

WSH Risk Management & OH Development in Singapore 2016

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Singapore



MINISTRY OF
MANPOWER

A Great Workforce A Great Workplace

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OSH Division



**OSH
Inspectorate**

**Work Injury
Compensation**

OSH Specialists

**Policy , Infor &
Corp Service**

**International
Collaboration**

**Engineering
Safety**

**Occupational
Medicine**

**Occupational
Hygiene**

**Major Hazard
Installation**

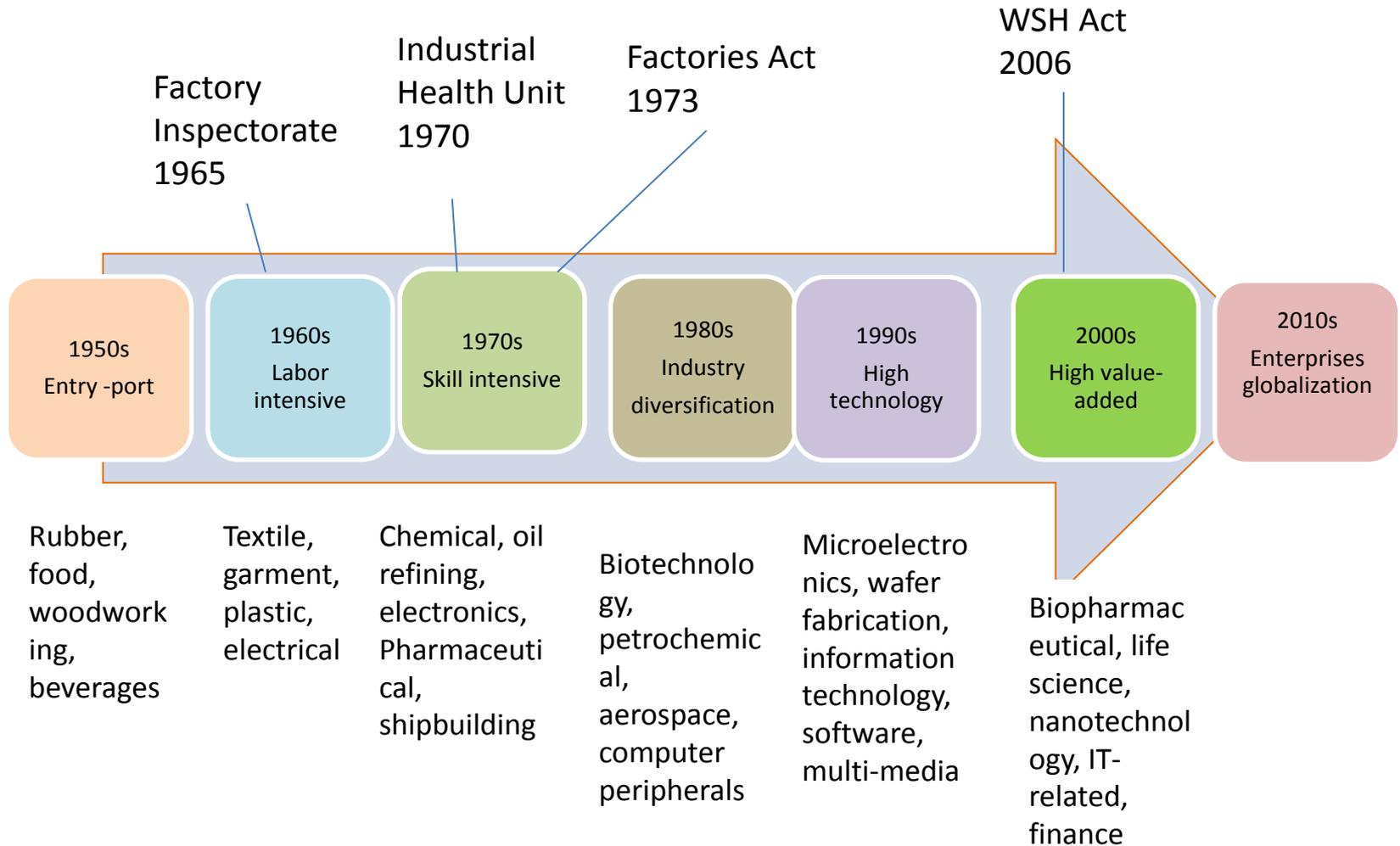
Agenda

1. OH Development in Singapore / RIH Certification Scheme
2. Risk Management (RM)
RA for Health Hazards / RM Regulations
/ RM Framework

OH Development in Singapore



History of Industrialization



2000s – transition from 3rd World to 1st

Backbone of Occupational Hygiene – OH-related Legislation

WSH Act

WSH (Risk Management) Regulations

WSH (General Provisions) Regulations

WSH (Noise) Regulations

WSH (Confined Spaces) Regulations

WSH (Asbestos) Regulations

WSH (WSH Officers) Regulations

WSH (WSH Committees) Regulations

WSH (S&H Management System and Auditing) Regulations

WSH (General Provisions) Regulations

OH-related Provisions	
Infectious agents & bio-hazardous material (3)	Biological hazards
Overcrowding (4)	Physical hazards
Ventilation (5)	
Lighting (6)	
Reduction of vibration (9)	
Protection against excessive heat or cold & harmful radiations (10)	
Toxic dust, fumes or other contaminants (39)	Chemical hazards
Permissible exposure levels of toxic substances (40)	
Hazardous substances (41)	
Warning labels (42)	
Safety data sheet (43)	

OH Competent Persons

Regulations	Competent Person	No. of competent persons as of 2009
WSH (Noise) Regulations	Noise monitoring	1,000
	Noise control	350
WSH (General Provisions) Regulations	Air monitoring	400
	Management of hazardous substances	1,500
WSH (Confined Spaces) Regulations	Confined Space Safety Assessors	NA
WSH (Asbestos) Regulations	Asbestos surveyor	110 (2014)
	Asbestos removal	104 (2014)

Persons Carrying out OH Work

1. Competent persons
2. OH Officers or Practitioners
3. WSH Officers (full-time or part-time)
4. Occupational or Industrial hygienists
5. WSH service providers (e.g. consultants)

OH Education & Training Framework

Training	Qualifications	Occupation Title
Postgraduate in OH (by NUS CBED)	Master in SHE (OH)	Occ or Ind Hygienist
Specialist Diploma in Occ Hygiene (by WDA)	Specialist Diploma (OH)	OH Officer / Practitioner
Specialist Diploma in WSH (by WDA)	Specialist Diploma (WSH)	WSH Officers
IH Short Course (by NUS SSHSPH)	Certificate	Nil

Master in SHE (Occupational Hygiene)

Core & Elective Modules	
1	Industrial Toxicology
2	Fundamentals of Industrial Hygiene
3	Industrial Ventilation
4	Noise & other physical hazards
5	Evaluation of Chemical Hazards
6	Principles of Epidemiology & Biostatistics
7	Chemical Safety
8	Fundamentals in Environmental Protection
9	Independent Study or Research Project on a specific OH Topic

Specialist Diploma in Occupational Hygiene (SDOH)

	Core & Elective Modules (308 to 334 hrs)
1	Interpret Basic Workplace Health Practices
2	Monitor Noise & Vibration
3	Control Noise & Vibration
4	Measure Exposure & Assess the Risks due to Hazardous Substances
5	Manage Hazardous Substances
6	Evaluate Ergonomics-Related Hazards
7	Assess & Control Thermal Stressors
8	Manage Asbestos & Other Fibres Risk
9	Manage Skin Exposure Risks

OHTA's Training Framework – OH Training Levels

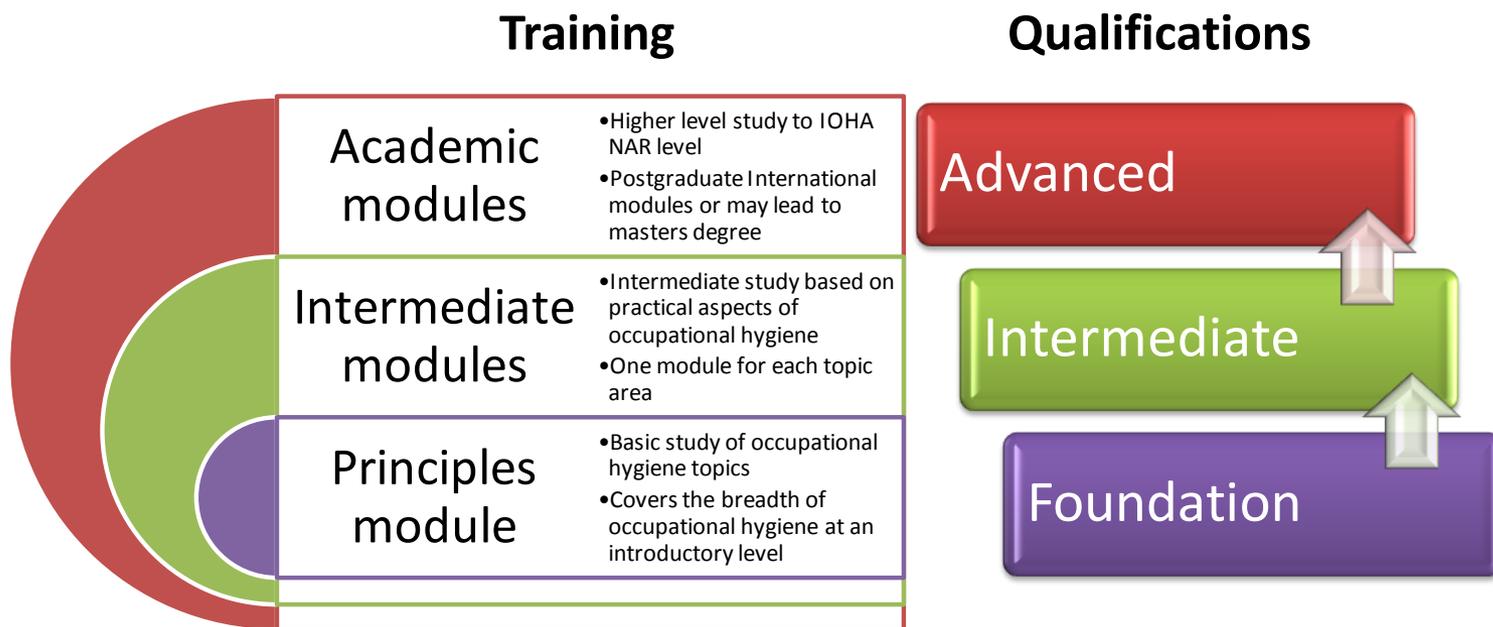
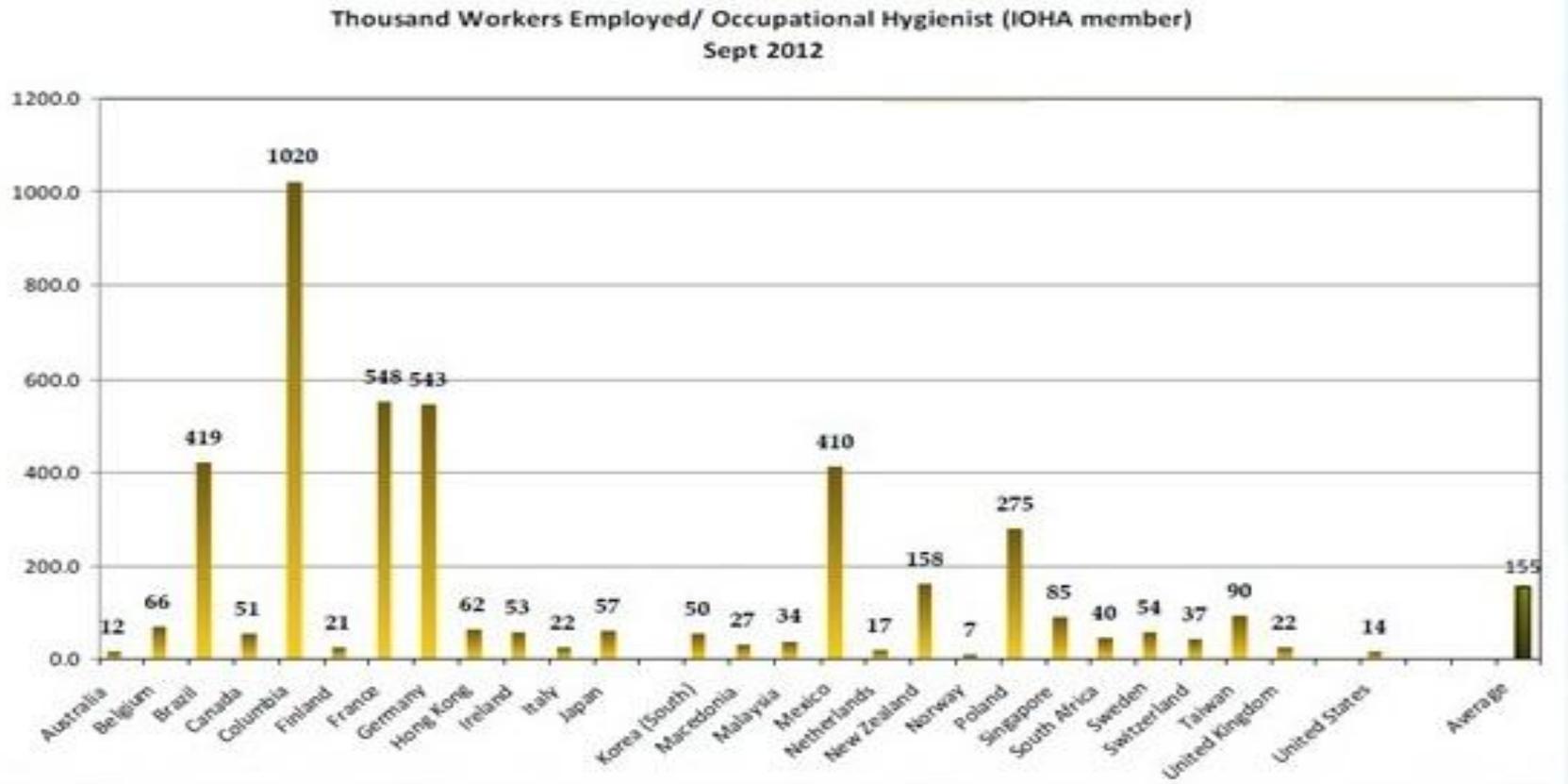


Figure 1 – Occupational Hygiene Training levels

No of Workers per Industrial Hygienists Worldwide



Data extracted from paper presented by Noel H Tresider at the International Occupational Hygiene Association Conference 2012, Kuala Lumpur, September 2012 “Growing the seeds of Occupational Hygiene”

OH in MOM – Career Progression

Job Level	Designation
ESO / SO / MX 13	Associate OH Specialist
ESO / SO / MX 12	OH Specialist
ESO / SO / MX 11	Senior OH Specialist
ESO / SO / MX 10	Principal OH Specialist
ESO / SO / MX 9	Deputy Director
ESO / SO / MX 8	Director / Senior Consultant
ESO / SO / MX 7	Div. Director

Registered Industrial Hygienist (RIH) Certification Scheme



Occupational and Environmental Health Society

RIH Certification Scheme

Aim: To advance & maintain a high level of professional competence of IH professionals in Singapore



Establishing and maintaining a registration system for IH professionals practicing in Singapore.

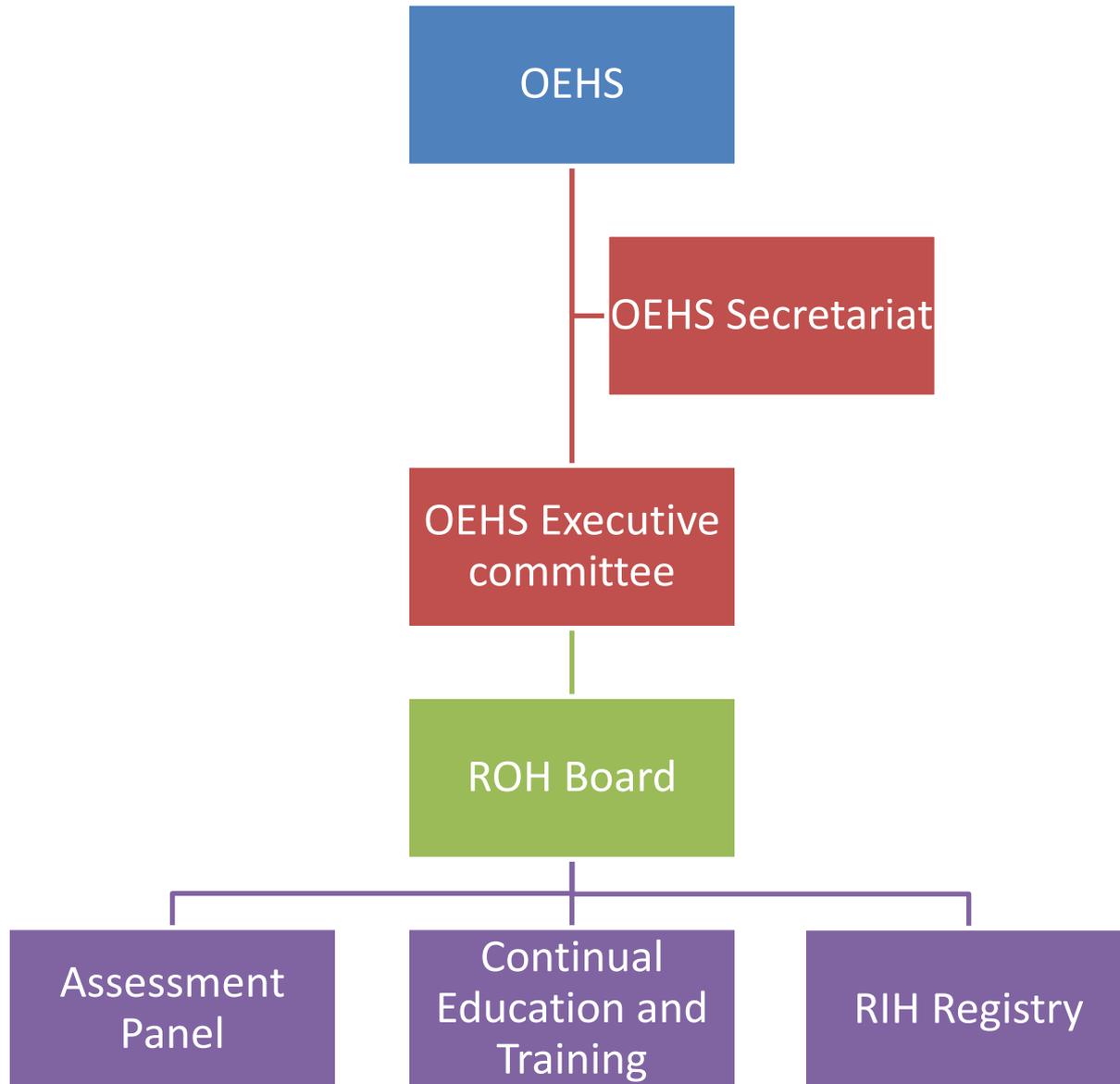


Developing a robust standard of assessment for registration of IH professionals based on academic education, practical experience and conduct.



Provide for continuing learning and training of registered IH professionals

RIH Certification Board – Structure



RIH Certification Board - Functions

1. Maintain a register of RIH
2. Process applications for registration as RIH
3. Establish & maintain standards of professional conduct & ethics of the IH profession
4. Promote learning & education in connection with IH profession



Qualifying Criteria for RIH Registration

Qualifications	A basic Degree in occupational hygiene , engineering, science or related field
Training received	SDOH or minimum 150 hours of OH / IH course work
Experience	minimum 4 years in OH / IH
Knowledge & skills in IH/OH	Assess through interview and/or examination
Integrity	Professional conduct and ethics, assess through testimony from two referees

OH Professionals Certification

4 years of full time comprehensive OH practice or equivalent

(1) Basic Degree in acceptable courses from universities recognised by the Board

(2) Recognised first degree or post graduate degree in OH or equivalent

Completed the Specialist Diploma in OH (SDOH) or 150hrs of OH coursework (written examination required*)

Assessment Interview

Registration as RIH

Risk Assessment & Risk Management



Risk Assessment

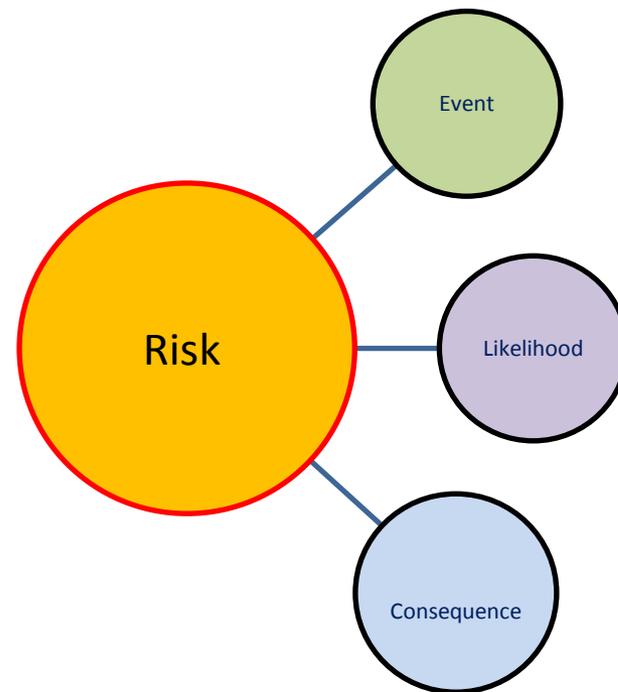
A process of identifying **hazards** & assessing the **risks** associated with the hazards

Hazard – legal definition

“Hazard” means **anything with the potential to cause bodily injury**, & includes any physical, chemical, biological, mechanical, electrical or ergonomic hazard

Risk – legal definition

“Risk” means the likelihood that a hazard will cause a specific bodily injury or harm to any person



Risk - Expression

Risk	Expression (Example)
Qualitative (descriptive)	Low (acceptable), Medium (tolerable) , High (Unacceptable)
Quantitative (incidence, rate or %)	<ul style="list-style-type: none">• Risk of NID is 25% at 90 dBA• Risk of death in a traffic accident is 1 in 10,000 per annum• Risk of death by lightning is 1 in 10 million per annum
Semi-quantitative (rating by number)	Risk Rating or ranking : 1 (very low risk), 2 (low risk), 3 (medium risk), 4 (high risk), 5 (very high risk)

Risk Matrix (Qualitative Risk)

Likelihood Severity or Consequence	Remote	Occasional	Frequent
Major	medium risk	high risk	high risk
Moderate	low risk	medium Risk	high risk
Minor	low risk	low risk	medium risk

Quantitative Fatality Risk Criteria

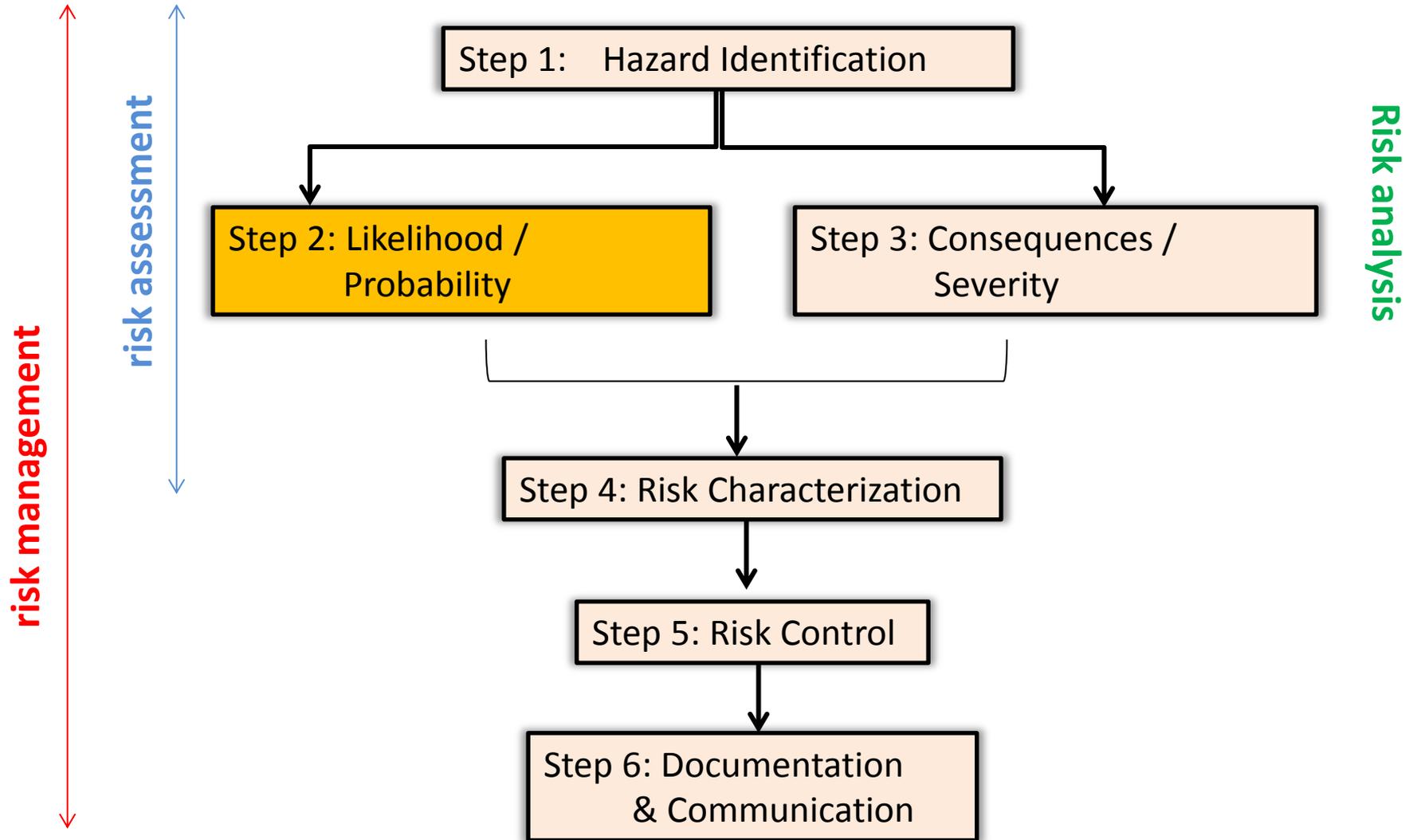
Level of Fatal Risk per Annum	Criteria
1 in 100 to 1 in 1,000	Unacceptable (intolerable)
1 in 10,000 to 1 in 100,000	Tolerable
1 in 1,000,000 to 1 in 10,000,000	Acceptable (Negligible)

Risk Management

A process of identifying hazards, assessing the risks associated with the hazards, and **preventing** or **controlling the risks**



Risk Management Process (WSH)



Step 1 – WSH Hazard Identification

Main Hazard Groups

Hazard	Example
Physical	Noise, radiation, vibration, heat
Chemical	Toxic, flammable, corrosive, reactive chemicals
Biological	Blood-borne pathogens
Ergonomics/ physco-social	Manual handling, mental stress
Mechanical	Rotating parts, moving machinery
Electrical	High voltage / current
Others	Wet floor, unsound structure, defective tools, stored energy,....

WSH Hazard Identification

- How to Identify / Recognise Hazards

1. Process / operation / work activity
2. Walk-through inspection – task observations
3. Sense of seeing, hearing, smell, feeling,...
4. Safety data sheet / technical specifications
5. Discussion / brainstorm / Interview of persons at work
6. Specialist hazard identification techniques e.g. checklist, HAZOP
7. Publications (legislations, code of practice, texts, reports,...),
8. Knowledge and experience

Events - Typical Accidents, Injuries & ill Health Caused by Hazards

- Fall from height
- Struck by moving object / Hit by falling objects
- Crushed by objects / buried under collapsed earth
- Collapse of structure
- Burned by hot or corrosive substances
- Electrocution / drowning / asphyxiation
- Burned by fire and explosion
- Slips / trips / falls
- Noise induced deafness
- Intoxication / poisoning
- Musculoskeletal disorders /
- Radiation sickness
- Heat disorders
- Skin irritation / dermatitis
- Other occupational diseases

Step 2 – Likelihood of Occurrence Ranking

3 categories & description

Likelihood	Description
Remote	Not likely to occur
Occasional	Possible or known to occur
Frequent	Common or repeating occurrence

Likelihood of Occurrence Ranking

5 categories & description

Likelihood	Description
Rare	Not expected to occur but still possible
Remote	Not likely to occur under normal circumstances
Occasional	Possible or known to occur
Frequent	Common occurrence
Almost Certain	Continual or repeating experience

Likelihood – Assessment & Factors

Assessment based on:

- Consideration of the control measures in place
- Accident / incident statistics or records
- Published data (relevant industry & national data)
- Industry practice / experience

Factors affecting likelihood:

- Design / safety features
- Degree & duration of exposure
- Condition of equipment
- Competence of workers
- Safe work procedures
- Environmental conditions
- Human factors

Step 3 – Severity / Consequences ranking

3 categories & description

Severity	Description
Minor	No injury, injury or ill-health requiring first aid treatment only (includes minor cuts and bruises, irritation, ill-health with temporary discomfort)
Moderate	Injury requiring medical treatment or ill-health leading to disability (includes lacerations, burns, sprains, minor fractures, dermatitis, deafness, work-related upper limb disorders)
Major	Fatal, serious injury or life-threatening occupational disease (includes amputations, major fractures, multiple injuries, occupational cancer, acute poisoning and fatal diseases)

Severity / Consequences ranking

5 categories & description

Severity	Description
Negligible	Negligible injury
Minor	Injury or ill-health requiring first-aid only (includes minor cuts & bruises, irritation, ill-health with temporary discomfort)
Moderate	Injury or ill-health requiring medical treatment (includes lacerations, burns, sprains, minor fractures, dermatitis & work-related upper limb disorders)
Major	Serious injuries or life-threatening occupational diseases (includes amputations, major fractures, multiple injuries, occ. Cancers, acute poisoning, disabilities & deafness)
Catastrophic	Death, fatal diseases or multiple major injuries

Severity – Assessment & Factors

Assessment of severity should be based on:

“the worst thing that could happen because of the hazard i.e. **no consideration of any control measures in place**”

Factors affecting severity:

- Extent of the hazard e.g. kinetic and potential energy, concentration or degree of exposure
- Number of persons involved including persons indirectly associated with the work & public
- Individuals at risk due to susceptibility or vulnerability

Step 4 - Risk Characterisation or Risk Evaluation

3X3 matrix

Likelihood Severity or Consequence	Remote	Occasional	Frequent
Major	medium risk	high risk	high risk
Moderate	low risk	medium Risk	high risk
Minor	low risk	low risk	medium risk

Risk Characterisation or Evaluation

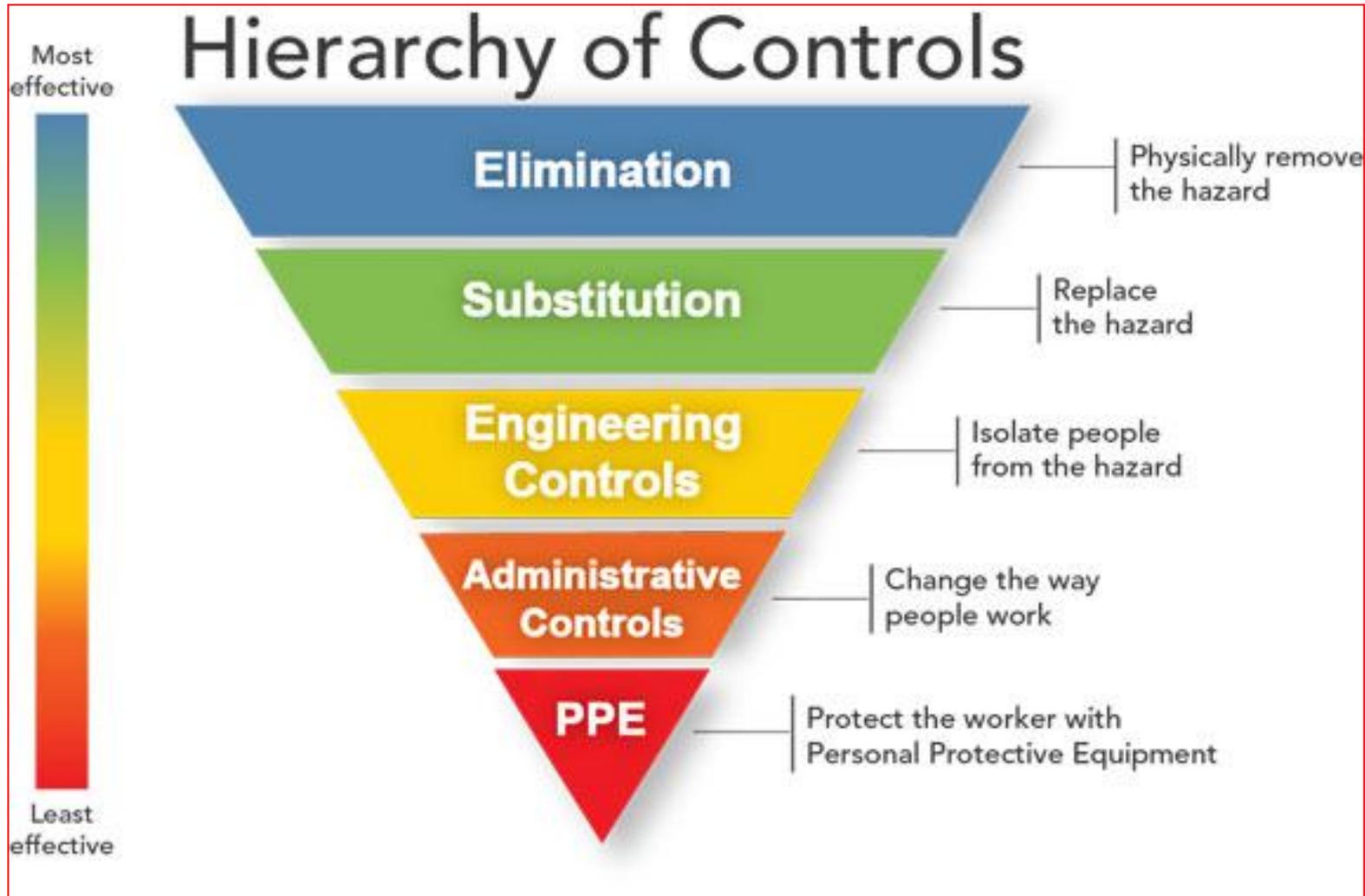
5X5 Matrix

Likelihood Severity	Rare	Remote	Occasional	Frequent	Almost Certain
Catastrophic	Medium	Medium	High	High	High
Major	Medium	Medium	Medium	High	High
Moderate	Low	Medium	Medium	Medium	High
Minor	Low	Medium	Medium	Medium	Medium
Negligible	Low	Low	Low	Medium	Medium

Acceptability of Risk & Recommended Actions

Risk level	Risk Acceptability	Recommended actions
Low Risk	Acceptable	No additional risk control measures may be needed. However, frequent review may be needed to ensure that the risk does not increase over time.
Medium Risk	Tolerable	A careful evaluation of the hazards should be carried out to ensure that the risk level is reduced to as low as is practicable within a defined time period. Interim risk control measures, such as administrative controls, may be implemented. Management attention is required.
High Risk	Not acceptable	High Risk level must be reduced to at least Medium Risk before work commences. There should not be any interim risk control measures & risk control measures should not be overly dependent on PPE. If need be, the hazard should be eliminated before work commences. Immediate management intervention is required before work commences.

Step 5 - Risk Control / Risk Treatment

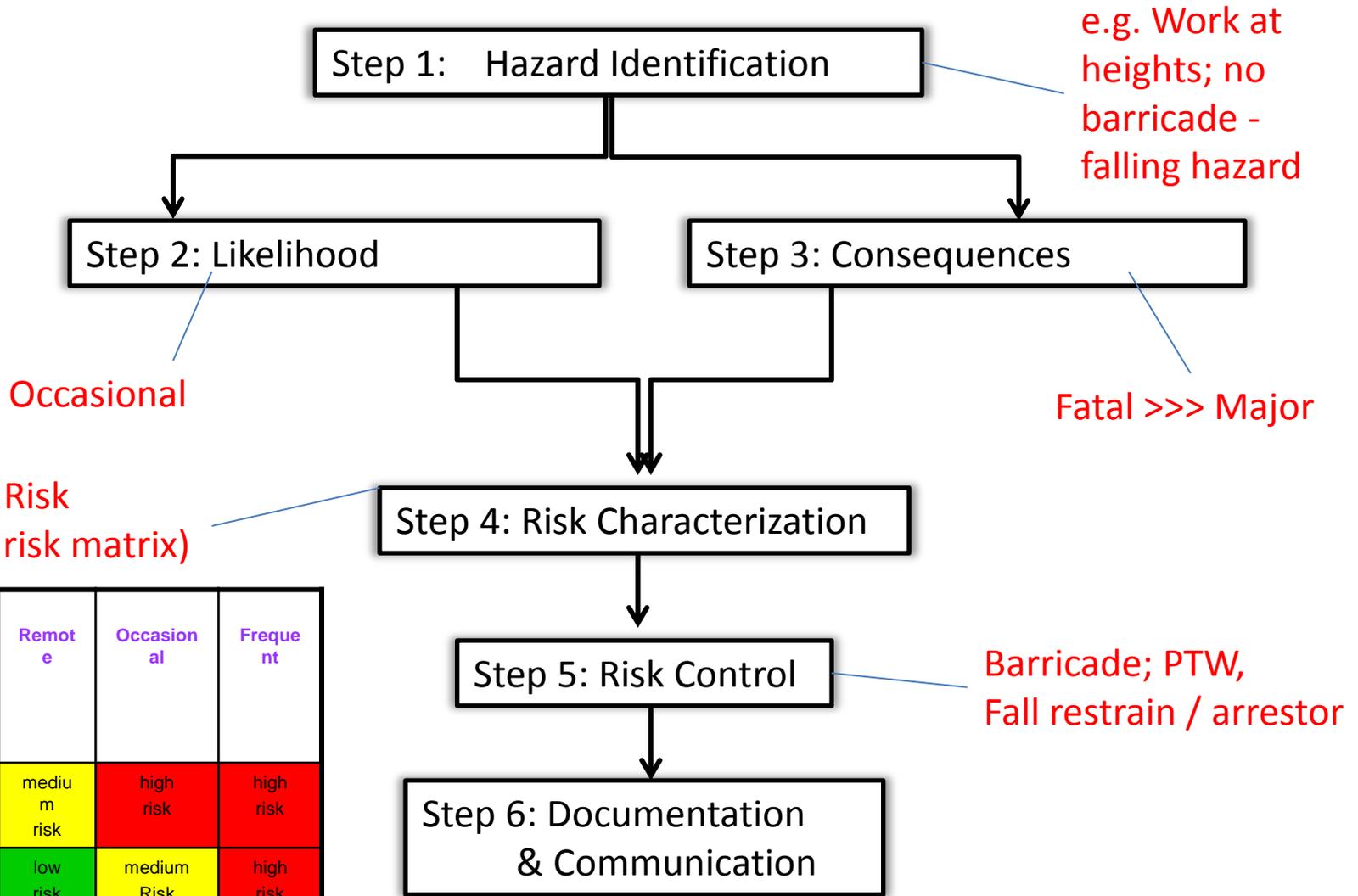


Engineering Controls

Physical means to limit the hazard e.g. :

- Isolation
- Enclosure
- Containment
- Modification / structural changes
- Physical barrier / guards
- Safety interlocks / sensors
- Exhaust ventilation

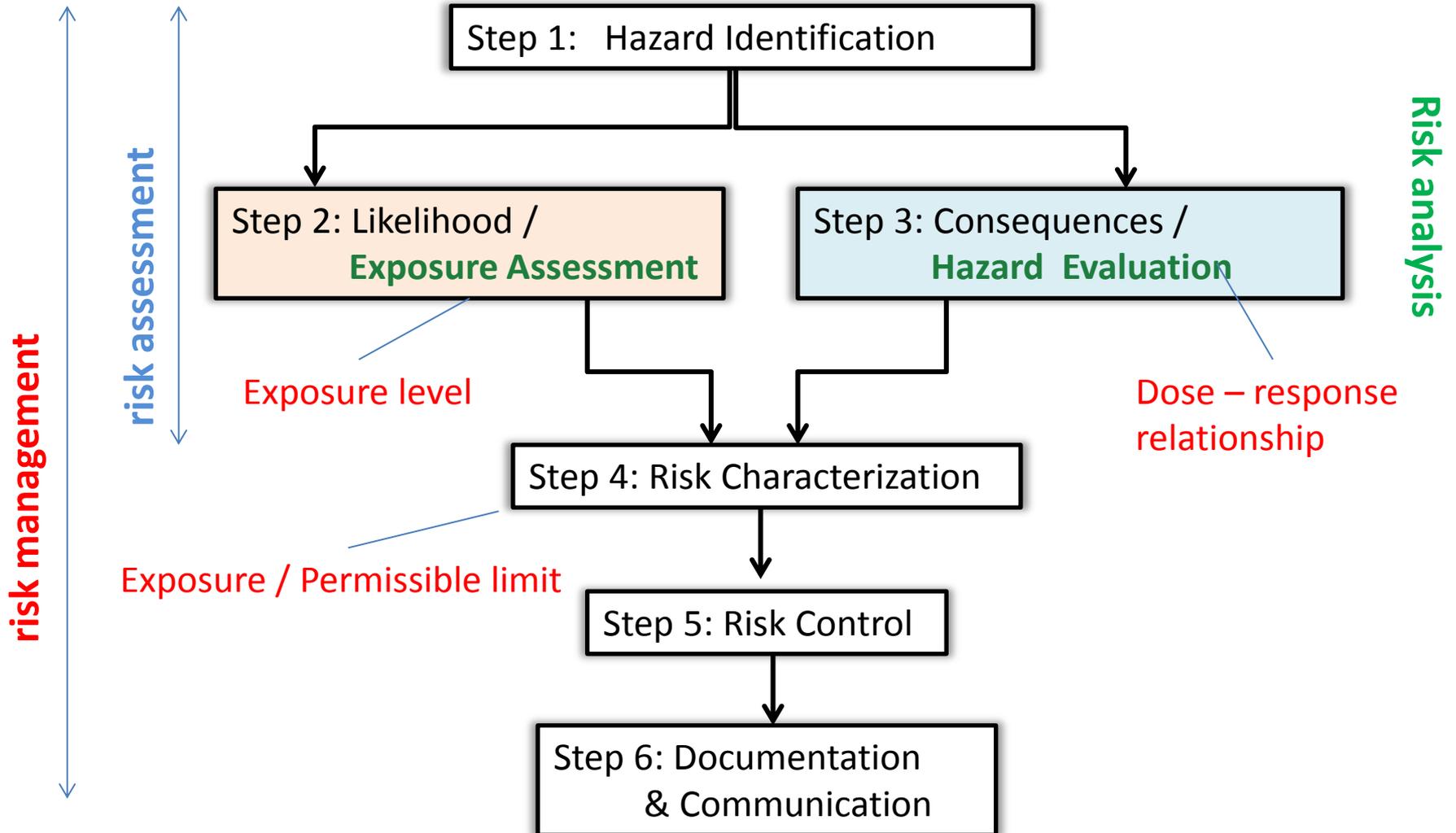
RM for Safety-Related Hazards - Example



Likelihood	Remote	Occasional	Frequent
Severity or Consequence			
Major	medium risk	high risk	high risk
Moderate	low risk	medium Risk	high risk
Minor	low risk	low risk	medium risk

RM for Health Hazards

RM Process for Health Hazards



Step 1

Health Hazards Identification

Physical

Form of energy
e.g. noise,
vibration,
heat &
radiation

Chemical

Hazardous
substances

Biological

Living
organisms or
non-living
substances

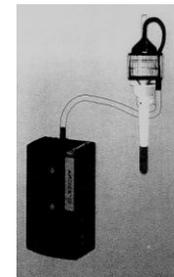
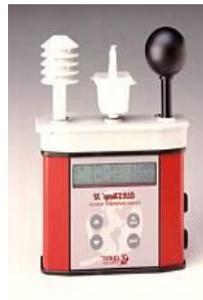
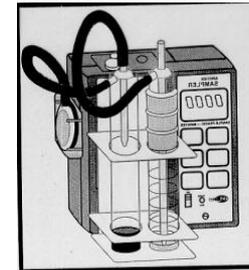
Ergonomics

Physical
over-burden

Step 2 - Exposure Assessment (Likelihood Determination)

1. What are the pathways / routes of exposure?
2. Consider the existing control measures
3. Who are or may be exposed and under what circumstances?
4. What is the frequency and duration of exposure?
5. **What is the exposure level?**

IH Equipment / Instruments



Health Hazards – Exposure Assessment

Health Hazard	Exposure parameter
Chemicals (airborne substances)	Volume concentration (ppm) Mass concentration (mg/m ³)
Noise	Sound pressure level (dBA)
Lighting	Illumination level (lux)
Radiation	Rontgen equivalent man (rem or mSv)
Heat	Temperature / humidity / air speed
Ergonomic factor	Force / posture / frequency

Step 3 - Hazard Evaluation (Consequence Determination)

1. What is the dose – response relationship?
2. What is the consequence or severity of exposure?
3. What will be the ill effects – acute & chronic?

Health Hazard Evaluation / Characterization

Fatal		Non-fatal
Acute	Chronic	Acute and chronic
Heat – heat stroke	Asbestos - asbestosis, cancer mesothelioma	Noise – NID Heat – heat exhaustion / cramp /rash
Chemicals – poisoning, fire & explosion	Chemicals – chronic diseases e.g. silicosis. cancers	Chemical – dermatitis, and others
Confined spaces – asphyxiation, poisoning	Bio-organisms – infectious diseases	Compressed air – bends, barotrauma
Radiation – radiation sickness	Radiation – somatic & genetic, cancers	Ergonomics – Musculoskeletal disorders
Lighting – fatal accident		IAQ – sick building syndrome, building-related illness

Step 4 – Risk Evaluation (Risk Characterization)

1. What are the exposure standards?
2. Compare the exposure with the standards
3. Determine the risk level
4. Is the risk acceptable, tolerable or unacceptable?

Occupational Exposure Standards for Health Hazards

Health Hazard	Occupational Exposure Standard
Chemicals (airborne substances)	PEL (Long Term); PEL (Short Term) OEL; TLV
Noise	Leq 85 dBA
Lighting	ISO 8995; CIE ; SS 531 CP for lighting of workplace
Radiation	50 mSv/yr (5 rem/yr)
Heat	WBGT, HSI
Ergonomic factor	Lifting Index
Biological agents & nano-materials	Limited standards

Risk Level – based on Exposure Assessment

Typical Example

Risk Level	Exposure Level / Exposure Standard
1 (low)	< 0.1 (10%)
2 (medium)	0.1 to 1.0 (10% to 100%)
3 (high)	> 1.0 (100%)

Risk Level – based on Likelihood & Severity

Likelihood Severity or Consequence	Remote	Occasional	Frequent
Major	medium risk	high risk	high risk
Moderate	low risk	medium Risk	high risk
Minor	low risk	low risk	medium risk

Step 5 - Risk Control or Treatment (Hazard Control)

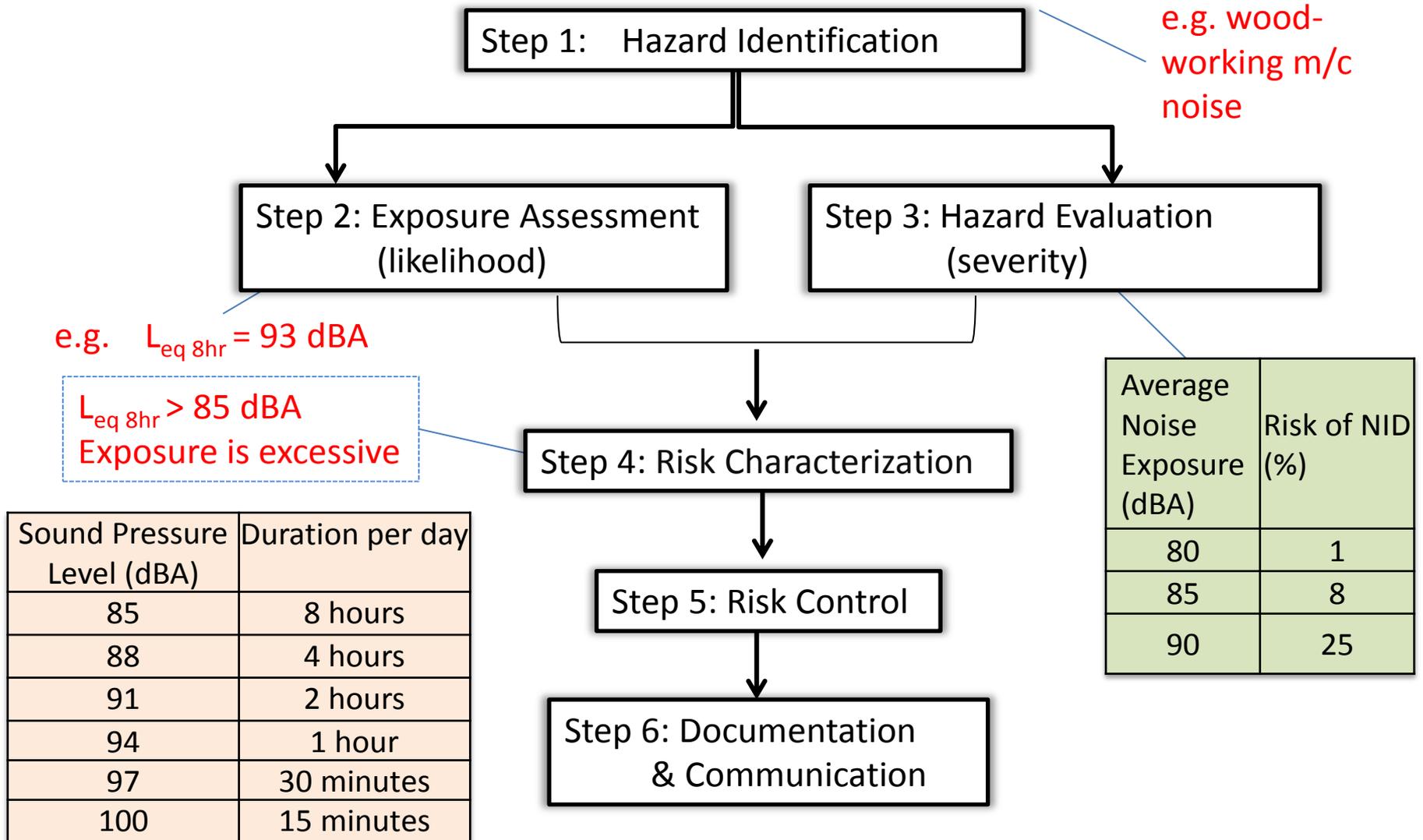
1. What control measures are required?
2. What can be done at the source, along the path, at the receiver?
3. Follow the hierarchy of control
4. Are the measures feasible?

Noise Risk Assessment

Main Risk Factors

1. Exposure Level
2. Exposure Duration / Frequency
3. Noise frequency

Risk Assessment for Noise Exposure



Risk Assessment for Noise Exposure

Full-shift Noise Monitoring

Step 2 - Exposure Assessment

Determine the % dose or TWA or $L_{Aeq,8hr}$ using a noise dosimeter

Example:

Wood Working Operator

Dose 625 %

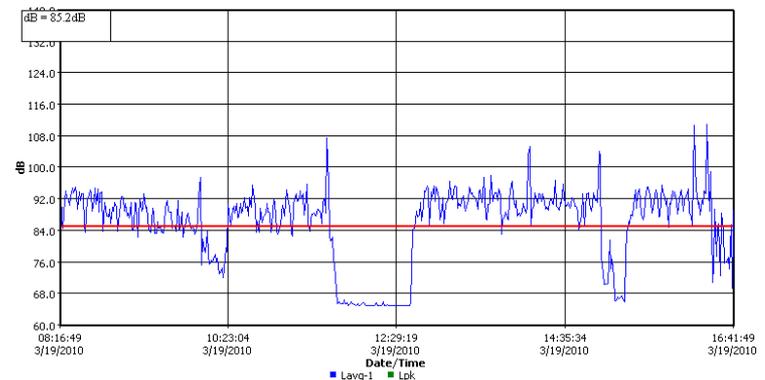
L_{pk} -- 149.9 dB

Peak time -- 3/19/2010 4:12:27 PM

L_{avg} 92.7 dB

TWA 92.9 dB \approx 93 dBA

Running time 08:25:34



Risk Assessment for Noise Exposure
Full-shift Noise Monitoring
Step 4 - Risk Characterization (Risk Rating)

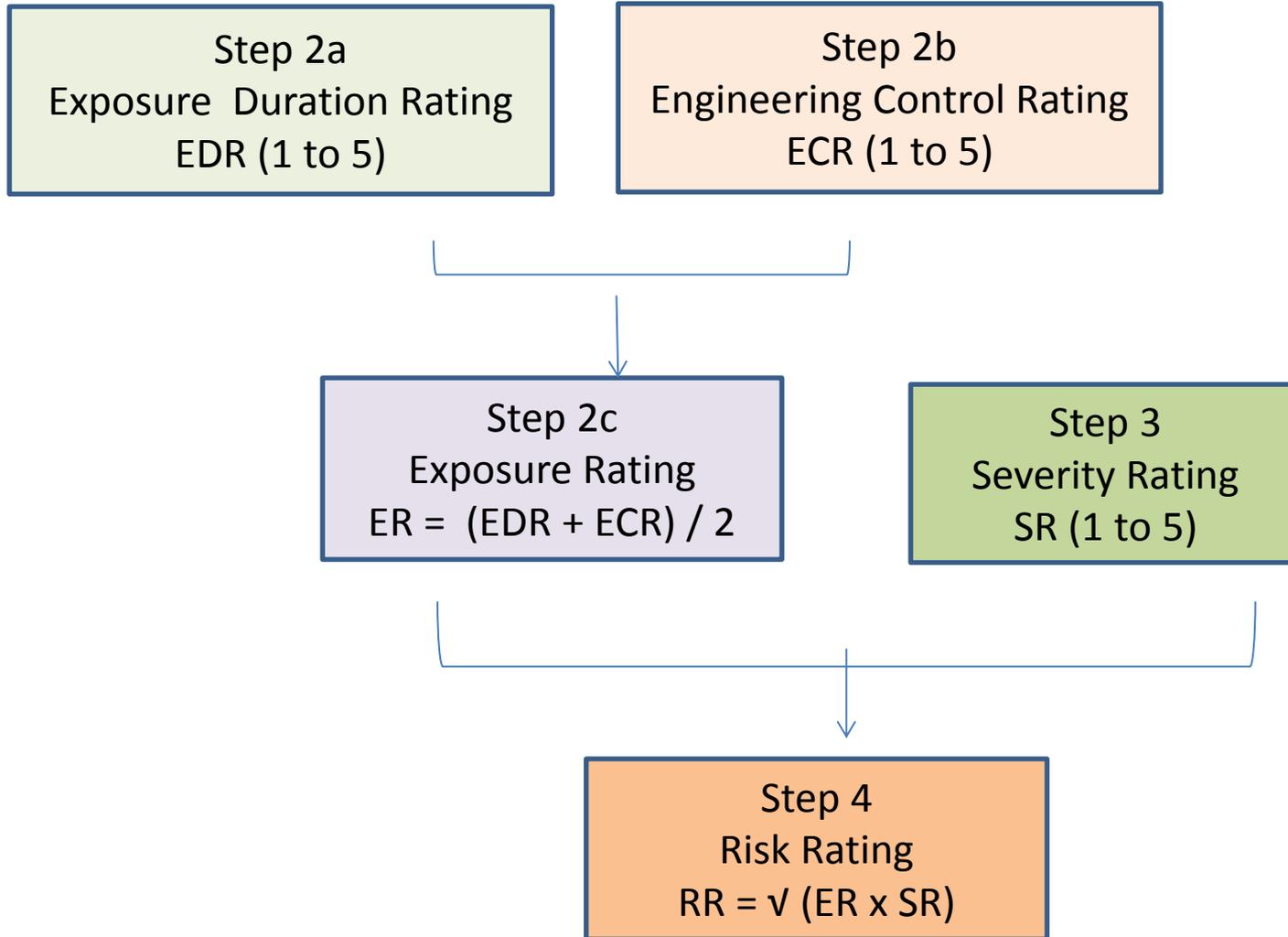
Determine the risk rating based on the $L_{Aeq,8hr}$ or %dose

Noise Risk Rating	$L_{Aeq,8h}$	Noise Dose	Risk Ranking
1	≤ 80 dBA	$< 30\%$	Very Low Risk
2	80 - < 85 dBA	$< 100\%$	Low Risk
3	85 - < 90 dBA	$< 300\%$	Medium Risk
4	90 - < 100 dBA	$< 3,000\%$	High Risk—
5	≥ 100 dBA	$> 3,000\%$	Very High Risk

Risk Assessment for Noise Exposure

Short Time Noise Measurement

Steps 2 to 4 - Risk Assessment for Noise Hazard



Short Time Noise Measurement

Step 2a - Exposure Duration Rating (EDR)

Exposure Duration Rating	Exposure Duration
1	< 2 hours
2	> 2 - 4 hours
3	> 4 - 6 hours
4	> 6 - 8 hours
5	> 8 hours

e.g. Exposure Duration = 3 hrs
EDR = 2

Short Time Noise Measurement

Step 2b - Engineering Control Rating (ECR)

Engineering Control Rating	Criteria
1	Full enclosure insulated with effective noise absorption materials, full partition wall. Noise reduction > 20 dBA.
2	Partial enclosure, noise barrier. Noise reduction 10 to 20 dBA
3	Silencer, vibration isolation, surface damping. Noise reduction < 10 dBA.
4	Room absorption. Noise reduction <5 dBA.
5	No noise reduction

e.g. No Control Measure
ECR = 5

Short Time Noise Measurement

Step 2c - Exposure Rating

$$ER = (EDR + ECR) / 2$$

Example

- $EDR = 2$
- $ECR = 5$
- $ER = (2 + 5) / 2$
 $= 3.5$

Short Time Noise Measurement

Step 3 - Severity Rating (SR)

Severity Rating	Noise Level
1	< 80 dBA
2	80 - <85 dBA
3	85 - <90 dBA
4	90 - <100 dBA
5	\geq 100 dBA

e.g. Noise level = 93 dBA

SR = 4

Short Time Noise Measurement

Step 4 - Risk Rating (RR)

Risk Rating = $\sqrt{\text{Exposure Rating} \times \text{Severity Rating}}$

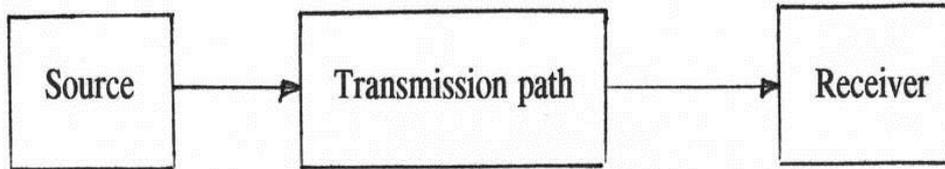
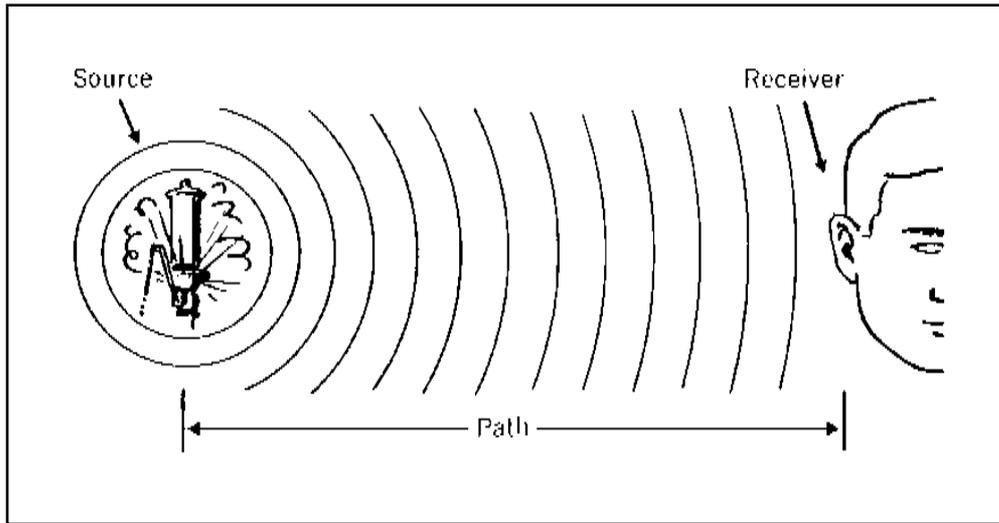
Risk Rating	Risk Ranking
1	Very Low Risk
2	Low Risk
3	Medium Risk
4	High Risk
5	Very High Risk

Example: ER = 3.5, SR = 4

RR = $\sqrt{3.5 \times 4}$

= 3.7

Noise Control



Elimination

- Eliminate noisy processes

Substitution

- Replace noisy machines/equipment

Engineering control

- Enclosure, barriers, silencer, isolators, damping

Administrative control

- Rotate employees

Hearing protection

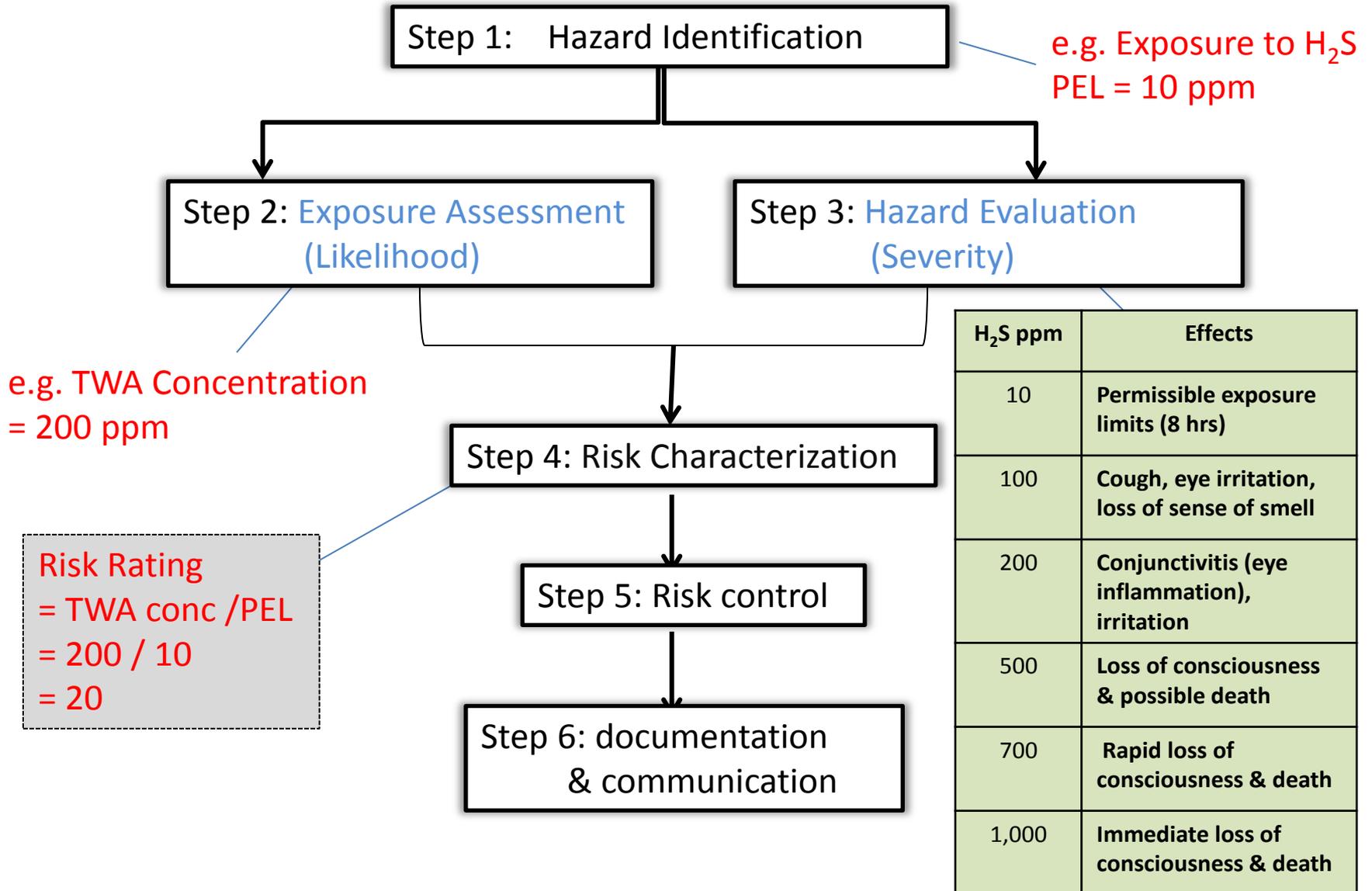
- Interim solution or last line of defence

Chemicals Risk Assessment

Main Risk factors

- Exposure concentration
- Exposure duration & frequency
- Quantity of usage
- Properties of the chemical e.g. VP

Risk Assessment for Chemical Exposure with Exposure Measurement



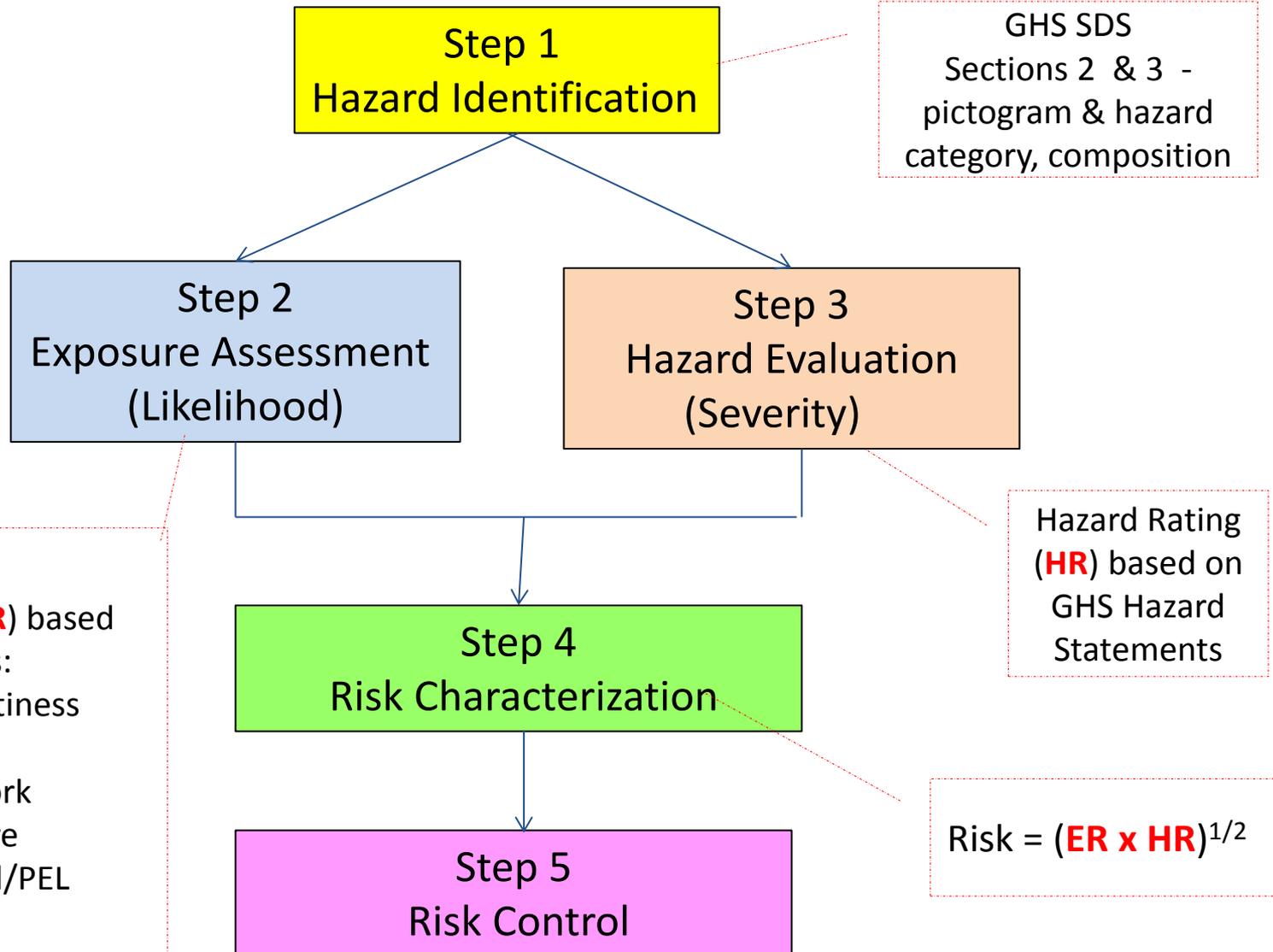
Risk Assessment for Chemical Hazard with Exposure Measurement Step 4 - Risk Rating

Compare the TWA exposure level to the PEL

Exposure level / PEL	Risk Rating
< 0.1	1
0.1 to <0.5	2
0.5 to <1.0	3
1.0 to <2.0	4
≥ 2.0	5

PEL - permissible exposure levels

Risk Assessment for Chemicals without Exposure Measurement



Step 1 - Hazard Identification

to determine whether the chemical is hazardous

SDS	Information Item
Section 2	Hazard identification (pictogram + signal word)
Section 3	Composition information on ingredients
Section 9	Physical, chemical properties
Section 10	Stability and reactivity
Section 11	Toxicological information
Section 12	Ecological information

Step 2 – Exposure Evaluation

to determine the degree of exposure

Exposure Rating (**ER**) is based on 5 Exposure Factors:

1. Volatility (VP) or dustiness (particle size)
2. Amount used
3. Duration of exposure
4. Control measures
5. Odor Threshold /Permissible Exposure Limit

Each factor is quantified by an Exposure Index (EI)

$$ER = (EI_1 \times EI_2 \times \dots \times EI_n)^{1/n}$$

Step 2

Exposure Assessment (Likelihood Determination)

$$ER = (EI_1 \times EI_2 \times \dots \times EI_n)^{1/n}$$

Exp. Index Exp. Factor	1	2	3	4	5
1. VP or D _a	< 0.1 mm Hg	0.1 – 1 mmHg	>1 – 10 mmHg	>10 – 100 mm Hg	100 mmHg
	Coarse or wet	Coarse or dry	> 100 um	10 – 100 um	< 10 um
2. Amt used / wk	< 1 kg or l	1 - < 10 kg or l	10 - < 100 kg or l	100 – 1000 kg or l	> 1000 kg or l
3. Work Duration/wk	< 8 hr	8 – 16 hr	16 – 24 hr	24 – 32 hr	32 – 40 hr
4. Control	Adequate + maintenance	Adequate + irregular maintenance	Adequate + no maintenance	Inadequate; dusty	No control; very dusty
5. OT / PEL	< 0.1	0.1 – 0.5	> 0.5 - 1	>1 - 2	> 2

Step 3 - Hazard Evaluation (Severity Determination)

Hazard Rating (**HR**) is based on GHS Hazard Statements which can be found in Section 2 of the SDS

Hazard Rating (HR)	GHS Hazard Statement (from SDS Section 2)
1	H 303, 304, 305, 313, 315, 316, 318, 319, 320, 333, 336.
2	H 302, 312, 332, 371
3	H 301, 311, 314, 317, 318, 331, 335, 370, 373
4	H 300, 310, 330, 351, 360, 361, 362, 372
5	H 334, 340, 341, 350

Health Hazard Statements

Example

Code	Statement
H300	Fatal if swallowed
H301	Toxic if swallowed
H302	Harmful if swallowed
H303	May be harmful if swallowed
H310	Fatal if contact with skin
H330	Fatal if inhaled
H350	May cause cancer

Step 4 - Risk Characterisation

$$\text{Risk Rating} = \sqrt{\text{HR} \times \text{ER}}$$

Hazard Rating (HR) \ Exposure Rating (ER)	1	2	3	4	5
1	1	1.4	1.7	2	2.2
2	1.4	2	2.4	2.8	3.2
3	1.7	2.4	3	3.5	3.9
4	2	2.8	3.5	4	4.5
5	2.2	3.2	3.9	4.5	5

-  negligible
-  low
-  medium
-  high
-  very high

Risk Rating

Risk Rating	Recommended Action
1 (negligible)	Review assessment every 5 yrs
2 (low)	Maintain control ; Determine if air monitoring is required Review assessment every 4 yrs
3 (medium)	Implement & maintain control Determine if air monitoring is needed Determine if employee training is needed Review assessment every three years
4 (high)	Implement effective engineering control Conduct air monitoring /training for employees Adopt Respiratory Protection Programme Provide suitable PPE Develop and implement safe work procedures Establish first-aid and emergency procedures if necessary Reassess the risk after all the above have been done
5 (very high)	As per Risk Level 4

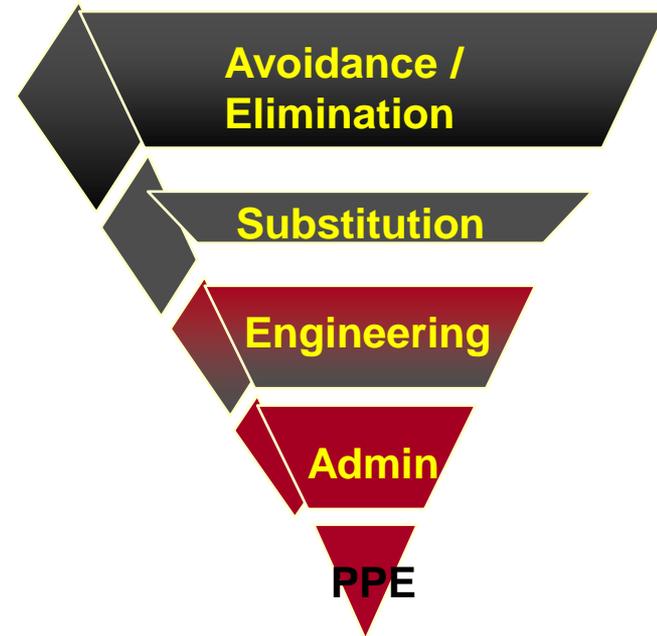
Risk Control – Principles & Hierarchy



Elimination
Substitution
Containment
Local exhaust
ventilation

Dilution
ventilation
Segregation
Monitoring &
warning

Control room
Administrative
Medical
surveillance
PPE



**GHS SDS (Section 8 - Exposure Controls, Personal Protection)
provides much of the information on exposure control**

Risk Assessment - Example

Mercuric Acetate (white crystalline powder form) is used in a laboratory as a catalyst in organic (assuming non-hazardous) synthesis. The work is carried out in a fume hood.

1. Coarse crystal
2. Amount of usage: 20 gm
3. Duration of exposure: 0.5 hr - once a month
4. Control measure: hand gloves + fume cupboard
5. Ordor Threshold / PEL : not available / established

Mercuric Acetate – GHS SDS

SDS section 2 (Hazards Identification)

- Acute Toxicity (Oral) Category 2,
- Acute Toxicity (Dermal) Category 1
- Acute Toxicity (Inhalation) Category 2
- STOT - RE Category 2, Acute Aquatic Hazard
- Category 1, Chronic Aquatic Hazard Category 1
- GHS label elements



- SIGNAL WORD : DANGER

Hazard Statements

- **H300** Fatal if swallowed
- **H310** Fatal in contact with skin
- **H330** Fatal if inhaled
- **H373** May cause damage to organs through prolonged or repeated exposure
- **H400** Very toxic to aquatic life
- **H410** Very toxic to aquatic life with long lasting effects

Mercuric Acetate – Risk Assessment

Step 1 – Hazard Identification

From the pictogram and hazard category, mercuric acetate is a hazardous substance

Step 2 – Hazard Rating (HR)

Based on Hazard Statements : H 300, H 310, H 330

The Hazard Rating (HR) is 4

Step 3 - Exposure Rating (ER)

Exposure Factors & Exposure Index (EI):

1. Dustiness - coarse crystal : EI = 1
2. Amount used : EI = 1
3. Work duration per week : EI = 1
4. Hazard control measure: adequate control with irregular maintenance : EI = 2
5. Odor threshold / PEL : Not available

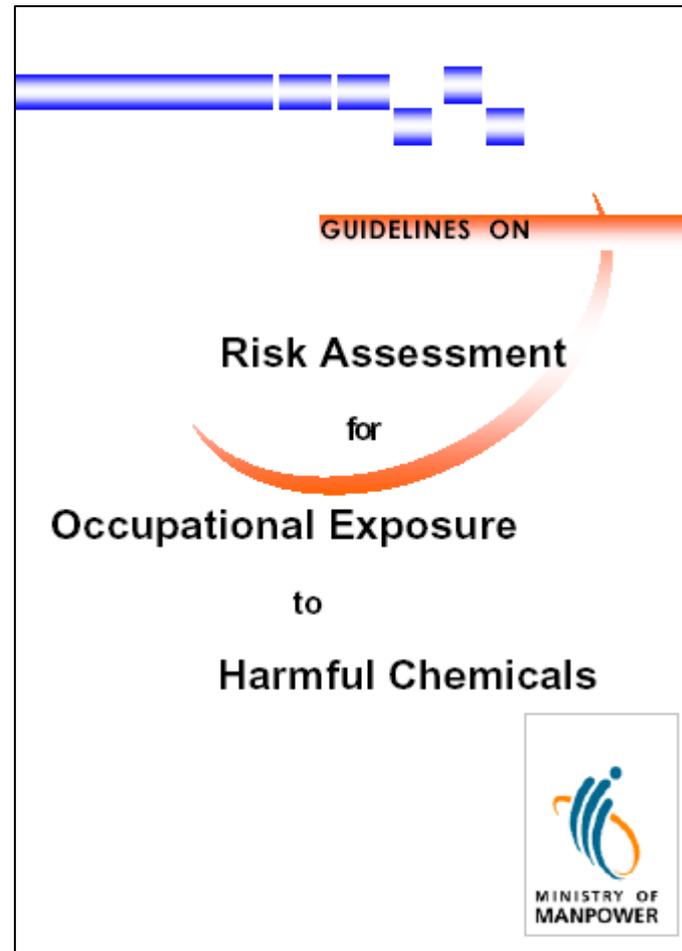
Exposure Rating (ER) = $(1 \times 1 \times 1 \times 2)^{1/4} = 1.20$

Step 4 - Risk Rating (RR)

$RR = \sqrt{HR \times ER} = \sqrt{4 \times 1.20} = 2.2$

The risk is low

MOM Semi-Quantitative Risk Assessment (SQRA) for Chemical Exposure



WHO – RA for Chemical Hazards

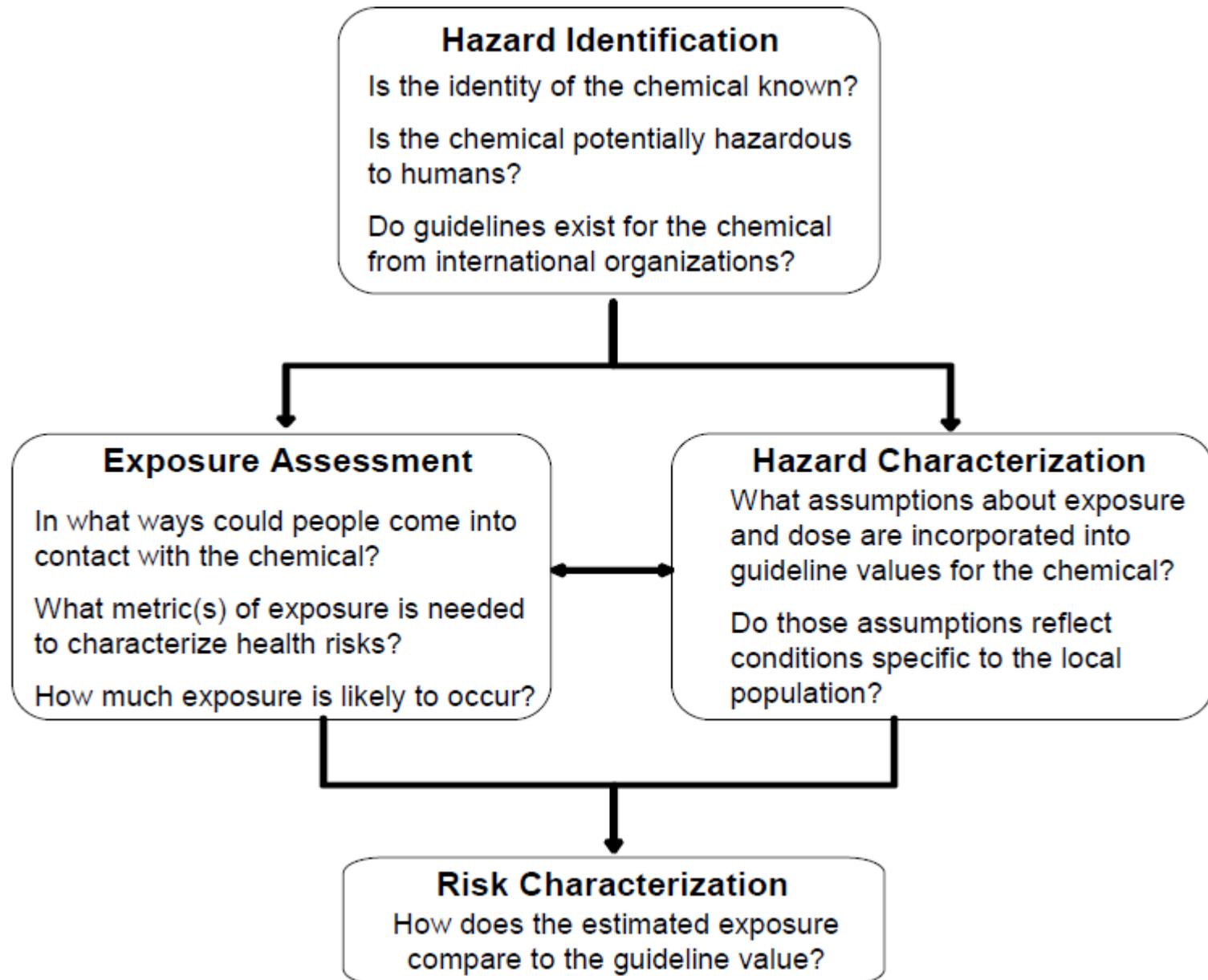
WHO Human Health Risk Assessment Toolkit: Chemical Hazards

Draft

January 2010



WHO Risk Assessment for Chemical Hazards Process



Other Risk Assessment Methods for Chemical Exposure

Country / Organisation	Control banding model
UK	HSE COSHH Essentials
ILO	International Chemical Control Toolkit
Germany	Chemical Management Guide
Singapore	Semi-Quantitative Risk Assessment
Netherlands	Stoffenmanager
Norway	KjemiRisk (Open to members only)
Korea	Korean Control Toolkit (Available in Korean only)
France	Risk Potential Hierarchy (Available in French only)
Belgium	Regetox and SOBANE (Available in French & Dutch only)

Ergonomics Risk Assessment

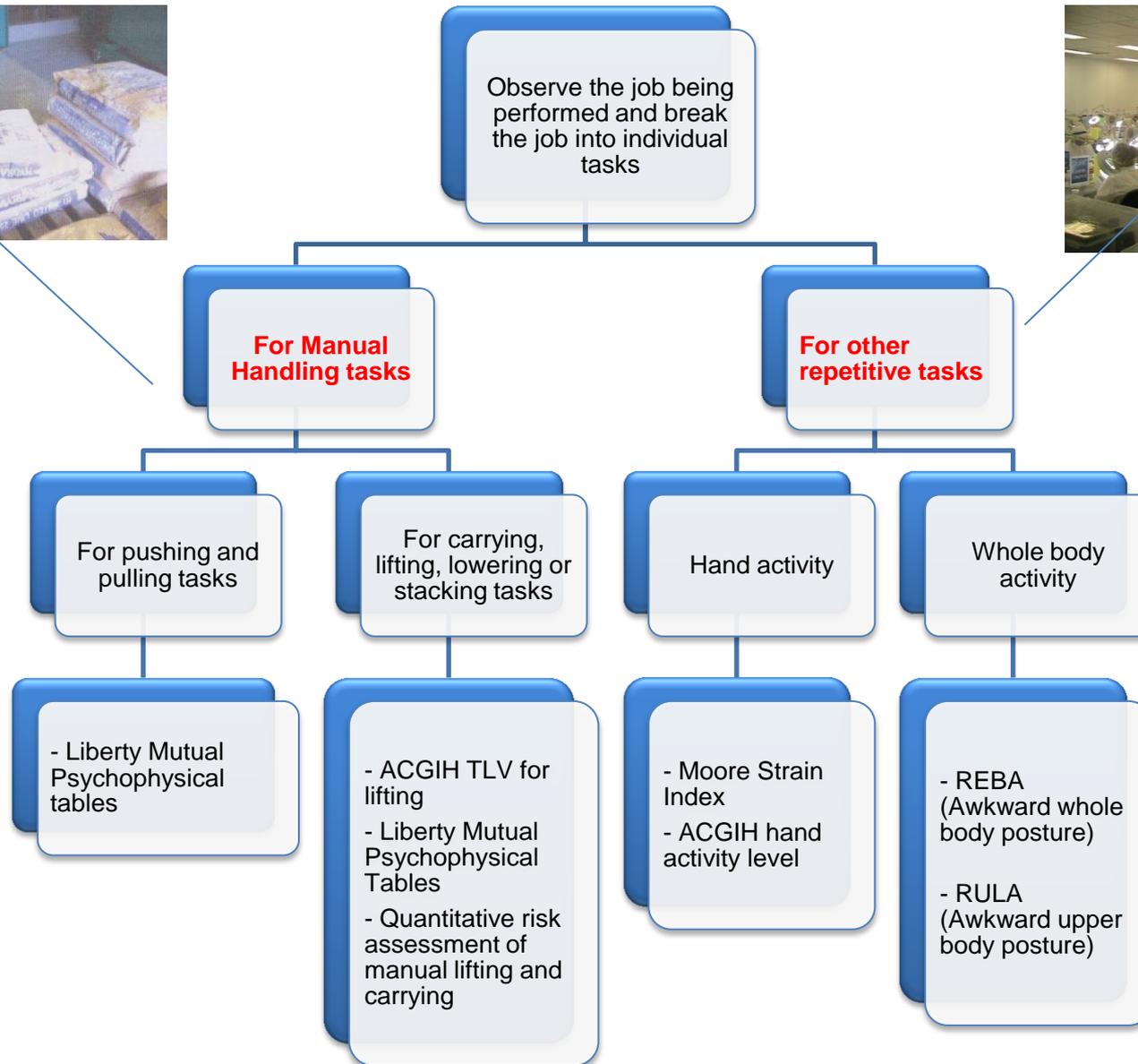
Main Risk Factors

1. Forces
2. Posture
3. Frequency of exertion

Ergonomics RA Toolkits

<p>Manual Material Handling</p> 	Lifting	NIOSH RWL
		ACGIH Lifting Liberty Mutual Table
	Carrying	Liberty Mutual Table
	Pushing	Liberty Mutual Table
	Pushing	Liberty Mutual Table
<p>Other Repetitive Work</p> 	Hands	Strain Index (awkward posture)
		Hand Activity Level (no awkward posture)
	Whole Body	RULA (semi-quantitative)
		REBA (semi-quantitative)
	VDT work	OSHA VDT Checklist

Ergonomics RA Tools

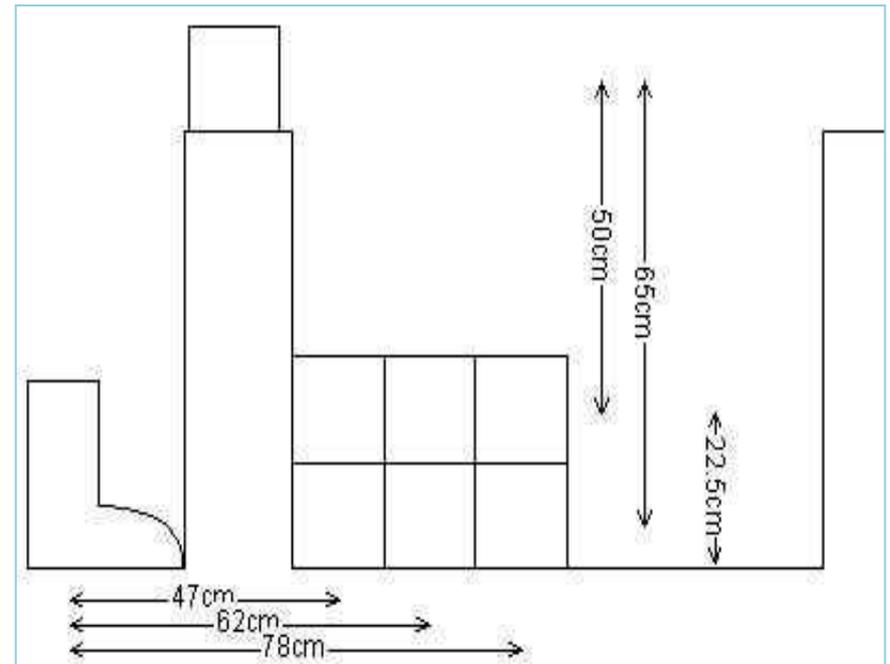


Ergonomics - Risk Control

Engineering Measures	Job / process redesign
	Workstation design
	Tool design
Work Practices	Work postures
	Safe work procedures
Administrative Control	Limit the manual lifting loads
	Team work when necessary
	Job & task rotation
	Frequent rest breaks when needed

Case Study – Lifting of Concrete Blocks

- Daily lifting of 100 concrete blocks (8 kg each)



NIOSH Revised Lifting Guide 1991

Recommended Weight Limit

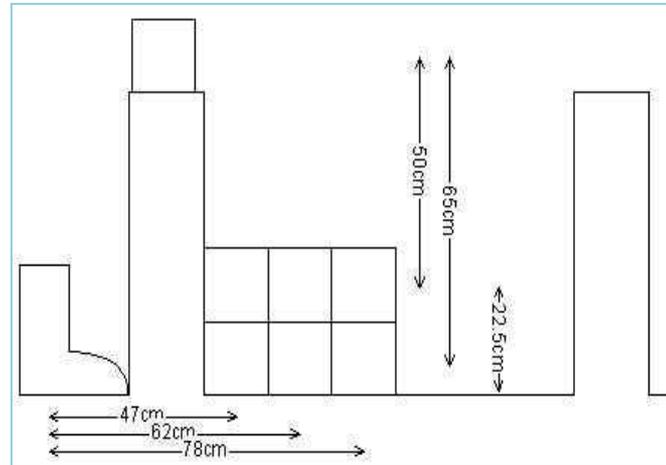
$$\text{RWL (kg)} = 25 \text{ kg} \times \text{HM} \times \text{VM} \times \text{DM} \times \text{FM} \times \text{CM} \times \text{AM}$$

- $\text{HM} = 25 / h \text{ cm}$ Horizontal multiplier
- $\text{VM} = 1 - 0.003 [(75 - v \text{ cm})]$ Vertical multiplier
- $\text{DM} = 0.82 + 4.5 / d \text{ cm}$ Distance multiplier
- FM: from table Frequency multiplier
- CM: 1.0(gd), 0.95(fair), 0.9(poor) Coupling multiplier
- $\text{AM} = 1 - 0.0032 \times A$ Asymmetric multiplier

Lifting index:

$$\text{LI} = \text{Load (kg)} / \text{RWL (kg)}$$

Case Study – Lifting of Concrete Blocks



Recommended Weight Limit (RWL)

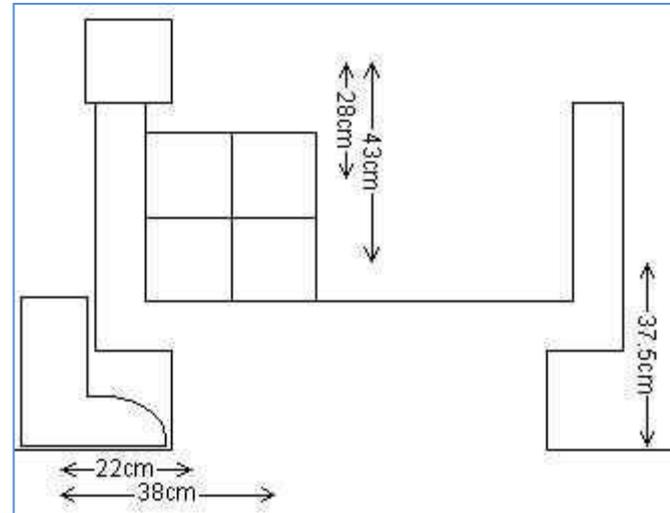
$$\begin{aligned} &= (25\text{kg}) * (0.40) * (0.84) * (0.90) * (0.85) * (0.95) * (1.00) \\ &= 6.10 \text{ kg} \end{aligned}$$

Lifting Index (LI)

$$\begin{aligned} &= 8 / 6.10 \\ &= 1.3 \end{aligned}$$

Case Study – Lifting of Concrete Blocks

Improvement: The base of the tank is raised and an inverted L-shaped recess added.



Recommended Weight Limit (RWL)

$$= (25\text{kg}) * (0.66) * (0.90) * (0.93) * (0.85) * (0.95) * (1.00)$$

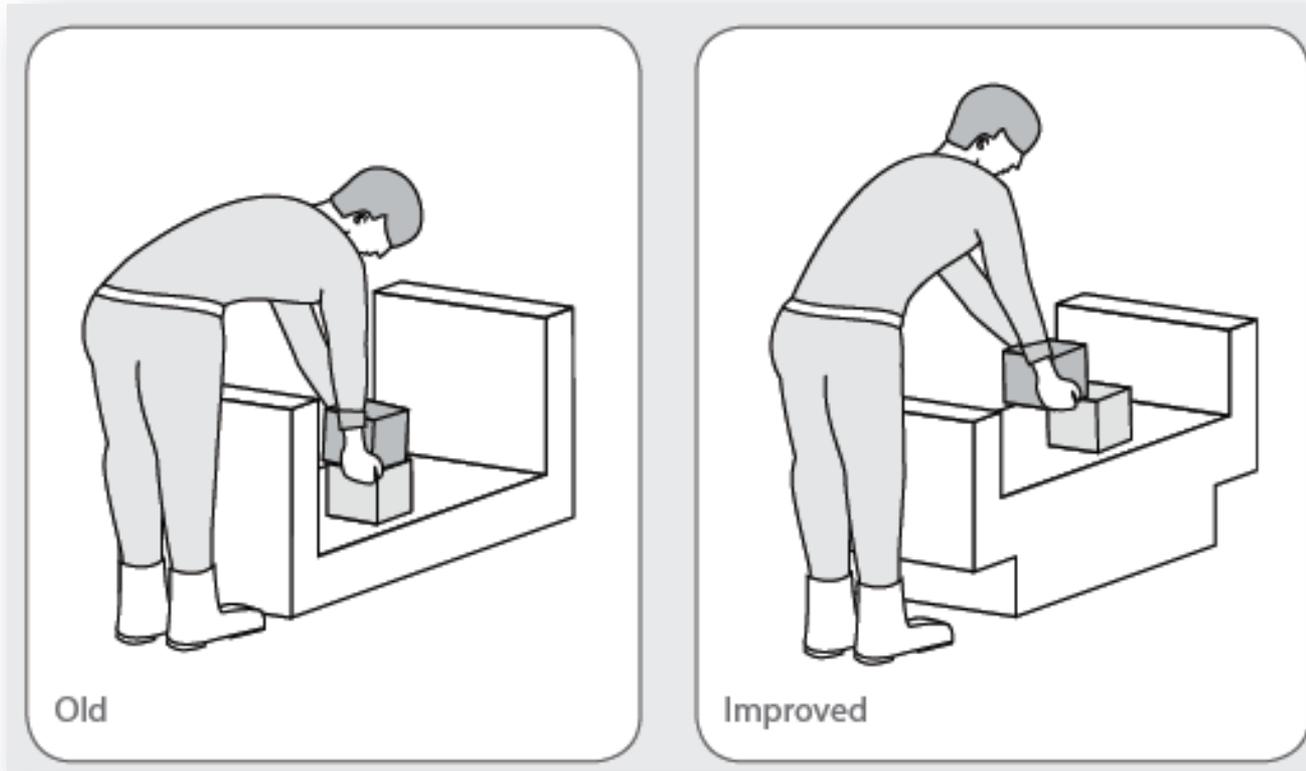
$$= 11.15 \text{ kg}$$

Lifting Index (LI)

$$8 / 11.15$$

$$= 0.72$$

Case Study – Lifting of Concrete Blocks



	Before	After
RWL	6.1 kg	11.15 kg
LI	1.3	0.72

Micro-organisms - Risk Assessment

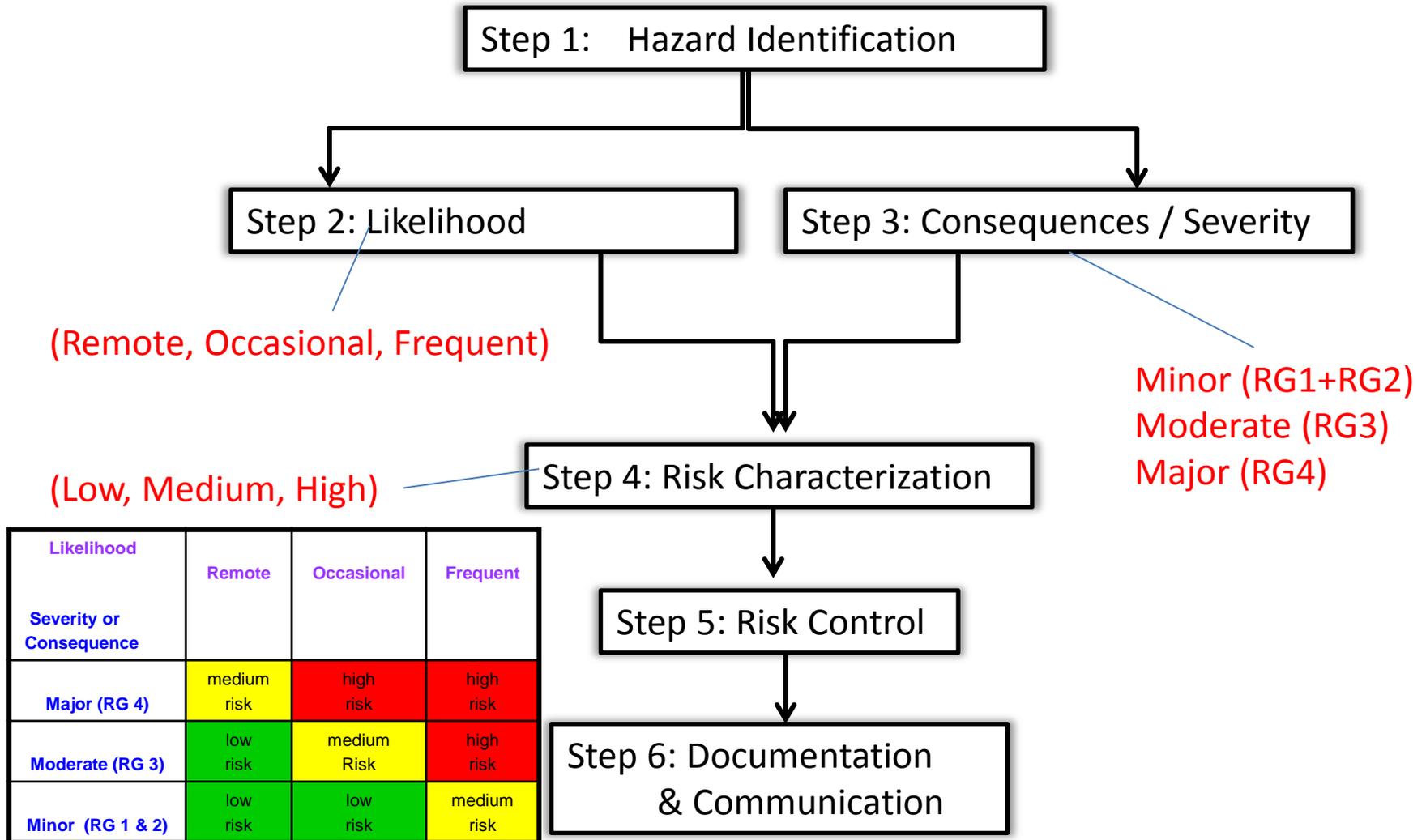
Main Risk Factors

1. Pathogenicity (degree of harm) of agent
2. Mode of transmission & host range
3. Availability of effective preventive measures
4. Availability of effective treatment

Risk Group Classification of Microorganisms

Risk Group	Criteria	Example
1	Not associated with disease No or low individual & Community risk	Bacillus subtilis, Eschericia coli-K12, eurospora crassa, saccharomyces
2	Rarely serious disease Preventive/therapeutic interventions often available Moderate individual risk Low community risk	Staphylococcus aureus, EB virus, E. Coli., adenovirus, anthrax, hepatitis, HBV
3	Serious / lethal disease Preventive/therapeutic may be available High individual risk, Low community risk	Mycobacterium TB, Brucella sp, rickettsia, VEE, West Nile Virus
4	Serious/lethal disease Preventive/therapeutic interventions not usually available High individual & community risk	Ebola, smallpox, Marburg, CCHFV

Microorganisms - Risk Assessment



Step 2 - Likelihood categories & description

Likelihood	Description
Remote	Not likely to occur
Occasional	Possible or known to occur
Frequent	Common or repeating occurrence

Step 3 - Severity of Microorganisms categories & description

Risk Group	Severity
RG 1 & RG 2	Minor
RG 3	Moderate
RG 4	Major

Step 4 - Risk Characterization

Likelihood Severity or Consequence	Remote	Occasional	Frequent
Major	medium risk	high risk	high risk
Moderate	low risk	medium Risk	high risk
Minor	low risk	low risk	medium risk

Biosafety Lab - Risk Control

Biosafety Level	Practices	Safety Equipment (primary barrier)	Facilities (secondary barrier)
BSL-1 Basic	Good microbiological technique (GMT)	Nil	Open bench top sink
BSL-2 Basic	BSL-1 plus: Limited access Biohazard warning signs sharps precautions	Class I or II BSC PPE: gloves, lab coat, respirators as needed	BSL-1 plus: Autoclave
BSL-3 Containment	BSL-2 plus: Controlled access Waste decontamination Lab clothing decontamination Baseline serum	Class I or II BSC PPE: gloves, lab coat, respirators as needed	BSL-2 plus: Physical separation from corridors Self-closing , double-door access Exhaust air not recirculated -ve airflow into lab
BSL-4 Max containment	BSL-3 plus: Clothing change before entering Shower on exit All material decontaminated on exit	Class III BSC +ve pressure suits Doubled end autoclave Filtered air	BSL-3 plus: Separate building or isolated zone Dedicated supply / exhaust vacuum & decon systems

Standard Microbiological Lab Practices for all BSLs

1. Access control
personnel, time
2. Hygiene practices
Hand washing, meal
3. Protective equipment / appliances
4. Laboratory practices
pipette, needle, glassware
5. Decontamination
disinfection, disposal of waste
6. Control of aerosols
centrifuge, blender, animal cage
7. Housekeeping
storage, cleaning, insect & rodent control
8. Emergency eyewash /shower

Heat Stress Risk Assessment

Main Risk Factors

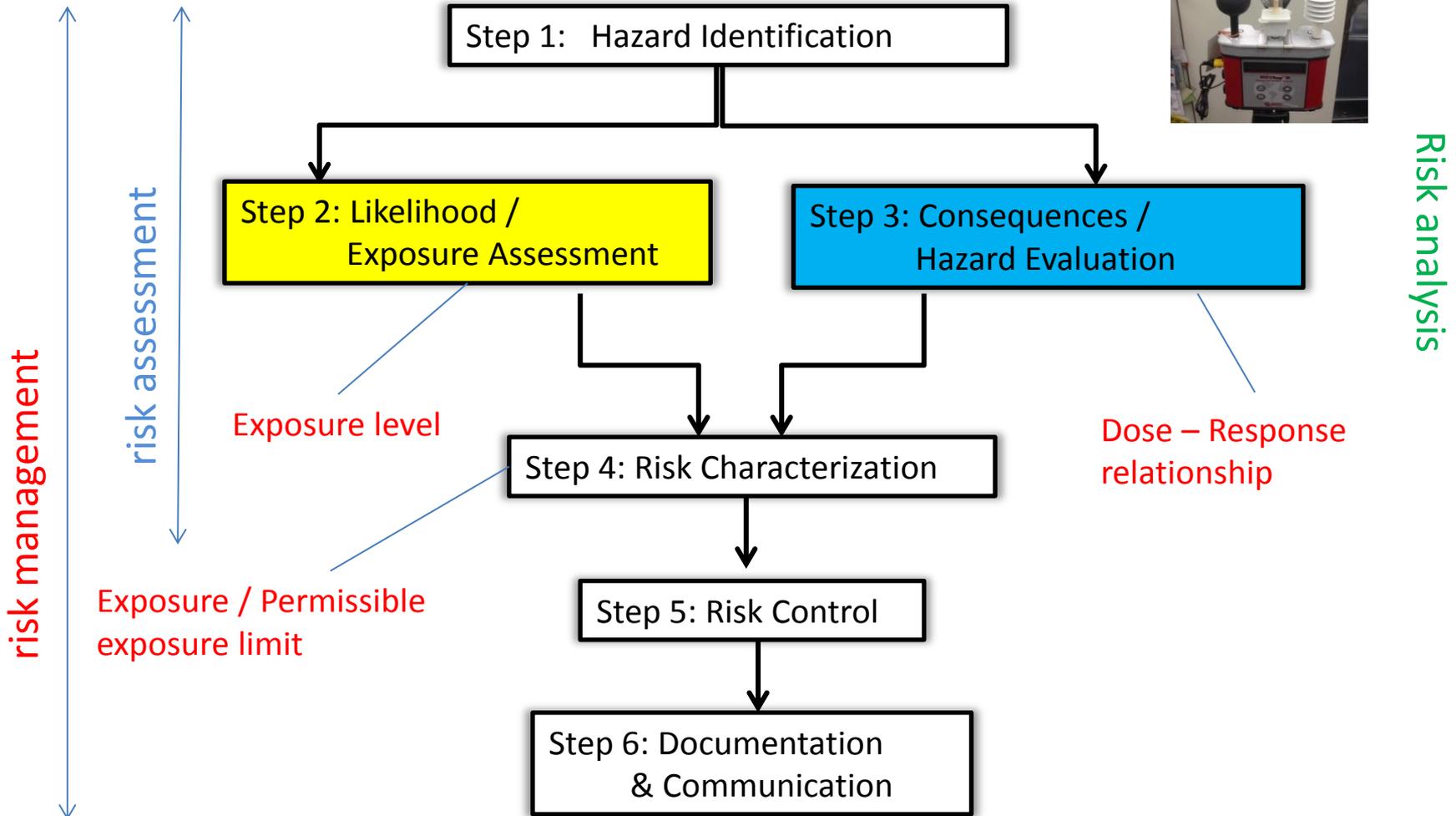
1. Dry bulb temperature
2. Wet bulb temperature
3. Radiant heat
4. Air speed
5. Physical work
6. Clothing
7. Acclimatization

Personal Risk Factors

- Susceptible Individuals

1. Cardiovascular diseases
2. Impaired renal function
3. Obesity (>25% overweight)
4. General poor health
5. Alcohol (lower ability to sweat) & drug abuse (reduced heat tolerance)
6. Physical exhaustion
7. Dehydration & starvation

Heat Stress – Risk Assessment



Step 2 : Exposure Assessment

Parameter	WBGT (wet Bulb Globe Temperature) WBGT = $0.7T_{nwb} + 0.2T_g + 0.1T_a$	HIS (Heat Strerss Index) (HSI = E_{req} / E_{max}) x 100
Dry bulb	√	√
Wet bulb	-	√
Natural wet bulb	√	-
Globe temperature	√	√
Air speed	-	√
Metabolic rate	√	√
Work demand	√	-
Clothing	√	√
Acclimatisation	√	-

Step 3 - Hazard Evaluation

Core Body Temperature & Effects

Core Temperature	Effects
44°C	Almost certainly death will occur
43°C	Normally death, or there may be serious brain damage, continuous convulsions & shock; cardio-respiratory collapse will likely occur
42°C	Subject may turn pale or remain flushed & red; may become comatose, severe delirium, vomiting, & convulsions can occur
41°C	Medical emergency - fainting, vomiting, severe headache, dizziness, confusion, hallucinations, delirium & drowsiness
40°C	Hyperpyrexia - fainting, dehydration, weakness, vomiting, headache & dizziness
39°C	Severe sweating, flushed & red, fast heart rate & breathlessness
38°C	Hyperthermia - hot, sweating, thirsty, uncomfortable
37°C	Normal
<35°C	Hypothermia - Max. shivering

Step 4 - Risk Characterisation

WBGT Index

WBGT	Risk Level
< 31°C	Low
31 to 32°C	Moderate
> 32°C	High

Some US military installations display a flag to indicate the heat category based on the WBGT

Category	WBGT °F	WBGT °C	Flag color
1	<= 79.9	<= 26.6	White
2	80-84.9	26.7-29.3	Green
3	85-87.9	29.4-31.0	Yellow
4	88-89.9	31.1-32.1	Red
5	=> 90	=> 32.2	Black

Step 4 - Risk Characterisation

HSI Index

HSI	Heat Strain
0 to 10	No thermal strain
10 to 30	Moderate
40 to 60	Severe
70 to 90	Very severe
> 100	Maximum

Heat Stress - Risk Control

Engineering	Insulation of hot surfaces / reduce emissivity
	Reflective screen / shield / shed vs radiant heat
	Automate or mechanize work
	Spot / evaporative cooling
Administrative	Acclimatization
	Work-rest regime / work rotation / work scheduling
	adequate water intake
	self-limit exposure / medical monitoring
PPE	Loose-fitting clothing / reflective garments
	Ice packs / Gel packs /Ice water circulated vests

Health Hazards Risk Assessment - Summary

Noise	Full-shift monitoring – L_{eq} compared with PEL Short time monitoring – risk rating based on exposure level, exposure time and noise control
Chemicals	TWA or short time measurement – TWA value compared with PEL Without measurement – control banding for RA
Ergonomics	RA toolkits for lifting and other repetitive tasks
Biohazard	Risk rating based on severity (risk group classification) and likelihood
Heat stressor	WBGT or HSI assessment – compared with permissible limits

ISO 31000 RM – Principles & Guidelines

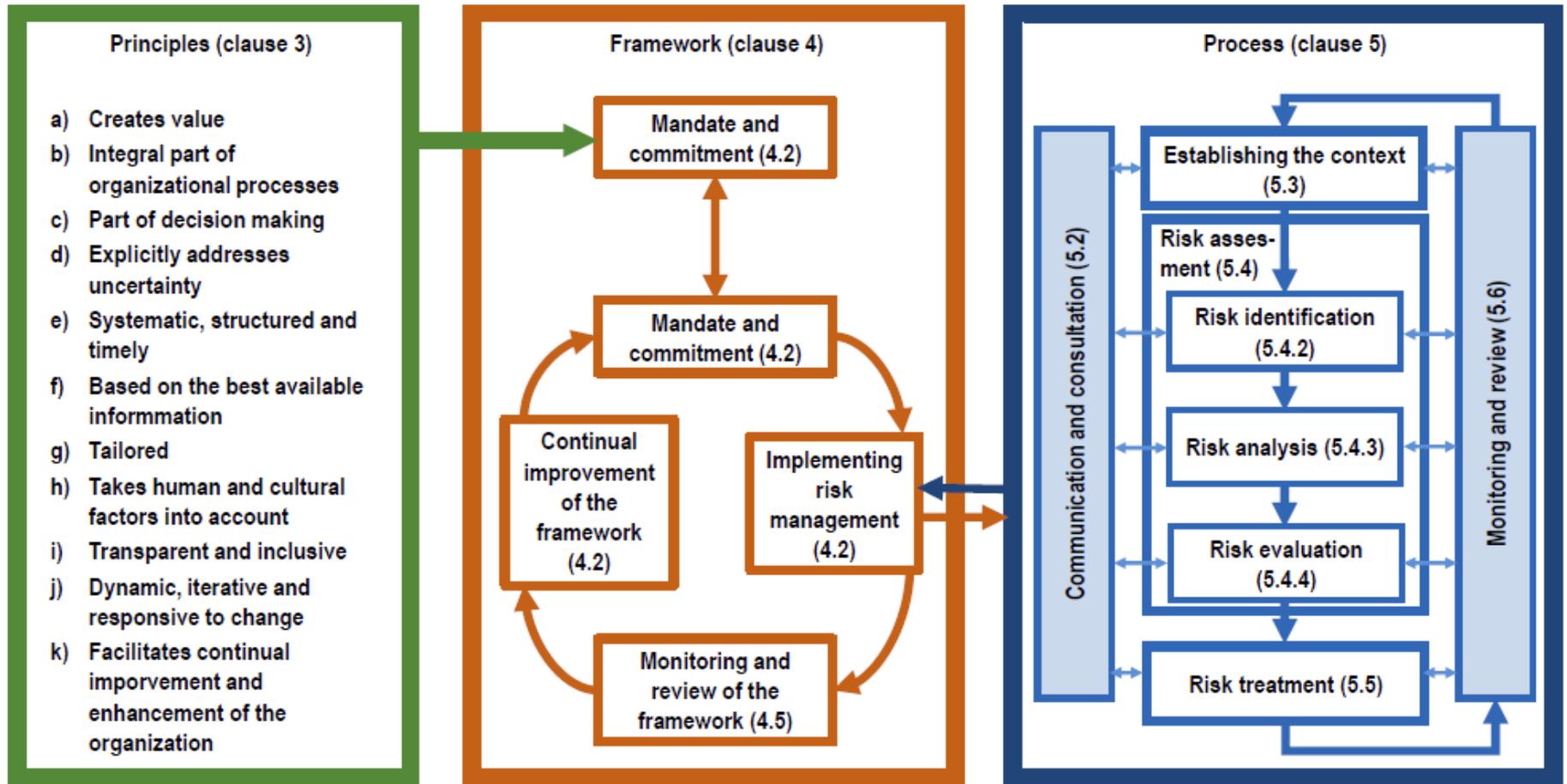
Objective – to harmonize risk management processes

Application - any type of risk and a wide range of activities including:

- ❖ operations
- ❖ processes
- ❖ functions
- ❖ projects
- ❖ products
- ❖ services
- ❖ assets

ISO 31000 Risk Management

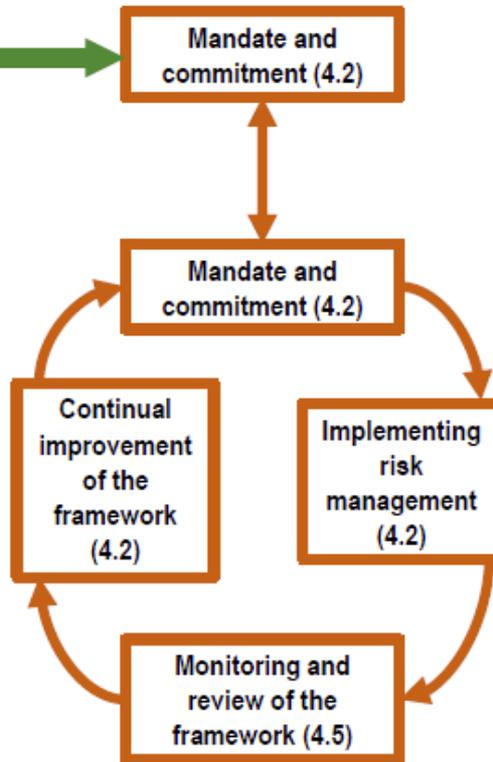
– Principles, Framework & Process



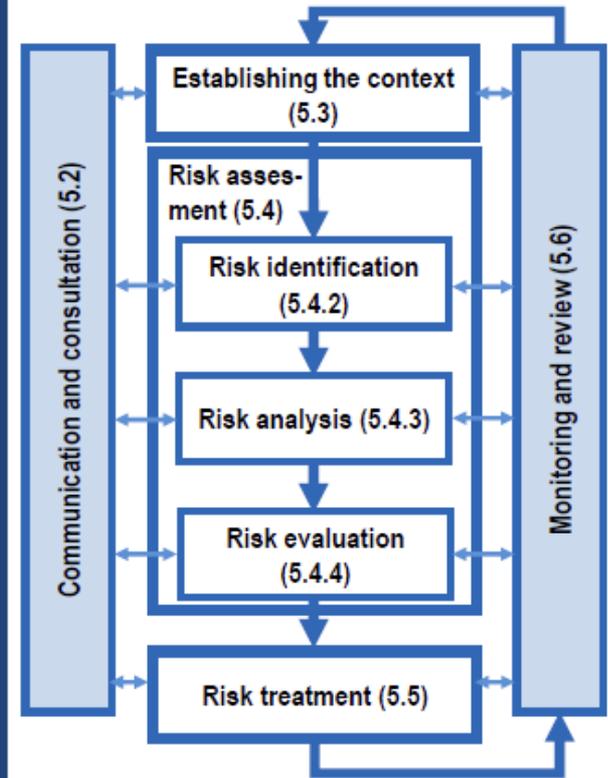
Principles (clause 3)

- a) Creates value
- b) Integral part of organizational processes
- c) Part of decision making
- d) Explicitly addresses uncertainty
- e) Systematic, structured and timely
- f) Based on the best available information
- g) Tailored
- h) Takes human and cultural factors into account
- i) Transparent and inclusive
- j) Dynamic, iterative and responsive to change
- k) Facilitates continual improvement and enhancement of the organization

Framework (clause 4)



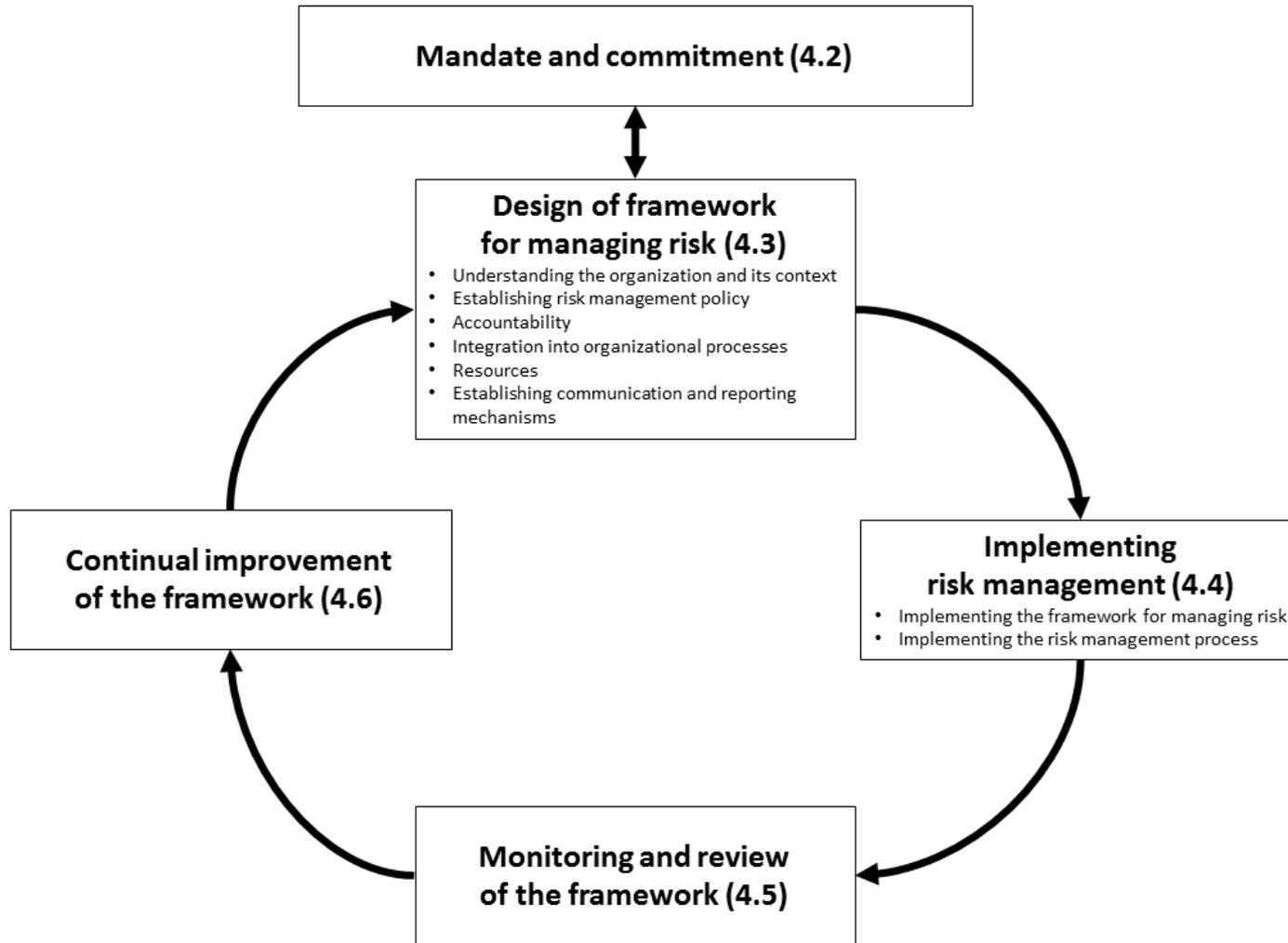
Process (clause 5)



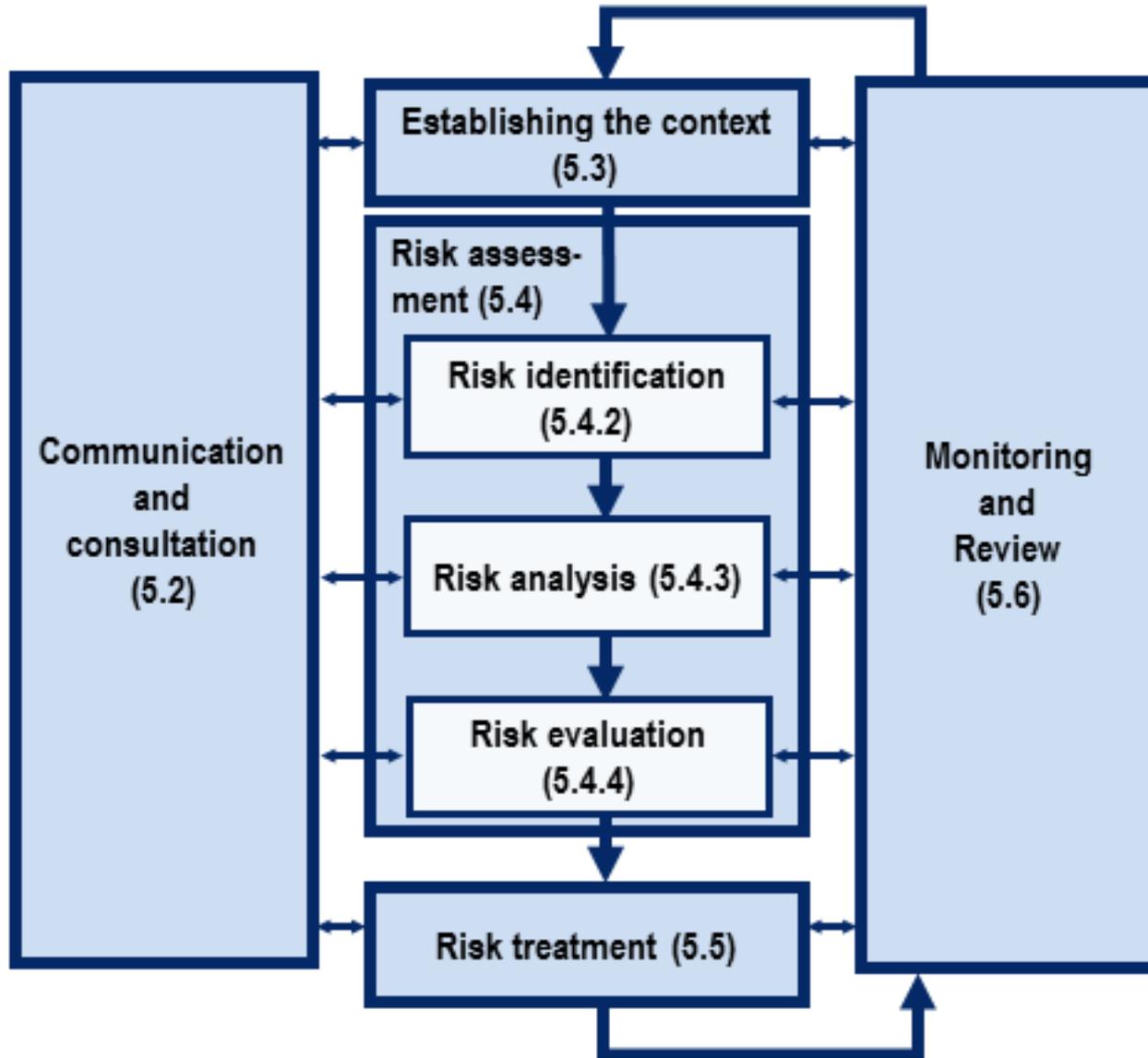
RM – Key Principles

1. Integral part of organisational processes
2. Part of decision making – address uncertainty
3. Tailored to the organisation,....
4. Take human and cultural factors into consideration
5. Create value and facilitate improvement of the organisation

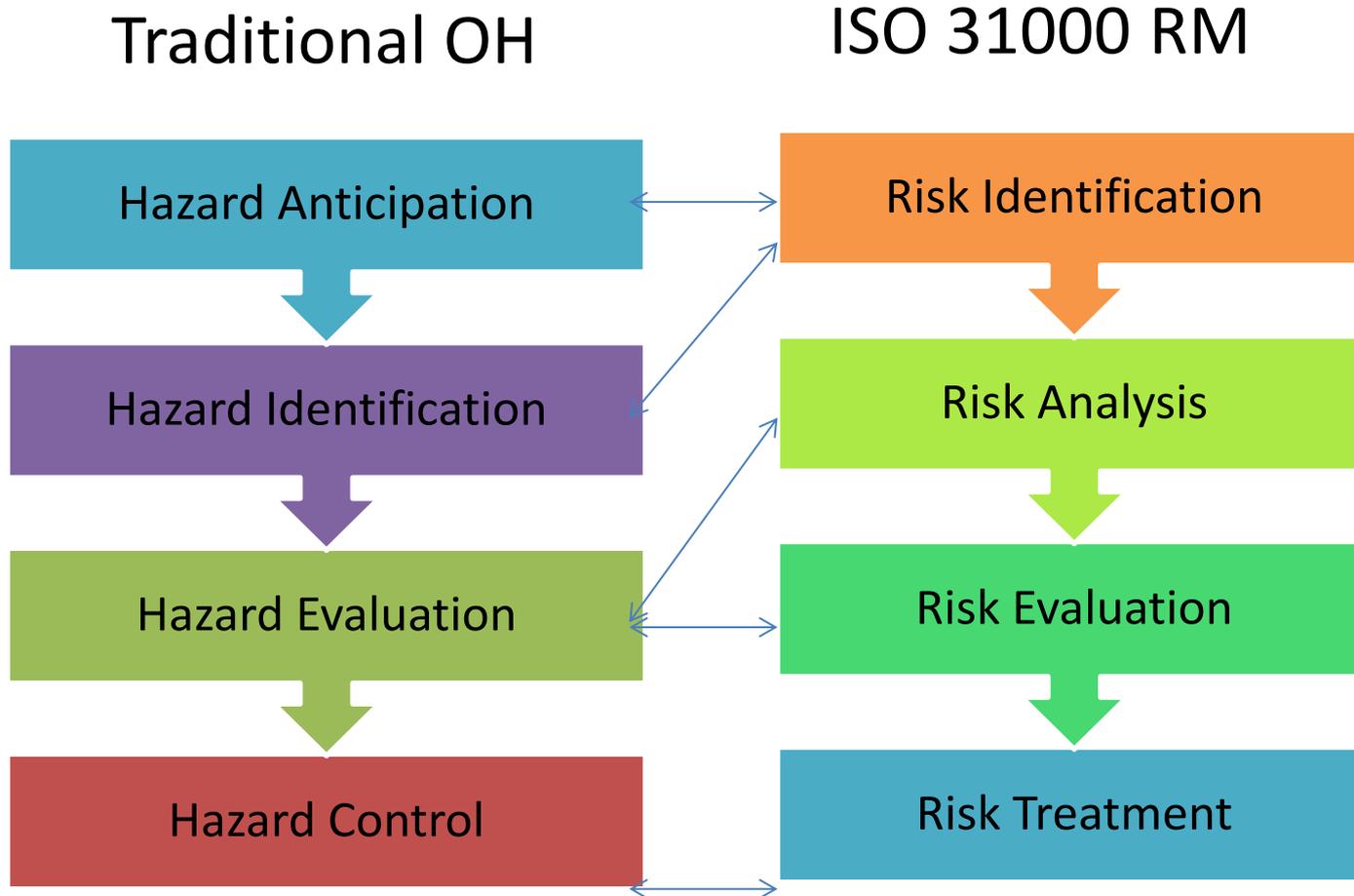
RM Framework (Corporate Level)



RM Process



Occupational Hygiene & Risk Management



OH is risk management of health hazards

Draft IEC 31010 Risk Management – RA Techniques

- Techniques primarily for identifying risks

1. Hazard & Operability Studies (HAZOP)
2. Structured What-If-Then (SWIFT)
3. Failure Modes & Effects Analysis (FMEA) & failure modes & effects & criticality analysis (FMECA)
4. Cindynic Approach
5. Scenario Analysis
6. Strategic Risk Identification

Draft IEC 31010 Risk Management – RA Techniques

- Techniques primarily for understanding Consequence & Likelihood

1. Event tree analysis (ETA)
2. Fault tree analysis (FTA)
3. Cause-consequences analysis
4. Value at Risk (VaR)
5. Conditional Value at Risk (CVaR) or expected shortfall (ES)
6. Markov Analysis
7. Cause Impact Analysis
8. Bayes Nets

Draft IEC 31010 Risk Management – RA Techniques

- Techniques primarily for evaluating the importance of risks

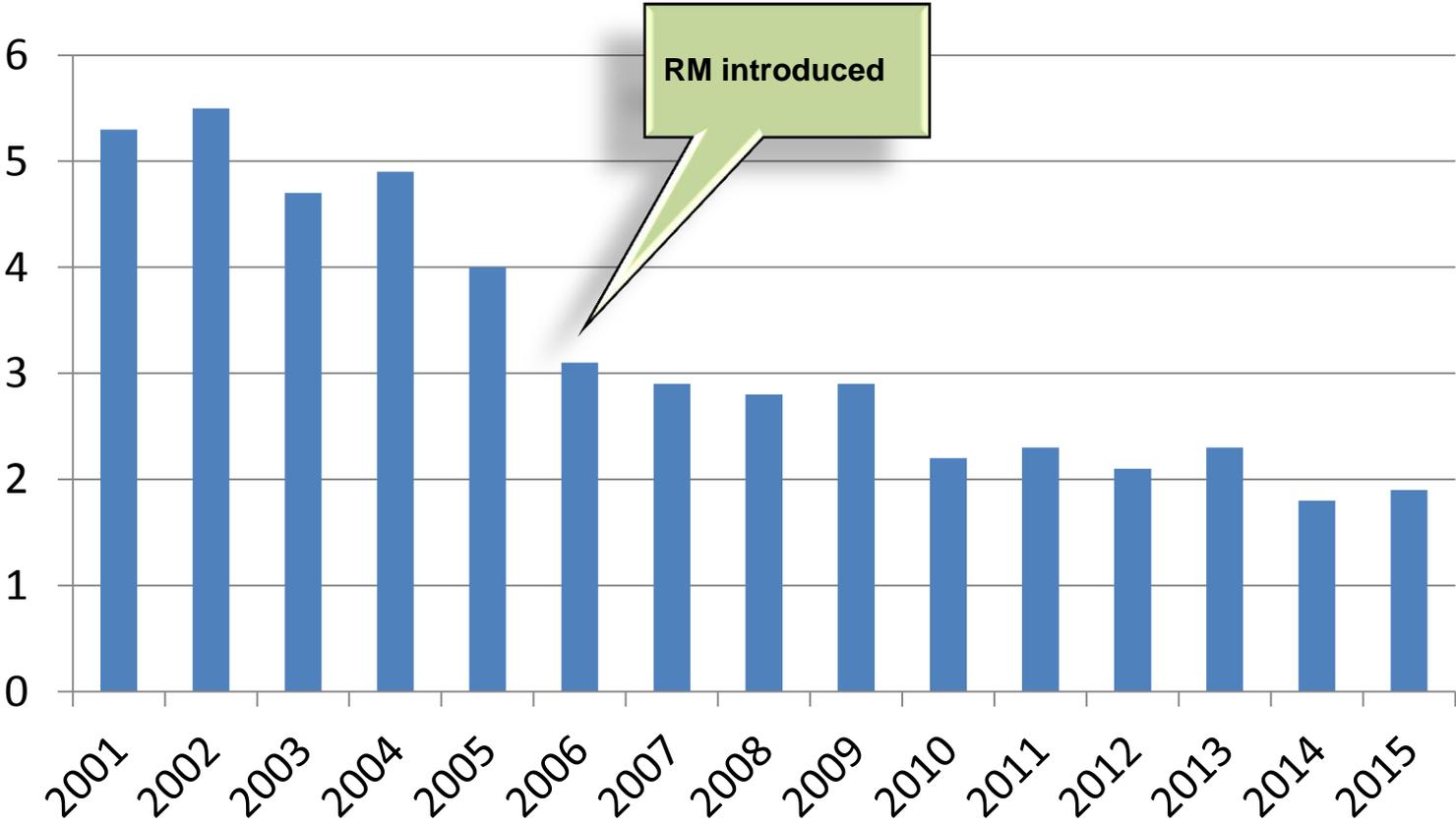
1. Risk Bearing Capacity (RBC)
2. Frequency-Number (F/N) diagrams
3. ALARP / SFAIRP
4. Risk indices
5. Pareto Charts

Draft IEC 31010 Risk Management – RA Techniques

- Causal analysis techniques
e.g. Fishbone or Ishikawa diagrams
- Techniques primarily for analysing controls
e.g. LOPA, HACCP, BIA
- Techniques to select between options
e.g. CBA, MCA
- Techniques for reporting and recording risks
e.g. risk registers, consequence / likelihood matrix

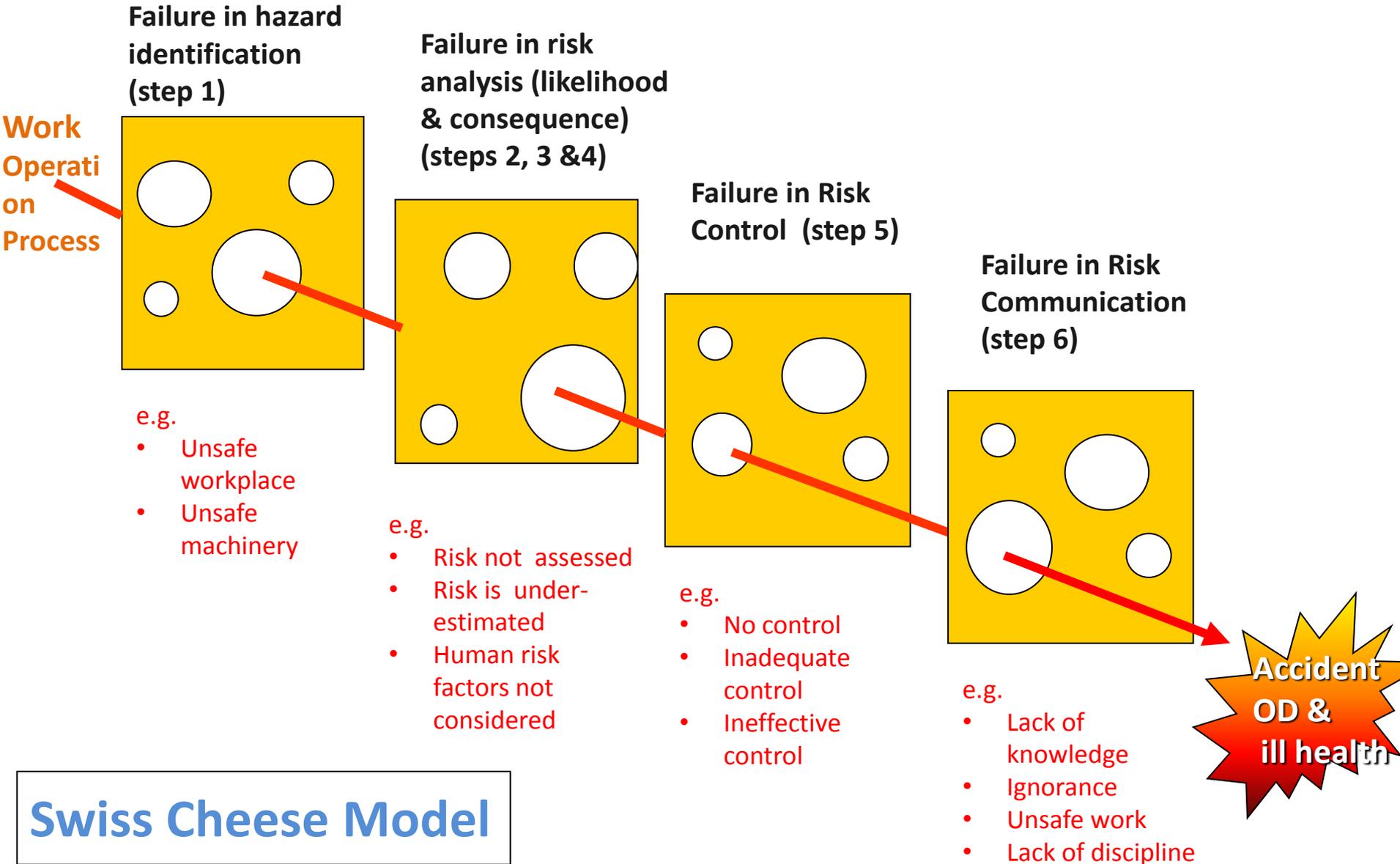
WSH (Risk Management) Regulations

Workplace Fatality Rates - 2001 to 2015

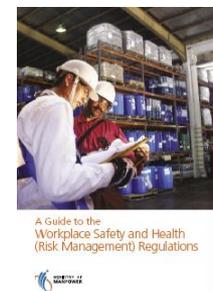


WSH Reform

Major Causes of Accidents / Ill-health – the 4 Failures



WSH (Risk Management) Regulations 2006 Summary



Reg	Title	Provision
2	Definition	Hazard, risk, risk assessment
3	Risk assessment	Employers / self-employed person / principal must conduct a risk assessment (RA) for all work undertaken
4	Elimination & control of risk	Take reasonably practicable measures to eliminate any foreseeable risk
		Implement measures (including substitution, engineering control, administrative control, use of PPE) to reduce the risk or implement SWP to control the risk
		Specify the roles and responsibilities of persons involved in implementing any measure or SWP
5	Records of RA	Maintain a record of any RA for at least 3 yrs
6	Provision of information	Inform employees of the risks involved & any risk control measures or SWP implemented
7	Review of RA	Review RA – at least once every 3 yrs or ,.....

RM Regulation 2 - Definitions

2. In these Regulations —

“**hazard**” means anything with the potential to cause bodily injury, and includes any physical, chemical, biological, mechanical, electrical or ergonomic hazard;

“**risk**” means the likelihood that a hazard will cause a specific bodily injury to any person;

“**risk assessment**” means the process of evaluating the probability and consequences of injury or illness arising from exposure to an identified hazard, and determining the appropriate measures for risk control.

Regulation 3 - Risk Assessment

3 - (1)

In every workplace, **employer, self-employed person,** and **principal** shall must conduct a RA in relation to the WSH risks posed to any person who may be affected by his undertaking in the workplace.

- (2) The Commissioner may determine the manner in which the risk assessment referred to in [paragraph \(1\)](#) is to be conducted

Regulation 4 - Elimination & Control of Risk

4-(1) In every workplace, the employer, self-employed person and principal shall take all reasonably practicable steps to **eliminate any foreseeable risk** to any person who may be affected by his undertaking in the workplace.

Elimination & Control of Risk

4-(2)

Where it is not reasonably practicable to eliminate the risk referred to in [paragraph \(1\)](#), the employer, self-employed person or principal shall implement

- (a) such reasonably practicable measures to **minimise** the risk; and
- (b) such safe work procedures to **control** the risk.

Elimination & Control of Risk

4-(3)

The measures referred to in paragraph (2)(a) may include all or any of the following:

(a) substitution;

(b) engineering control;

(c) administrative control;

(d) provision and use of suitable personal protective equipment

Elimination & Control of Risk

4-(4)

The employer, self-employed person or principal shall specify the **roles and responsibilities of persons** involved in the implementation of any measure or safe work procedure referred to in [paragraph \(2\)](#).

.

Regulation 5 - Records of Risk Assessment

- 5.—(1) Every employer, self-employed person and principal shall —
- (a) maintain a record of any risk assessment conducted under [regulation 3\(1\)](#), and any measure or safe work procedure implemented under [regulation 4\(2\)](#); and
 - (b) submit the record referred to in [sub-paragraph \(a\)](#) to the Commissioner when required by him from time to time.
- (2) Every record referred to in [paragraph \(1\)](#) shall be kept by the employer, self-employed person or principal for a period of not less than 3 years.

Regulation 6 - Provision of information

6.—(1) In every workplace, the employer, self-employed person and principal shall take all reasonably practicable steps to ensure that any person in the workplace who may be exposed to a risk to his safety and health is informed of —

(a) the nature of the risk involved; and

(b) any measure or safe work procedure implemented under [regulation 4\(2\)](#).

(2) The employer, self-employed person and principal shall comply with [paragraph \(1\)](#) whenever any risk assessment referred to in [regulation 3\(1\)](#) is revised, or where any measure or safe work procedure implemented under [regulation 4\(2\)](#) is changed.

Regulation 7 - Review of Risk Assessment

7.—(1) In every workplace, the employer, self-employed person and principal shall review and, if necessary, revise the risk assessment referred to in [regulation 3\(1\)](#) at least once every 3 years.

(2) Notwithstanding [paragraph \(1\)](#), the employer, self-employed person and principal shall review and revise the risk assessment referred to in [regulation 3\(1\)](#) —

(a) upon the occurrence of any bodily injury to any person as a result of exposure to a hazard in the workplace; or

(b) where there is a significant change in work practices or procedures.

Regulation 8 - Offence

8. Any employer, self-employed person or principal who contravenes [regulation 3\(1\)](#), [4\(1\)](#), [\(2\)](#) or [\(4\)](#), [5](#), [6](#) or [7](#) shall be guilty of an offence and shall be liable on conviction —

(a) for a first offence, to a fine not exceeding **\$10,000**; and

(b) for a second or subsequent offence, to a fine not exceeding \$20,000 or to imprisonment for a term not exceeding 6 months or to both.

UK HSE
Management of Health & Safety at Work
Regulations 1999

Regulation 3 Risk Assessment

3.—(1) Every **employer** shall make a suitable and sufficient assessment of—

(a) the risks to the health and safety of his employees to which they are exposed whilst they are at work; and

(b) the risks to the health and safety of persons not in his employment arising out of or in connection with the conduct by him of his undertaking

UK HSE – Five Steps to Risk Assessment

Step 1

- Look for the hazards

Step 2

- Decide who might be harmed and how

Step 3

- Evaluate the risks & decide whether the precautions are adequate or whether more should be done

Step 4

- Record your findings

Step 5

- Review your assessment & revise it if necessary

WSH RM Framework

Set of components that provide the foundations and arrangements for designing, implementing, monitoring, reviewing and continually improving RM

Risk Management Strategies

Vision : Vision Zero



Strategic Outcome:
Effective risk assessment & risk control at workplace

1
Promoting
RM

2
Building
capability

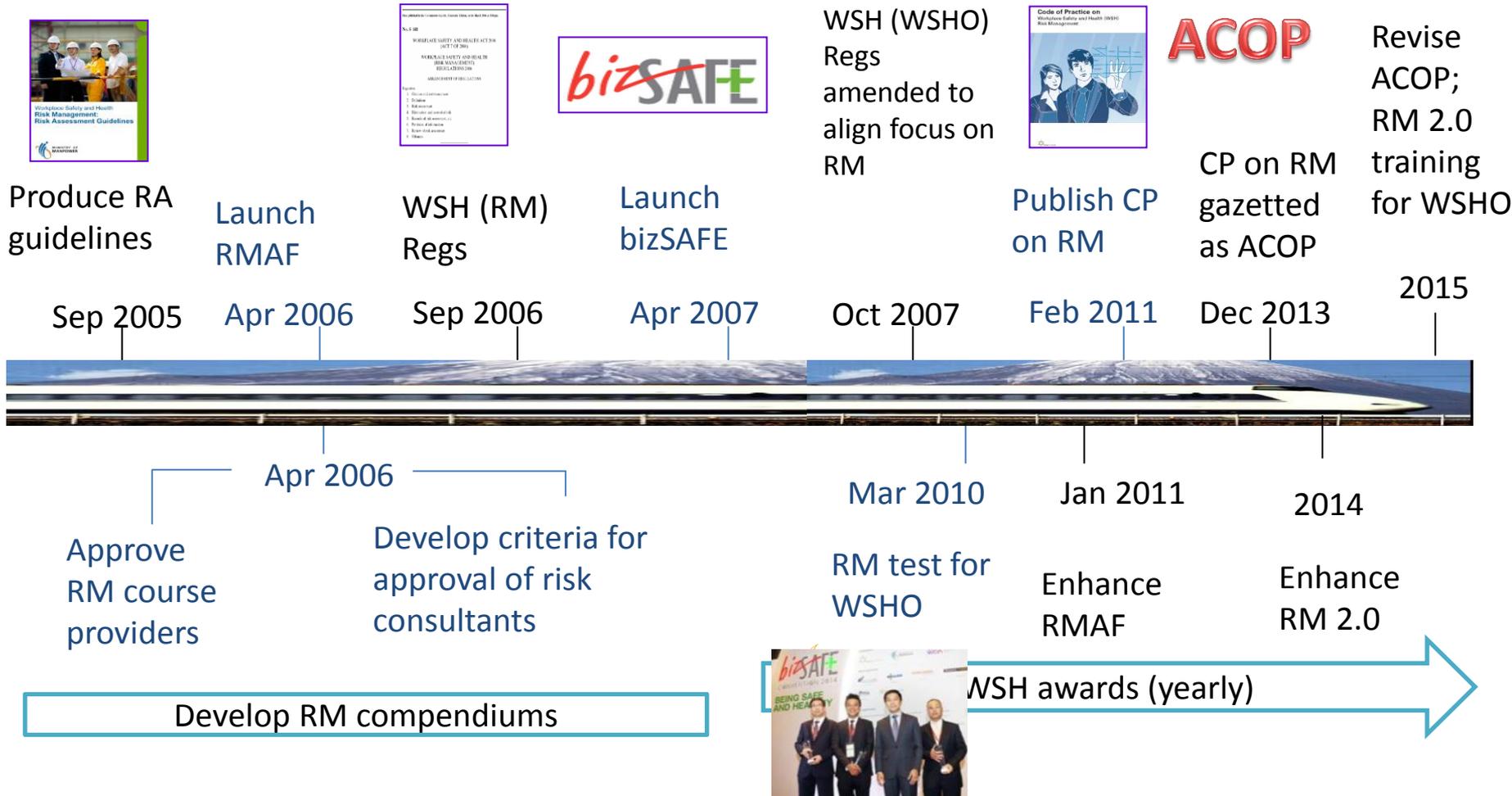
3
Engaging
stakeholders

4
Legislation
&
enforcement

5
Compliance
assistance

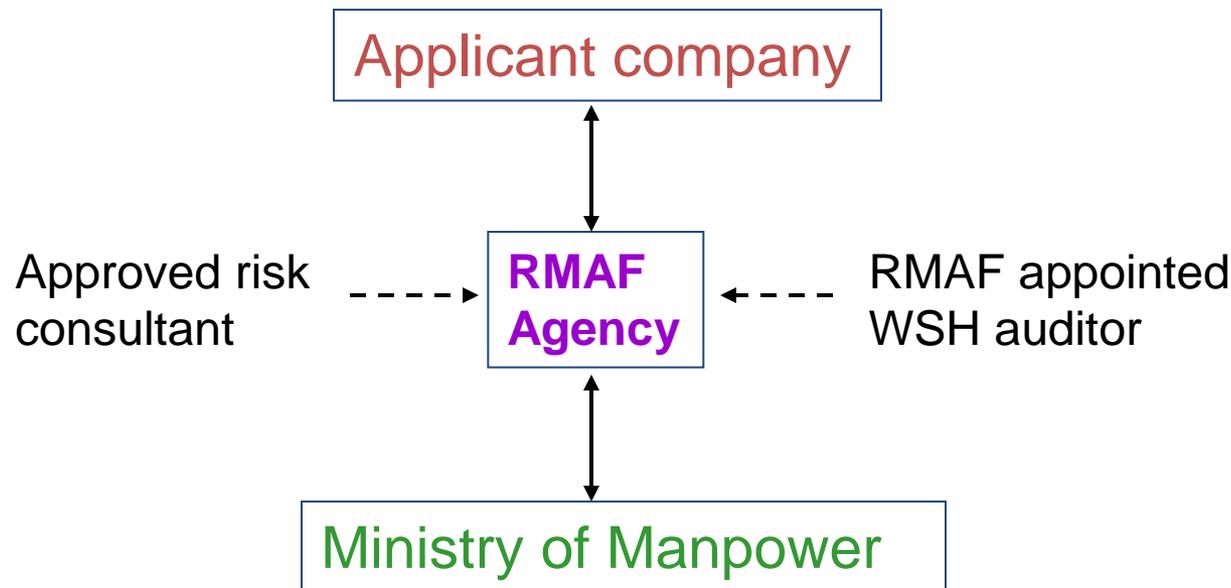
Strategies

Our Risk Management Journey



RM Compliance Assistance Risk Management Assistance Fund

- \$5 + \$8 million RMAF
- Defray the cost of RA & capability building
- 70% of consultancy cost with a max. \$7,500



bizSAFE Programme - 5 Levels of Recognition

23,000 bizSAFE-certified companies as of Feb 2016

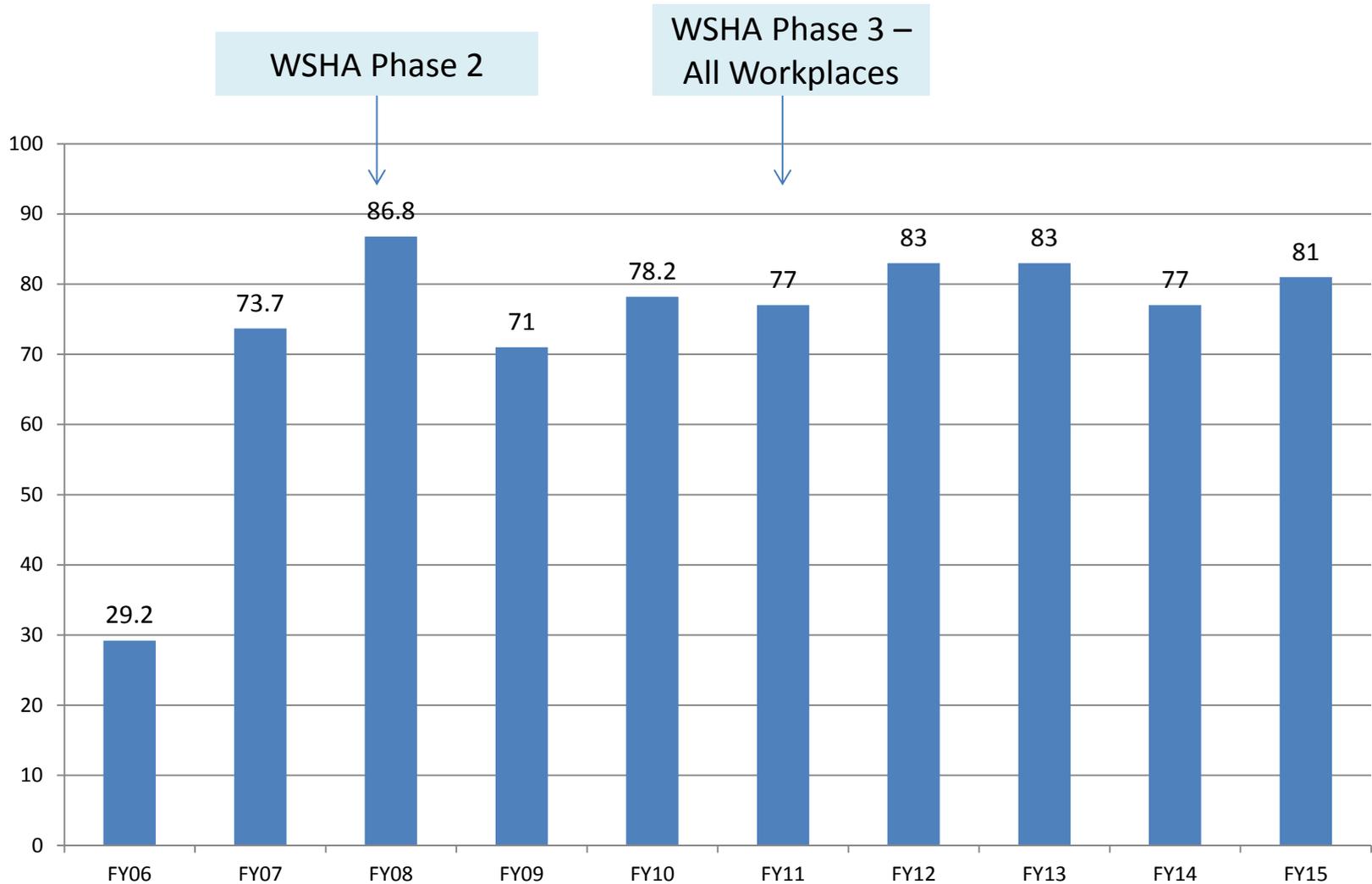


bizSAFE – Promote & Build Capability in Risk Management / Safety Management System

- bizSAFE Workshop for company CEO/Top Management
- bizSAFE Course on Risk Management
- bizSAFE Course on WSH Management System
- bizSAFE Annual Conference
- bizSAFE Awards
- bizSAFE Logo

Risk Assessment Implementation Status

% of workplaces inspected that have implemented RA (1st Inspection)



Inspection Checklist on RM implementation

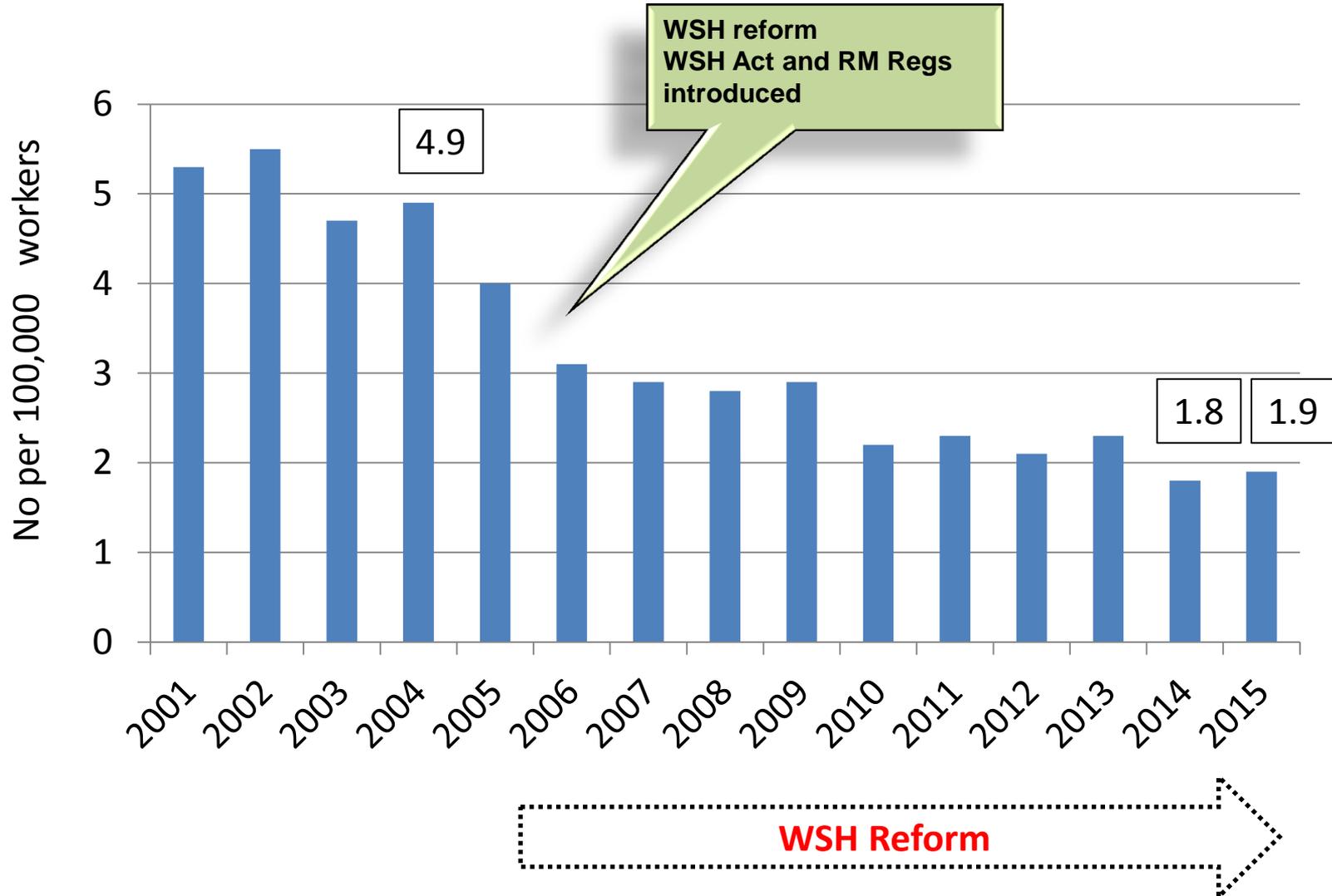
s/no	Inspection Checklist	Yes	No
1	RA team(s) formed with competent person(s) trained in RA		
2	RA is conducted & documented includes risk control measures following the hierarchy of control		
3	An effective communication plan for RM is established		
4	Regular monitoring & reviewing of RM to ensure it remains relevant		

WSH (RM) Regulations

- Prosecution, Composition Fines & NNC Cases

Enforcement Action	Number of Cases	Quantum
Prosecution (2009 to 2013)	7	\$39,500
Composition Fine (2006 to 2015)	367	\$ 425,000
Notice of Non-compliance (2006 to 2015)	12,697	-----

Workplace Fatality Rates -2001 to 2015



Enhanced Risk Management

ISSUES

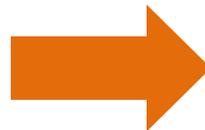
RM is a “paper exercise”



Over-reliance on procedures & PPE



RM does not consider personal risk factors



RM 2.0

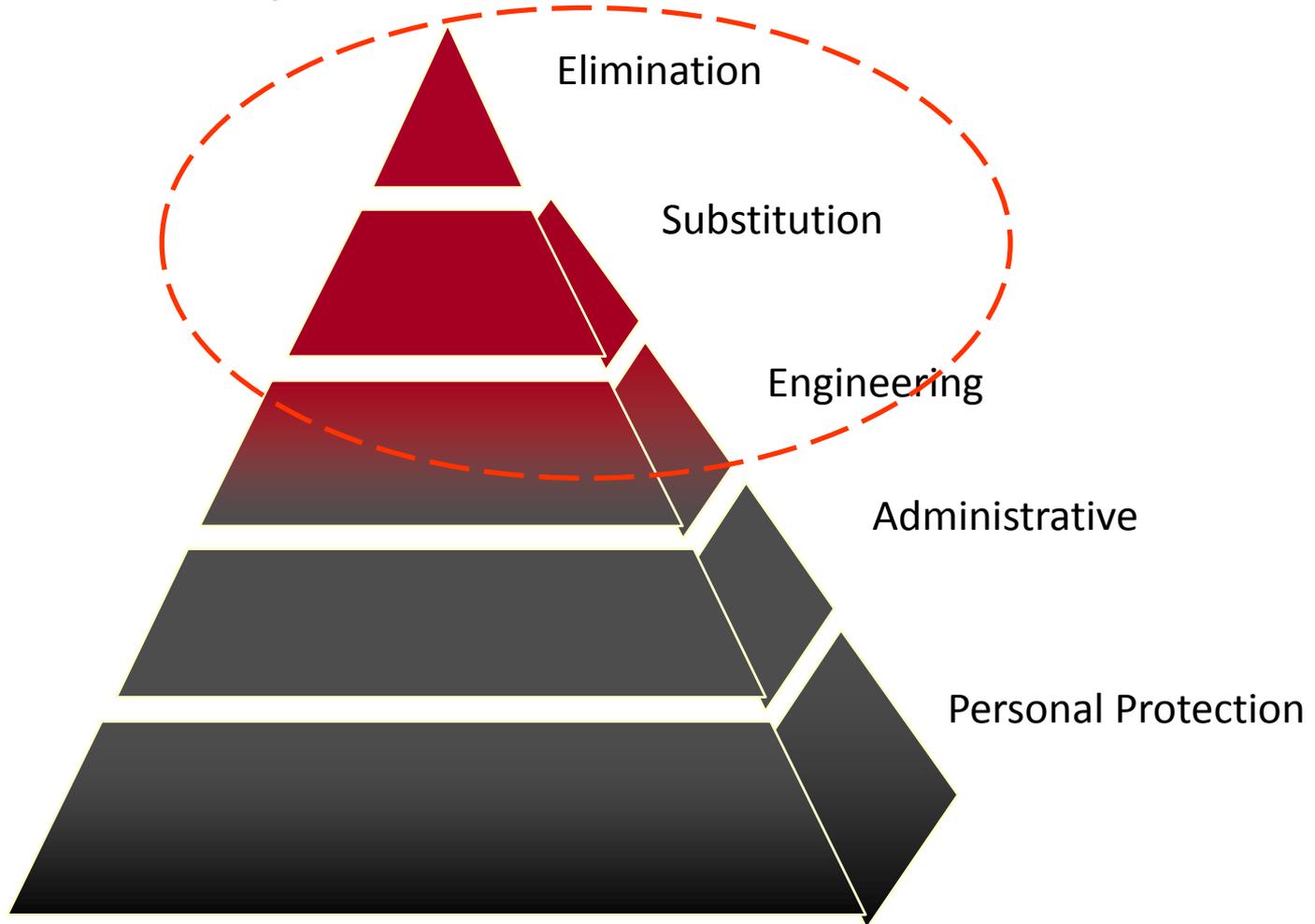
Pragmatic:
Effective on-site implementation

Upstream risk controls

Holistic:
Consideration for health hazards & human factors

Risk Control Measures Hierarchy

- Upstream Risk Control



The Way Forward – RM Initiatives

Building Capabilities

- RM 2.0 workshop for WSH Professionals
 - starting in April 2015 by SISO
- Updated WSH Courses
 - Relook at Hierarchy of Control and on-the-ground implementation
 - To include human and cultural factors

Compliance Assistance

- Online RA database
- RA awareness posters for workers
- Simplified RM DIY Guide

Legislation & Enforcement

- Review WSH (RM) Regulations
- RM enforcement protocol and checklist

Promotion & Engagement

- Conference, seminar, forum, focus group discussion, public consultation

New RM Inspection Checklist

– from 1 Mar 2016

s/no	Inspection Checklist	Yes	No
1	Are there any hazard(s) present in the workplace which are not addressed?		
2	Are control measures implemented to reduce WSH risks?		
3	Are workers aware of the hazards, control measures & safe work procedures?		
4	Are upstream risk control(s) implemented?		
5	Are individual, organisational or environmental factors considered in risk assessment?		

WSH RM - Summary

- A cornerstone of WSH Management System
- RM is part of business process
- It helps to prevent accidents, injuries and ill health
- It can make a difference to the WSH landscape
- It is a journey not destination
- The vision of RM is Vision Zero – all accidents and ill health are preventable

XXI World Congress on WSH in 2017 in Singapore



XXI WORLD CONGRESS ON
SAFETY & HEALTH
AT WORK 2017

Global Forum for Prevention
Singapore, 3–6 September 2017

www.safety2017singapore.com

A Global Forum for Prevention - The triennial Congress is the largest OSH platform for the exchange of knowledge and perspectives by safety and health experts, business leaders, government decision-makers, social partners, and everyone with an interest in occupational safety and health.

Singapore is hosting the 21st World Congress on Safety and Health at Work on **3 – 6 Sep 2017 at Marina Bay Sands, Singapore.**

Motto

“A Global Vision of Prevention”

Theme

Vision Zero – From Vision to Reality
Healthy Work – Healthy Life
People-Centred Prevention

THE ORGANISERS



International
Labour
Organization





Join us in Singapore

3-6 September 2017



Visit our website at www.safety2017singapore.com for more information

Thank You