforce operational performance reducing the frequency of incidents becoming emergencies; d. Introduction of operational procedures to avoid the occurrence of an emergency; e. Demonstrable effectiveness of training provided. An indicator could therefore be Number of events for which a response is made divided by Number within a year , for high, medium and low events as collected from the central control room log

Records – Evidence of historical activities that reports the outcome or result of an activity or task. Records can not be modified although they may be subject to updating with additional data as it is acquired. Examples include completed forms (regarding such things as inspections, training, manifests, etc.); monitoring log sheets, audit reports, incident reports, final reports and meeting minutes (compare Documents, above).

Root Cause – The management system breakdown that permitted a substandard action or condition (immediate cause) to occur. Root Causes may also be referred to as System Causes or Underlying Causes.
Safeguards can be considered as the devices that help to reduce the occurrence frequency of the deviation or to mitigate its consequences. Safeguards helps in monitoring, preventing or compensating the deviation.

Strategic response will be that which is necessary to protect the business from undue criticism and will be handled centrally within the Emergency room. The strategic response will, instinctively, support the onsite team by mobilising, finding and, if necessary procuring resources – labour, materials, plant and equipment, as well as any specialist skills. The strategic response team will take strategic action such as changing supply systems and bringing in additional sources. A key task of the strategic team will be communication with external parties to be notified and with the media and public.

T**actical response** will be the site focused response i.e. by the repair team and local management. The tactical team will (i) attend to the cause of the emergency to affect a repair; (ii) otherwise end the emergency and (iii) deal with any local consequences of the emergency e.g. in the case of a water utility this would be property flooding from a sewer collapse or broken water main

2.2 The Approach to an Emergency

The approach to be adopted by a business unit typically for the response to an emergency is a four layer response as follows .
1. Provide a procedure to trigger an emergency alert. One of the most common failings in responding to an emergency is the slow realization that an "incident" has or is progressing to an emergency, or that an emergency has commenced;
2. Analyse the risk. When the emergency event is alarmed, the next steps are to analyse the risk by:
a. Identifying the Nature and Reasons for the Emergency
b. Assessing the consequences
c. Considering the effects
3. Determine the Required Level of Response. Only and after the risk has been analysed is it possible to ascertain the required level of response
4. Manage the Emergency. The emergency event is to be managed (i) strategically and (ii) tactically, as discussed below

Typically organizations will set up a multilevel organisational structure, which is functional, and includes for standby rotas to provide for seven days per week, 24 hours a day. There needs to be a clear escalation process that matches response with risk. The process is typically initiated by a Head of an Emergency Department and, as the level of the severity of the emergency increases, provides for Strategic and Tactical Response Leaders.
When a crisis is identified, all necessary resources are to be mobilized promptly in accordance with the appropriate level of severity of the emergency.
For example in a utility business locally, the alert is conveyed by treatment plant or pumping station operators and/or by network O&M staff to the central control room; is observed by the control room staff from the SCADA or

is notified to the control room by a member of the public or outside organisation. Depending on the severity of the emergency, local or national teams may be mobilized from other than the organization themselves.

The goals of an emergency response plan are to document and understand the stages needed to:

- Ensure the professional management of the emergency
- Delegate authority to those required to take emergency response actions
- The right people are in place to handle the emergency – the formulation of the strategic and tactical response teams
- The resources are available, or can readily be made available to resolve and/or mitigate the situation to minimise the effect upon customers, the environment and the wider public
- The response teams have at hand a full list of support and back-contacts and those to be notified at the start, during and at the end of the emergency
- Provide emergency public information concerning progress on the emergency and where to obtain alternative water supplies and generally keep customers informed
- A feed-back facility is in place as a means for on-going learning from an emergency
- Develop the organisation's experience of emergency handling through the holding of regular exercises
- Rapidly restore business as normal service after an emergency
- Minimise asset system damage
- Minimise impact and loss to internal and external customers
- Minimise negative impacts on public health and employee safety
- Minimise adverse effects on the environment
- Keep customers and other concerned organisations informed of progress with the emergency Respond positively to criticisms of performance

It is vital that any organization developing contingency procedures must take the development of these contingencies seriously as a serious incident can affect the organization at any time

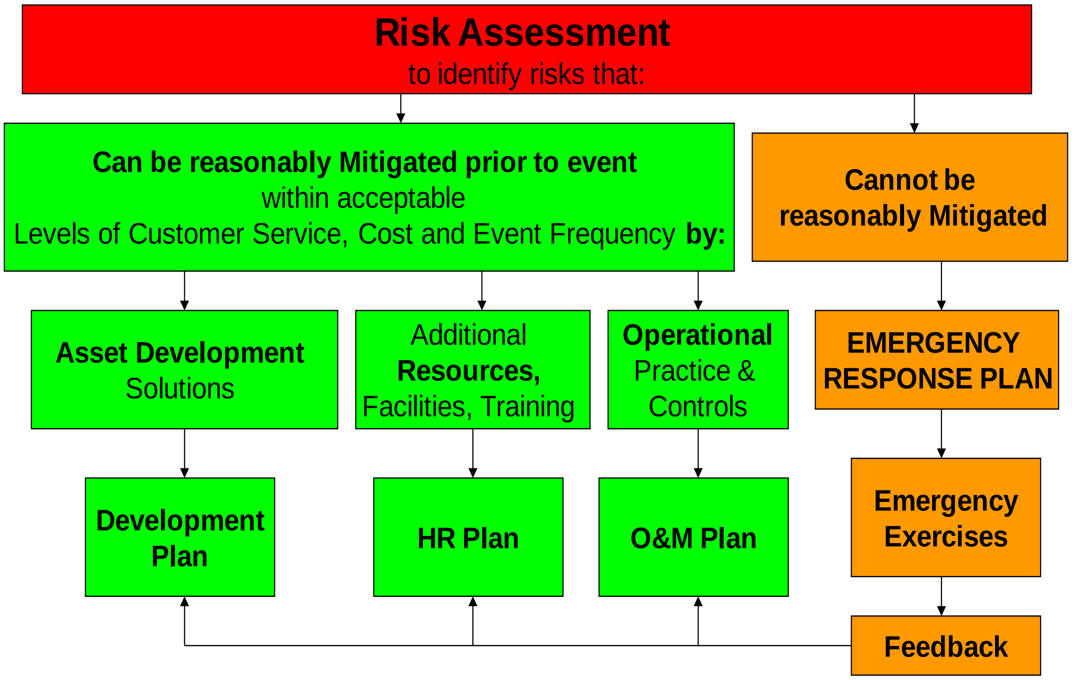
1. The planning out of the system identified risks that can be removed at a reasonable cost.
2. Secondly, for risks that have been identified – specific or generic – that cannot be designed out of the system, or are awaiting investment of the solution, the effects of the emergency can be mitigated:
a. *Before an Emergency* by holding regular Emergency Exercises with feedback into Business Plans
b. *During an Emergency* by having in place an Emergency Response Plan
3. Finally, emergency planning includes for managing the emergency with a:
a. Strategic response – to manage the impact on the business and is directed from a central incident room location
b. Tactical response – the on-site action to correct the event and reduce local effects

The organization would need to prepare a comprehensive list of all potentially serious incidents that could affect the normal as -is operations. Each serious incident should be given a probability rating related to the potential impact severity level if the incident did occur.

Emergency planning is contained within a Risk Management approach that comprises the planning out of the system identified risks that can be removed at a reasonable cost and secondly, for risks that have been identified – specific or generic – that cannot be designed out of the system, or are awaiting investment of the solution, the effects of the emergency can be mitigated:

Before an Emergency by holding regular Emergency Exercises with feedback into Business Plans and Operating Procedures and during an Emergency by having in place an Emergency Response Plan

The following figure illustrates the place of the Emergency Response Plan within a risk management approach.



2 Developing the Plan

The Emergency Response Plan should be maintained as **a "live" document**. As such the Plan is to be regularly updated and modified in the light of changed circumstances and experiences gained both in responding to emergencies and from emergency exercises.
The goals of this plan would be to document and understand the stages needed to:

1. Ensure the professional management of the emergency;
2. Delegate authority to those required to take emergency response actions – for example, the informed supervisor or Duty Engineer has to go on site to (i) identify the nature and reasons of the emergency (ii) to assess accurately the consequences (classifying the situation according to severity). The specific procedure does give some guidance. This risk analysis is essential. It is used to trigger the emergency and ensure optimal management;
3. Based upon the above step, the right people are in place to handle the emergency – the formulation of the strategic and tactical response teams;
4. The resources are available, or can readily be made available to resolve and/or mitigate the situation to minimise the effect upon internal and external customers with the organisation, the environment and the wider public;
5. The response teams have at hand a full list of support and back-contacts and those to be notified at the start, during and at the end of the emergency;
6. Provide emergency public information concerning progress on the emergency and where to obtain alternative water supplies and generally keep customers informed;
7. A feed-back facility is in place as a means for on-going learning from an emergency;
8. The organisation has experience of emergency handling through the holding of regular exercises.

A typical procedure is as follows :

Procedure Owner: Managing Director

Purpose: To set out the procedure and frequency for revisions to the Emergency Response Plan and the methodology for issue.

1. Methodology and type of Review

The Procedure shall be updated under the control of the Head of the Emergency Department at a specified frequency as mentioned below. In order to develop the framework of the emergency response planning it is important that an organization or business unit sets up a dedicated committee is set up to structure and lead Risk Management. This normally has no specific empowerment within the organization and is aimed to be both a think-tank and a taskforce intending to help and propose solutions to the management of the business which is in charge of making appropriate decisions and implementing them. The aims would be as follows

- Identify the business risks;
- Identify mitigation actions;
- Implement mitigation actions;
- Develop crisis situation Management Strategy (emergency);
- Develop the procedures for performing emergency drills (contingency);
- Develop the procedures for checking and updating the efficiency of the Risk Management throughout the business functions.

2. Frequency of Review

The Emergency Response Plan shall be reviewed and updated in the event of one of the following:

- Change of circumstances related to the commissioning and decommissioning of assets.
- Changes in staff within posts or nominations to committees
- Changes in the organisation structure of the company
- Any requirement that has been specified within the Plan that has subsequently found to be inadequate or in some way insufficient e.g. facilities within the Incident Room
- After an Emergency Exercise has been held and the wash-up meetings has revealed a requirement for change;
- Any other event or happening that removes the currency of the Plan, as issued.

3. Issue of the Plan

The Emergency Response Plan shall be considered as a Quality Controlled Document and its issue and control be in accordance with the Business Quality Control Procedure.

4. Testing and Monitoring the Plan

Developing the plan in itself is not enough and before it can be implemented it should be vigorously tested. This process needs to be properly planned and carried out in as realistic and authentic conditions as feasible. The objective of enacting the emergency plans at any time would be also to test the procedures and simulations employing both operational and technical failures. To avoid complacency, regular audits of the staff will take place on a monthly basis to check the readiness of staff in case an incident arose. The essentials of this planning process and audits will include: The emphasis of the plan must be on the response to the incident and not the cause of the incident, the plan must be flexible - it has to work on holidays, weekends or in extreme weather conditions (e.g. sandstorms) , it is clearly written and easily understood and all involved must clearly understand their role

The key individuals highlighted in developing the plan need to be fully involved in any testing activities and the test procedures need to be documented, results recorded and any feedback used for fine tuning the contingency procedure. The suggested roles are mentioned below
The organization also needs to recognizes the need to audit the plan itself and the backup arrangements supporting it on a regular basis. To properly implement the contingency procedures it is imperative that the personnel, who will be involved in implementing these procedures, are fully aware of their responsibilities and properly tested.

It is also important that appropriate resources will be held available and deployed at the earliest opportunity to protect the interests of customers and the company's assets. For example, adequate plant, equipment and emergency stores are to be available for dealing with the emergency and chemical reserves retained in case enhanced treatment is necessary at the treatment plants. The resources need not be owned by the buisiness but could be hired or otherwise made available.

The response will be at two levels, strategic and tactical:

1. The strategic response will be that which is necessary to protect the business from undue criticism and will be handled centrally within the Incident Room. The strategic response will, instinctively, support the onsite team by mobilising, finding and, if necessary procuring resources – labour, materials, plant and equipment, as well as any specialist skills from another business unit or organization for example. A key task of the strategic team will be communication with external parties to be notified and with the media and public
2. The tactical response will be the site focused response by the repair or other action team, and by local management.

<u>Role of the Emergency Strategic Response Leader, SRL</u>
The Emergency Strategic Response Leader would normally be expected to undertake the following tasks- This person would manage the emergency but may choose to delegate some of his tasks, but not his responsibility for the management of the emergency:

- Locate himself in the Emergency room
- Assume full charge for the response to the emergency
- Identify the causes for the emergency and the strategic response required
- Manage the strategic response
- Assemble the strategic response team which can consist of specialist business unit managers (for example IT, HR, O & M , logistics manager, stock manager, specific tasks manager etc.)
- Maintain communication with the Emergency Tactical Response Leader and respond to all requests for assistance, resources an advise
- For a higher severity emergency, appoint a log-keeper
- in conjunction with the Public Relations Person, arrange for press-releases and handle requests from the media
- Ensure that customers are kept informed of where alternative water supplies can be obtained and generally kept informed
- Chairs the subsequent de-briefing meeting and prepares a report on the emergency;
- Keeps directors and senior managers abreast of the situation
- Notify the person immediately below them on the Emergency Response duty stand-by rotas of the emergency and to place them on stand-by
- For a prolonged incident, ensures that back up for strategic response and tactical response teams is in place
- Delegate all his regular day-to-day activities to a deputy
- Raise the level of severity, if he considers it appropriate. This action may be taken in consultation and conjunction with others.

<u>Role of the Emergency Tactical Response Leader</u>

The Emergency Tactical Response Leader would normally be expected to undertake the following tasks. The Tactical Response Leader is to appoint assistance as he thinks appropriate and, if the emergency is expected to be of long duration, assemble a stand-by team and a deputy Tactical Response Leader.
If the "normal" response team i.e. standby gang is employed for the emergency, the Emergency Tactical Response Leader will assemble a second response team to cover for any other emergency that might arise. This might require the use of staff from say outside of the affected location and will be arranged through the Emergency Strategic Response Leader :

- Immediately go to the site of the emergency
- Appraise the situation and make a report to the Emergency Strategic Response Leader
- Manage the on-site response and assemble the strategic response team
- Take appropriate action to rectify the emergency and manage the on-site activities
- If appropriate, evacuate the building and/or ensure the public are kept away
- Request additional resources as may be required
- Keep the Emergency Strategic Response Leader informed of progress with as early warning as possible of difficulties
- Provide assistance to members of the public who may have been affected by the emergency
- At the end of the emergency prepare a report upon the emergency

Clearly, effective communication is the key to successful emergency management and communication is required between:
1. The strategic and tactical response teams;
2. Appropriate external entities;
3. Media and other means of communication with customers;
4. Internal support staff;
5. Strategic and tactical response back-up teams

3 Training

Effective emergency management requires that emergency managers have good knowledge of their responsibilities, that managers are trained in the use of a comprehensive emergency plan, and that the team of emergency managers works effectively together.

The organisation should ensure that specific emergency response training is to be provided regularly in:

a. The implementation of the Emergency Response Plan, in particular:
(i) The recognition of an emergency
(ii) Identifying the seriousness of the event
(iii) Dealing professionally with an emergency
b. Communication skills in an emergency
c. Record keeping during an emergency

Other training requirements (including technical and safety training) may prove necessary and will be identified through the emergency exercises and/or the various senior managers following an emergency event or not.
The exercise should be used to test the efficiency and capability of the organisation to react professionally and competently to an emergency as well as the adequacy of the Emergency Response Plan's components.

The nature of the exercise shall be determined by the senior management of the organisation based upon likely scenarios that could occur.
The only advance notice of the exercise shall be a general note to all staff that say, an exercise will be held within the next 4 weeks. The exercise say , can be held anytime within that four week period. Senior managers of the organisation are also not normally informed of the date or nature of the exercise.

Unless otherwise considered as a special need, the exercise shall take place during “normal” working hours. The exercise can be conducted when key players are not available due to leave, training, meetings or other such reasons in order to test the standby procedure
The note shall also set out the extent to which the exercise is to be played out. For an exercise that is simulating a burst main, for example, this will usually be limited to people attending a site, checking location and operability of valves but not actually operating the valves; checking availability of plant and repair couplings etc.
The exercise is to be given a code name and all messages prefixed with the words: “For the purposes of Exercise [Name] only” to differentiate from a real emergency.
During an exercise, all procedures, actions described in the various component and procedures of the emergency response applies with the exception of external bodies/entites (e.g. fire fighters) unless previously agreed with them.

During the exercise, participating staff shall maintain a record of their actions, communications made and other information that will be required for the subsequent debriefing meeting.

Following the exercise, a debriefing meeting shall be held to which key players are to be invited. The actions taken within the exercise are to be critically discussed as an aid to improved performance.
After the debriefing meeting the Managing Director or a person designated by him is to prepare a report of the exercise and, if required, amend the Emergency Response Plan.

Notes

1. Informal training may be done with video simulations of emergencies or refresher programs.
2. Reviewing emergency case studies may help managers understand emergency scenarios, and achieve consensus on what was done well, and what could be done better.
3. The organisation’s emergency Team should share news stories about industry related emergencies in other countries in the world in order to stimulate discussion and stay up-to-date. These news stories may also be used to stimulate discussion about how to improve emergency management and the emergency plan.
4. The organisation’s Emergency Team should participate in annual emergency management scenarios (see below).

Emergency Scenarios

The scenario should be planned in such a way as to avoid having it be interpreted as a real occurrence. Care must be taken to avoid alarm. It is important that all written material and oral communications clearly indicate that *‘this is a drill*.’

1. Identify the aim of the exercise:
   a. Are you trying to build a basic familiarity with the plan?
   b. Do you want to test the entire plan or do you want to test select components of the plan? Are you interested in using specific documents?
   c. Are you testing activation decisions?
   d. Are you working on incident assessment skills?
   e. Are you trying to encourage team building?
   f. Do you want to test communication among the organisation’s Emergency Team, Emergency Operations Control Group?
   g. Do you want to include all of the agencies involved in incident response?
   h. Do you want to work on effective communications with the public, media and special users?
2. Identify the constraints:
   a. How much time can you commit to the exercise?
   b. What resources can you commit to the exercise? Can all team members participate in the exercise? Can staff members participate in the exercise? Will the exercise be interrupted to allow normal business operations to continue?

3. Develop an exercise that will be a positive experience.
   a. Start with simple exercises, and work up to more complex exercises.
   b. Set objectives that are attainable. Do not attempt to test the group to the point of failure.
   c. Determine whether the team should be told the basic characteristics of the planned scenario in advance to allow review of relevant documents.
4. Determine what type of exercise is appropriate.
   a. In a static (or tabletop) exercise, an emergency scenario is created on paper. Successive events are presented on paper, by a facilitator who is present in the meeting room, by incoming telephone calls, or via radio messages. These are simple to run, and require few resources; however, they only test some aspects of emergency response. In addition, the exercise must be planned carefully to ensure that the limitations of the exercise do not preclude effective emergency management.
   b. Telecommunications exercises are used to test the effectiveness of emergency notification systems, communications systems, and may be used to analyze effectiveness of risk communications with the media and the public. Telecommunications exercises may not require the assembly of all members of the organisation's Emergency Team.
   c. Field exercises are the most complicated type of emergency scenario. They test information flow and decision-making under realistic conditions. During a field exercise, all members of the organisation's Emergency Team should be assembled and a Command Post should be established). The organisation's staff may be involved in response activities and on-site investigations may be performed, depending on the characteristics of the scenario.
5. Setting up the exercise
   a. Is this a static, telecommunications or field exercise?
   b. Plan a schedule of exercises.
   c. Create a scenario, and a sequence of events.
   d. Identify the information needs of the group, and plan appropriate cues.
   e. Review the scenario, sequence of events and cues to determine the appropriate responses of the organisation's Emergency Team. If the team does not earn the information required to keep the exercise on track, the facilitator may interrupt the exercise when it is appropriate and provide the required information. The problem in the exercise or in team responses should be reviewed later.
   f. Identify any control or safety requirements.
   g. Identify staff requirements.
   h. Identify resource requirements:
      i. Assemble maps showing all facilities
      ii. Obtain all necessary forms
      iii. Gather an adequate number of emergency plans
      iv. Set up a meeting room with a blackboard or a whiteboard, an overhead projector, a flip chart, communications tools (radios, telephones, fax, computers), and any other requirements.
      v. Create message cues, and determine how they will be delivered.
   i. Plan site preparation and clean-up.
   j. Plan debriefing.
6. Explain the expectations of the exercise. Note that this is a friendly exercise, designed to be used to determine the adequacy of emergency management tools and training, rather than as a test of individual member's performance.
7. Give the participants instructions:
   a. You will be given a scenario, with necessary information at the outset. Your actions will determine what additional information you obtain.
   b. Use appropriate procedures and other documentation.
   c. Document your actions and fill out applicable forms.
   d. Plan response activities with the assumption that adequate staff and resources are available. Document your intended responses.
   e. Do not operate equipment.
   f. Be careful to always indicate on papers and in oral communications that '**this is a drill.**'
   g. Communications with outside groups, including the public, media and staff who are not involved in the

emergency scenario should be simulated by contacting the facilitator.

8. Perform the exercise.
9. Immediately debrief all participants.
   a. Assess the success of the exercise and make recommendations for improvements.
   b. Recommend changes to the emergency plan.
   c. Recommend changes to task allocation among the organisation's Emergency Team Members.
   d. Evaluate the effectiveness of communications among the organisation's Emergency Team members.
   e. Evaluate the effectiveness of decision-making of the organisation's Emergency Team.
   f. Evaluate the effectiveness of communications with other agencies (if applicable).

4 Resilience

In the event of a credible warning or threat of a potentially serious incident or circumstance, the organisations' Emergency Team should be informed immediately. The team may decide to activate the Emergency Plan Alternatively, the team may prefer to remain in an alert condition. During an alert situation the buinsess operations may be changed, and the team should be kept informed of changes in circumstances, , for example as follows for a water utility - but formal implementation of the plan is not required

Example of Water Utility - Ensuring maximum resilience in the system

1. Ensure maximum resilience in the system. This may involve increasing the amount of water in storage by filling reservoirs and towers, switching operations to generator power, implementing water use restrictions , etc.
2. Consider implementing precautionary water-use restrictions.
3. Consider shutting down or increasing monitoring of sources or areas of the distribution system that may be affected by the incident.
4. Determine whether to isolate areas of the system or turn off non-critical sources.
5. Prepare for the loss of electrical power or telephone lines. Do computerized control systems operations need to be altered? Should operations be set to manual mode in anticipation of loss of phone systems or failure of computerized control systems?

5 Simplified Assessments

The aim of hazard identification is to identify all relevant potential causes of harm to people, damage to the environment and damage to property. Once hazards are identified they can be assessed and if necessary avoided, prevented or controlled.

Hazard identification techniques used should be:

Formalised: The hazard identification should be carried out according to a documented procedure.
Thorough: The hazard identification process should be complete within a boundary, which should be defined beforehand.
Repeatable: Experienced personnel carrying out the same hazard identification exercise should furnish similar results.
Structured: The procedure used should ensure that adequate attention is given to all parts of the plant, procedures or other items under study and that nothing is missed.

The technique selected for a particular application should take account of the specific requirements of that application, especially the end use of the hazard identification process.
The output of the hazard identification process should be followed up to ensure that risks are assessed and control measures implemented as appropriate. Typically, a hazard identification type study will result in a series of actions such as the requirement to:

- Modify the design of plant.

- Modify operational procedures.
- Modify maintenance procedures.
- Evaluate the need for modifications to plant, procedures or maintenance activities.
- Carry out more detailed assessments.

An appropriate action tracking system should be used to ensure that all actions are carried out and closed out in a timely fashion, including further actions and recommendations that may result from detailed studies. The action tracking system should record all data necessary to ensure that the action is properly closed out including:

As part of the preparedness for emergency response planning also the understanding of hazards should be clear with the associated use of the Management Information System (MIS) – where accessing data and other information from the MIS will mean that the data is current and common to all users. It follows that data held on the MIS for the hazards applicable to the business unit should be accurate and current and that hardware is available so that those who require the data, can freely access the MIS.
Hazards can be classified regarding their causes and consequences – further example is provided in the Appendix 1

	Causes	**Consequences**
Quality management	Deviation from: - Customer expectations; - Regulatory Rules; - Business policies.	Customer non-satisfaction Legal prosecution / fees
Health and Safety Management	Hazardous situation Unsafe practices	Injury or diseases for: - Employees - Contractors - Customers
Environment protection		Environment pollution or damages

A simplified approach can be as follows with example taken for a water utility company, where the risk rating would also effect the escalation and level of management involvement

Probability →

Severity ↑

	High	**Moderate**	**Low**
High – Crisis	High probable events for area or region	Vandalism or terrorism Chemical spills Microbial contamination	Earthquake
Moderate - Disruptive	Failure of a delivery main	Severe winter weather	Large fire
Low -Manageable			Construction accident Failure of IT systems

Where High Probability and High Severity = **High risk** and Low Probability and Low Severity =**Low risk**

Definitions of severity

Severity level	Severity Indicators	Example (for water utility)
Level 0: An Incident	No adverse affect upon the ability of the business to maintain a normal service to customers.	No impact to customers at all
Low - Manageable	a.Customers/public may be affected but no widespread consequences and incident can be managed by local staff; b. There is adequate storage capacity to see the emergency through or additional water could be made available from other sources; c. No adverse public reaction is expected; d. Unsatisfactory water quality sample from local area; e. Low security threat.	Destruction, malfunction or failure would have no immediate effect on service operations or resources. (Financial Impact) - These items would affect the availability of water, but would not affect essential uses of water. For example, loss of some water supplies could lead to the need for reducing water demand, but not to the extent that would lead to serious impacts upon consumers.
Moderate - Disruptive	a. Widespread affect on the organization ability to maintain a service with adverse consequence to the public; b. Due to the complexity of the incident, access problems or availability of spare parts etc., the duration of the emergency is likely to be such that water storage volumes will be seriously depleted with consequential expansion of the area initially affected; c. Critical customers are affected and media attention can be expected; d. Medium security threat;	Destruction, malfunction or failure while not immediately affecting emergency operations could affect public safety function, resources and public services in the short or long term. (Service Disruption) The infrastructure in this category could affect water availability (due to shortage, or water distribution problems) in areas of the city, but the situation is not severe enough to affect public health or safety.
High - Critical	a. An incident that will cause severe public reaction with potential serious affect upon the business image and reputation. b. High level security threat; c. A non organisation related incident that has serious consequences At this level also an emergency might develop into, or immediately be a “crisis”. Such events are rare but may occur. Such incidents by their nature would normally also be too great for the business to tackle alone.	Destruction, malfunction or failure of these items would have an immediate effect on emergency operations and public services. The critical infrastructure of an organisation represents those components of the infrastructure which if

	They would in all probability require the assistance of the outside agencies (eg police , military etc) and would be tackled at regional, if not national level.	destroyed or seriously damaged could for example contribute to a severe water shortage, lead to an inability to maintain sewage lift or treatment operations, seriously affect drinking water distribution or alternatively affect the availability of water for fighting fires

An alternative more sophisticated approach would be to utilize methodological tools such as the Ishikawa diagram (also known as the 6M Methodology: Manpower, Material, Method, Milieu, Machine, Measurement).
The criticality of a risk is defined as **C = L x S**

		Severity			
		Low	Medium	High	Very high
Likehood	Permanent	High	High	Extreme	Extreme
	Frequent	Moderate	High	Very high	Extreme
	Occasional	Moderate	Moderate	High	Very high
	Unlikely	Low	Moderate	High	Very high
	Rare	Negligible	Low	Moderate	High

The likelihood means the probability for a hazard to occur. It can be evaluated regarding the following table

Frequency	Likelihood	Rating
Once a day	Permanent	5
Once a week	Frequent	4
Once a month	Occasional	3
Once a year	Unlikely	2
	Rare	1

The severity of a hazard means the seriousness of its consequences if it occurs.

Consequence				
Quality	Health & Safety	Environment	Severity	Rating
Deviation from regulatory rules	Death	Irreversible effects or wide area impacted (more than 1km)	Very high	4
Deviation from international standards	Irreversible effect	Long-term reversible effects, Impact area around one hundred meters	High	3
Deviation from the organization's Policies	Accident with work leave - reversible effects	Short term reversible effects. Impact area around ten meters	Medium	2
Deviation from Site / company rules	Minor injuries, without work leave	Negligible impact	Low	1

For risk whose criticality is rated beyond 8, the risk control level shall be assessed.
It is calculated by the formula **Ct = Mt x Mn**
Where:
Mt means the mitigation of the risk
Mn means the monitoring of the risk

Mitigation	Rate	Rating
No mitigation measure.	Very low	4
few mitigations actions currently exists	Low	3
Every mitigation action is undertaken	High	2
Every mitigation action is undertaken, tested with records of the results and enhanced if needed.	Very high	1

This criterion evaluates the monitoring of the risk. It could include either technical equipment (probes, detectors…) or management scheme (legal review…).

Monitoring	Rate	Rating
No monitoring system..	Very low	4
A few monitoring systems currently exists	Low	3
Every monitoring system is implemented	High	2
Every monitoring system is implemented, tested with records of the results and enhanced if needed..	Very high	1

Once the risk are assessed and their criticality and level of control are calculated, the global risk level can be calculated by RL = C x Ct.
The final ranking according to the Global Risk Level will highlight the risks that should be tackled in priority.

Appendix : Risk Assessment Matrix

Kind of risk (Q)(HS)(E)	**Processes / Sub-process -** Task / Operation Facilities / Equipment	Risk		Assessment				Risk Control			Ranking		Related documents	Comments
		Causes Customer Expectations (Q) **Hazardous Situations (HS)** **Environment (E)** Environment pollution (E)	**Consequence** Customer non satisfaction (Q), Employee/contractors injuries or diseases (HS) Environment pollution (E)	Likelihood	Seriousness	Criticality, = L*S	Significant if Range ≥ 8 (Yes, Y – No- N)	Mitigation	Monitoring	Control	Risk level	Rank		
Q				2	3	6	N	3	3					
E				2	4	8	Y	2	3	6	48	1		
HS				4	4	16	Y	2	2	4	64	1		

In the above example there may be additional or alternative codes to suit the business applications – for example

Processes / subprocesses involved

AM Asset Management
CD Capital Delivery
CS Customer Services
ICT Information and Communication Technologies
ISS Industrial Security and Safety
OM Operating and Maintenance
P&C Procurement and Contracts

Causes

Mgmt Management (involvement, distribution of information…)
Mnpw Manpower (skills, knowledge…)
Mthd Methods (procedures, Guidelines…)
Eqpt Equipment (gears, tools, devices)
Mat Material (raw product, data, environment…)

Consequences

Emp H&S Employee health and safety
Cont H&S Contractor health and safety
Cust H&S Customer health and safety
Asset dmg Asset damages
Env. Environmetal pollution
Leg. Legal prosecution
Fin. Financial loss

Criticality

L Likelihood

1 Rare
2 Unlikely
3 Possible
4 Likely
5 Certain

S Seriousness of consequences

1 negligeable
2 Marginal
3 Critical
4 Catastrophic

SECTION 6 : RISK REVIEW CHECKLISTS

1 Introduction

Webster's New Collegiate Dictionary defines sustainable as "maintain, or cause to continue, in existence or a certain state." The word 'sustainable' is now used to define a world that is able to "maintain in existence" all life that now exists. To attain that goal, human activities will need to change. With respect to the utility sector this means the efficient and economic use of the utilities without losses or upsets In a related vein, inherently safer processing addresses the need to prevent catastrophes that not only pose immediate danger, but also can result in environmental contamination. The challenge is therefore to have the sustainable processes that not only meet the definition above, but that are also profitable, meet or exceed regulations, satisfy customers needs, maintain support from the customers, and fulfill the capacity building and institutional strengthening needs of the organization

The International Process safety Group (IPSG) and the AIChemE Center for Chemical Process Safety (CCPS) have published a working definition of Inherent Safety Design which will be applied in this section to the review checklists as a general means of risk mitigation as well . There are the following four key words for mitigations. Decision for the mitigation measures may quite often be dependant upon further studies eg modeling, further sampling and analysis , trials etc – but the below checklist provides an indicative start towards assessing the risks in your working places

Minimize: (or intensify): eg reducing the period of risk or for example in the case of use of hazardous chemicals using smaller quantities
Substitute: eg changing the working conditions or O &M parameters which the risk is exposed to – or for example using less hazardous materials, processes, conditions.
Moderate: (or attenuate):reduce risk conditions through change in O & M , design conditions or in the case of chemicals using less hazardous conditions of forms of substance.
Simplify: eliminate unnecessary complexity, "user friendly" plants or design processes that eliminate unnecessary complexity and are tolerant to human error. In this case it should also be noted that the use of Human Factors/Ergonomics is defined as the systematic process of designing for human use through the application of our knowledge of human beings to the equipment they use, the environments in which they operate, the tasks they perform, and the management systems that guide the safe and efficient operations . Keeping it simple, stupid', whether in design or operation, is general seen as key to encouraging good human performance. However, the disadvantage of the simplification concept is that it can engender boredom, which can result in errors. In this respect ensuring operators are involved earlier in plant design and modification is important as is also ensuring control rooms and systems were are designed with ergonomic and practical issues for the optimization of O & M activities including issues such as validation of data inputs, screens and graphics, 'alarm flooding', simplicity and consistency. Simulations in operator rooms might be used for emergency situations.

The below checklists are intended to be a representation only and not an exhaustive or comprehensive list. The below is intended to show the reader the need to develop a unique checklists for review, auditing and verification based upon site or business specific needs

2 General Example of Global Checklists

Requirement	Y / N	Comments			
		Minimize	**Substitute**	**Moderate**	**Simplify**
1.0 General Health & Safety Management					
1.1 Accidents, Diseases and Dangerous Occurrences					
Are accident and incident reporting systems in place for all contractors and sub-contractors?					
Are all accidents reported and investigated?					
Are recommendations from accident investigations and audits properly implemented?					
1.2 General Safety Management					
Has a health and safety policy statement been prepared and is it displayed on site?					
Have site rules been prepared and implemented?					
Has a system for monitoring compliance with Site health & safety requirements been implemented?					
Is there a permit to work system in operation? If 'yes', is it operating satisfactorily?					
Does the business audit compliance with ISO/OSHA HSE requirements?					
Has the issue of a multi-lingual site been adequately addressed?					
Are safety signs and notices displayed in appropriate languages, so as to be readily understood by all persons on site?					
Is there a regular Site HSE safety meeting? Do representatives from all contractors and cub-contractors attend?					
Have separate pedestrian and vehicle access points and routes around the site been provided? If not, are vehicles and pedestrians kept separate wherever possible?					
Have one-way systems or turning points been provided to minimise the need for reversing?					
Where vehicles have to reverse, do properly trained banks men control them?					
1.4 General Personnel Safety and Training					
Has suitable protective equipment, e.g. hard hats, high visibility clothing, fall arrest harnesses, overalls, safety boots, gloves, eye protectors, respiratory protection equipment and life jackets been provided where appropriate?					
Is the equipment in good condition and worn by all who need it?					
Do appropriate items of the PPE supplied (e.g., hats, overalls) clearly identify the employer?					
Has suitable protective equipment, e.g. hard hats, high visibility clothing, fall arrest harnesses, overalls,					

safety boots, gloves, eye protectors, respiratory protection equipment and life jackets been provided where appropriate?		
Have suitable toilets been provided and are they kept clean?		
Is suitable clothing provided for those who have to work in wet, dirty or otherwise adverse conditions?		
Does the facility have a chemical safety specific training program on safe use and handling of chlorine that is documented for employees, new hires, contractor.		
Are accidents and incidents investigated and reviewed with operating personnel		
Is a current MSDS available for all chemicals used		
Are warning signs, Chemical Safety Wall Charts, and/or other safety information used and visible		
Does the facility have a Personnel Protective Equipment (PPE) policy for chemical loading and unloading?		
Does the facility have a policy for respiratory protection in all aspects of chemical handling and emergency response?		
Are safety showers and eyewash stations adequately located and easily accessible from all areas of the unloading site?		
Are the safety showers and eyewash stations periodically inspected for proper operation?		
Are there facilities for changing, drying and storing clothes?		
Is drinking water available?		
Is there a site hut or other accommodation where workers can sit, make tea and prepare food?		
Are welfare facilities easily and safely accessible to all who need to use them?		
1.4 Protection of the Public		
Are the public fenced off or otherwise protected from the work?		
At the end of the working shift:		
Is the site secured?		
Is the perimeter fencing secure and undamaged?		
Are all ladders removed or their rungs boarded so that they cannot be used?		
Are excavations and openings securely fenced?		
Is all plant immobilised to prevent unauthorised use?		
Are materials safely stacked?		
Are flammable or dangerous substances locked away in secure storage places?		
2.0 **Training**		
Has an induction programme been established?		
Have all persons working on the site been inducted?		
Is specific training given on specialist health & safety		

issues related to the site?		
Are toolbox talks an established part of the work arrangements?		
3.0 Good Housekeeping		
Are all working areas and walkways level and free from obstructions such as stored material and waste?		
Is the site tidy and are materials stored safely?		
Are there proper arrangements for collecting and disposing of waste materials?		
Is hazardous waste kept separate from general waste?		
4.0 **Fire First Aid & Emergency Provision**		
Has the workforce been properly advised as to how and where to raise the alarm and call for assistance?		
Does the alarm system consider the difficulties of language when raising the alarm?		
Is the alarm tested at *weekly* intervals?		
Does the site test emergency and evacuation procedures?		
Are portable fire extinguishers provided at appropriate points?		
Are portable fire extinguishers inspected regularly?		
Is there a procedure for replacing 'used' fire extinguishers?		
Are appropriate persons trained in the use of fire extinguishing equipment?		
5.0 First Aid		
In the event of an accident, are steps taken to protect casualties from further harm?		
Is First Aid and medical treatment facilities, including trained personnel, provided on site?		
Are records of all treatment and injuries maintained?		
Is the workforce aware of how to obtain first aid or medical treatment?		
6.0 **Emergency Response**		
Is there a site emergency response plan (ERP) that is up to date and reviewed annually?		
Have emergency responders received training and if so is this training satisfactory ?		
Are periodic drills performed by emergency responders?		
Are the appropriate emergency kit(s) on-site, complete, inspected, and located in an appropriate location?		
Is the emergency responder equipment (BA, suits, etc.) inspected regularly and maintained in suitable condition?		
Are wind socks or other means of determining wind direction appropriately located and easily visible from all areas of the plant?		
Has the facility assessed the need for process and		

perimeter monitoring, and implemented as appropriate?		
Have emergency procedures been developed, e.g. evacuating the site in case of fire or rescue from a confined space?		
Are workers aware of the procedure?		
Is there a means of raising the alarm and does it work?		
Are there adequate escape routes and are they maintained?		
Is there a site emergency response plan (ERP) that is up to date and reviewed annually?		
Have emergency responders received training and if so is this training satisfactory ?		
Are periodic drills performed by emergency responders?		
Are the appropriate emergency kit(s) on-site, complete, inspected, and located in an appropriate location?		
Is the emergency responder equipment (BA, suits, etc.) inspected regularly and maintained in suitable condition?		
Are wind socks or other means of determining wind direction appropriately located and easily visible from all areas of the plant?		
Has the facility assessed the need for process and perimeter chemical residue monitoring, and implemented as appropriate both in the workplace and on the perimeters ?		
Is there a site emergency response plan (ERP) that is up to date and reviewed annually?		
Have emergency responders received training and if so is this training satisfactory ?		
Are periodic drills performed by emergency responders?		
Are the appropriate emergency kit(s) on-site, complete, inspected, and located in an appropriate location?		
Is the emergency responder equipment (BA, suits, etc.) inspected regularly and maintained in suitable condition?		
Are wind socks or other means of determining wind direction appropriately located and easily visible from all areas of the plant?		
Has the facility assessed the need for process and perimeter monitoring, and implemented as appropriate?		
7.0 Safe Means of Access		
7.1 Safe Places of Work		
Can everyone reach their place of work safely, i.e. are roads, gangways, passageways, passenger hoists, staircases, ladders, scaffolds and other access		

equipment in good condition?		
Are there guard rails, equivalent protection or other control measures in place to stop falls from open edges, e.g. scaffolds, mobile elevating work platforms, buildings, gangways, excavations, etc.?		
Are holes and openings securely guard railed, provided with an equivalent standard of protection, or provided with fixed, clearly marked covers to prevent falls?		
Where it is essential to work at an open edge is the opening fenced as far as possible and is safety harnesses used by operatives?		
Are structures stable, adequately braced and not overloaded?		
Are all working areas and walkways level and free from obstructions such as stored materials and waste?		
Is the site tidy, and are materials stored safely?		
Are there proper arrangements for collecting and disposing of waste materials?		
Is the work area adequately lit? Is sufficient additional lighting provided when work is carried on after dark or inside buildings?		
7.2 Scaffolds		
Are scaffolds erected, altered and dismantled by competent persons?		
Is there safe access to the scaffold platform?		
Are all uprights provided with base plates (and, where necessary, timber sole plates) or prevented in some other way from slipping or sinking?		
Are all uprights, ledgers, braces and struts in position?		
Is the scaffold secured to the building in enough places to prevent collapse?		
Are there adequate guardrails and toe boards or an equivalent standard of protection at every edge from which a person could fall 2m or more?		
Where guard rails and toe boards or similar are used:		
Are the toe boards sufficiently high (at least 150 mm)? Is the upper guardrail positioned at a suitable height (at least 910mm) above the work area? Are additional precautions, e.g. intermediate guardrails or brick guards in place to ensure that there is no unprotected gap of more than 470mm between the toe board and upper guardrail?		
Are the working platforms fully boarded and are the boards arranged to prevent tipping or tripping.		
Are there effective barriers or warning notices in place to stop people using an incomplete scaffold, e.g. one that isn't fully boarded?		
Has the scaffold been designed and constructed to cope with the materials stored on it and are these distributed evenly?		
Does a competent person inspect the scaffold		

regularly, i.e. at least once a week; always after it has been substantially altered and following extreme weather?		
Are the results of inspections recorded?		
If it is not reasonable to provide a scaffold or alternative safe means of access where persons may fall more than 2 metres, are safety harnesses etc. used?		
7.3 Powered Access Equipment		
Has the equipment been erected by a Competent Person?		
Is fixed equipment, e.g. mast climbers, rigidly connected to the structure against which it is operating?		
Does the platform have adequate guardrails and toe boards or other barriers to prevent workers and materials falling off?		
Have precautions been taken to prevent people being struck by the moving platform, projections from the building or falling materials, e.g. a barrier or fence around the base?		
Are the operators trained and competent?		
Is the power supply isolated and the equipment secured at the end of the working day?		
7.4 Ladders or similar means of access		
Are ladders the right means of access for the job?		
Are they secured to prevent them slipping sideways or outwards?		
Do ladders rise about 1m above their landing places? If not, are there other handholds available?		
Are the ladders positioned so that users don’t have to over-stretch or climb over obstacles at work?		
Are all ladders in good condition?		
7.5 Roof Work		
Are there enough barriers or is there other edge protection to stop people or materials falling from roofs?		
Do the roof battens provide safe hand and foot holds? If not, are crawling ladders or boards provided and used?		
During industrial roofing, are precautions taken to stop people falling from the leading edge of the roof or from thin or partially fixed sheets, which could give way?		
Are suitable barriers, guardrails or covers, etc. provided where people pass or work near fragile material such as asbestos cement sheets and glass or near roof lights?		
Are crawling boards provided where people must work on fragile roofs?		
Are people excluded from the area below the roof work? If this is not possible, have additional		

precautions been taken to stop debris falling onto them?		
8.0 Hot Work & Fire Prevention		
Are method statements presented to a Site HSE Officer before commencing work on or adjacent to plant containing flammable substances?		
Is the quantity of flammable material on site kept to a minimum?		
Are there proper storage areas for flammable liquids and gases, e.g. LPG, acetylene, solvents, paint thinners?		
Are containers and cylinders returned to these stores at the end of the shift?		
If liquids are transferred from their original containers are the new containers suitable for flammable materials?		
Is smoking banned in areas where gases or flammable liquids are stored and used? Are other ignition sources also prohibited?		
When gas cylinders are not in use, are the valves fully closed?		
Are adequate bins or skips provided for storing waste?		
Are cylinders kept safely upright?		
Are gas cylinders stored outdoors when not in use?		
Where gas cylinders are connected to heaters or cookers in temporary buildings, are the cylinders kept outside the building?		
Is flammable waste regularly removed?		
Are the right number and type of fire extinguishers available and accessible?		
Are work areas inspected one hour after completion of welding / burning activities?		
Are adjacent work areas protected during hot work by the use of screens or mats?		
Are workers using appropriate PPE during hot work operations?		
9.0 **Site Electrical Supplies**		
Is the supply voltage for tools and equipment the lowest necessary for the job (could battery operated tools, reduced voltage tools, e.g. 110V or lower in wet conditions, be used)?		
Where mains voltage has to be used, are trip devices, e.g. residual current devices (ELCBs) provided for all equipment?		
Are ELCBs protected from damage, dust and dampness and checked daily by users?		
Are cables and leads protected from damage by sheathing, protective enclosures or by positioning away from causes of damage?		
Are all connections to the system properly made and are suitable plugs used?		

Is there an appropriate system of user checks, formal visual examinations by site managers and combined inspection and test by competent persons for all fixed & portable tools and equipment?		
Are scaffolders, roofers, *etc*. or cranes or other plant, working near or under overhead lines? Has the electricity supply been turned off, or have other precautions such as 'goal posts' or taped markers been provided to prevent them contacting the lines?		
Have underground electricity cables been located (with a cable locator and cable plans), marked, and precautions for safe digging been taken?		
Are all installation, modification and maintenance work carried out only by trained and competent persons?		
Does the installation include high standards of electrical insulation?		
10.0 Special Processes & Procedures		
10.1 Confined Spaces		
Has a system for safe working in confined spaces been established, e.g. permit for work system?		
Are suitable steps taken to ensure that confined spaces are vented and purged of toxic, flammable and asphyxiating gases?		
Have workplaces in which gases, vapours or fumes could accumulate or a shortage of oxygen could arise been recognised and clearly identified?		
Does a competent person sign a declaration that an area is safe to enter prior to work commencing?		
Are guards positioned at all points of access whilst work is being carried out in confined spaces?		
10.2 Excavations		
Is an adequate supply of timber, trench sheets, props or other supporting material made available before excavation work begins?		
Is this material strong enough to support the sides?		
Is a safe method used for putting in the support, i.e. one that does not rely on people working within an unsupported trench?		
If the sides of the excavation are sloped back or battered, is the angle of batter sufficient to prevent collapse?		
Is there safe access to the excavation, e.g. by a sufficiently long, secured ladder?		
Are there guardrails or is there other equivalent protection to stop people falling in?		
Are properly secured stop blocks provided to prevent tipping lorries falling in?		
Does the excavation affect the stability of neighbouring structures?		
Are stacked materials, spoil or plant stored near the edge of the excavation likely to cause a collapse of the		

side?		
Does a competent person at the start of every shift inspect the excavation; and after any accidental collapse or event likely to have affected it's stability?		
Is a suitable system of formal control of excavations in place? Is this procedure followed for all excavations?		
11.0 Chemicals and Hazardous Substances		
Have all harmful materials, e.g. asbestos, lead, solvents, paints, *etc*. been identified?		
Have the risks to everyone who might be exposed to these substances been assessed?		
Are method statements produced for all work involving removal or installation of thermal insulation material?		
Have precautions been identified and put in place, e.g. is protective equipment provided and used; are workers and others who are not protected kept away from the exposure?		
Are proper storage facilities allocated and used?		
12.0 **Noise**		
Are breakers and other items of plant or machinery fitted with silencers?		
Are barriers erected to reduce the spread of noise?		
Is work sequenced to minimise the number of people exposed to noise?		
Are others not involved in the work kept away?		
Is ear protection provided and worn in noisy areas?		
What are the maximum permissible noise levels adjacent to the construction site?		
Are controls set up to monitor noise levels adjacent to the construction site?		
13.0 **Radiography**		
If appropriate have procedures for the control and safe use of radiation generators or radioactive sources been produced?		
Is the procedure properly implemented when radiography is carried out?		
14.0 Work Equipment & Safe Working Practises		
14.1 Compressed Air		
Have all workers been trained in the correct use of air-operated tools?		
Have the dangers of directing compressed air at the body been highlighted to the workforce?		
Are heavy-duty hose clamps used?		
Are quick-acting couplers, designed to seal upstream air pressure on disconnection and slowly vent on the downstream side, used?		
Are hoses kept clear of walkways/roadways?		
Is regular maintenance of equipment, including safety devices carried out?		

14.2 Manual Handling		
Are hoists, telehandlers, wheelbarrows and other plant or equipment used so that manual lifting and handling of heavy objects is kept to a minimum?		
Are materials such as cement ordered in appropriate size bags for safe manual handling?		
Can the handling of heavy blocks be avoided?		
14.3 Hoists		
Is the hoist protected by a substantial enclosure to prevent someone from being struck by any moving part of the hoist or falling down the hoist way?		
Are gates provided at all landings?		
Are the gates kept shut except when the platform is at the landing?		
Are the controls arranged so that the hoist can be operated from one position only?		
Is the hoist operator trained and competent?		
Is the hoist's safe working load clearly marked?		
If the hoist is for materials only, is there a warning notice on the platform or cage to stop people riding on it?		
Is the hoist inspected weekly, and thoroughly examined every six months by a competent person?		
Are the results of inspections recorded?		
14.4 Cranes and Lifting Equipment		
Is the crane on a firm, level base?		
Are the safe working loads and corresponding radii known and considered before any lifting begins?		
If the crane has a capacity of more than one tonne, does it have an efficient automatic safe load indicator that is inspected weekly?		
If an excavator is used as a crane, does it have the necessary check valves and is its maximum safe load clearly marked?		
Are all drivers trained and competent?		
Have the banksman and slingers been trained to give signals and to attach loads correctly?		
Do the driver and banksman find out the weight and centre of gravity of the load before trying to lift it?		
Are cranes inspected weekly, and thoroughly examined every 12 months by a competent person?		
Are the results of these inspections recorded?		
Does the crane have a current test certificate?		
Has a *Lifting Plan* for carrying out heavy lifting operations been prepared? Is this plan implemented		
Are areas where lifting operations are taking place clearly identified? Are unauthorised persons excluded from this area?		
Is lifting equipment kept under strict control?		
Is the SWL and unique identity marked on every item of lifting equipment?		

Is there proof of inspection/certification of all lifting equipment?		
15.0 Plant and Machinery		
Are all dangerous parts, e.g. exposed gears, chain drives, projecting engine shafts, guarded?		
Are guards secured and in good repair?		
Is the machinery maintained in good repair and are all safety devices operating correctly?		
Are operators trained & competent?		
16.0 Hand and Power Tools		
Are the correct tools provided and used properly for each task?		
Are regular checks of tools carried out to ensure that they are in good condition?		
Are steps taken to ensure that untrained persons do not use tools?		
When cartridge operated tools are used, are method statements made available to the HSE Officer?		
Are home made tools only used after authorisation by a competent person?		
17.0 Vehicles		
Are vehicles maintained? Are maintenance records available? Do the steering, handbrake and footbrake work properly?		
Have drivers received appropriate training and do they hold written authorisation for the type of vehicle?		
Are site vehicles locked when not in use?		
Are vehicles, which operate inside buildings fitted with both visual and audible warning devices?		
Are vehicles securely loaded?		
Are passengers prevented from riding in dangerous positions?		
18.0 Working near water		
Have appropriate controls, e.g. barriers, warning signs, been erected to warn workers of open water?		
Do persons working on or over water use life jackets & safety lines or safety nets?		
Are buoyancy aides provided where a high risk of individuals falling into water exists?		
Is a safety boat provided downstream of work over / on rivers?		
Have supervisors and persons who work on, over or adjacent to water received appropriate training?		
Are boats and vessels suitable for purpose?		
Is there a suitable emergency procedure and adequate back up?		
19 Containers Securement / Preparation		
Are gas detectors present in packaging and process areas that are interfaced into an alarm system with appropriate detection limits being utilized for the alarm set points? (if applicable)		

Are cylinders and ton containers segregated between full and empty? (if applicable)		
Are full ton containers stored so that each end is accessible in case a repair is needed? (if applicable)		
Are written operating procedures available and being utilized by employees that address the appropriate steps for evacuating and filling cylinder and ton containers? (if applicable)		
Do procedures exist for testing for leaks prior to filling each cylinder and ton container? (if applicable)		
Do procedures exist for proper evacuation of lines before disconnecting?		
Do procedures exist for inspection and change out of valves? (if applicable)		
Do procedures exist for appropriate torque settings of valves and packing nuts? (if applicable)		
Do procedures exist for proper labeling and marking of cylinders and ton containers? (if applicable)		
Are ton containers secured to prevent them from rolling? (if applicable)		
Are appropriate lifting devices being utilized to move ton containers? (if applicable)		
Are gas detectors present in packaging and process areas that are interfaced into an alarm system with appropriate detection limits being utilized for the alarm set points? (if applicable)		
Do facility procedures verify that delivery vehicles are properly placarded with the Hazchem system		
Is lighting or emergency lighting provided to allow for safe operation and emergency response?		
Is a checklist or other procedure used to assist with the performance of pre- unloading, post unloading, and prerelease inspections?		
Are workers performing higher risk activities like line breaks or disconnections being appropriately monitored?		
Are unloading lines and air padding lines purged, evacuated, disconnected, and capped immediately when not in use to minimize moisture entry into the piping system?		
Are piping leak checks conducted prior to unloading (if applicable)		
Do operating procedures require leaks to be repaired before allowing operations to begin or continue?		
Are liquid angle valves completely open when unloading is in progress? (if applicable)		
If the container is disconnected, lines capped, and protective housing cover closed and sealed after unloading has ceased for the day? (if applicable)		
Are piping connections purged to a scrubber or VOC containment, process application, or containment		

prior to piping disconnection? (if applicable)		
Are all the staff (including labourers) involved in unloading the fuel or chemicals from the delivery vehicles trained		
Is PTFE tape or non-reactive pipe dope used on threaded connections? (if applicable)		
Are procedures in place to prevent PTFE tape from interfering with angle valve closure? (if applicable)		
Have lubricants being used in the chemical handling been confirmed to be compatible		
Is there a remotely operated or automatically actuated emergency shutoff valve system in place which can safely isolate both ends of transfer hoses / flexible piping? (if applicable)		
Is the emergency shut-off system tested routinely?		
Are there shutoff valves on both sides of transfer hoses		
20 Process Piping		
Do piping and all components comply with recommendations of such as metallurgy, schedule, welding requirements, etc?		
Are all hoses in contact with fuel or chemicals tested or replaced on a preventive maintenance basis?		
Is the piping system adequately supported / braced with pipe shoes or other support ?		
Is the piping system protected from vehicular traffic?		
Is new or replacement piping properly cleaned and inspected ?		
Are the gaskets used compatible		
21 Underground Piping		
Is underground piping system continuously monitored for leaks? How?		
Has cathodic protection, used for underground piping, been considered?		
22 Building Systems		
Is there potable gas monitors for monitoring of areas within and around the building for gas leaks **-** (if applicable) (are there alarms, warning lights)?		
All facilities having leakage test kit (e.g. ammonia, water and swabs or other acceptable detector) to be provided in clearly marked locations		
Is sufficient and appropriate ventilation provided (i.e. reference to be made to NIOSH standards)		
What are the safety systems in place such as pressure type switch located on the doors to chlorination rooms which shall activate the exhaust fan automatically when the door is opened. (if applicable)		
23 VOC / scrubbing / venting systems		
Is there a means available to process vent gases and the emergency evacuation of equipment containing Gas ? ie Maintaining safe vent conditions		

Is the venting design based upon the worst case Preventing fires, explosions, and toxic releases		
Is the system clear for understanding normal process operations, such as intentional routine controlled venting and emergency operations, like overpressure relief		
Does the system mitigating the impacts of end-of-line treatment devices, such as scrubbers, flares, and thermal oxidizers, on the vent header system		
If so does the scrubber capacity designed to process the facility's most probable release scenario?		
Does the scrubber have 'passive' scrubbing capability or is it equipped with emergency stand-by power sources?		
Are the materials of construction Adequate		
Is the scrubbing solution either designed or monitored / analyzed to confirm required minimum capability?		
Is the scrubbing vent monitored to detect gas breakthrough?		
Is there adequate backflow detection		
Does the system comply with regulations		
24 Containment , Bunding and Overflow		
Is there systematic assessment of safety integrity level requirements ie what is the overall systems for tank-filling control is this of high integrity and with sufficient independence to ensure timely and safe shutdown to prevent tank overflow. Do Site operators meet the latest international standards		
Does the methodology of safety integrity level (SIL) requirements for overfill prevention systems take into account of the existence of nearby sensitive resources or populations; the nature and intensity of depot operations; realistic reliability expectations for tank gauging systems; and the extent/rigour of operator monitoring.		
Is the Protecting against loss of primary containment use of high integrity systems in line with the appropriate standards		
Does the management systems for maintenance of equipment and systems to ensure their continuing integrity in operation include, but not be limited to reviews of the arrangements and procedures for periodic proof testing of storage tank , overfill prevention systems to minimise the likelihood of any failure that could result in loss of containment; review of the effectiveness of equipment and systems in preventing loss of containment or in providing emergency response , high integrity, automatic operating overfill prevention system (or a number of such systems, as appropriate) that is		

physically and electrically separate and independent from the tank gauging system.		
Does the overfill prevention system (comprising means of level detection, logic/control equipment and independent means of flow control) should be engineered, operated and maintained to achieve and maintain an appropriate level of safety integrity in accordance with the requirements of the recognised industry standard for 'safety instrumented systems' detection, logic/control equipment and independent means of flow control) – ie is this engineered, operated and maintained to achieve and maintain an appropriate level of safety integrity in accordance with the requirements of the recognised industry standard for 'safety instrumented systems'		
Is the engineering, design, operation and maintenance against escalation of loss of primary Secondary and tertiary containment in line with required international standards		
20 Security		
Have security guards received information and training of dealing with alarms or dealing with emergency events		

3 Sector Specific Examples

3. 1 Wastewater Treatment Plants

The below provides an general suggestion of checklists – It is of course very important that there should be a well developed and implemented emergency response plan for the site which details the plans and actions required for all such events

Issue	Y / N	Comments			
		Minimize	**Substitute**	**Moderate**	**Simplify**
1.0 Site Flooding					
The wastewater treatment sites can be flooded through a number of occurrences: works overflowing; heavy rainfall on the site and flooding from an adjacent Wadi					
works overflowing		Minimise : Flooding caused by heavy rainfall can be addressed by ensuring the adequacy of the site drainage system, avoiding location of critical plant or places to which access is required on low ground within the site and, if required, by providing adequate pumps to lift the water from the site drainage system into wherever the permit for			

		drainage is discharged
heavy rainfall on the site		Moderate : The normal acceptable options would be to (i) include for the additional flow within the treatment capacity; (ii) provide storm water overflows within the collection system; (iii) provide specific landscaped areas to which storm water can be discharged or (iii) provide a storm water holding reservoir on the works site.
flooding from an adjacent flood plain		Moderate : earth bunds can be constructed around the works or critical plant raised to a height above a reasonably expected flood level.
2. Loss of Power		
		Moderate : ensuring adequate on-site generating capacity for essential plant / critical drives eg on site electrical standby generation with appropiate maintenance scheduling or arrangement with hire companies from whom plant and equipment such as mobile generators can be obtained. Substitute : by having two separate and independent electricity supplies into the Works.
3 Pollution or Debris arriving in inlet		
Pollution may cause environmental damage , particularly in cases there is no storm water or overflow tank into which a polluted sewage can be safely discharged and action taken to remedy the matter, it could cause breach or non compliance of discharge limits and may make the operator liable to prosecution by the environmental enforcement agency -		Moderate : Should the biomass be killed as a result of the pollution action plan for dealing with reformulation of the biomass through transplating (ie sourcing new biomass and reseeding) and in cases of foaming to ensure appropriate mitigation measures for analysis of the foam and use of antifoaming measures. Remember that it is difficult to determine by sight if activated sludge is failing so that it is necessary to measure oxygen consumption and parameters of treatment performance such as MLSS, SSVI, SRT etc for a true ongoing understanding of performance (this can include the use of on line plant SCADA systems and portable dissolved oxygen monitoring equipment) Simplify – on the basis that '"prevention is better than cure", ' there should be in place a rigorous policy for the monitoring of industrial discharges into its sewers and inspections of manholes – automatic / early monitoring upstream of the plant in the incoming network for pollutants can also provide necessary mitigation measures early on. In the case of sewer cleaning operations particular care needs to be taken to ensure that debris is removed from the sewer and not, unless planned, allowed to pass through to the Works. Substitute : Redundancy or duplication of process

		streams (ie where "spare" treatment capacity is available) as dictated through the asset management and operation / maintenance plan. Note : this option may also be assisted by preplanning of modeling scenarios in the design analysis ; operation and maintenance and emergency response plans Substitute : Consideration for tankers to be filled at a failed works or divert toxic influent into spare tank and for tankers to discharge at another. In some locations, it might be possible to divert flows from one catchment to another albeit with temporary overland pumping as dictated by the emergency response plan and escalation of actions as agreed with stakeholders Minimise : This relates to determination of the source of the pollution through investigation steps including implementing an appropriate detailed analysis and sampling plan covering such events and taking immediate steps to prevent any continuing pollution and a re-occurrence
4 Structural Failure – Blocked / collapse pipes / tanks		
		Moderate : All water retaining tanks to be regularly inspected for signs of stress prior to any failure ; in addition as part of criticality plan to ensure that all adequate sewer repair lengths and couplings are available and, emergency mobile pumps and hoses etc are available (ie as per agreed schedule of availability of warehouse covering spare parts, sewer repair lengths, couplings etc.) According also to a synergy and cross referencing between asset management and O & M plans to specify according to the situation for on site teams to repair or clear the blocked / collapsed tank or pipe and any localised flooding could be dealt by re-directing the incoming flow from the failed unit or for consultant/contractor to effect an emergency repair and/or prepare designs and implement asset replacement..
5 Gas Leaks		
For example methane , chlorine or high hydrogen sulphide alarms in the process units or atmospheric monitoring stations within the sites		a. Prior to an emergency: i. Ensure that alarms are operable, breathing equipment is available and that staff are fully trained in the required response; ii. Have on site a wind sock or other device for ascertaining the direction of the wind; iii. Liaise with all stakeholders connected with emergency services on emergency procedure.

		b. During an emergency (according to the defined strategic and response team role) i. Ascertain the extent of the damage and the consequences including plan of response for dealing with staff affected by the leakage and for the site response leader to adopt the controlling and management of the incident; ii. If the consequences will have an effect upon the neighbouring area, the emergency response plan should cover the appropriate notifications and evacuation procedures; iii. Site staff involved in the implementation of the emergency response plan and depending upon the severity and criticality of alarms according to the plan if of tactical response then wearing breathing apparatus and when safe to do so, isolate the cause of the leak; if of strategic level response then evacuating the area and as per the response plan calling in the civil defence / emergency ambulance services iv. When safe to do so, isolate the tank and re-direct the gas for safe disposal, v. Assess the extent of any damage and ascertain if a repair can be affected.
6 Loss of Treatment Process		
This refers to a significant loss of process capability for example lifting capacity at the inlet works, or at an intermediate pumping station, loss of blowers or major pumps or process units eg loss of de-watering capacity		a. Prior to an emergency allow for: i. Vulnerability assessment of equipment and evaluation of redundancy in plant or availability in stock of spares ii. Ensure that a schedule is available of plant hire companies - Boilerplate contracts for example could be drafted for situations that may occur and kept available for adaptation to specific circumstances when necessary. This could save time and effort that would otherwise be necessary to prepare from “scratch” during an incident iii. Operation & Maintenance and emergency response plan developed to include response actions eg emergency holding tanks etc b. During an emergency: i. Ascertain the cause and consequence of failure eg loss of lifting capacity and the consequences; ascertaining the extent to which the sludge can be retained within the process units; ii. Where “spare” treatment capacity is available, redirect the wastewater incoming flow; iii. Use mobile pumps to lift the influent to the next stage of the works, and iv. If failure is due to power failure, link in emergency generators

7 Loss of IT systems		
In general, when information technology (IT) vulnerabilities are addressed, robust and flexible technology solutions can be assured to continue to support business functions under a wide variety of conditions		Single points of failure in the supervisory control and data acquisition (SCADA) system Periodic identification and back up of “operational-critical” applications, databases, and to an off-site facility Vulnerability/penetration tests on SCADA systems The SCADA system connection to the LAN/WAN Secure locations for the SCADA system components (RTUs, central monitoring)

3. 2 Water Treatment and Supply

As above the below provides an general suggestion of checklists – It is of course very important that there should be a well developed and implemented emergency response plan for the site which details the plans and actions required for all such events

Issue	Y / N	Comments			
		Minimize	**Substitute**	**Moderate**	**Simplify**
1.0 Distribution Line Failure					
Following the assessment of the reason for the interruption, the cause and whether it can be rectified the service level impacts including HSE issues would be already identified as part of the preplanning Response items would involve resource and asset requirements such as location and operability of isolating valves , draining down issues etc		a. Prior to an emergency : i. Vulnerability assessment with consideration of various scenarios of deteriation in situations and how the problems can worsen - this may require GIS/network modeling to assess service impacts iii. Consider PR implications and actions required of Customer services/ Public relations(if appropriate) iii. Ensure that a schedule is available of actions and required resources - Boilerplate contracts if required with contractors for example could be drafted for situations that may occur and kept available for adaptation to specific circumstances when necessary. This could save time and effort that would otherwise be necessary to prepare from “scratch” during an incident iv. Evaluation of redundancy in network or availability in stock of spares v. Operation & Maintenance and emergency response plan developed to include response actions eg emergency holding tanks etc b. During an emergency: i. In conjunction with Operations and control room staff what are the current reservoir levels, how long are supplies likely to last subsitute actions eg tankers on standby; ii. Implement “spare” treatment / distribution capacity if available			

2 Water Quality Failure		
This would be linked to the implementation of water quality safety plans (in line with the principles of HACCP) and of course the integration of the O & M and water quality sampling & analysis and emergency plans		a. Prior to an emergency : i. Vulnerability assessment with consideration of various scenarios of deteriation in situations and how the problems can worsen - this may require GIS/network modeling to assess service impacts to the network, how the spread can be limited and the pre-planning of actions such as alternative supplies , what reservoirs need emptying and how and flushing mains programmes etc iii. Consider PR implications and actions required of Customer services/ Public relations(if appropriate) iii. Ensure that all stakeholders including the water quality safety plan driven by the chemist and the O & M , emergency response plans are integrated for schedule of proposed preplan actions b. During an emergency: i. The actions would be dependant upon site specific requirements as developed with the emergency response plan (for example alternative supplies , impacts (if appropriate) to reservoirs and network flushing and cleaning etc etc
3. Reverse Osmosis Treatment		
When feed water quality and operating parameters – pressure, temperature, differential pressure and recovery are constant, permeate flow rate and permeate quality should be within an acceptable tolerance of the suppliers recommended values without substantial fluctuations or trends to change performance Frequency of normalizations based upon assessment of the operation and maintenance log book on time and date of events will also depend on extent and frequency of variations in feed quality and operating conditions such as feed water quality (composition of monovalent and polyvalent ions, suspended solids, fouling index , SDi, Langelier saturation index (LSI); Ryznar Stability Index (RSI); Puckorius Scaling Index (PSI); and other aggressive indices, feed pH, temperature , pressure, recovery (conversion) ratio and permeate flow rate, salt rejection and salt passage measures etc		Mitigation measures : Monitoring of the operating parameters would provide the only means of a solid basis for evaluating RO performance. Recognised deviant performance trends for salt passage, permeate flow or pressure drop would enable timely selection of countermeasures as per the supplier's trouble shooting guidelines and guidelines for operation and maintenance in order to avoid irreversible damage to membrane elements or other system components (the later for example with particular respect to considerations for cleaning eg evaluation measures for the effectiveness of cleaning (eg foulant levels of metal hydroxides, inorganic colloids, organic or bacterial matter scaling , permeate flow rates and solute rejection etc - ie also linked to preservation and concentration of conservation solutions , operating conditions before shutdown and duration of conservation) and maintenance issues such as record of routine and corrective maintenance, mechanical / welding failures and replacements, change of element locations etc etc) The emergency response plan for RO membranes would be dependant upon the suppliers criteria for quality of plant monitoring and in order to evaluate in particular normalized performance

		data and actual system data for detecting trends early it would be important to ensure the O & M / emergency response plan includes SIMPLIFIED measures such as systematic graphical monitoring charts Recommended procedures would be as required to be developed with the supplier covering any possible deviant events in down stream such as variations in individual ions (and flushing needs) ; fluctuation pressure (or possible water hammer) and need for automation and control sequence of valve operations etc etc
4. Loss of Power		
		Moderate : ensuring adequate on-site generating capacity for essential plant / critical drives eg on site electrical standby generation with appropiate maintenance scheduling or arrangement with hire companies from whom plant and equipment such as mobile generators can be obtained. Substitute : by having two separate and independent electricity supplies into the Works.
5 Loss of IT systems		
In general, when information technology (IT) vulnerabilities are addressed, robust and flexible technology solutions can be assured to continue to support business functions under a wide variety of conditions		Single points of failure in the supervisory control and data acquisition (SCADA) system Periodic identification and back up of "operational-critical" applications, databases, and to an off-site facility Vulnerability/penetration tests on SCADA systems The SCADA system connection to the LAN/WAN Secure locations for the SCADA system components (RTUs, central monitoring)

3. 2 Landfilling - Waste Management

Clearly ,the best-designed landfill is of little value unless it is constructed and operated properly – from perspectives of personnel responsibilities, safety practices, machinery and the overall operations of the landfill
To show the value of adhering to a specific procedure for all landfill employees there should be
a list of benefits/consequences that may result from compliance or non-compliance to the procedures
Landfill sites require careful planning and operation. How a landfill is operated and managed effects the public health, environment and economics.

Some basic issues , which apply to any type of waste landfill are as follows .

- Apropiate documentation , monitoring and control is important in ensuring that landfill sites are operated and managed safely, efficiently and effectively from both the technical and financial perspectives.
- The rate and method of waste deposition for landfill sites should be considered in terms of its minmizing its impacts to the environmental and general public health and safety.

Landfill operations need to be reviewed with respect to optimizing the usage of land space and should consider the optimisation of multiple issues such as landfill placement, compaction and covering and the types /

characterization of the wastes. Some general problems associated with landfill sites which do not have proper operational and management plans can be described as follows :

- Poor usuage of landfill space.
- Lack of control and monitoring of vehicle reception and offloading.
- Poor security and supervision and entry to scavengers
- Lack of control and inspection of waste leading to mixing of both general and hazardous wastes from both industry and community sources – giving rise to associated risks through the incorrect handling and disposal.
- High risk to the health and safety of both the staff and users of the landfill sites through unsafe landfill practices.
- Environmental impact of an incorrect operated and managed landfill can be through both direct and indirect, short term and long term effects - ie odours, groundwater contamination etc

<u>The objectives of reviewing and studying the existing operation of the landfill sites and producing management / emergency contingency plans can be outlined as follows :</u>

- To ensure the cost effective and efficient operation of the sites with respect to the usuage of land , equipment and manning resources.
- To ensure the minimsation of risks to the public health and safety of the staff and users of the landfill sites through the adoption of working procedures and instructions that ensure the implementation of best practices.
- To ensure the sustainable development of the landfill sites through the adoption of appropiate plans and strategies
- To implement the high standards of quality and professionalism of best landfill practices.

Issue	Y / N	Comments			
		Minimize	**Substitute**	**Moderate**	**Simplify**
1.0 Unknown quantity / quality of waste disposal					
The types and quantity of all waste should be recorded to provide for a continuing assessment of waste inputs and with cover requirements as well as enabling predictions to be made on rate of filling, engineering requirements and future restoration. (The rate of filling may be determined from the records obtained from a weighbridge and by measured / regular surveys of the site void.)		**Simplify** : Recording and monitoring should reflect the inspections made to ensure that wastes deposited are only those permitted .			
2 Ineffective use of landfill space					
Although the actual sequence of land filling will depend on many factors such as the topography, weather conditions, traffic flow.		Moderate : Good planning and its implementation is essential to ensure that site roads are located and maintained where they are required. Eg access roads leading to the working face of the disposal area should provide effective traction for the vehicles The working face should be sufficiently extensive to permit vehicles to maneuver and unload quickly and safely without impeding			

		refuse spreading and compaction and allowing site equipment to be operated easily. The size and operation of the working face should be regularly reviewed as part of the recording and inspection of the site activities. Operating a cellular method of filling should enable waste to be deposited in a tidy manner; preferably bunds, walls or some form of demarcation should be created to define, restrain and conceal the active waste tipping area and optimize the void space age. Bund walls would be created by the utilization of suitable incoming waste or by the use of cover material which could be removed at the end of the day and used as the face cover. The design and operation of the cells should be influenced by the rate of waste input and its absorptive capacity, number of incoming vehicles and sufficient space for safe turn-round of vehicles.
3. Environmental nuisance		
This refers to uncontrolled environmental effects on internal or external receptors – for example odour, fly (vector) nuisance, leachate etc		Mitigation measures : Mitigation measures would normally be developed as part of the environmental impact assessment process for the regulatory and concerned stakeholders this would include the design , operation and emergency response planning in accordance with required standards (example include the design of lining and operational monitoring of groundwater boreholes and leachate control programmes) Necessary precautions include for example as part of the O & M and emergency planning the use of daily cover ass • It improves the appearance of the site and minimized windblown litter. • Depending on the type of material used, movement of vehicles over the waste can be facilitated. • It will inhibit any pest control nuisance (e.g. from flies in particular). • It will help to reduce landfill odors. • It will minimize the risk of fire.
4. Vehicle Safety		
Typically, (subject to the most efficient and economic heavy plant for the particular application) landfill sites may use vehicles such as steel wheeled compactors, tracked bulldozers, rubber tyred front wheel loaders (shovellers).		Simplify : All staff and users of the landfill site should be fully aware of site safety regulations. These need to be displayed also to the users of the sites; this perhaps will require site boards and instructions. Examples of which need to be included in the site operation plan include issues such as Speed limits and control (eg working areas at a landfill site is dangerous since people and

		vehicles are maneuvering in close proximity to each other) , Overhead power lines (Raising tipper lorries and tail gates of waste collection vehicles) ; Lack of stability possible for large vehicle whilst discharging their waste ; or the issue of Overloaded vehicles and their stability, where in particular the surface of landfill may be unsuitable Simplify : Removable poles can be considered as a means of signboarding the working face and ensuring vehicles only discharge in the designated areas and do not travel over any unstable area..
5 Fires/explosions		
In general, this would considered as part of the risk assessment (health and environmental) for the site and actions made as appropiate		Fire Remediation Measures include proposal for permanent intrusive monitoring points and a programme for long term monitoring and progressive containment of, and quenching of the fires. This would involve the agreeing the Trigger Levels in order to monitor the success of the remedial actions. For example , the England and Wales Environment Agency states in their guidance (Technical Guidance Note TGN04,) concentration of 25 ppm CO as a level above which the operator should seek further evidence of the underground fire. The American guidance “Landfill Fires – their Magnitude, Characteristics and Mitigation” advises to treat as suspicious levels of CO between 100 and 1000 ppm Moderate : Operation and Maintenance plan include use of thermal imaging for subsurface temperature monitoring and f Installation of permanent observation/monitoring points in selected locations for carbon monoxide presence with portable instrumentation and chemical indication tubes. As well as Instigation of collecting of the data from these monitoring points (gas composition, carbon monoxide, temperature) in order to observe effects of the remedial measures undertaken these for example can also constitute vertical wells, possibly prepared for later controlled gas distribution or pumping of leachate or other sources of water used to quench the effects of possible underground fires. Substitute : Based upon above, consideration of n of installation series of shallow wells connected with header pipes, designed for introducing large volumes of liquids with suppressant agent into the affected areas. (based upon criteria of maximum flexibility for further operation)

		Minimise : Based upon the above O & M and emergency planning consideration may be for ensuring supply of liquid with suppressant agent and possibly foam supply to carry out remedial actions..

References

There is a plethoria of excellent in depth guidelines and reference materials available for further reference. Below is a representative example only

EU Publications

Chemical Agents Directive (98/24/EC), *http://www.bbp-facts.com/C-L/Legislation/98_24_Chemical_Agents_at_Work_Directive.pdf*

Guidance on the Preparation of a Safety Report to Meet the Requirements of Council Directive (96/82/EC) (Seveso II), 1997. *http://mahbsrv.jrc.it/downloads-pdf/Safety-report.pdf*

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HSE Publications

Assessing compliance with the law in individual cases and the use of good practice, *http://www.hse.gov.uk/dst/alarp2.htm*

Designing and Operating Safe Reaction Processes, 2000, *HSG 143, Health and Safety Executive, ISBN: 0 7176 1051 9*

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Reducing Risks, Protecting People; HSE's decision-making process, *http://www.hse.gov.uk/dst/r2p2.pdf*

The Safety Report Assessment Manual, *http://www.hse.gov.uk/hid/land/comah2*

Principles and Guidelines to Assist HSE in its Judgements that Duty- Holders Have Reduced Risk As Low As Reasonably Practicable, *http://www.hse.gov.uk/dst/alarp1.htm*

Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR). *http://www.hmso.gov.uk/si/si2002/20022776.htm*

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