
MASTER STUDY MATERIAL: INDUSTRIAL SAFETY (Chapters 1-10)

CHAPTER 1: SAFEGUARDING OF MACHINES

Syllabus: Statutory provisions, Principles of machine guarding, Types of guards (design/selection), Guarding of specific machinery (wood, paper, rubber), Built-in safety, Maintenance.

1. Statutory Provisions (The Factories Act, 1948)

- **Section 21 (Fencing of Machinery):** Mandates that every dangerous part (prime movers, transmission machinery, etc.) must be securely fenced.
- **Section 22 (Work on Motion):** Strict rules for examining or lubricating moving machinery. It must be done by a specially trained adult male wearing tight-fitting clothing.
- **Section 23 (Young Persons):** Prohibits young persons (under 18) from working on dangerous machines unless fully instructed and supervised.

2. Types of Guards

- **Fixed Guards:** A permanent barrier with no moving parts. The safest type but limits access.
- **Interlocked Guards:** Connected to the power source. The machine cannot start if the guard is open, and stops if the guard is opened during operation.
- **Adjustable Guards:** Can be adjusted for different material sizes (e.g., Band saw blade guard).
- **Self-Adjusting Guards:** The guard is pushed open by the stock (material) and closes automatically (e.g., Circular saw).
- **Trip Guards:** Devices (bars, curtains, wires) that stop the machine immediately upon contact.

3. Design and Selection Principles

- **Prevent Contact:** Must stop hands/body from reaching danger zones.
- **Secure:** Must be tamper-proof and durable.
- **No New Hazards:** The guard itself must not have sharp edges.
- **No Interference:** Must not impede the worker's efficiency.

4. Guarding of Specific Machinery

- **Woodworking:**
 - *Circular Saw:* Requires a **Riving Knife** (to prevent kickback), Top Hood, and Push Stick.
- **Paper & Rubber:**
 - *Hazards:* Nip points (in-running rollers).
 - *Guards:* Nip guards (barriers at the intake) and Trip Wires (emergency stop cables).
- **Grinding Machines:**
 - *Wheel Guard:* Strong casing to contain fragments if the wheel bursts.
 - *Work Rest:* Gap must not exceed **3 mm** from the wheel.

5. Safety Devices & Maintenance

- **Built-in Safety:** Two-hand controls (requires both hands to operate, keeping them safe).
- **Maintenance:** Guards must be inspected frequently. Repair or replace damaged guards immediately.

CHAPTER 2: MANUAL HANDLING & STORAGE OF MATERIALS

Syllabus: Hazards, Kinetic methods, Max loads, Lifting shapes, Safe use of accessories, Storage.

1. Hazards in Manual Handling

- **Musculoskeletal Disorders (MSDs):** Back pain, slipped discs, hernias due to improper lifting.
- **Acute Injuries:** Cuts, fractures from dropped loads, slips, and trips.

2. Kinetic Method of Lifting (The Correct Technique)

Using the strong leg muscles instead of the weak back muscles.

1. **Feet Position:** Hip-width apart, one foot slightly forward for balance.
2. **Bend Knees:** Squat down to the load; keep the **Back Straight**.
3. **Firm Grip:** Use palms, not just fingers.
4. **Load Close:** Hold the object close to the body's Center of Gravity (CG).
5. **Lift:** Straighten legs smoothly.

3. Maximum Loads (Model Rules)

- **Adult Male:** ~50-55 kg.

- **Adult Female:** ~30 kg.
- **Adolescent Male:** ~30 kg.
- **Adolescent Female:** ~20 kg.

4. Safe Use of Accessories

- **Hooks:** Keep sharp; use for bales/crates.
- **Crowbars:** Ensure good fulcrum; avoid slipping.
- **Rollers:** Use for moving heavy machinery; never adjust with hands (use a hammer).

5. Storage of Materials

- **Stacking:** Broad base, tapering to the top (Pyramid shape). "Interlock" or cross-tie layers for stability.
- **Height Limit:** Generally, stack height should not exceed **3 times** the narrower dimension of the base.
- **Cylinders:** Store vertically, chained, with valve caps on. Segregate Oxygen from Flammable gases.

CHAPTER 3: MECHANICAL HANDLING OF MATERIALS

Syllabus: Lifting machinery (Cranes/Forklifts), Safety in design/testing, Lifting tackles (chains, ropes, hooks, SWL calculation).

1. Lifting Machinery (Cranes, Hoists)

- **Statutory (Sec 29):** All lifting machines must be thoroughly examined by a **Competent Person** at least once every **12 months**.
- **Testing:** Proof Load Test = **1.25 times** the Safe Working Load (SWL).
- **Safety Devices:**
 - **Limit Switches:** Stop the hoist at the top (over-hoist) and bottom (over-lower).
 - **Safe Load Indicator (SLI):** Warns if the load/radius combination is unsafe.
 - **Brakes:** Must hold the full load if power fails.

2. Power Trucks (Forklifts)

- **Stability Triangle:** Forklifts have a 3-point suspension. If the Center of Gravity moves outside this triangle, it tips over.
- **Operation:** Keep load low (10-15cm off floor) while traveling. Drive in reverse when going down ramps.

3. Lifting Tackles (Rigging Gear)

- **Wire Ropes:** Inspect for "Bird-caging" (strands opening) or >5% broken wires. Factor of

Safety = 6:1.

- **Chains:** Must be **Annealed** (heat treated) periodically to fix metal hardening. Factor of Safety = 4:1.
 - **Hooks:** Must have a **Safety Latch**. Reject if throat opening increases by >15%.
 - **SWL Calculation (Sling Angles):**
 - Formula: $SWL = W \times \cos(A)$
 - **Rule:** The wider the angle between sling legs, the **lower** the lifting capacity (stress increases).
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CHAPTER 4: HAND TOOLS & PORTABLE POWER TOOLS

Syllabus: Accidents, Centralized control, Dressing/Tempering, Safe use, Non-sparking tools, Power tools.

1. Accident Causes & Control

- **Main Causes:** Use of wrong tool, defective tool, or unsafe method.
- **Centralized Tool Control:** Tools are purchased, inspected, and maintained by a central "Tool Crib" rather than owned by workers.

2. Maintenance of Tools

- **Dressing:** Grinding off the "Mushroomed Head" of a cold chisel to prevent metal fragments from flying off.
- **Tempering:** Heat treatment to ensure the metal is not too brittle (shatters) or too soft (bends).
- **Handles:** Files must have handles to prevent the tang from piercing the hand. Hammers must have tight wedges.

3. Safe Use

- **Wrenches:** Always **PULL**, never push (prevents knuckle injury if it slips).
- **Screwdrivers:** Never hold the workpiece in the palm of your hand.

4. Portable Power Tools

- **Electrical Safety:** Must be **Double Insulated** (Symbol: Square within a square) or properly Grounded (3-pin plug).
- **Grinders:** Must have a guard covering **180°** of the wheel. Check RPM rating.
- **Circular Saws:** Retractable lower guard required.
- **Deadman Switch:** A trigger that stops the tool immediately when released.

5. Special Tools

- **Non-Sparking Tools:** Made of **Beryllium-Copper** or Aluminum-Bronze. Mandatory in explosive atmospheres (Refineries/Mines).
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CHAPTER 5: ELECTRICAL HAZARDS

Syllabus: Dangers, Limits, Clearances, Protection, Earthing, Borrowed neutrals, Flameproof, Static electricity.

1. Dangers & Limits

- **Shock:** Current (Amps) kills, not just voltage.
 - **30 mA:** Threshold for respiratory paralysis (Trip setting for ELCB).
 - **50-100 mA:** Ventricular Fibrillation (Fatal heart rhythm).
- **Safe Distances (Overhead Lines):**
 - Low/Medium Voltage: **2.5 meters** vertical clearance.
 - High Voltage (>650V): **3.7 meters** vertical clearance.

2. Protection Systems

- **Overload:** MCB or Fuse (Protects wires).
- **Earth Fault: ELCB / RCCB** (Protects Life). Detects leakage and trips at 30mA.
- **Earthing:** Provides a low-resistance path (< 5 Ohms) to ground. Industrial motors require **Double Earthing**.

3. Common Hazards

- **Borrowed Neutral:** Sharing a neutral between circuits causes "Floating Neutral" and over-voltage (fires/damage).
 - **Static Electricity:** Generated by friction (fluids in pipes). Controlled by **Bonding** (connecting metals) and **Grounding**.
 - **Flameproof Equipment (Ex-rated):** Enclosures designed to withstand an internal explosion without igniting the gas outside. Used in Hazardous Zones.
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CHAPTER 6: INDUSTRIAL LIGHTING

Syllabus: Purpose, Safety (Glare/Stroboscopic), Principles, Standards, Design, Maintenance.

1. Purpose & Safety

- **Goals:** Visibility, Safety, Morale.

- **Hazards:**
 - **Glare:** Excessive brightness causing discomfort or "Disability Glare" (blindness).
 - **Stroboscopic Effect:** AC light flicker (50Hz) makes rotating machinery appear stationary. Dangerous! Remedy: Phase splitting.

2. Standards (IS 3646)

- **Unit:** Lux (Lumens per square meter).
- **Passageways:** 50 - 100 Lux.
- **Rough Work:** 150 Lux.
- **Office/Medium Work:** 300 - 500 Lux.
- **Fine/Precision Work:** 700 - 1000 Lux.

3. Design & Maintenance

- **Lumen Method:** Formula to calculate the number of fixtures needed.
- **Maintenance Factor (MF):** Accounts for dirt and aging.
- **Group Relamping:** Replacing ALL lamps at 80% of rated life to ensure uniform light and save labor costs compared to spot replacement.

CHAPTER 7: SAFETY OF PRESSURE VESSELS

Syllabus: Fired/Unfired, Statutory, Testing (Hydro/NDT), Boiler safety/operation.

1. Classification & Statutory

- **Fired Vessels (Boilers):** Heated by flame. Regulated by **The Indian Boilers Act, 1923**.
- **Unfired Vessels:** Storage tanks (Air, LPG). Regulated by **SMPV Rules, 2016**.

2. Safety Devices (Mountings)

- **Safety Valves:** Minimum **2** required on boilers. Relieves excess pressure.
- **Water Level Indicator:** Critical to prevent dry-firing (overheating).
- **Fusible Plug:** Melts if water level is critically low, extinguishing the fire.
- **Blow-down Valve:** Removes sludge/sediment from the bottom.

3. Testing

- **Hydrostatic Test:** Pressurize with **Water** to **1.5 times** the Design Pressure. Water is used because it does not store explosive energy like compressed air.
- **NDT:** Radiography (X-ray) for welds; Ultrasonic for thickness checks.

4. Operation

- **Low Water Emergency:** Stop firing immediately. Do NOT add cold water (thermal shock

will crack the boiler).

CHAPTER 8: VENTILATION & HEAT CONTROL

Syllabus: Physiology, Indices, Natural/Mechanical/Process ventilation, Heat control.

1. Physiology & Heat Stress

- **Heat Balance:** $S = M - C - R - E$. (Evaporation is the main cooling method when Air Temp > Body Temp).
- **Indices:**
 - **WBGT (Wet Bulb Globe Temperature):** Standard industrial index.
 - **Formula (Indoor):** $0.7 \times NWB + 0.3 \times GT$.
 - **Instruments:** Wet Bulb (Humidity), Globe Thermometer (Radiant Heat), Kata Thermometer (Air Velocity).

2. Ventilation Types

- **Natural:** Wind action + **Stack Effect** (Hot air rises out of roof monitors, cool air enters below).
- **Mechanical:** Plenum (Positive pressure) vs. Exhaust (Negative pressure).
- **Local Exhaust Ventilation (LEV):** Captures contaminants at the source.
 - **Components:** Hood \rightarrow Duct \rightarrow Air Cleaner \rightarrow Fan \rightarrow Stack.
- **Dilution:** General airflow. Only for low toxicity substances.

3. Control of Heat

- **Radiant Heat:** Use **Reflective Shields** (Aluminum/Tin) to reflect heat.
- **Convection:** Use fans (Man coolers).
- **Source:** Insulation (Lagging) of hot pipes.

CHAPTER 9: MACHINE CONTROL & DISPLAYS

Syllabus: Location/Sequence, Natural expectation, E-Stop, Displays, Coding.

1. Controls Layout & Stereotypes

- **Natural Expectation:**
 - Up / Right / Clockwise = **ON / Increase**.
 - Down / Left / Anti-Clockwise = **OFF / Decrease**.
- **Sequence:** Arranged in order of operation (Power \rightarrow Start \rightarrow Stop).

- **Protection:** Recessed buttons or Shrouds (especially on Foot Pedals) to prevent accidental activation.

2. Emergency Stop (E-Stop)

- **Design:** Mushroom-headed button.
- **Color:** Red button on Yellow background.
- **Logic:** Latching type (must be manually twisted/pulled to reset). Accessible from all danger zones.

3. Displays

- **Analog (Dial/Pointer):** Best for seeing Trends, Rate of Change, and rapid "Check Reading".
- **Digital:** Best for Precision and recording specific values.
- **Audio Signals:** Warning (Siren) vs. Caution (Buzzer). Frequency 500 - 3000 Hz (most audible).

4. Color Coding

- **Red:** Danger / Stop / Fire.
- **Yellow:** Caution / Warning.
- **Green:** Safe / Start / First Aid.
- **Blue:** Mandatory Action (e.g., Wear PPE).

CHAPTER 10: SAFETY IN INDUSTRIES

Syllabus: Engineering, Jute/Textiles, Agro, Forging & Foundry, Port & Dock.

1. Textile & Jute Industry

- **Hazards:** Fire (high risk due to fibers/static), Noise (Looms > 90dB).
- **Health: Byssinosis** (Monday Fever) - Lung disease from inhaling cotton/jute dust.

2. Agro-Industry (Agriculture)

- **Tractors:** Rollover is the #1 cause of death. Requires **ROPS** (Rollover Protective Structure).
- **Pesticides:** Poisoning via skin/inhalation.
- **Grain Silos:** High risk of **Dust Explosions**.

3. Forging & Foundry

- **Hazards:** Molten metal burns, Heat Stress.
- **Explosion:** Steam explosion (if water touches molten metal).

- **Health: Silicosis** (Lung disease from silica sand molds), Metal Fume Fever (Zinc/Lead fumes).

4. Port & Dock Safety

- **Hazards:** Lifting gear failure (cranes/slings), Falls into water (Drowning).
- **Confined Space:** Entering ship holds (Oxygen deficiency, toxic fumigants).
- **Statutory:** The Dock Workers (Safety, Health and Welfare) Regulations, 1990.
- **Controls:** Certified lifting gear (SWL marked), Life jackets, Gas testing before entry.