GEOTHERMAL SAFETY

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Training for Engineers on Geothermal Power Plant

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Geothermal Hazards - Hazard Potential

Geothermal piping systems and equipment use hot pressurized geothermal fluid for generating electricity or for direct heat applications. The geothermal fluid can include significant amounts of non-condensable gases (NCG), predominantly hydrogen sulfide (H_2S) and carbon dioxide (CO_2). These gases are asphyxiants and above certain concentrations are highly toxic, and indeed potentially fatal. In addition, geothermal brine contains other impurities, including silica and boron, which can be both hazardous to people and the surface environment. Geothermal fluid, may need to be discharged to the environment under certain circumstances and these situations need to be carefully considered and allowed for in the design. In volcanic environments in particular, an elevated construction hazard may be present. This is particularly so for the gathering system which may be spread out over a large area of often challenging terrain. Additionally topographical geo-hazards such as lahar flow paths, areas of steaming ground, and areas with hydrothermal eruption risk should need to be considered.

HAZARD POTENTIAL ON GEOTHERMAL FIELD

Power Generation Capital Plant Hazards

In the case of geothermal power generation a number of energy conversion technologies, or power cycles, can be utilized to convert the geothermal fluid energy into electricity. Common options for power plants are flash condensing steam Rankine Cycles, Organic Rankine Cycle (ORC), or hybrid configurations. More generic (non-geothermal) hazards for generating plant include high and low voltage electrical systems, rotating equipment (e.g. pumps), high fluid temperatures and pressures, elevated working areas and elevated noise levels. For large projects a construction work force can include hundreds of people from different organisations on site during periods of peak activity. This increases the potential for exposure to hazards and there a number of mechanisms that can be employed to foster an appropriate safety culture (Ware and Hochwimmer, 2000) during this phase of a project. These include contractual requirements, training, inspections and audits, and mobilization meetings. Eliminating exposure to a hazard through the design process is desirable as it reduces the overall risk during the construction of the facility.

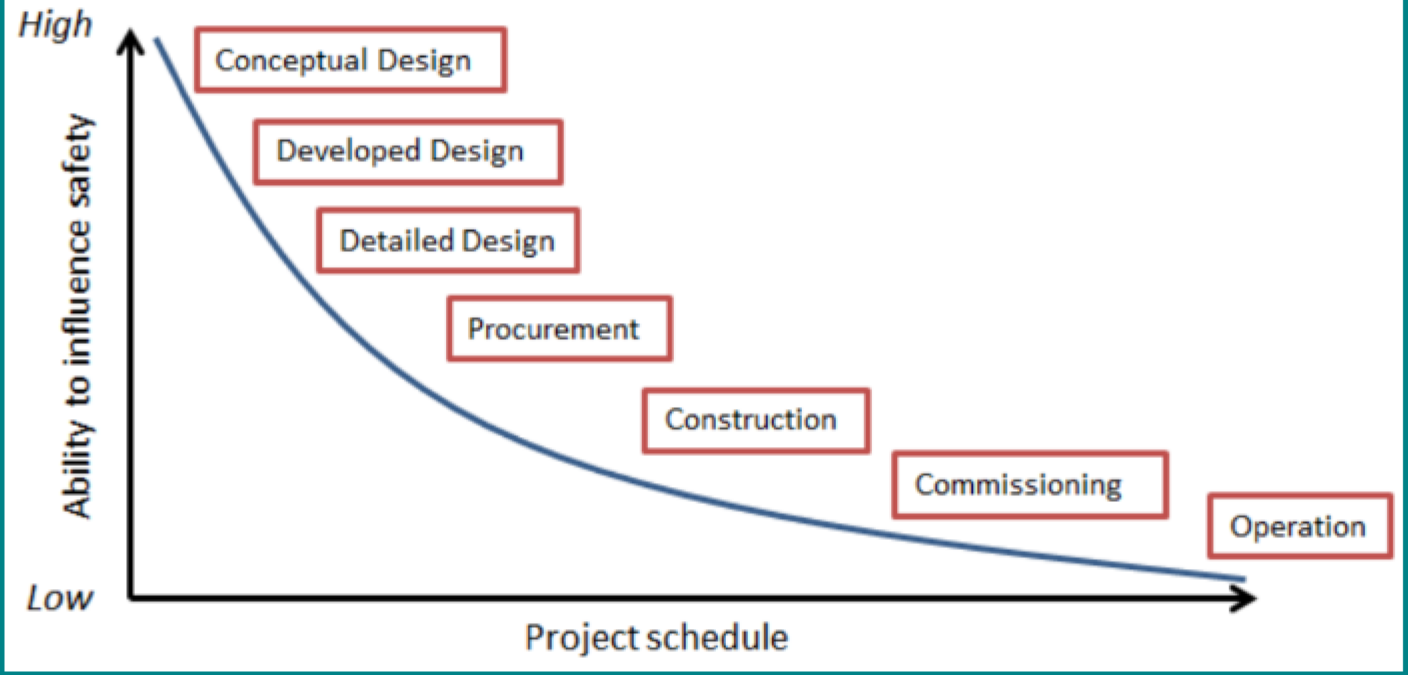
Facility Lifecycle

Generally hazards are most readily apparent during the construction and operation phases of the facility. It is easy for decommissioning and eventual demolition to be overlooked as these are not ‘front of mind’ at the outset of a project. It is helpful therefore to consider the lifecycle of equipment or systems as having a number of discrete phases:

- Conceptual Design
- Developed Design
- Detailed Design
- Procurement
- Construction
- Commissioning
- Operation (including Maintenance)
- Decommissioning
- Demolition

Facility Lifecycle

The ability to influence the inherent safety of a piece of equipment decreases through its lifecycle. This is illustrated in Figure 1. Considering safety aspects at any early stage of the project (i.e. at conceptual, developed, or detailed design phases) is critical. These decisions will influence the subsequent phases of the project and any later changes may require considerable rework which translates into additional project cost and additional delay. If safety aspects are not addressed, then the outcome will be an increased level of residual risk in the project.



Safe Action – Work at Height

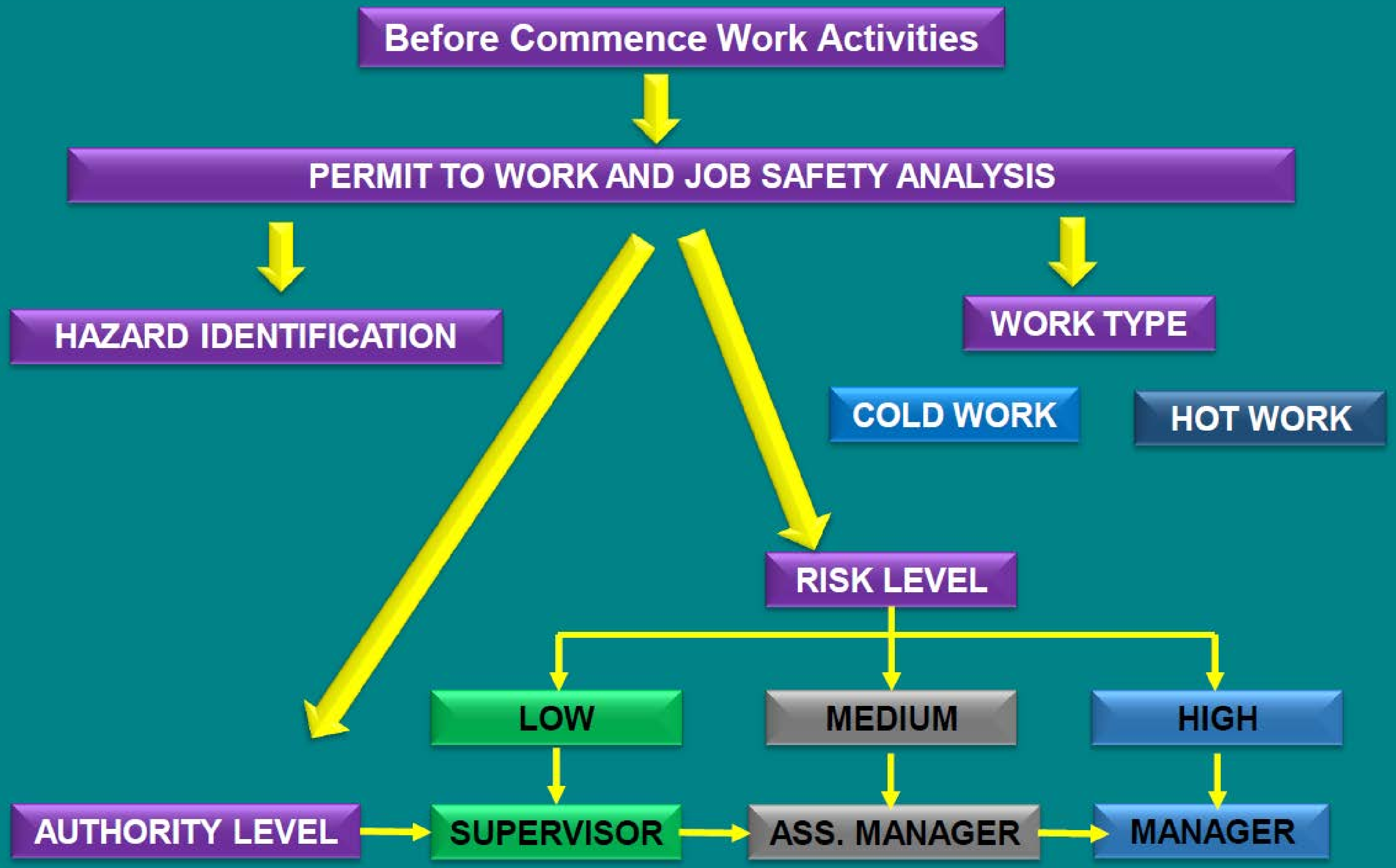
Indonesian Working at Height Regulation

→ Permen No 9 Tahun 2016

Related Regulation

1. Permenakertrans No Per 01/Men/1980 tentang K3 pada konstruksi bangunan
2. Permenaker No Per 05/Men/1985 Tentang pesawat angkat dan angkut Pasal 35 s/d 48
3. DJPPK Direktur Jendral Pembinaan Pengawasan Ketenagakerjaan No KEP. 45/DJPPK/IX/2008 Pedoman K3 Bekerja di Ketinggian dengan menggunakan akses tali (Rope Access)
4. UU No 1 Tahun 1970 tentang Keselamatan Kerja
5. EN Standard/CEN Standard/CE Standard : EN-12277 : Harnesses, EN-12492 : Helmets, EN-12275 : Connectors, EN-12276 : Frictional Anchors.
6. OSHA PART 1910, BS 1139 Metal Scaffolding, AS/NZS 1576 Scaffolding

SAFETY AT WORK



Positive Safety Culture And Safety Performance

The Way We Do Things Around Here (How HSSE Risks Management Practices in E&P)

Thinking and Believing (All Incidents can be prevented. Safety is every body responsibility)

Acting and Doing (Safe behavior On and Off The Jobs)

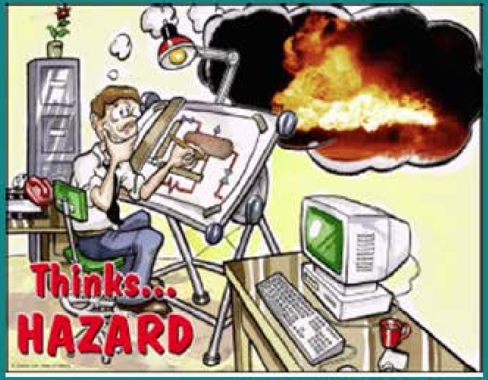
Unintentional and Deliberate Actions (Reduce un-safe acts)

Improved HSSE Performance and Work Environment

*) Reference : Iwan Jatmika, VP QHSSE PT. Pertamina Hulu Energi

What Does Positive Safety Culture mean?

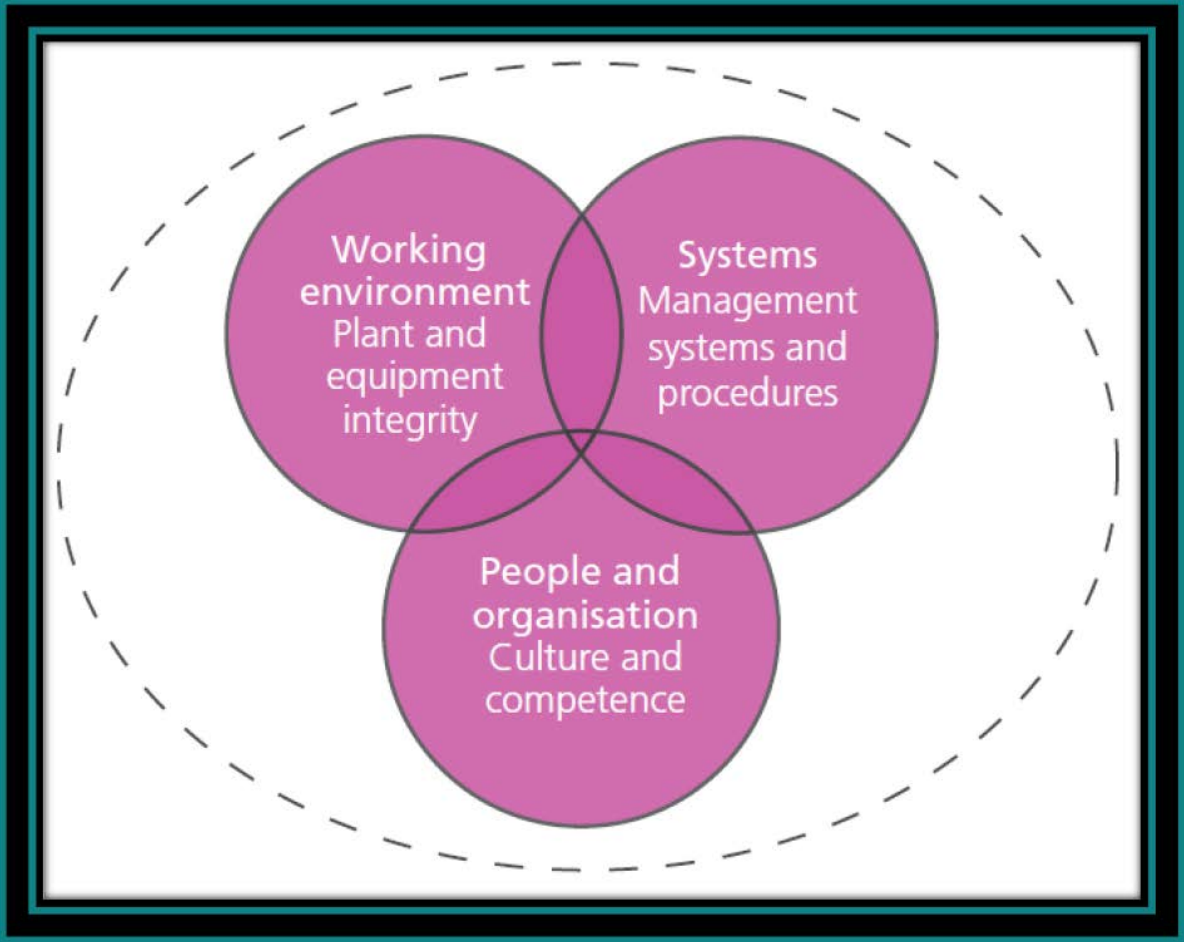
- *I know the nature of works and its scope and steps*
- *I understand the hazards & risks may exposed*
- *I can plan and program the risks control and mitigation reasonably*
- *I manage the residual risks within my budget and authority of control*
- *I have the anticipated emergency and crisis situation responses readiness*



To ignore safety does not indicate bravery; <u>only foolishness</u>

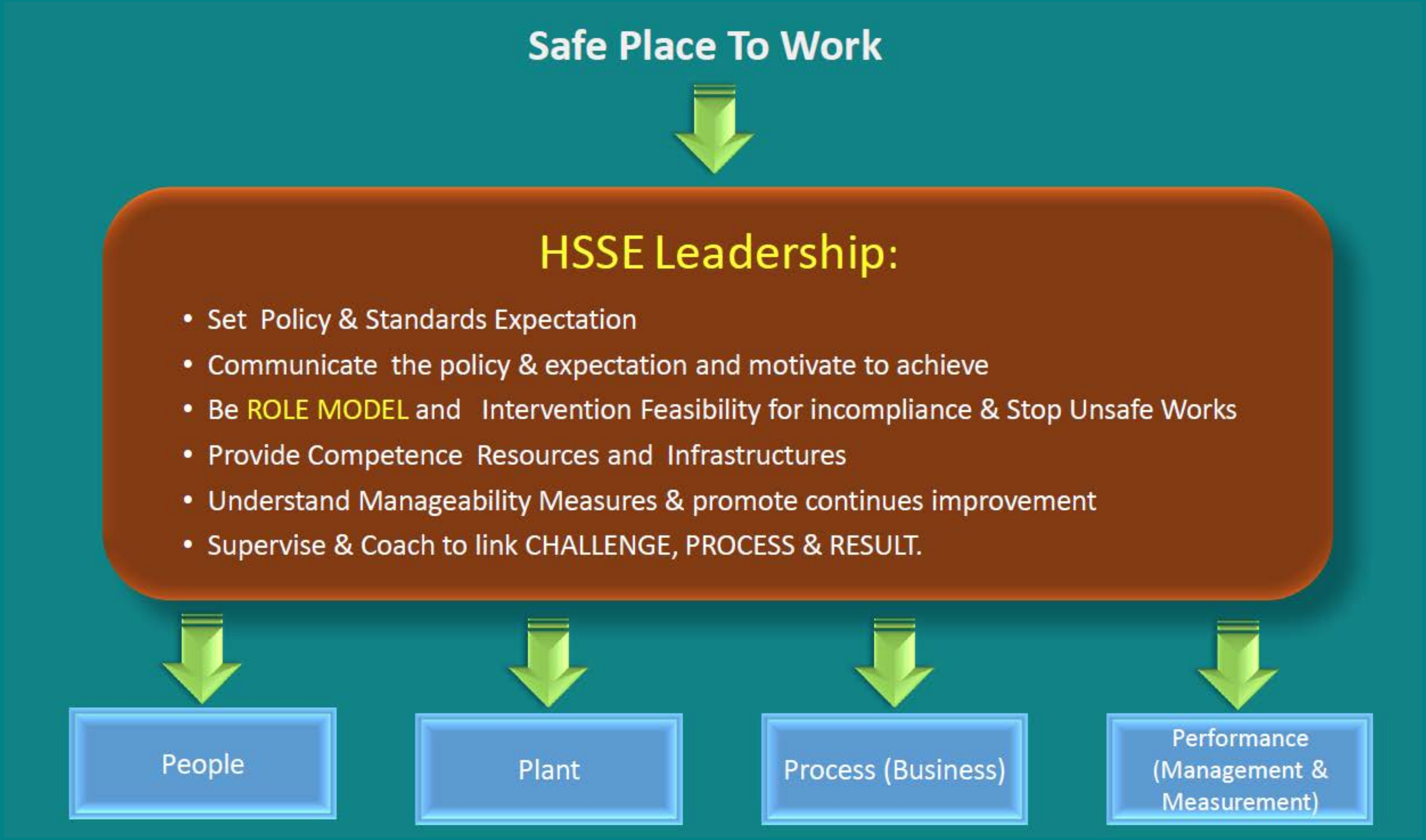
*) Ref. : www.iosh.co.uk/positiveculture

Positive Safety Culture



*) Ref. : www.iosh.co.uk/positiveculture

STRONG HSSE CULTURE



*) Ref. : www.iosh.co.uk/positiveculture

STRONG HSSE CULTURE

PEOPLE

- *Safe Behavior Observation – 3 HSSE Golden Rules*
- *Competency - Trainings, Assurance, Certification and Authorization*
- *Leadership & Supervisory - MWT, Safe System Of Work Organization & Authorization (SC/ AA/ PA/ AGT/ IA)*
- *Individual HSE Performance Contract*

PLANT

- *Process Safety – CRR/ HAZID/ HAZOP/ LOPA/ SIL, Proses Setting, Process Control, Shutdown System & Fire Deluge System*
- *Facility Integrity Management System*
- *Inspection, Maintenance and Repair / TA Program*

*) Ref. : Iwan Jatmika, VP QHSSE PT. Pertamina Hulu Energi

STRONG HSSE CULTURE

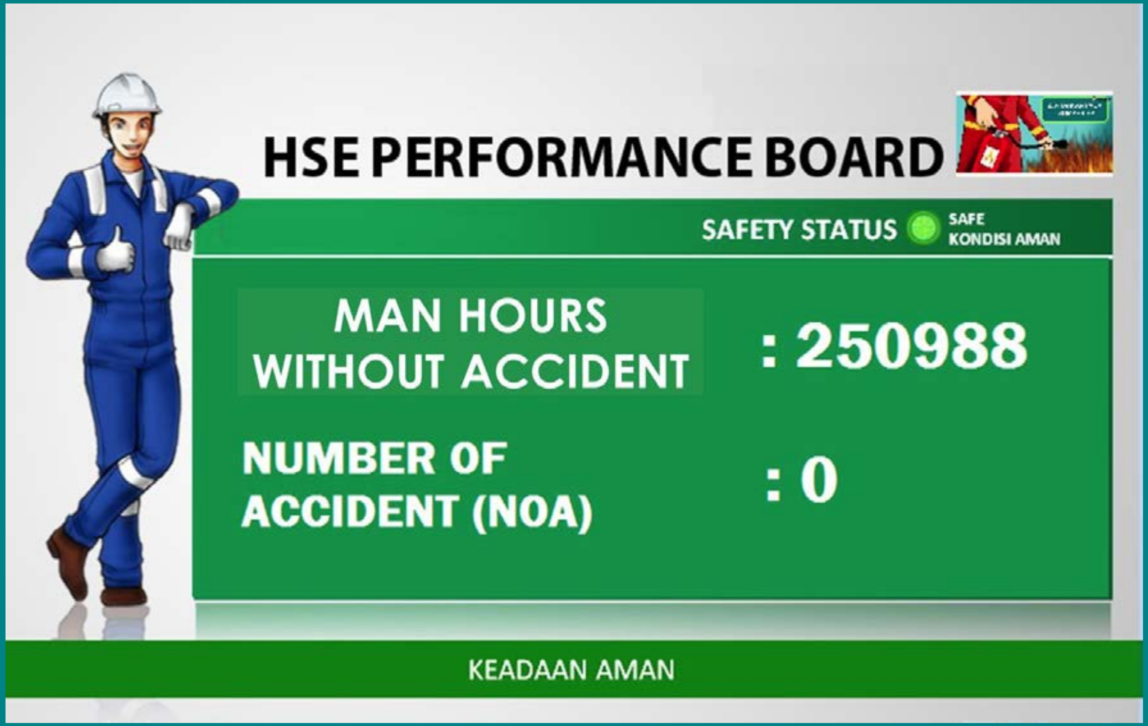
PROCESS (Business)

- *Contractor Safety (CSMS) for contracted services works*
- *Project/ Non-Routine HSE - Risk Register/ PHSER/ PSSR/ Handover Certification in PUDW Cycle*
- *Control of Work (CoW) for safe work execution/ 9 Aspect Fundamental Safety/ Basic Safety Rules*
- *Site Pre-Mobilization Readiness: HSE Passport, SBTC, Crew Induction, Go/No-Go readiness check list.*
- *Investigation, Emergency Response and Crisis Mgmt..*

PERFORMANCE (Management & Measurement)

- *Introduce Management System & Measurement (ISRS)*
- *Set Up Relevant KPI & Genuine Excellent People/ Plant/ Process leading and Lagging metrics*
- *Performance data Analysis & Synthesis to intervene*

Safety by Design (SbD)



A geothermal design must consider many different criteria including safety, operational performance, usability, environmental impact, capital cost, operational cost, constructability, redundancy, and future proofing. Project stakeholders will have different, and sometimes competing, views of which criteria are important and a good design will need to achieve an appropriate balance of these factors.

SbD is therefore a multidisciplinary group activity, heavily reliant upon the experience of others (e.g. designers, constructors, operators, asset owners) to achieve the appropriate balance. These are two main sections consist of **Hazard Prevention by Design** and **Design Risk Management**.

Hazard Prevention by Design

Hazard Prevention by Design is a set of design steps that are applied in the formative stages of the design process. They embody the approach that 'prevention is better than cure'. A project SbD plan encapsulates the specific approach to be taken, and provides visibility to all stakeholders on that approach. It is an important document. The SbD plan considers information and standards specific to both the client and project. Relevant ‘lessons learned’ from past projects are referenced. The SbD approach for the project needs to be agreed, documented in the plan, and approved prior to the developed design commencing. Some example considerations for geothermal design include:

- Design life, redundancy, future expansion and reliability criteria
- Reference to OSHA (Occupational Safety & Health Administration) regulations for platforms and access
- Design guidelines for access, and ergonomic considerations, for operations and maintenance
- Consideration of logical equipment tagging
- Noise limits
- Lighting requirements
- Equipment isolation practices for all types of energy sources
- Pressure relief philosophy
- Provision of safety lines for safety harnesses on pipe bridges
- Physical separation of pipelines from roads
- Pipe support design, e.g. piled stanchion except in the vicinity of power lines
- Standardisation of designs

Standardized design components

The design of geothermal steam gathering systems and power generating facilities provide an opportunity for some standardization of component design, equipment selection, and plant layout (e.g. well pads, separator stations, and steam vent stations, electrical and instrumentation equipment).

Where practicable the use of standardized components provides a range of general benefits in terms of:

- constructability,
- capital cost,
- operational familiarity,
- maintenance and
- project schedule.

The operational familiarity can improve operator safety, reduce risk of operator errors and minimize production losses. As operational experience is obtained standardized designs are refined and improved, encapsulating a large number of lessons learned.

An example of this is standard access platforms that are designed to be fully galvanized prior to erection on site, and this avoids the need for any cold galvanizing after erection. We have observed poor platform construction and maintenance practices in some locations.

Design Risk Management

Decisions taken later during the design process to address identified hazards are called Design Risk Management. This process can include formal procedures but they require a relatively mature (detailed) design to achieve maximum benefit. If serious issues are discovered at this later stage, then design rework will probably be required. Designers always consider project hazards as part of the design process. Often this process happens in a collaborative way during multi-disciplinary design co-ordination and review meetings. A hierarchy of controls is considered in the treatment of each risk - the first, elimination, being the preferred control:

1. Elimination of the hazard, i.e. design or engineer out the hazard. (e.g. move discharge equipment away from traffic areas)
2. Substitute a less hazardous material, process or equipment
3. Redesign equipment or adjust a work process
4. Consider administrative controls, for example adjust the time or condition of risk exposure
5. Personal Protective Equipment (PPE)

Environmental Issue

Environmental issues that may occur during geothermal power generation projects, include the following:

- Effluents
- Air emissions
- Solid waste
- Well blowouts and pipeline failures
- Water consumption and extraction

Effluents - *Drilling Fluids and Cuttings*

Steam production and re-injection wells may be installed during exploration, development, and operational activities. Drilling fluids employed during drilling activities may be water-or oil based, and may contain chemical additives to assist in controlling pressure differentials in the drill hole and to act against viscosity breakdown. Cuttings from oil-based mud are of particular concern due to the content of oil-related contaminants and may necessitate special on-site or off-site treatment and disposal. Recommendations for the management of drill cuttings and fluids include:

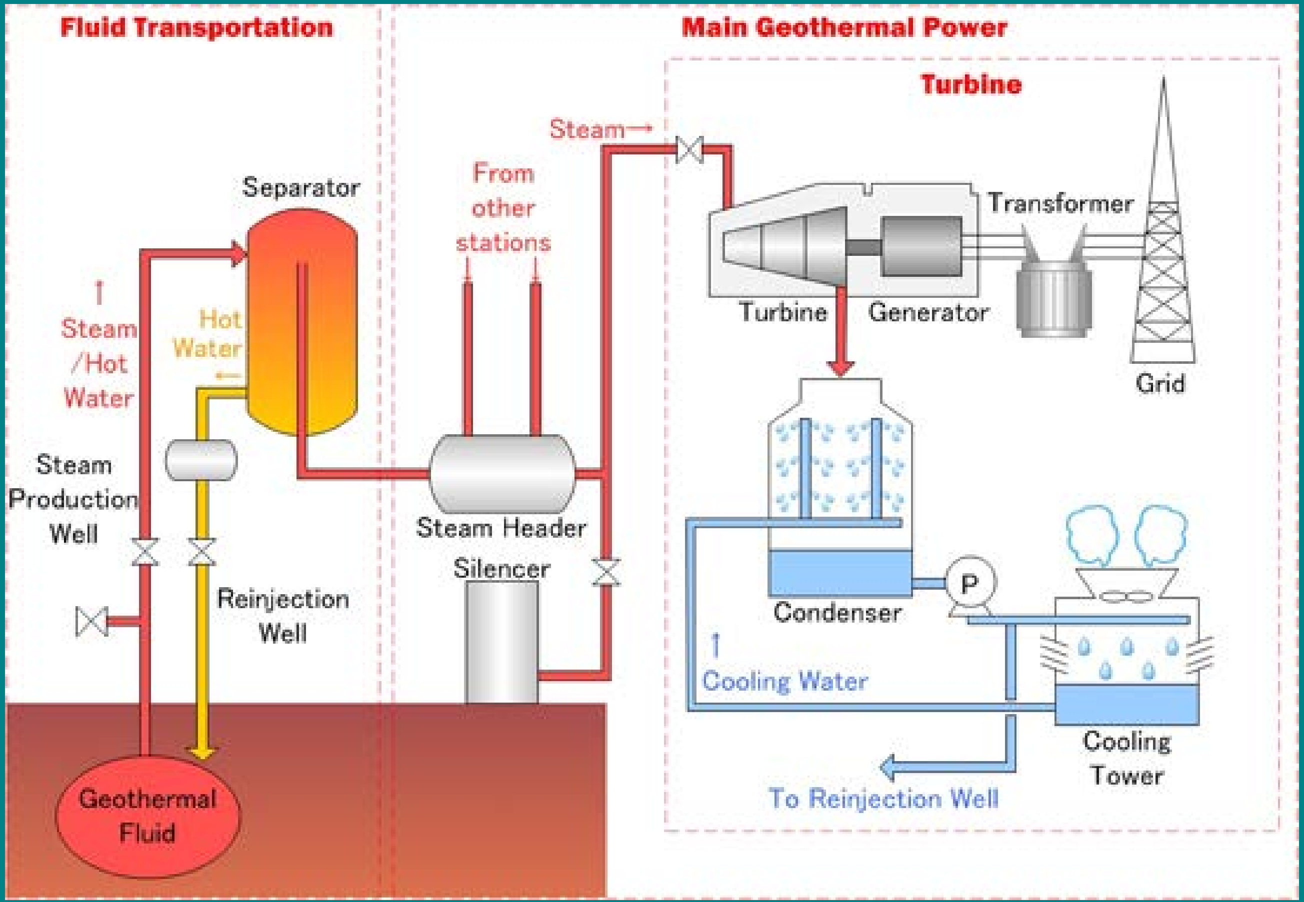
1. Recovery and storage of oil-based drilling fluids and cuttings in dedicated storage tanks or sumps, lined with an impervious membrane
2. Reuse of drilling fluid, where feasible
3. Removal of tanks or sumps to avoid the present or future release of oil-related
4. Disposal of water-based drilling fluids into the bore hole following toxicity assessment
5. During acid treatment of wells, use of leak-proof well casings to a depth appropriate to the geological formation in order to avoid leakage of acidic fluids to groundwater.

Effluents - *Spent Geothermal Fluids*

Spent geothermal fluids consist of the reject water from steam separators (rejected water is water that initially accompanies the steam from the geothermal reservoir), and condensate derived from spent steam condensation following power generation. Facilities that use water cooling towers in an evaporative process typically direct geothermal condensate into the cooling cycle. Geothermal condensate may be characterized by high temperature, low pH, and heavy metals content. Recommended management of geothermal fluids includes the following:

1. Carefully evaluating potential environmental impacts of geothermal fluid discharges depending on the selected cooling system.
2. If facilities do not re-inject all geothermal fluids underground, effluent discharge quality should be consistent with the receiving water body.
3. Where reinjection is the selected alternative, potential for contamination of groundwater should be minimized by installation of leak-proof well casings in the injection wells.
4. Opportunities for reuse of reject geothermal fluids should be considered, including:
   - Use of binary power generation technology;
   - Use in downstream industrial processes if reject water quality
   - Final discharge of used fluids according to the treatment and discharge requirements of the applicable activity

Effluents - Reinjection Sytem



www.yokogawa.com

www.energybc.ca

Air Emissions

Geothermal power plant emissions are negligible compared to those of fossil fuel combustion-based power plants. Hydrogen sulfide and mercury are the main potential air pollutants associated with geothermal power generation employing flash or dry steam technologies. Carbondioxide is present in the steam although its emission is also considered negligible compared to fossil fuel combustion sources. Recommended methods for the management of air emissions include the following:

1. Considering technological options that include total or partial re-injection of gases with geothermal fluids within the context of potential environmental impacts from alternative generating technologies together with other primary factors.
2. When total re-injection is not feasible, venting of hydrogen sulfide and non-condensable volatile mercury if, based on an assessment of potential impact to ambient concentrations, pollutant levels will not exceed applicable safety and health standards.
3. If necessary, use of abatement systems to remove hydrogen sulfide and mercury emissions from noncondensable gases. Examples of hydrogen sulfide controls can include wet or dry scrubber systems or a liquid phase reduction/oxidation system.

Air Emissions
Hydrogen Sulfide Analyzer

analyticalsystemkeco

www.liquidgasanalyzer.com

Solid Waste

Geothermal technologies do not produce a substantial amount of solid waste. Sulfur, silica, and carbonate precipitates are typically collected from cooling towers, air scrubber systems, turbines, and steam separators. This sludge may be classified as hazardous depending on the concentration and potential for leaching of silica compounds, chlorides, arsenic, mercury, vanadium, nickel, and other heavy metals.

www.researchgate.com

www.sciencedirect.com

Well Blowouts and Pipeline Failures

Although very rare, well blowouts and pipeline failures may occur during well drilling or facility operations. Such failures can result in the release of toxic drilling additives and fluids, as well as hydrogen sulfide gases from underground formations. Pipeline ruptures may also result in the surface release of geothermal fluids and steam containing heavy metals, acids, mineral deposits, and other pollutants. Recommended pollution prevention and control methods to address well blowouts and pipeline ruptures include:

1. Regular maintenance of wellheads and geothermal fluid pipelines, including corrosion control and inspection; pressure monitoring; and use of blowout prevention equipment such as shutoff valves.
2. Design of emergency response for well blowout and pipeline rupture, including measures for containment of geothermal fluid spills.

Water Consumption and Extraction

Surface water extraction is necessary for a variety of geothermal power generation activities, including well drilling, injectivity testing of subsurface formations and for use in cooling systems. Surface water used for non-contact single pass cooling is typically returned to the source with some increase in heat content, but no overall change in water quality.

The following management measures are recommended to conserve water sources:

1. Assessing hydrological records for short and long-term variability of streams serving as source water.
2. Monitoring temperature differential of effluent and receiving water bodies to comply with local regulations respecting thermal discharge.

Occupational health and safety issues

Occupational health and safety issues during the construction and decommissioning of geothermal power generation projects are common to those of other industrial facilities and their prevention and control.

Specific health and safety issues in geothermal power projects include the potential for exposure to:

- Geothermal gases
- Confined spaces
- Heat
- Noise

Geothermal Gases

Occupational exposure to geothermal gases, mainly hydrogen sulfide gas, may occur during non-routine release of geothermal fluids (for example, pipeline failures) and maintenance work in confined spaces such as pipelines, turbines, and condensers. The significance of the hydrogen sulfide hazard may vary depending on the location and geological formation particular to the facility. Where there is a potential for exposure to hazardous levels of hydrogen sulfide, geothermal power facilities should consider the following management measures:

1. Installation of hydrogen sulfide monitoring and warning systems.
2. Development of a contingency plan for hydrogen sulphide release events, including all necessary aspects from evacuation to resumption of normal operations
3. Provision of facility emergency response teams, and workers in locations with high risk of exposure.
4. Provision of adequate ventilation of occupied buildings to avoid accumulation of hydrogen sulfide gas.
5. Development and implementation of a confined space entry program for areas designated as ‘Confined Spaces’.
6. Providing workers with a fact sheet or other readily available information about the chemical composition of liquid and gaseous phases.

Confined Spaces

Confined space hazards in this and any other industry sector are potentially fatal. Confined space entry by workers and the potential for accidents may vary among geothermal facilities depending on design, on-site equipment, and presence of groundwater or geothermal fluids. Specific and unique areas for confined space entry may include the turbine, condenser, and cooling water tower.

Heat

Occupational exposure to heat occurs during construction activities, and during operation and maintenance of pipes, wells, and related hot equipment. Non-routine exposures include potential blowout accidents during drilling as well as malfunctions of the steam containments and transport installations.

Recommended prevention and control measures to address heat exposure include:

1. Reducing the time required for work in elevated temperature environments and ensuring access to drinking water.
2. Shielding surfaces where workers come in close contact with hot equipment, including generating equipment, pipes etc.
3. Use of personal protective equipment (PPE) as appropriate, including insulated gloves and shoes.
4. Implementing appropriate safety procedures during the exploratory drilling process.

Noise

Noise sources in geothermal facilities are mainly related to well drilling, steam flashing and venting. Other sources include equipment related to pumping facilities, turbines, and temporary pipe flushing activities. Temporary noise levels may exceed 100 dBA during certain drilling and steam venting activities. Noise abatement technology includes the use of rock mufflers, sound insulation, and barriers during drilling, in addition to silencers on equipment in the steam processing facility.

geodipa

Community Health and Safety

Community health and safety issues during the construction and decommissioning of geothermal power generation plants are common to those of most large industrial facilities. Community health and safety issues during the operation of geothermal power generation plants include:

- Exposure to hydrogen sulfide gas
- Infrastructure safety
- Impacts on water resources

Hydrogen Sulfide

The potential for exposures to members of the community should be carefully considered during the planning process and the necessary precautions implemented. Where the potential for community exposure is significant, examples of mitigation measures include:

1. Siting of potential significant emissions sources with consideration of hydrogen sulfide gas exposure to nearby communities.
2. Installation of a hydrogen sulfide gas monitoring network with the number and location of monitoring stations determined through air dispersion modelling.
3. Continuous operation of the hydrogen sulfide gas monitoring systems to facilitate early detection and warning.
4. Emergency planning involving community input to allow for effective response to monitoring system warnings.

Infrastructure Safety

Communities may be exposed to physical hazards associated with the wells and related pipeline networks. Hazards may result from contact with hot components, equipment failure, or the presence of active and abandoned well infrastructure. Recommended management techniques to mitigate these impacts include:

1. Placement of access deterrents, such as fences and warning signs, to prevent access and warn of existing hazards;
2. Minimizing the length of necessary pipeline systems;
3. Consideration of the feasibility of subsurface pipelines or heat shields to prevent public contact with hot geothermal pipelines;
4. Managing closure of infrastructure such as pipelines and access roads, including: cleaning, disassembly, and removal of equipment; analysis of soil quality with cleanup where warrante.
5. Managing closure of well heads including sealing well with cement, removing the well head, and backfilling depression around the well head, as necessary.

Impacts on Water Resources

The extraction, reinjection, and discharge of geothermal fluids may affect the quality and quantity of surface and groundwater resources.

Recommended measures to prevent and control these impacts include:

1. Elaboration of a comprehensive geological and hydrogeological model including overall geological, structural and tectonic architecture, reservoir size, boundaries, geotechnical and hydraulic host rock properties;
2. Completion of a hydrogeologic and water balance assessment during the project planning stage to identify hydraulic interconnections between the geothermal extraction and reinjection points.
3. Isolation of steam producing sources from shallower hydrologic formations which may be used as sources of potable water through careful site selection and properly designed and installed well casing systems.
4. Avoiding negative impacts on surface water by introducing strict discharge criteria and appropriate means to bring water quality and temperature to acceptable standards.

EMERGENCY PROCEDURES

Fire Emergency Checklist

1. Raise the alarm
2. Evacuate people from the area
3. Activate any emergency shutdown systems
4. Call emergency services
5. Call your manager

Precautions

- Do not endanger yourself
- Make sure you have an escape route
- Do not use water on petroleum or electrical fires
- Do not leave the site unattended if there is a risk of further outbreak
- Advise your manager of the incident

*) Ref. : Environmental protection authority, NZ Gov.

EMERGENCY PROCEDURES
DISASTER STRIKES - EARTHQUAKE

During the earthquake

1. Keep calm
2. Stay indoors where practical
3. Keep away from windows and heavy furniture
4. Take cover – use a doorway or get under a strong table or other sturdy structure

After the earthquake, if the building is damaged

- -Turn off water, electricity, and gas at mains (Operator)
- -Follow the instruction from safety officer
- -Go to muster points
- -Treat injuries
- -Get in touch with neighbors – they may need help
- -When help is needed go to your nearest civil defense post
- -Advise manager of damaged sustained

*) Ref. : Environmental protection authority, NZ Gov.

Performance Indicators and Monitoring
- Emissions

Minor air emissions of hydrogen sulfide, mercury vapor, and sulfur dioxide may arise as fugitive emissions from the cooling tower if the condensation process involves direct contact of steam with cooling water. Guideline values for process emissions and effluents in this sector are indicative of good international industry practice as reflected in relevant standards of countries with recognized regulatory frameworks. Although geothermal energy projects do not normally generate significant point source emissions during construction and operations, hydrogen sulfide emissions, or other types of emissions, should not result in ambient concentrations above nationally established air quality standards or, in their absence, internationally recognized guidelines.

Performance Indicators and Monitoring
- Effluents

Spent geothermal fluids are typically re-injected to the host rock formation, resulting in minor effluent volumes involving reject waters. Potential contaminants in geothermal effluents will vary according to the mineralogy of the host geological formation, temperature of the geothermal water, and site-specific facility processes. If spent geothermal fluids are not re-injected, effluents should meet site-specific discharge levels for surface water.

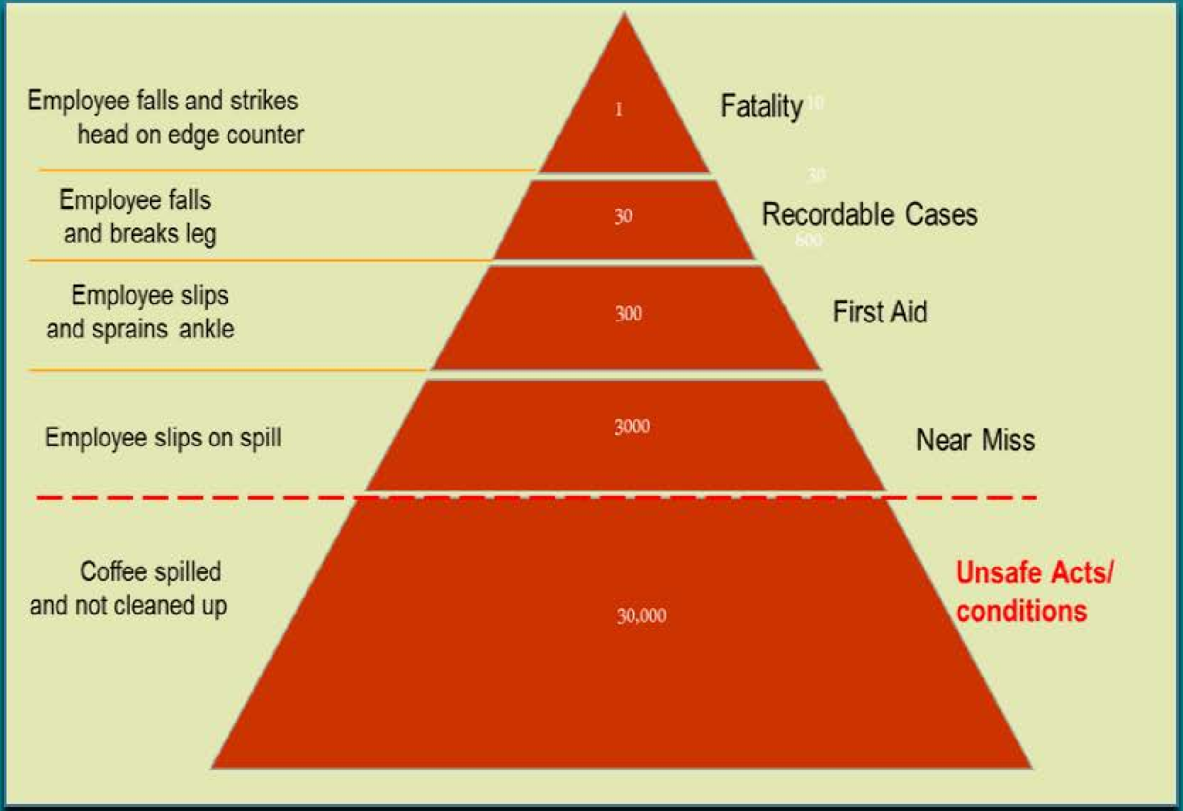
Performance Indicators and Monitoring
- Environmental Monitoring

Environmental monitoring programs for this sector should be implemented to address all activities that have been identified to have potentially significant impacts on the environment, during normal operations and upset conditions. Environmental monitoring activities should be based on direct or indirect indicators of emissions, effluents, and resource use applicable to the particular project.

Monitoring frequency should be sufficient to provide representative data for the parameter being monitored. Monitoring should be conducted by trained individuals following monitoring and record-keeping procedures and using properly calibrated and maintained equipment. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken.

Hazard Management

1. No intervention or in-effective investigation/ symptomatic only or recommendations are not follow up effectively
2. Less Pay attention or No intervention, No HSSE 3 Golden Rules commitment



*) Ref. : Iwan Jatmika, VP QHSSE PT. Pertamina Hulu Energi

Risk Assessment

Purposes :

- Identify the hazards created at work and evaluate the risks associated with these hazards,
- Determine what measures they should take to protect the health and safety of their employees and other workers
- Evaluate the risks in order to make the best informed selection of work equipment, chemical substances or preparations used, the fitting out of the workplace, and the organization of work
- Check whether the measures in place are adequate

*) Ref. : European Agency for Safety at Work

Risk Assessment

Purposes :

- Prioritise action if further measures are found to be necessary as a result of the assessment
- Demonstrate to themselves, the competent authorities, workers and their representatives that :
    1. 1.All factors pertinent to the work have been considered,
    2. 2.An informed valid judgment has been made about the risks
    3. 3.The measures necessary to safeguard health and safety
- Ensure that the preventive measures and the working and production methods, which are considered to be necessary and implemented following a risk assessment
- Provide an improvement in the level of worker's protection.

*) Ref. : European Agency for Safety at Work

Risk Mitigation

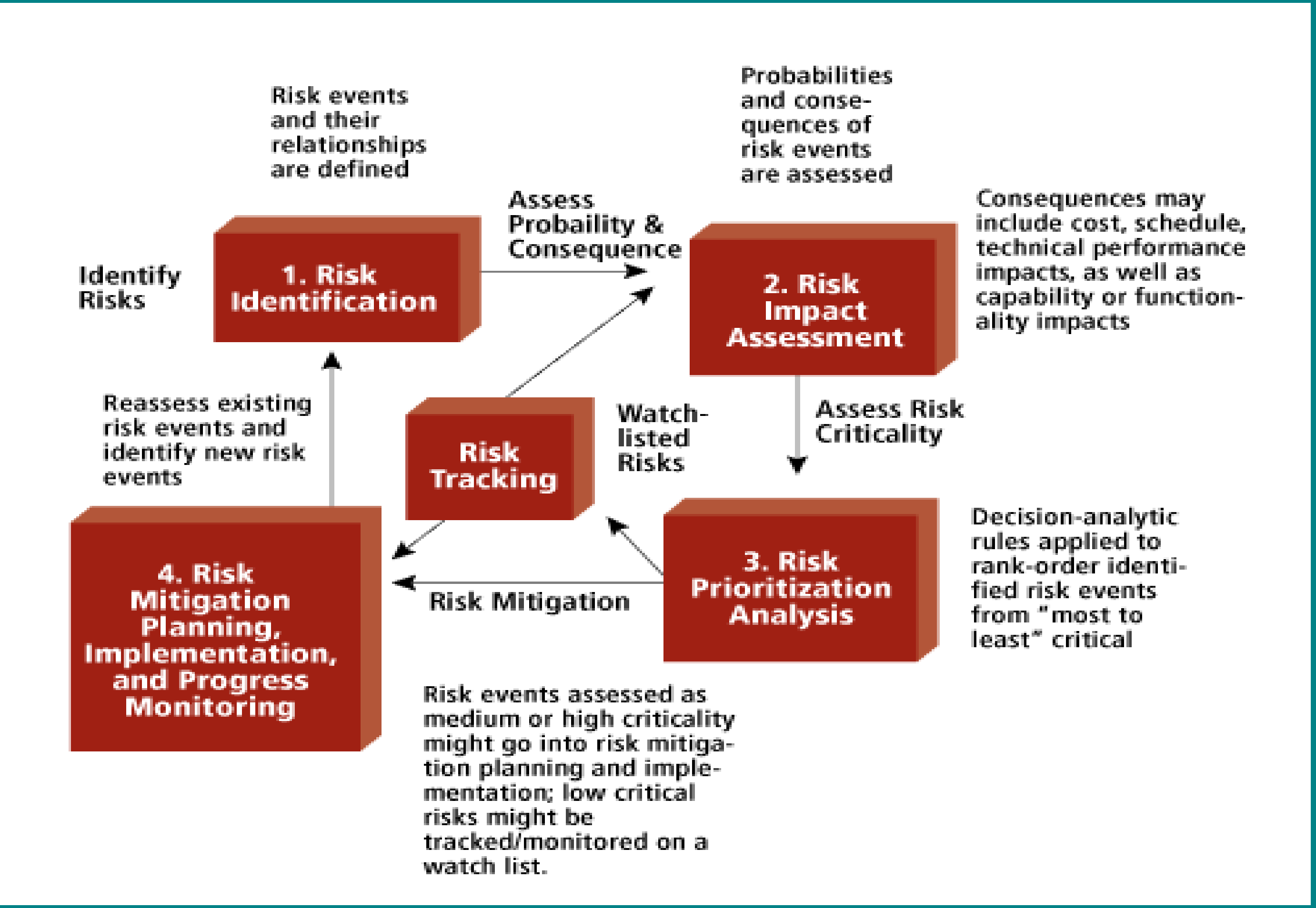
Risk mitigation planning is the process of developing options and actions to enhance opportunities and reduce threats to project objectives

Risk mitigation implementation is the process of executing risk mitigation actions

Risk mitigation progress monitoring includes tracking identified risks, identifying new risks, and evaluating risk process effectiveness throughout the project

*) Ref. : Project Management Institute, A Guide to the Project Management Body of Knowledge, (PMBOK Guide), Fourth Edition, ANSI/PMI 99-001-2008, pp. 273-312

Risk Mitigation



*) Ref. : Project Management Institute, A Guide to the Project Management Body of Knowledge, (PMBOK Guide), Fourth Edition, ANSI/PMI 99-001-2008, pp. 273-312

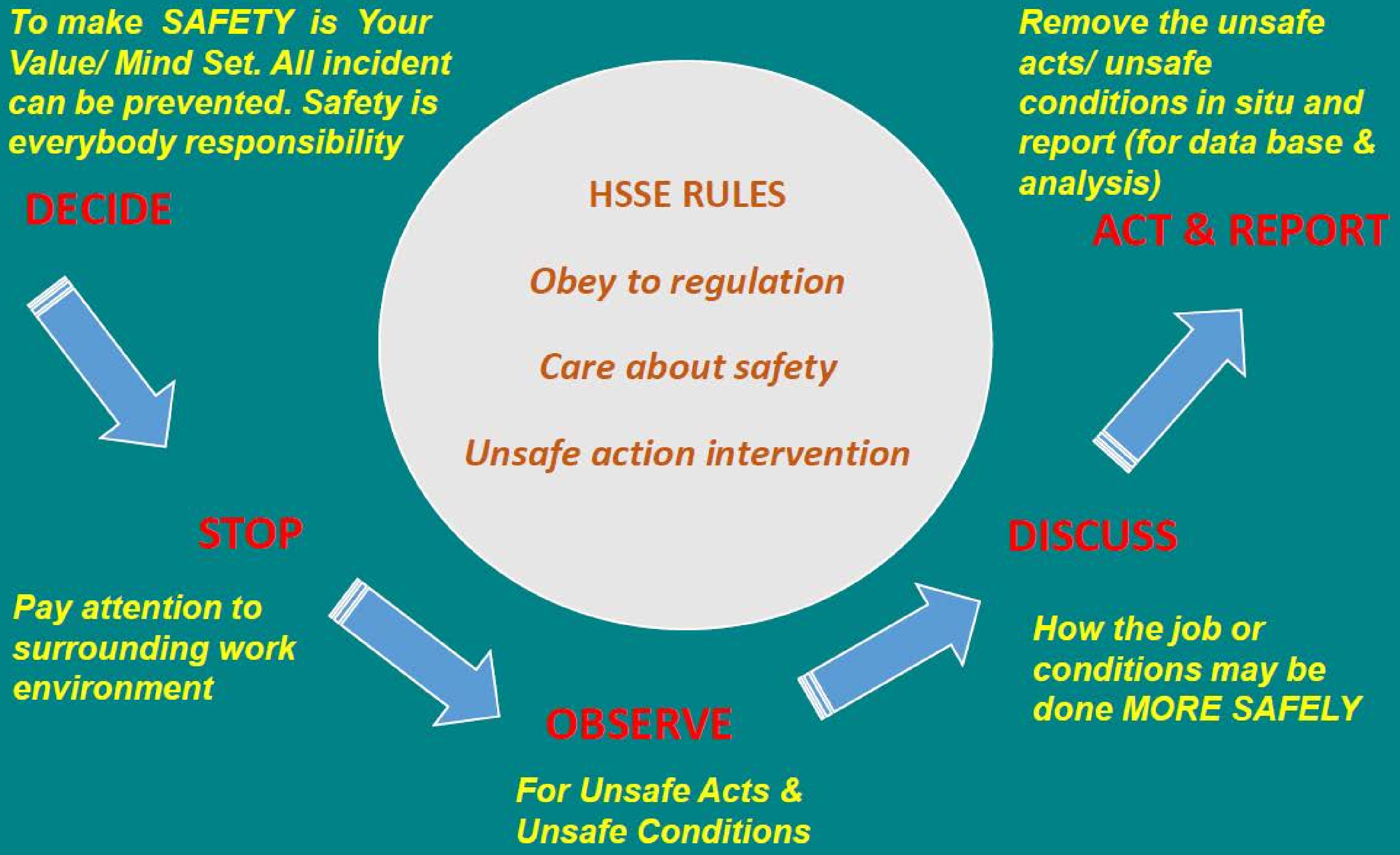
Risk Register - Practical

Risk Description → Possible Root Cause → Positive Factor → Qualitative Impact → Risk Symptoms → Strategy - Mitigate → Risk Mitigation Plan → Actual Mitigation Activities → GOAL

GOAL :

1. Zero Accidents
2. Minimize risks
3. Achieve targets
4. Cost Efficiency
5. Well maintaince of equipment

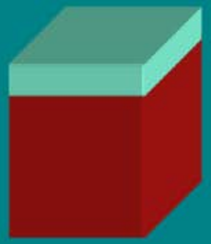
Safety Observation & Intervention Cycle



Safety Observation & Intervention Cycle

RISK CONTROL IS ABOUT PEOPLE

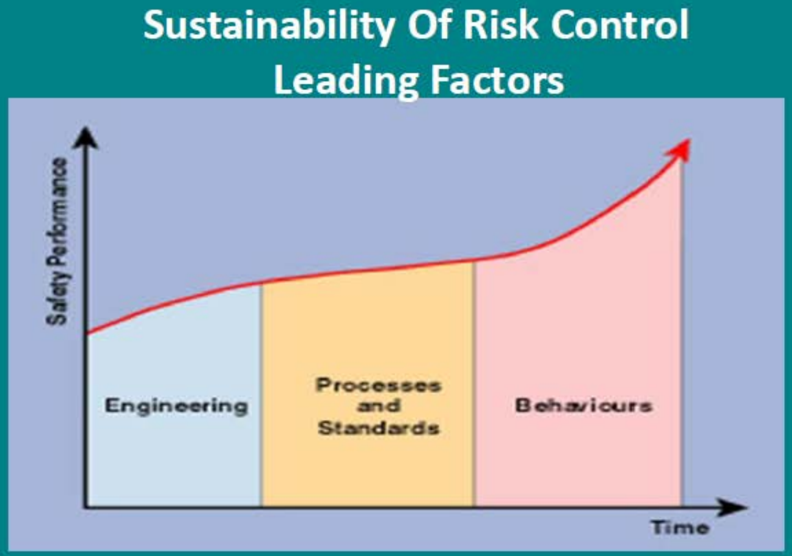
Heinrich's Domino Theory says that Incident:



02% Are Unavoidable

10 % Caused by Unsafe Conditions

88 % Caused by Unsafe Acts !!!!! (it is about people)



Substandard Ladder

Standard Ladder

Standard Grating

*) Reference : Iwan Jatmika, VP QHSSE PT. Pertamina Hulu Energi

Unsafe Action – Work at Height

Without Body harness

*) Reference : Iwan Jatmika, VP QHSSE PT. Pertamina Hulu Energi

Unsafe Action – Work at Height

Without Body harness

*) Reference : Iwan Jatmika, VP QHSSE PT. Pertamina Hulu Energi

Unsafe Action – Work at Height

Without Platform

*) Reference : Iwan Jatmika, VP QHSSE PT. Pertamina Hulu Energi

Safe Action – Work at Height

Wearing Body harness

*) Reference : Iwan Jatmika, VP QHSSE PT. Pertamina Hulu Energi

THANK YOU