



# **Share best practice and use technology to comply to OHSE regulations**

Electrolytic Products Division (EPD) Workshop

Chongqing City, 13 September 2009

Mrs. Madelein Todd – EPD Committee



# Sustainable development

- Sustainable development is defined as development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends.
- For the production of EMM and EMD, this would relate to all of the following:
  - Raw materials (ore, chemicals, durables & consumables, water)
  - Energy
  - Employees
  - Natural environment surrounding factories
  - Communities surrounding factories
  - Market and customers



# Sustainability Model

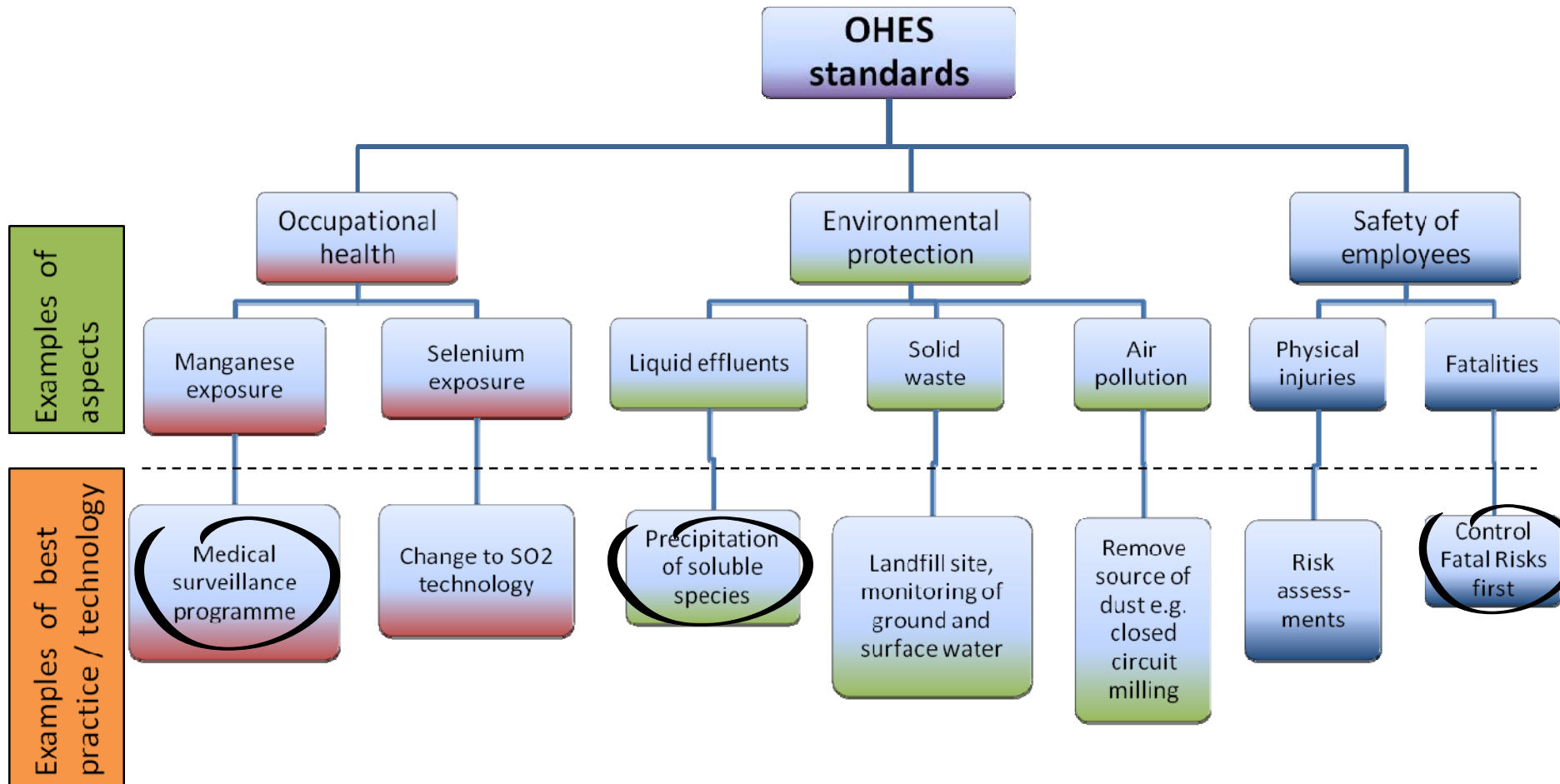


Focus on compliance by all members of an industry:

- Protects natural resources and the human population for all companies involved
- Protects the reputation of the industry for all companies involved
- Establishes a fair and transparent way for pricing of products in the market to include the cost of compliance to standards
- Specific focus on occupational health, environment and safety within the EPD of the IMnI.



# Share best practice and use technology





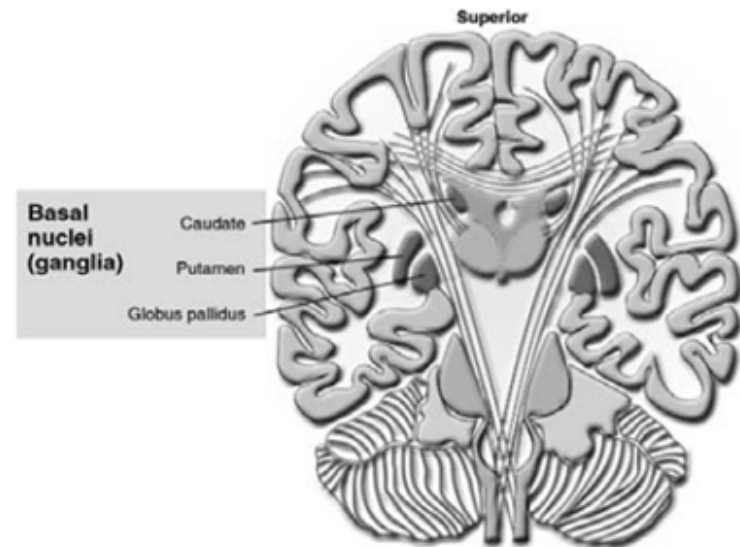
## Example 1

Monitor manganese exposure of  
employees



# Manganese exposure

- High occupational exposure to manganese results in neurotoxic symptoms, similar to Parkinson's disease.
  - The syndrome is called 'manganism'.
  - Mn deposits form in the basal ganglia of the brain.
  - Clinical symptoms include movement disorders and neurological dysfunction.
- The WHO recommends an occupational exposure limit (OEL) for respirable manganese of  $0.3\text{mg}/\text{m}^3$  air.
  - The OEL differs between different countries, poor correlation makes setting a standard difficult.
- Production processes should be designed to keep the airborne manganese concentration below the OEL.
- Regular biological monitoring of employees is needed
  - Medical surveillance programme
  - Blood Mn-Fe levels
  - Neurological examination



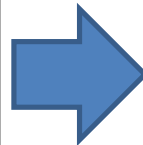
**Outline of the brain showing sites of manganese accumulation and action**



# Surveillance programmes to monitor employee health

## When to do examinations?

- Initial (pre-employment)
  - Make sure no condition exists that increases the risk for manganism
- Periodic (routine)
  - Once per year for employees working in areas of low potential exposure
  - Once per quarter for employees working in areas of high potential exposure
  - Should be risk specific (physical requirements and workplace conditions)
- Change of risk (re-placement)
- Exit (termination of employment)



## What to include in your examinations?

- Medical examination
  - Blood pressure, heart beat, weight etc.
- Neurological examination
  - Questionnaire plus palmomental reflex
- Blood Mn and Fe levels
- Liver function test
- Audiometric screening
- Vision screening
- Urine analysis
- Lung function screening
- Chest x-ray
- Evaluation of health records, sick leave record and injury on duty record



# Risk factors for manganism

- Any significant disease of the blood or haemopoietic system.
- Evidence of liver pathology or failure, or enlarged liver or spleen.
- A history of epilepsy or any other type of fits or fainting.
- A history of psychiatric problems or mental disorders e.g. severe anxiety or depression, Schizophrenia or Dementia.
- Disorders of the nervous system of a disabling nature such as a stroke or significant brain dysfunction.
- Migraine.



# Manganese-iron ratios in blood

## **Case study: FeMn factory in Zunyi, Guizhou**

- Part of the The Manganese Health Research Program (MHRP) of the IMnI. Study area lead by Dr. Wei Zheng, to research biomarkers of Mn neurotoxicity. (*What are the warning signs that a person is being poisoned by Mn?*)
- Sample group was 323 persons: 106 unexposed workers, 122 office workers and 95 manganese exposed smelter workers.
- Final report issued in October 2008.

## **Conclusions of study:**

- Manganese exposure, even at low levels, causes an increase in blood manganese and a decrease in blood iron. The Mn/Fe ratio in blood is a useful biomarker of Mn exposure. It correlated with airborne manganese levels measured for the 3 sample groups.
- Low level manganese exposure can lead to detectable neurobiological changes which can be detected by Purdue pegboard testing (hand-eye coordination test).
- Magnetic Resonance Spectroscopy (MRI) allows tracing of brain regions with Mn accumulation.
- Gamma-aminobutyric acid (GABA) testing has been suggested as another possible biomarker for Mn exposure in a separate study on the same sample groups.



**Casting of ferro-manganese from a smelter furnace**



# Neurological questionnaire

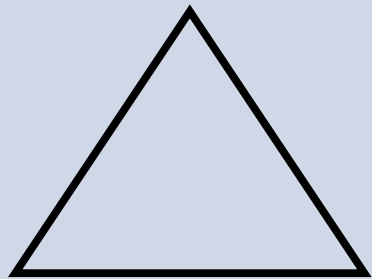
Area of health	Symptom
Mood	Do you often feel irritated without reason? Does your mood change quickly without reason?
Memory	Do you find it difficult to remember things?
Tiredness & Concentration	Are you abnormally tired? Do you often have problems concentrating?
Tremor	Have you developed shaking of your hands?
Coordination	Do you find it difficult buttoning & unbuttoning?
Gait	Do you feel that the way you walk has changed?
Dysphagia	Do you find it hard to swallow food and drink?
Muscle pain	Do you get cramps in your muscles? Do you get painful muscles without an explanation?

Easy to perform, not expensive. Can be initiated immediately as a screening test to identify workers that might require blood Mn and Fe analysis.



# Draw pictures to test coordination

Employee to repeat diagram



Employee to repeat diagram

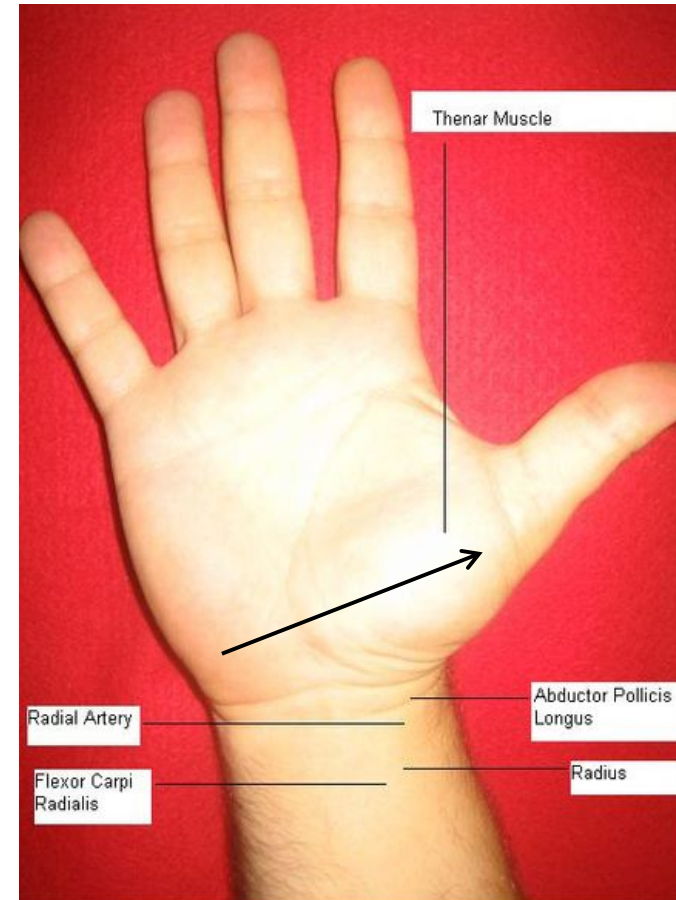


Part of the neurological questionnaire. Hand-eye coordination and motor function are affected if the worker has had over-exposure to Mn.



# Palmomental reflex

- The *thenar eminence* (muscle on palm of hand beneath the thumb) is stroked briskly with a thin stick, from edge of wrist to base of thumb using moderate pressure.
- A positive response is considered if there is a single visible twitch of the *mentalis muscle* (chin muscle) on the same side as the hand tested.
- A successful method to do screening tests for manganese over-exposure, 80% correlation with MRI scans.
- Easy to perform, not expensive.
- Must be part of routine surveillance program, to identify potential problems early on and remove worker from source of exposure if necessary.





## Example 2

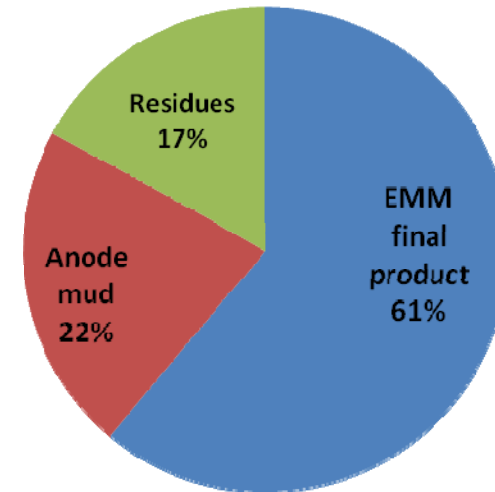
Technologies for the removal of selenium from industrial wastewaters



# Selenium discharge limits

- China Integrated Wastewater Discharge Standard (GB8978-1996) specifies the maximum permitted discharge concentration for selenium as follows:
  - 0.1mg/L when discharged into class 1,2,3 water sources (i.e. “clean water”)
  - 0.2mg/L when discharged into class 4,5 water sources (i.e. “industrial/agricultural water”)
  - 0.5mg/L when discharged into city or town sewage system which has a secondary wastewater treatment plant
- China’s drinking water standard for Se is 0.01mg/L.
- China’s ground water standard for Se is 0.01mg/L for class 1,2,3 water sources and 0.1mg/l for class 4,5 water sources.
  - Ground water is contaminated more often by seepage of leachate from solid waste landfill sites than by industry effluent.
- China’s environmental regulations for Se are generally similar to other countries’ guidance levels.

## What happens to Se in the EMM process?



**Destiny of selenium in a typical Chinese EMM factory. Mass balance contained in study done by Chinese Research Academy of Environmental Science, Jan2006.**

Environmental Site Investigation data collected in Huayuan County included effluent samples containing up to 40mg/L Se and ground water samples containing up to 8 mg/L.



# Challenges to remove Se from water

- Selenium can exist in many forms, depending pH and Eh:
  - Elemental selenium
  - Selenite ( $\text{SeO}_3^{-2}$ ), reduced form, oxidation state 4+
  - Selenate ( $\text{SeO}_4^{-2}$ ), oxidized form, oxidation state 6+
  - Organoselenium compounds, if organic matter is present
- The anions selenite and selenate do not react with cations such as calcium and magnesium under normal ambient conditions, thus they remain soluble in most water bodies.
- Selenate (6+) is the predominant form of selenium in surface and wastewaters and the most difficult to remove through treatment, since it must first be reduced. Reduction is favored thermodynamically but it is kinetically very slow.
- Methods for the analysis of selenium (as approved by the US EPA):
  - Hydride generation-atomic absorption spectrometry
  - Graphite furnace atomic absorption spectrometry
  - Inductively coupled argon plasma-atomic emission spectrometry or ICP-AES.
- The presence of elevated total dissolved solids and sulfur anions such as sulfate can produce considerable variation in low level measurements of selenium.

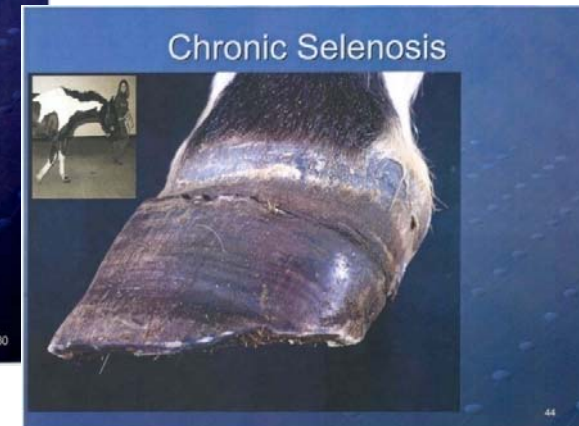
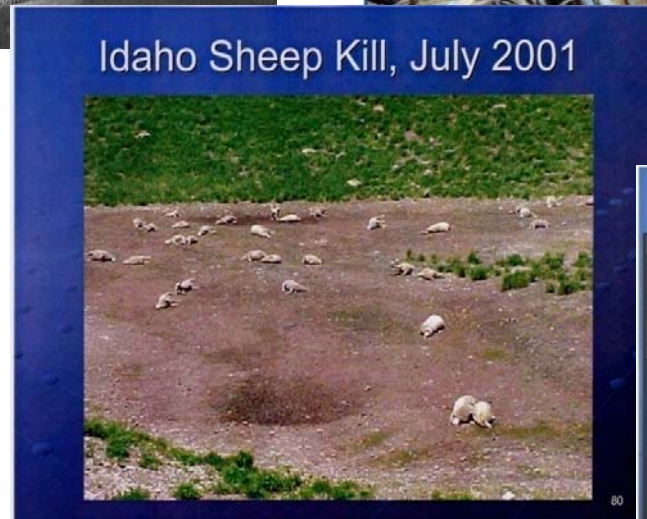
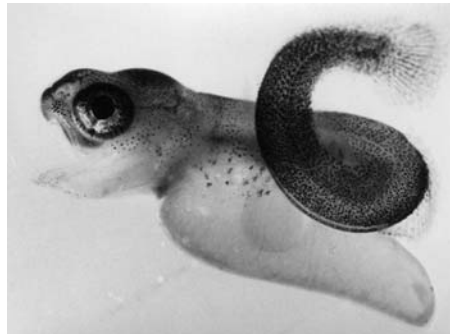
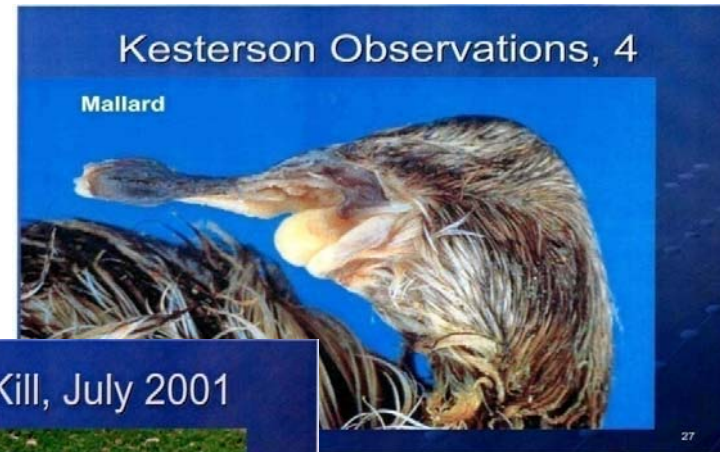
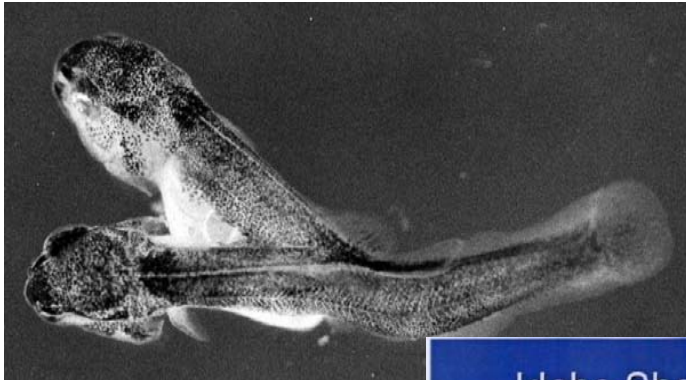
Anions remain  
in solution

Reduction  
is very slow

Analytical  
methods are  
complicated



# Why remove selenium?



- Se is **essential** to life but also **highly toxic** above relative low concentrations.
- Released into the environment, Se results in aquatic life & mammalian impacts such as skeletal deformities, neurological and reproductive disorders.
- It bio-accumulates in the food chain - fish advisories in several US states.

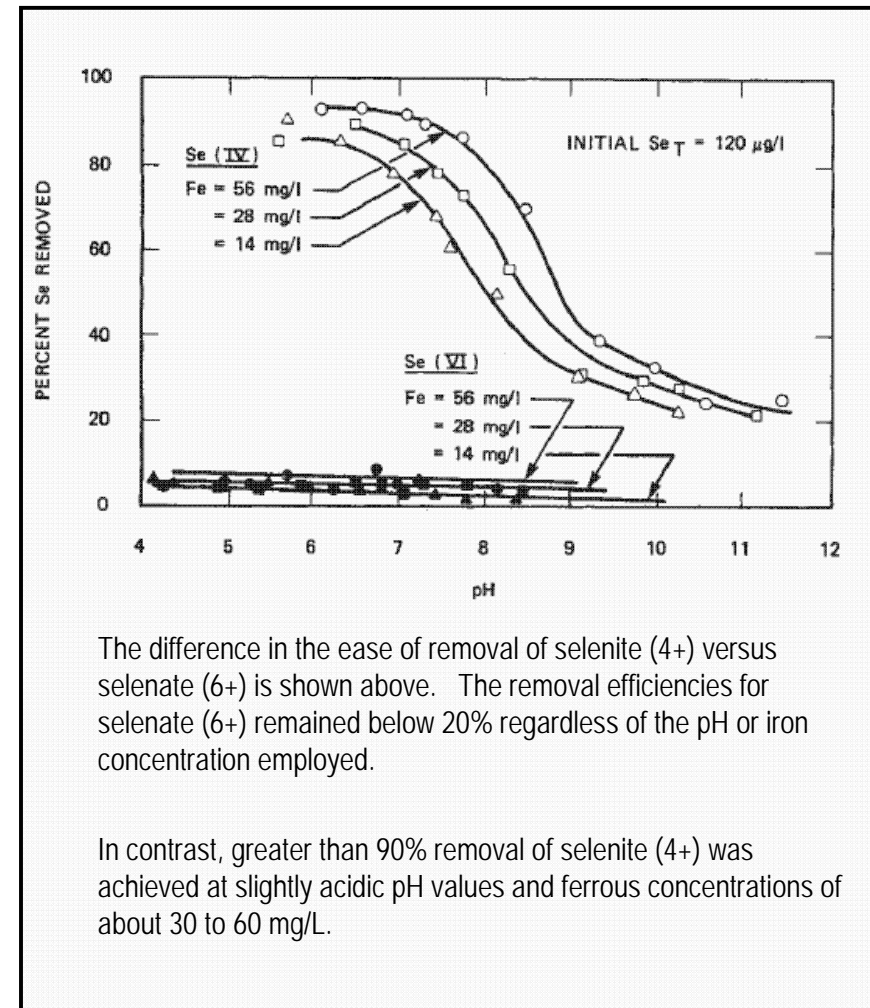


# Available technologies

- Treatment processes that have been shown to be effective on a commercial full-scale basis:
  1. Chemical precipitation (with and without reductants)
  2. Biological processes
  3. Ion exchange
  4. Adsorption
  5. Membrane technologies
- Methods 1 and 2 are the preferred treatment options.
- Best management practices place strong emphasis on water management and source control.

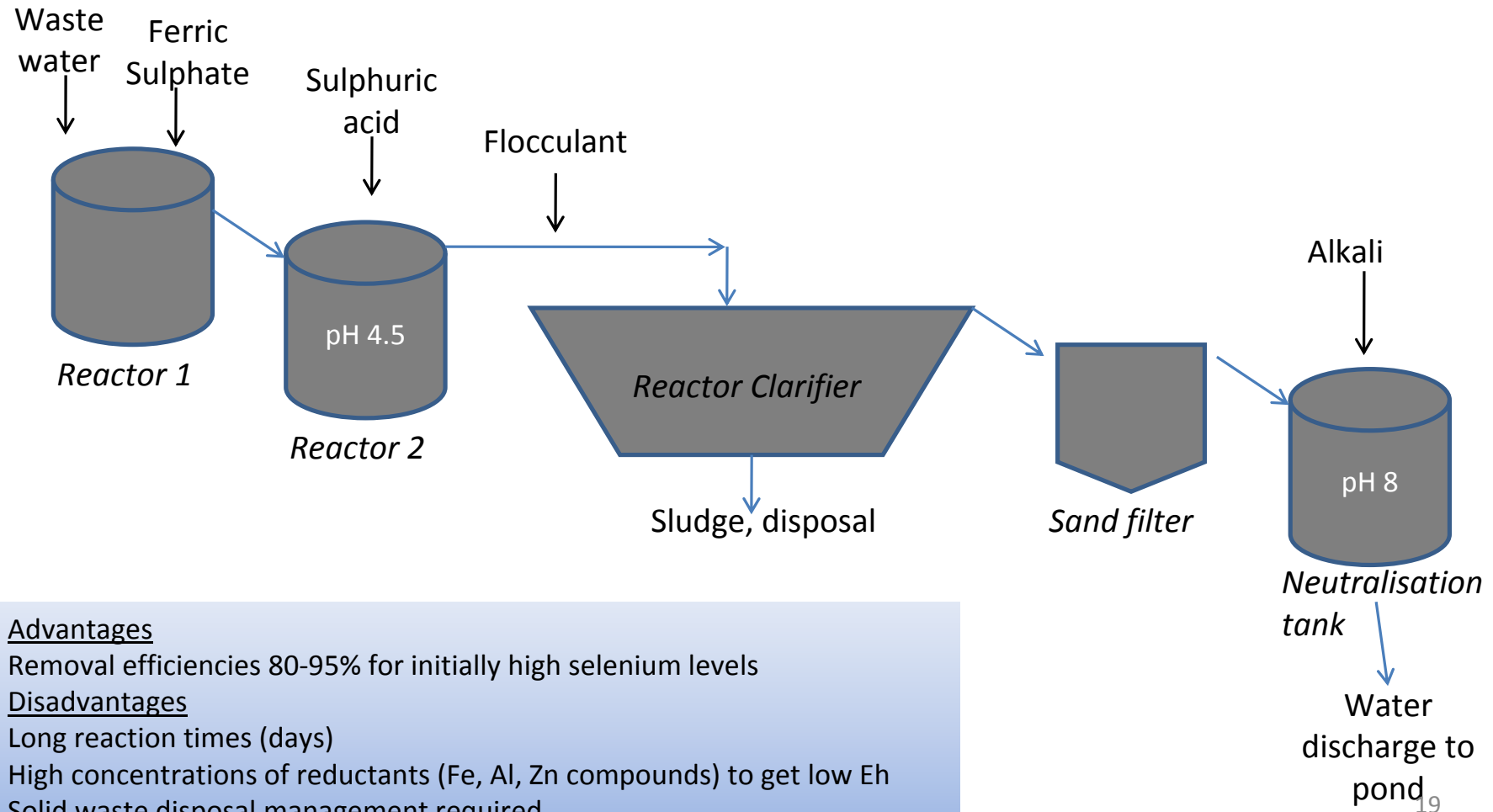
# Chemical precipitation

- The most commonly employed treatment process for the removal of selenium involves chemical precipitation using iron or aluminum salts at a pH of 5 to 7.
- If selenate (6+) is present in the wastewater, a reductant must be added prior to the chemical precipitation process, to convert selenate (6+) to selenite (4+).
- Various reductants including sulfite, powdered iron and powdered zinc have been employed.





# Typical flow sheet for chemical reduction & precipitation method



## Advantages

Removal efficiencies 80-95% for initially high selenium levels

## Disadvantages

Long reaction times (days)

High concentrations of reductants (Fe, Al, Zn compounds) to get low Eh

Solid waste disposal management required



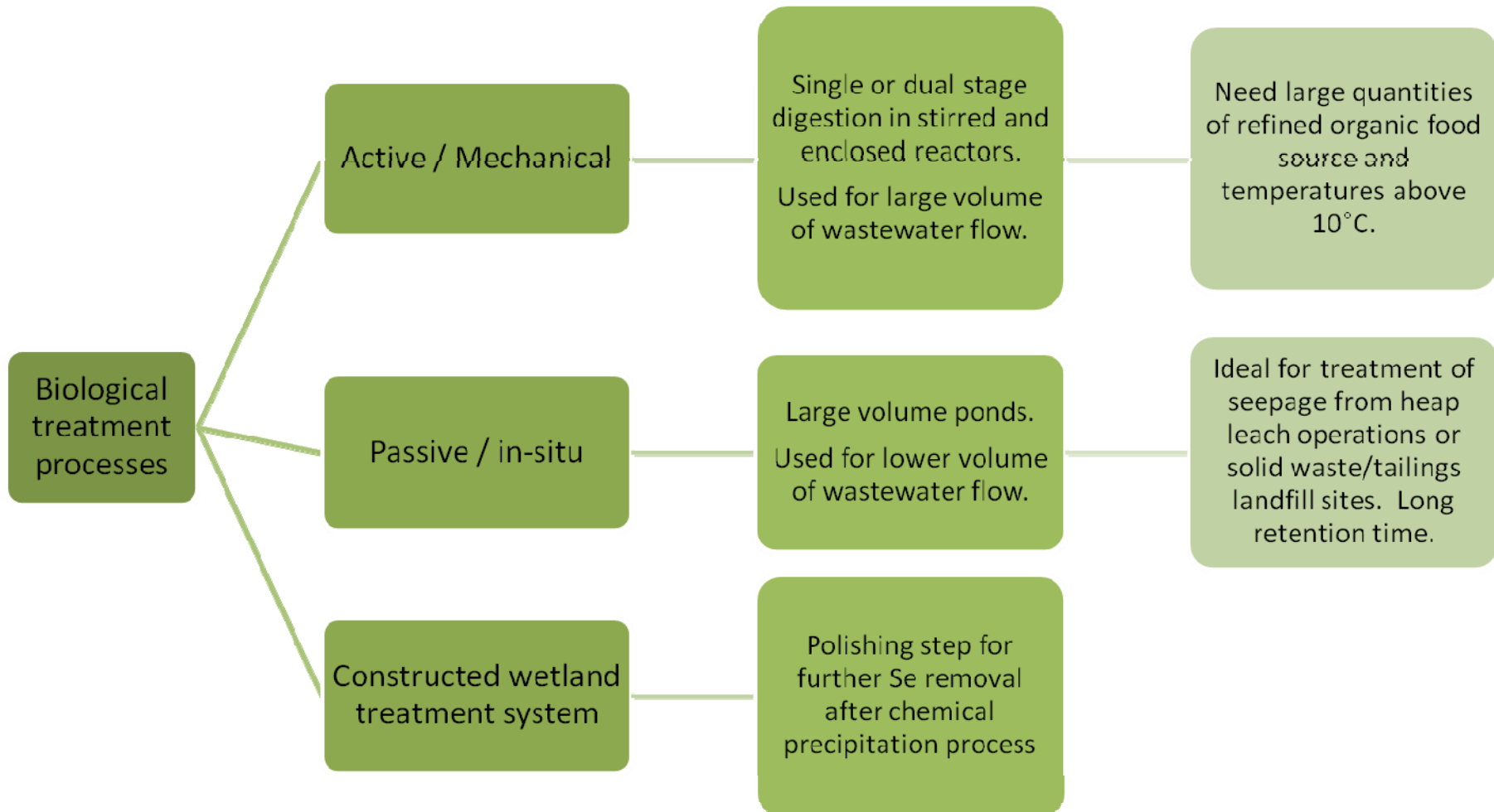
# Biological reduction

- Use bacteria, aquatic plants, algae or fungi to remove selenium from wastewater.
- Biological mechanisms for Se removal include reduction, precipitation, physical sorption and accumulation. Biological transformations can also form volatile methylated selenium compounds, such as dimethyl selenide and dimethyl diselenide.
- Anaerobic biological processes can completely reduce selenate (Se 6+) to a lower oxidation state.
- Heterotrophic sulfate reducing bacteria are used.
- The bacteria require an organic food source such as sugar, alcohol, wood chips or manure, and nutrients to aid in cell synthesis.





# Biological treatment processes





# Efficiency of biological removal

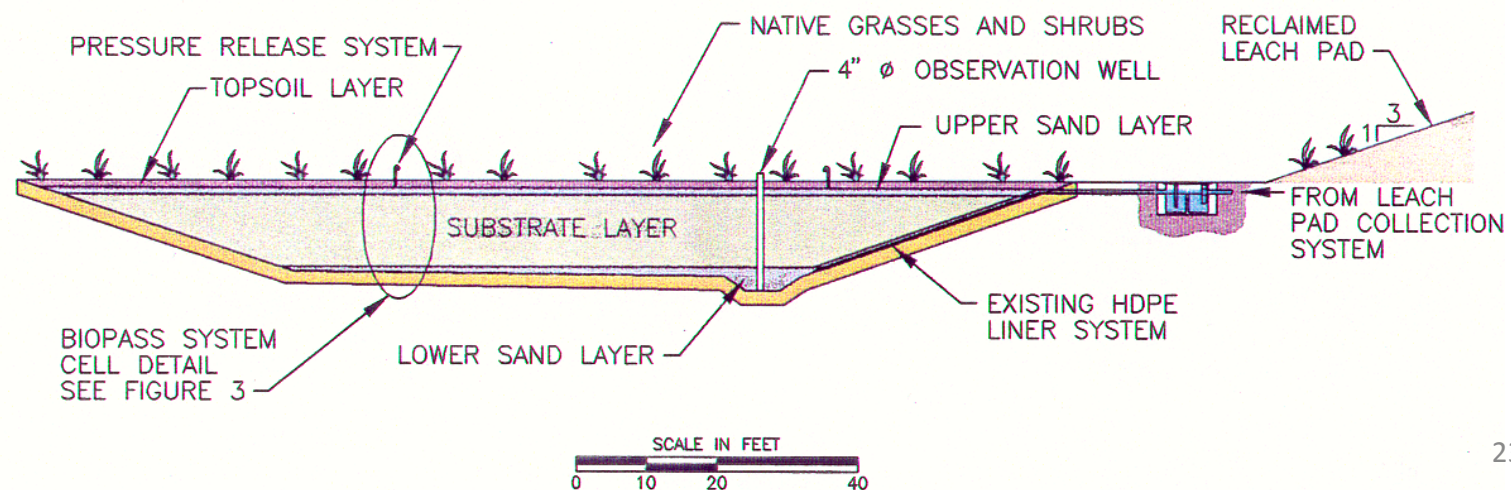
Technology Description	Influent Selenium (mg/L)	Effluent Selenium (mg/L)	Selenium Removal
Anaerobic Sequencing Batch Reactor	--	--	86-90%
Anaerobic Bacteria and Algae	0.2 to 0.4 mg/L	~ 0.01 mg/L	>95%
Anoxic Biological Reactors	>0.5 mg/L	0.01 to 0.05 mg/L	>90%
Algae in Ponds	--	--	94%
Anaerobic Biological Reactors	0.35 to 0.45 mg/L	~ 0.01 mg/L	>95%
Biopass System Full Scale	0.6 mg/L	<0.10 mg/L	>80%
Biopass System Pilot Scale	0.4 mg/L	0.01 to 0.02 mg/L	>95%

**Source:** Proceedings of Annual TMS Meeting, 2009. SELENIUM TREATMENT TECHNOLOGIES & CASE STUDIES. Karen Hagelstein, Terry I. Mudder



# Case study: Biopass Process

- Used at the Santa Fe gold mine of Homestake Mining Company in Nevada, USA, during decommissioning.
- Partially decomposed manure placed in a lined basin.
- Covered with soil and vegetation to exclude oxygen, creating anaerobic conditions for sulfate and selenate reduction.
- Crushed rock added as support medium to minimize settling as the organic matter was consumed over time.
- Untreated mine wastewater directed by gravity into the organic matter, where bacteria transformed the harmful selenium compounds.



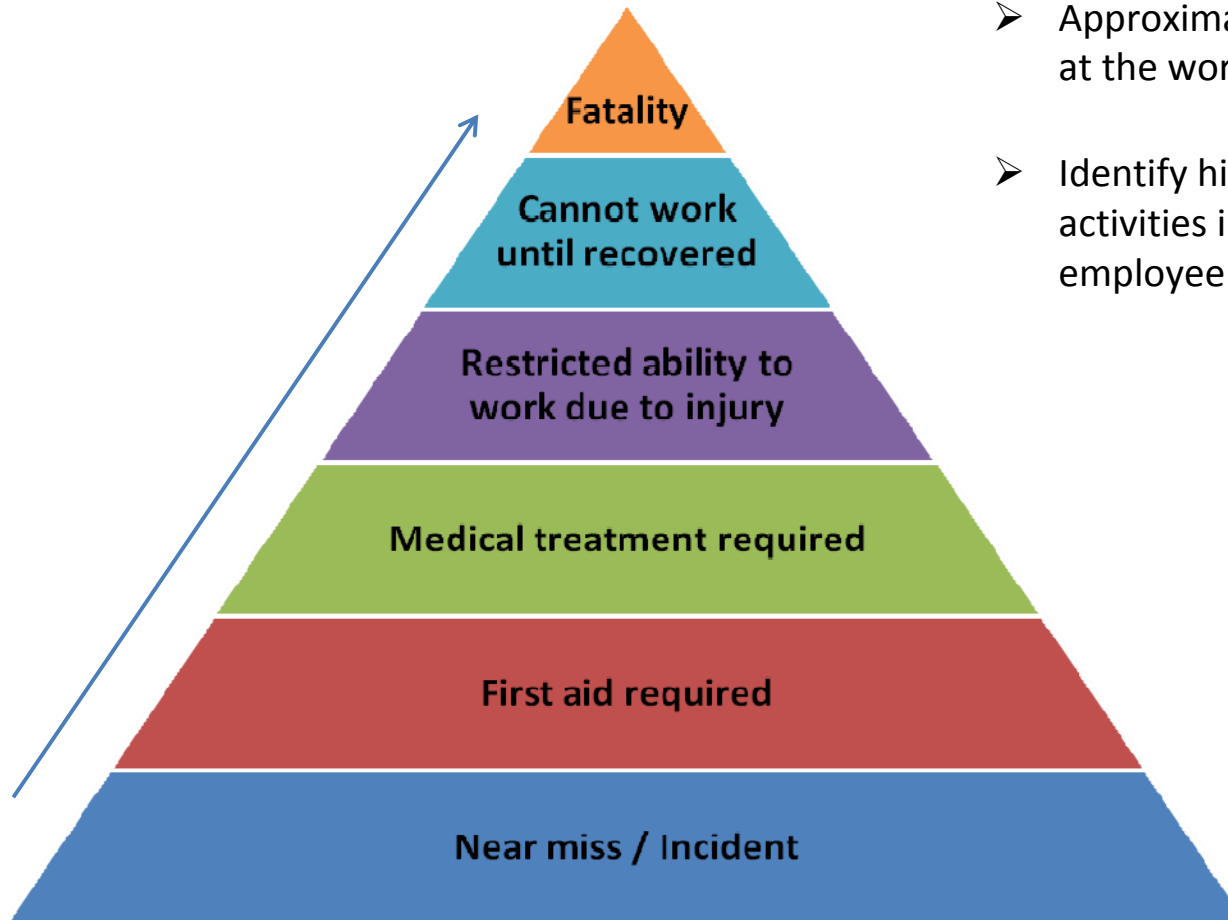


## Example 3

Improve employee safety by  
increased focus on fatal risks



# A fatality follows after many incidents



- Approximately 600 incidents happen at the workplace for each fatality.
- Identify high risk areas and high risk activities in order to improve employee safety.



# Concentrate on the fatal risks first

Research within large mining and metal industry companies has shown the following aspects to be most likely to cause a fatality or serious injury:

- Working at heights
- Hazardous materials
- Road going vehicles such as cars and trucks
- Mobile equipment such as forklifts or mine shuttle cars
- Overhead lifting operations (cranes, tackle)
- Lack of equipment safeguarding on moving parts
- **Lack of isolation and permit to work system**
- Molten materials
- Explosives and blasting
- Ground stability during mining operations

Applicable to EMM  
and EMD factories

Companies within the same industry will be facing the same challenges at each of these risk areas. Best practices can be shared in a forum such as the EPD.



# Isolation system

- Objective: ensure that equipment and devices are completely isolated for the duration of maintenance or installation work.
- Most common types of isolation: electrical and mechanical. Others include pneumatics, steam, chemicals and radioactive sources.
- Method of isolation: use a mechanical device that physically prevents the transmission or release of energy.
- Examples: a manually operated electrical circuit breaker; a line valve; a block.
- Switching off a push button or selector switch does not account for isolation of energy.
- Lockout: the placement of a lock on an energy isolating device, ensuring that the equipment being isolated cannot be operated until the lock is removed.
- Locks to be used by both operation and maintenance personnel. Each device is locked by more than one person, to ensure control of the device until the maintenance work has been completed.





# Permit system

- Ensure that only competent persons perform potentially dangerous work.
- Have an in-house system to issue a permit to allow an employee to perform potentially dangerous work.
- Permit required for the following:
  - Hot work (e.g. open flame, welding, grinding, gas-cutting, drilling and sand blasting)
  - Cold work (e.g. cleaning inside tanks & other confined spaces, working on pumps, doing test work on live equipment)
  - Working at heights (higher than 2 meters and no handrails or physical barriers to prevent a person from falling)
- Permits usually interact with the isolation system.
- All employees involved as well as section manager to sign the permit register.

*Important: provide **training** to employees regarding the isolation and permit system, ensure **compliance** to the system and **design or specify** new equipment to make isolation easier and safer.*



Thank you