Exothermic chemical processes rely on efficient control of temperature and pressure to prevent the phenomenon of ‘runaway reaction’ (thermal runaway) when mixing chemicals in a reactor.

Outline the methods used to control temperature and pressure in such circumstances. (10)

**Exothermic** = gives out heat energy  
**Endothermic** = takes in heat energy

High integrity temp detection  
Pressure rise detection linked to cooling, venting, auto-shutdown  
External cooling – chilled water jacketing  
Air cooled heat exchangers  
Pre-chilling of reactant before mixing  
Limiting rates of addition to within safe thresholds

**Maintenance** ensure clean, efficient vessels, maint programme, regular internal cleaning to prevent build up,  

**Location** away from other heat sources.

(a) In relation to automatic fire detection and alarm systems, outline the basic principles of operation of:  

(i) heat detectors; (4)  
(ii) smoke detectors. (4)

(b) Identify the circumstances in which EACH type of detector would be inappropriate. (2)

**Rate of rise heat detector**  
Responds to rapid increase in temperature, electronic resistors  
**Use where smoke detector is undesirable**  
i.e. flammable liquids

**Fixed temperature heat detector**  
Sensing element at fixed temperature, set at pre-determined temperature – uses a thermocouple.  
Triggers alarm  
**Kitchens or boiler rooms – rate of rise no good**  
**Ionisation SMOKE Detectors**
Smoke particles pass between 2 electrodes
Causes ionisation of surrounding air and a small current flow
Added weight of smoke particles slows down transmission rate, alarm triggered

Fast fuming fires, small particles of smoke
**False alarms from burning odours**

**Optical smoke detectors**
IR light refracting off smoke particles entering detection chamber, onto a light sensor which triggers alarm
Good for large particles of smoke
Smouldering fires, fabrics, furnishings
**Prone to false alarms caused by steam or dusty environments**

(a) **Outline the principles of gamma radiography.** (3)

(b) **Outline the advantages and disadvantages of gamma radiography as a form of non-destructive testing.** (7)

Transmission of Gamma rays from sealed ionising radiation source
Through test object onto film placed on opposite side
Film records intensity of radiation received
Cracks and flaws = hollow = less radiation absorbed, defects shown as darker areas on film

**Advantages**
Detects internal defects
Permanent record
Wide range of materials
Does not require power source

**Disadvantages**
Requires full compliance with IRR
Requires large exclusion zone
Access required both sides of test piece
Special shielded bays
Time consuming
Expensive
Results not instant
Need for competence
Detailed SSOW required to control hazards exposure to employees / other persons

**Aircrafts**

**Pressure vessels**

**Bridge girders**

**Pipes**

The Lifting Operations and Lifting Equipment Regulations 1998 specify fixed intervals between thorough examinations of lifting equipment but also includes an option for thorough examination to be carried out in accordance with an ‘examination scheme’.

Outline the factors that a competent person would need to take into account when deciding whether less frequent examinations might be justified. (10)

- Age of equipment
- Std’s and specifications of manufacture / design
- Quality conformance of materials at manufacture time (current std's??)
- Manufacturers recommendations on testing, inspection, maint
- History of equipment – extent of use, loads, environments, current / future use
- Accident, breakdown, repairs history
- Modifications records
- Similar equipment
- Previous records of examinations
- Insurance company requirements

The residents of a village have recently been affected by a fallout of dust on their cars and property. They allege that the dust comes from a cement works situated a few miles away.

Outline the steps that should be taken by those responsible for the cement works in order to investigate whether emissions from the works are the cause of the problem. (10)

- MGT – contact residents
- Look at records – previous cases?
- Weather patterns
- Wind direction
- Other potential sources in area?
- Check plant for obvious faults
- Maintenance records
- Monitor on site emissions
- Off site background monitoring
- Analyse dust samples from village – does it match produce?
Consult and liaise with LA
Also Environment agency – inform / consult

In relation to a newly designed machine that falls within Schedule 2 Part 4 Annex (iv) of the Supply of Machinery (Safety) Regulations 2008, outline the procedures that must be followed, and the requirements that must be met, before such a machine is placed on the market for sale in the European Economic Area. (10)

Designer / Manufacturer to ensure compliance to EN standards
EHRS = Essential Health and Safety Requirements (as in directive)
Compile technical file
Manufacturer to carry out internal quality checks in accordance with an EC body
When machinery conforms with Machinery Directive (EC) then = CE Marking
Declaration of conformity
Then entitled to free circulation in EEA

**Technical File**
Description
Wiring / circuit diagrams
Drawings
Lists of standard applied
Risk assessments and controls recommended
Data sheets
Part list
Copies of any markings or labels
Instructions
User, maintenance, installation
Test reports
QC and commissioning procedures
Declaration of Conformity
A company has been contracted to undertake maintenance work on the roof of a building that is partly constructed of fragile material.

(a) Identify the characteristics of the fragile material that may contribute to the risk of falls through the roof. (6)
(b) Outline the measures to be taken to minimise the risk to persons involved with the work. (14)

<table>
<thead>
<tr>
<th>Type of materials</th>
<th>Fibre board, asbestos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Properties of the material</td>
<td>Thickness, known strength</td>
</tr>
<tr>
<td>Age / condition of Material</td>
<td>Corroded, rotten, water sodden, weathered, broken, damaged, repaired previously</td>
</tr>
<tr>
<td>Design of structure</td>
<td>Supports, distance between and position of</td>
</tr>
</tbody>
</table>

(b)
Risk Assessment of works to be carried out
Method statement detailing SSOW and any other relevant controls to be provided
Includes proposed means of access to area of work:
  Scaffold, crawling boards, erection of edge protection, guard rails, toe boards,
Identify fragile areas of the roof – mark with barriers or signs
Provide safety nets / air bags under fragile areas
Identify the need for safety harnesses / fixing points
Hoists for transporting tools and materials
Chutes for removal of rubbish
Competent personnel – fully briefed and aware of risks / controls / precautions
Emergency procedures
Barriers / signs for workers / occupants / public in close proximity
Contractors are required to work in a sewer chamber that is accessed via a vertical shaft. Due to their enclosed nature, the shaft and chamber may have to be categorised as confined under the Confined Spaces Regulations 1997.

(a) Outline the hazards the contractors could be exposed to when undertaking this activity. (7)

(b) Outline the risks that would be classed as ‘specified risks’ under the Confined Spaces Regulations 1997. (6)

(c) Outline the issues to consider when developing emergency arrangements that will be provided during this activity. (7)

**Hazards**
- Unsafe access / egress
- Slippery surfaces – risk of falls / slips
- Gases / vapours / toxic / flammable
- Oxygen deficient atmosphere
- Sudden ingress of water
- Chemical / biological contaminants
- Restricted space
- Low headroom
- Poor light
- Material falling down shaft
- Presence of sharps
- Hot / cold

**Specified risks**
- Injuries from fire / explosion
- Loss of consciousness or asphyxiation – gas / fumes / lack of oxygen / vapours
- Drowning – increased / sudden ingress water levels
- Loss of consciousness from increase in body temperature

**Emergency arrangements**
- Carry out dynamic risk assessments
- Raising alarm
- Rescue operation plan
- Trained and competent rescue team
- Procedures for alerting public emergency services, providing with relevant information
Means of communication – 2 way / inside and outside chamber
Rescue and resuscitation equipment – lifelines, breathing apparatus, lifting equipment
PPE for rescue teams – overalls, face protection, foot / head protection
Fire precautions – extinguishers / evacuation
Identify plant nearby to be shut down in emergency
First aid equipment and personnel
Access points for rescue teams – bear in mind possible remoteness of the site

In relation to dust explosions:

(a) explain the conditions that must be present for a primary dust explosion to occur; (4)

(b) explain the additional conditions necessary for secondary explosions to occur; (4)

(c) identify the causes and effects of the General Foods dust explosion, Banbury 1981; (4)

(d) identify the design features that would minimise the likelihood and effect of a dust explosion. (8)

Primary
Dust = combustible, airborne, mixing with air, particle size and distribution capable of propagating flame

Concentration must fall within explosive limits
Ignition source of sufficient energy
Atmosphere = enough oxygen to sustain combustion

Dust Explosion Pentagon

![Dust Explosion Pentagon Diagram]
Secondary
Dislodgement of accumulated dust from horizontal surfaces, by pressure wave and consequent air turbulence created by primary explosion

Airborne suspension of this dust is ignited by original ignition source / combustion of products from primary explosion / any other ignition source with sufficient energy

General Foods Banbury 1981
Initial fault in pneumatic conveying system
Overfilled holding bin
Air pressure caused outlet filter to fail
Emission and build up of cloud of custard powder
Ignited by electrical arc from broken cable
Injured 9 and damage to wall

Minimise effects of explosion

**Design** of ducting and equipment to withstand effects of explosion
Ensure ducting was dust tight
LEV at transfer points
**Suppression systems** including explosion and fire
**Conveyors** screw instead of pneumatic
**Interlocks** to prevent overfilling and over-pressurisation
**Clearly visible** instrument systems with integral emergency shutdown
**Safe electrical equipment**
**Earthed equipment**
**Prevent build up** – sloped surfaces
**Humidification** – mechanically
A corrosive substance has a flash point of 20°C. An electrical subcontractor has been employed to design and install the electric supply to an open air production plant which is used to manufacture the corrosive substance. This plant is located next to the sea.

(a) Outline the aspects of this situation which the designer of the electrical supply must address to ensure that the installed system will be compliant with the Electricity at Work Regulations 1989. (10)

(b) Describe the types of fault that may be found in fixed electrical systems under such conditions. (10)

**Mechanical damage**
Impact, stress, strain, abrasion, wear, vibration, pressure

**Weather impacts**
Resistant to adverse conditions, UV degradation

**Environmental**
damp, dirt, corrosive leaks, salty air / water,

**Flammable**
Vapour leaks, spills, effluents,

**Supply factors**
Lighting, instrument panels, maintenance requirements, restricted spaces, low temperature

**Faults**
Equipment unsuitable for wet / corrosive conditions, exposed live conductors, damaged or perished insulation, damaged conduits.
Corroded access grills, transformer casings – ingress of water = short circuits
Poor earthing
Damage to means of isolation – corrosion
Incorrect fuses = inadequate protection from excess current
Outline factors to be considered when developing a planned preventive maintenance programme for safety-critical machinery. (10)

Manufacturer’s recommendations
Servicing / insurance requirements
Reliability of critical components – predicted failure
Effects of failure on other parts and on the process in general
Need to store parts in readiness for replacement
H+S risks of malfunction
Age and condition of machinery
Usage / breakdown history / operating environment
Timing – weekends? Prevent disruption
Recording of maintenance
Competence – specialist training?
Legislation requirements – HASAWA, PUWER, Elec at Work Regs.

A manually operated lathe is to be fitted with a Computer Numeric Control (CNC) system.

Outline:
(a) additional hazards this may introduce; (4)

(b) measures required to minimise the risks associated with these hazards. (6)

Hazards
Increased speed
Rise in noise levels
Unexpected movements
Errors in programming / software
Setting risks
Lack of competency

Controls
Risk assessment for new equipment
Fixed / interlocked guards to prevent access during automatic cycle
Manual operation for setting / cleaning
Relocate controls outside danger zone
Training – competency
A diesel engine is being used to power a machine in a potentially flammable atmosphere.

(a) Identify sources of ignition associated with the diesel engine. (4)

(b) Outline the protection that should be applied to the diesel engine to minimise the risk of an explosion. (6)

**Ignition sources**
- Flames / sparks from exhaust system / inlet system
- Sparks from engine electrical system – overspeeding / overloading
- Impact sparks from cooling fan – friction

**Protection**
- Spark arrestors – stops hot carbon particles exiting the system
- Inlet shutdown valve – shuts engine down if overspeeding – includes flame arrestor
- Water cooled exhaust gas cooler – limits surface and exhaust temp
- Flameproof alternator
- Insulated battery compartment
- Exhaust flame arrestor
- Zone 1 and 2 compliant electrical equipment
- Cooling fans made from plastic with adequate clearance from other parts of engine to prevent friction sparks

(a) Outline the principles of a boiling liquid expanding vapour explosion (BLEVE) AND give examples of actual incidents to support your answer. (8)

(b) Outline the effects of a BLEVE. (2)

**BLEVE**
- Storage of liquid under pressure in a vessel
- Presence of external heat source
- Increase in pressure as liquid absorbs the heat resulting in the opening of a relief valve
- Expulsion and ignition of vapour to release pressure
- Subsequent lowering of liquid level in the tank
- More of the tank surface exposed to absorb heat
- Development of overpressure – rupture of the vessel
- Emission of boiling liquid and vapour which is then ignited by the heat source
Mexico City 1984

PEMEX LPG Terminal
Gas leak – not detected. Overflowed from bunds after 10 minutes
Wind carried it to the waste gas flare pit.
Vapour cloud explosion which then caused the first BLEVE, flowed by 12 more over the next hour at separate tanks.

Local town – demolished houses, propelled metal fragments from explosions, up to 1200m.
Much of the tow destroyed
500 – 600 deaths
5000 to 7000 serious injuries
Radiant heat generated by the inferno

Palermo 1996
LPG tank lorry involved in accident in a large tunnel
Gas leaked and ignited, minutes later causing a BLEVE from the remaining gas
Most people managed to escape the tunnel due to the time delay
5 dead, 20 severely injured

Effects
Rapid spread of boiling liquid and vapour (explosion)
Fireball producing substantial thermal radiation
Debris and missiles projected from the vessel
Possible shockwave (dependant on the size of the vessel / explosion)

Outline the characteristic features of, and factors that promote, the following types of materials failure:

(a) brittle fracture; (5)

(b) ductile failure. (5)

Brittle
Without warning or prior evidence of distress
Crystalline structure failure
Minimal deformation
Characteristic “chevron” marks from point of initiation
Sudden failure from rapid stress loading
High tensile stresses
Sudden loading which does not give material time to deform
Case hardening
Low temps
Degree of brittleness of material

Ductile
Smooth fracture surface
Plastic deformation of material before final fracture
Final fracture often brittle due to insufficient material left to sustain the load
Single stress overload
High temps
Cold work hardening
Plasticity of material

A company intends to build a flammable solvent distribution facility as part of its chemical manufacturing premises. The facility will include three 40,000 litre storage tanks that are pump filled via pipelines from batch reactors. The storage tanks supply an outdoor road tanker filling system as well as a small container filling facility located inside a warehouse.

Outline the design features that should be adopted to prevent or minimise leakage and spills from the proposed installation. (10)

All pipework is of weld construction
Minimum number of flanges
Suitably corrosion resistant material
Pipework routed along a containment trench / double skinned
Further protected by barriers near vulnerable points (roads etc.)
Storage tanks in bunded area capable of containing 110% capacity
Base and walls impervious and free from breaches for services
Tanks fitted with high level detectors interlocked with pump cut out / emergency shut down
Pumps in bunds
Road tanker stands located in shallow bund
Snap shut connections on filling lines
All valves designed to prevent leaks – double mechanical seal to prevent leaving accidently open
Manual filling lance – dead man’s handle together with supply cut out when expected weight / volume is reached
A three-storey building is situated with one side fronting on to a pedestrian walkway. The building is to undergo extensive maintenance to the external fabric which includes a sloping roof.

Outline:
(a) the health and safety issues of the work that will need to be considered before work starts; (11)

(b) the features of a scaffold designed to provide a safe place of work for working at height during the maintenance activity. (9)

Environment / planning / PPE / Controls / SSOW

Barriers
Protection from plant and falling materials
Screening
Work at height precautions
Safe access for materials / loading
SSOW – sand blasting, water jetting etc.
Suitable plant and equipment – roof ladders, access equipment
Security
Safety of occupants
Asbestos? Flammable?
Other hazardous materials
Need to consult any health and safety files
Proximity / location of services
Effects on neighbouring buildings
Exposure to sun / inclement weather
Bird droppings
PPE
Welfare

Scaffold
Safe erection
Upright standards positioned on base plates
Stable level ground
Horizontal ledgers
Tight couplers
Adequate bracing
Guard rails
Tie into structure
Platforms wide enough to work safely
Fully boarded platforms
Safe access
Minimise / plug gap between scaffold and structure
Special working platform below the eaves
Protect from vehicle collision at base
Chute for disposal of waste
Erected by competent persons
Only used at designed and correct levels and not overloaded
Inspection at regular intervals

An independent tied scaffold to a new ten-storey office block has collapsed into a busy street.

(a) Outline the factors that may have affected the stability of the scaffold. (8)
Scaffold not followed intended design
Design inadequate
Unsuitable ground
Surface water or excavation / ground works compromising foundations
Incorrect / damaged fittings
Bent standards
Lack of ties
Unauthorised alterations
Overloaded – materials or blocked waste chutes
Impact – cranes, vehicles
Severe weather conditions

Construction work is to take place in a rural area where electrical power for the site is to be gained from an existing 11kV overhead supply that cuts across the site on wooden poles.
Outline control measures that should be taken to reduce risks associated with the:
(a) overhead supply; (8)
Consider re-routing the lines
Consult utility company
Identify safety distances
Barriers
Marking tape
An insulated chemical reactor vessel has become coated internally with a sticky by-product of a chemical reaction which is interfering with the efficiency of the process. It is decided that the reactor must be cleaned of the material.

The substance in question becomes liquid and mobile at 60°C. However, it decomposes exothermically at 95°C reacting with the oxygen content of air.

The vessel, which was an 8m long cylinder of 2m diameter, was laid on its side, adjacent to its usual plant location to facilitate entry for cleaning via a hatchway in the base.

As warm water proved to be a very slow cleaning medium it was decided to use steam cleaning delivered by hand-held lances and rake out the softened material with metal rakes.

Shortly after commencing the steam cleaning the operatives involved heard a rumbling and noticed a blue flame on the surface of the reactor wall. They evacuated the vessel and had just done so when a jet of flame was emitted from the hatchway which travelled 30m to the wall of the company office building and continued playing on it for 2 minutes. The resultant fire in the office building caused multiple fatalities.

(a) Describe the nature of the combustion reaction involved in generating the incident. (5)

Exothermic runaway reaction

Reactive chemical heated to decomposition
Reacted with oxygen in the air
Insulation of vessel together with bulk of liquid formed = build-up of heat and rapid rise in reaction rate (quicker than heat is removed)
Gases created would ignite = enough energy to create a jet of flame

(b) Outline the technical and operational failings that could account for the conditions which led to the incident and the resultant fatalities. (8)

No adequate risk assessment prior to work being carried out
Failure to analyse by product before cleaning
Failure to recognise possibility of exothermic runaway reaction
Did not understand the nature of decomposition products (flammable gas)
Did not appreciate effects of applying steam at 100°C
Design stage failings – did not consider need for cleaning / maintenance
Metal rakes could produce sparking
Lack of effective supervision – likely cause of abandonment of warm water cleaning
No PTW system used – no control of ignition sources

(c) Outline the controls necessary in such installations to prevent repetition in similar circumstances. (7)

Removal of vessel to safe, secure, remote quarantined site
Removal of vessel insulation to aid heat removal
Use of appropriate solvent for cleaning at ambient temperatures
Forced ventilation into vessel – ensure gases kept to safe limits
PTW system to control ignition sources, entry, hot work
Selection of suitable electrical equipment –
Employees fully instructed and trained in the hazards and controls

A factory manufactures upholstery using fabrics, and plastic pellets.

These raw materials are delivered to a warehouse. The fabrics and plastic pellets are machined to form furniture coverings and cushions.

The finished product is then stored in a despatch warehouse prior to distribution. The movement of goods around the premises is carried out by Liquid Petroleum Gas (LPG) fuelled forklift trucks. The company is located on the outskirts of a small town and employs 230 people.

Outline the range of factors that must be addressed to ensure a suitable and sufficient fire risk assessment is made for the premises. (20)

Fuels
LPG for trucks
Flammable coverings produced
Untreated fillings (pellets)
Building construction materials

Ignition Sources
Electricity
Static from machinery (lack of maintenance)
Illegal smoking
Poor maintenance controls – hot work etc.
Arson?

People
Number to be evacuated
Including visitors and contractors
Disabled persons

Preventative actions
Segregated LPG storage
Bunding and sprinklers
Regular maintenance of electrical systems
Cleaning of trucks and machinery
Fire resistant covering materials
Minimum stock kept on shop floor
Good housekeeping
Segregation of waste

Mitigating actions
Compartmentalisation of higher risk areas (plastic store)
Selection and location of firefighting equipment
Adequate supply of water and foam
Ensure audibility of alarms
Access for emergency services

Means of escape
Correctly specified fire doors
Consider travel distances
Multi storey, stairwells etc.
Clear signage
Management systems
Maintenance and testing of equipment and precautions
Appointment and training of fire wardens
Fire drills
Training for evacuation, use of equipment, raising alarm

(a) Outline the duties of designers under the Construction (Design and Management) Regulations 2007 (CDM 2007). (6)

Designers
Avoid foreseeable health and safety risks in design, of any person:
- Carrying out construction work
- Future maintenance
- Cleaning of structure
- Using as a workplace

Sufficient information to client / other designers / contractors so they can comply with their own duties
Produce information as required for the health and safety file
Check that the client is aware of his duties
Notifiable project: required notification has been made
Necessary competence

(b) Outline examples of the ways in which designers can affect the health and safety performance of a construction project. (4)
Specify safer materials from a COSHH perspective
Reduce manual handling by reducing block size
Promote safer construction methods – fit windows from inside, work at height reduced to minimum

(c) A contractor is to be engaged to demolish a disused factory. Outline examples of the information that the client should provide to the tendering contractors to fulfil their duty under CDM 2007. (10)

Location of buried services, underground tanks
Hazardous and flammable substances on site
Hazardous machinery or equipment remaining
Contamination of ground or drains
Asbestos
Weaknesses in structure – fragile roofs, rot, unstable ground
Previous uses of the land
Means of access
Traffic routes
Proximity of neighbours
Details of project coordinator

Is the project notifiable?? Projects which last longer than 30 days OR involve more than 500 person days of work

Health and safety file for building

The Health and Safety File should contain the following information:

- a brief description of the work carried out
- any residual hazards which remain and how they have been dealt with (e.g. information concerning asbestos, contaminated land, buried services etc.)
- key structural information (e.g. bracing, sources of substantial stored energy – including pre- or post-tensioned members etc.)
- safe working loads for floors and roofs, particularly where these may prohibit placing scaffolding or heavy machinery
- hazardous materials used (e.g. pesticides, special coatings which should not be burnt off etc.)
- information regarding the removal or dismantling of installed plant and equipment (e.g. any special arrangements for lifting, special instructions for dismantling etc.)
- health and safety information about equipment provided for cleaning or maintaining the structure
- the nature, location and markings of significant services, including underground cables; gas supply equipment; fire-fighting services etc.
- information and as-built drawings of the structure, its plant and equipment (e.g. the means of safe access to and from service voids, fire doors and compartmentalisation etc.)

Tanker drivers are routinely required to access the top of road tankers during normal operations.

Outline the factors that should be considered when assessing the risk of falls whilst undertaking the work on top of the road tanker. (10)

Access to top of tanker – if unavoidable then consider:
Height of tanker
Frequency of access required
Task being performed
A zoo is drawing up a waste management policy and associated procedures. Taking account of the types of solid waste produced, outline the issues that should be addressed by such a policy and the associated procedures. (10)

POLICY =
STATEMENT OF INTENT
ALLOCATION OF RESPONSIBILITIES
PRACTICAL ARRANGEMENTS

Statement of intent
The need to minimise production of waste
Recycle as much as possible
Comply with environmental legislation
To protect the health and safety of employees, public, contractors and animals.

Responsibilities
Clearly defined and allocated to managers, employees, contractors

Arrangements
Segregation
Procedures – biological waste handling
With reference to European machinery standards, explain the meaning of the following categories of standard: Type A, Type B1, Type B2 and Type C AND give a practical example in EACH case. (10)

Type A
Basic safety concepts, design criteria
Apply to all machinery
*Principles for risk assessment, general safety requirements*

Type B1
In support of General Principles of Type A
*Safety distances – for design of light curtains*

Type B2
Protective devices – performance
*Design and testing of stop buttons, safety switches, light guards*

Type C
Specific risks
Controls for specific risks on specified machines
*Hydraulic presses*

*If a Type C exists, it takes priority over A and B.*
*If no C, A + B should be applied in risk reduction when designing or manufacturing a machine.*
A new, self-contained air compressor is to be installed in a workshop.

(a) Identify THREE protective devices that may be necessary to control the risk of over pressurisation AND for EACH device outline its purpose. (6)

**Pressure gauge** – identify pressure of the receiver
**Safety valve** – relieve excess pressure when max safe working pressure reached at receiver
**Pressure cut-out** - cuts off compressor when working pressure is reached

(b) Identify the information that must be displayed on the air receiver in order to comply with EU requirements for pressure vessels. (4)

**CE Marking** – with last two digits of year of manufacture
Max / Min safe working pressure / Temp
Capacity of vessel in Litres
Name of manufacturer
Type / serial number
Reference to EN stds.
**Easily legible and indelible**

The condition of pipework 4m above ground requires inspection. It is proposed, in the absence of the availability of a mobile elevating work platform, to utilise a personnel cage lifted to the required height by a forklift truck.

Outline the factors to be considered when assessing the risks associated with this method of access. (10)

**EQUIPMENT**
Cage = adequate design and construction, toe boards, guard rails,
Total weight of cage + persons not to exceed 50% of SWL of FLT
Cage weight displayed clearly
Means to fix cage securely to forks
Guarding from moving parts of FLT
Cage and FLT examined and tested in accordance with LOLER

**TASK**
FLT on firm, even ground
Mast vertical
Forks in mid position
Mechanically locked to prevent inadvertent operation
Driver at controls at all times
FLT must not move
Means of communication
Barriers around the area – collision, falling materials
Fall arrest equipment
Hazards with equipment being inspected – heat, steam, asbestos…

As part of its water treatment system, a manufacturer is to install a plant suitable for the reception and storage of sulphuric acid and caustic soda, both of which will be delivered in bulk tankers. Both of these substances are highly corrosive and can react together violently.

Outline the safety provisions required for:
(a) the design; (10)
Chemical resistant materials
Organic materials avoided – acid
Delivery inlets – different connectors to avoid wrong connections
Separate bunds – each capable of entire contents + 10%
Protection from all weather conditions
Colour coded pipework to BS
Level indicators and high level alarms
Cut-out pump interlocks
Good vehicle access for tankers
Spill containment arrangements
Good lighting
Measures to avoid tankers driving off whilst connected

(b) the operation; (6)
SSOW agreed with suppliers – 2 man operation for filling
Emergency procedures – spills
Prevention of drain contamination
Provide and maintain spill kits
Training – drivers,
PPE - suits, gloves, full face protection

(c) the maintenance of the proposed storage facility. (4)
Examination and testing of safety critical equipment
PTW systems
Flushing out and isolation before maintenance
Regular cleaning of bunds
Training including for emergency procedures

A warehouse that stores stationery products generated six false fire alarms over a three month period while in the process of expanding its premises.

On each occasion, the local Fire and Rescue Authority attended the premises. After the last occasion, the Fire and Rescue Authority inspected the warehouse and discovered that the employees had failed to evacuate on all but the first occasion.
They also discovered that no testing or maintenance had been carried out on the fire alarm system for five years.

(a) Outline the range of enforcement action options the Fire and Rescue Authority may take as a result of their inspection findings. (10)

Fire authority – if they consider to be high risk premises – alteration notice – employer must send proposals for improvements together with completed risk assessment

If dissatisfied with risk assessment or proposed action – enforcement notice – 28 days to make improvements

If considered serious risk – prohibition notice – prohibits or restricts use of premises until remedied. May be enforced immediately or after specified period

Failure to comply – prosecution by fire authority.

(b) Identify the possible causes of the false alarms. (6)

Corrosion
Wiring defects
Wrong choice of detectors
Wrong positioning of detectors
Failure to isolate zones for hot work
Dust / spillage activating optical sensors
Smoking
Deliberate alarms / horseplay
Identify the actions the warehouse company should take to ensure their employees respond appropriately to fire alarms. (4)

Minimise false alarms
Adequate training
Reminders – pocket cards, posters
Fire drills – senior mgt play leading part
Incentives for best evacuation times
Disciplinary action for persistent offenders

Outline what is meant by the term ‘fixed guard’ and ‘automatic guard’ in relation to machinery safety AND identify the circumstances where each type of guard might be appropriate AND give a typical example in EACH case. (8)

Fixed:
Fixed by screws, nuts, welding.
Can only be removed by use of special tools, or destruction of means of fixing.
Not connected to any controls.
For when infrequent or no access is required to hazardous parts of machinery.
Examples – guarding a belt and pulley drive, flywheels, chain drives.

Automatic:
Moves into position automatically by the machine
Removes any part of person away from the danger zone
Example – slow moving, long stroke power presses

To ensure that machine operators are adequately protected, describe the factors to be considered in the design and use of:

(i) fixed guards; (6)

Design:
Material – robust enough to withstand rigours of workplace and ejection of material
Allow sight of the process
Fixing – use of a tool for removal
Openings – do not allow access to dangerous parts, size of opening is relative to safe distance from hazardous parts
Noise – does not vibrate
Use
Monitor and supervise – guard is not compromised – safety tours etc.
SSOW – maintenance and setting etc.
Training for maintenance and operators

(ii) automatic guards. (6)

Design:
Compatible with machine – speed / stroke?
Convenience of use? Space restrictions?
Height and reach of operator
Force and movement of guard
Possibility that the guard might fail to danger
Possibility of defeating guard

Employees in a vehicle maintenance workshop undertake spray-painting of vehicles using a solvent based paint that has a low flash point.

Assuming that a risk assessment has been carried out, outline the practical measures to control the risk of fire and explosion associated with the paint spraying activity. (20)

Workshop – fire resistant design
Paint in fire resistant booth
Possibly replace paint with less flammable one?
Restrict amount of stock held in workshop
Non-spill containers with lids
Separate external flammable stores – safe distance from workshop / other buildings
Ventilation – high and low level
LEV for spraying activity
Electrical equipment – flame proof, safe for flammable atmospheres, good earthing
Anti-static footwear and clothing
Spills – containment and cleaning procedures
Firefighting equipment and training / procedures / escape routes
Training for all employees
Outline the issues that need to be addressed when planning a fire evacuation procedure for a multi-storey office building. (10)

- Raising alarm
- Informing emergency services
- Liaise with emergency services – advice on response times etc.
- Consider all abilities – physical and sensory
- Travel distances
- Alternative routes
- Safe refuges – stairwells etc.
- Evacuation equipment
- Phased evacuation for different floors
- Emergency lighting
- Clear signage of routes
- Assembly points
- Access for emergency services
- Clarifying staff responsibilities
- Training
- Accounting for personnel
- Preventing re-entry
- Security – theft whilst evacuated
- Liaise with neighbours – if affected by emergency
- Drawn up and summarised – on notice boards etc.
- Tested with regular drills

In order to install a large item of machinery such as a turbine rotor, it is sometimes necessary to perform adjustments while the rotor is in motion. These adjustments are necessarily undertaken with the rotor in an unguarded condition.

Outline the elements of a safe system of work for this activity. (10)

- Competent workers – NOT for young / inexperienced workers
- Fully trained
- Single one piece overalls – no external pockets
- No other entanglement hazards – jewellery, long hair
- Temporary guards to isolate unnecessarily exposed parts
- Use of jigs to ensure workers’ hands are distanced from rotor
- Stand by men – in direct communication – ready for emergency
- Emergency stop / braking if needed
- Inching device / use of slowest speed of rotor
Maintenance work on electrical distribution panels and control circuitry commonly involves diagnostic testing and fault finding on live systems.

Outline the requirements of the Electricity at Work Regulations 1989 that apply to this situation AND the practical precautions that should be in place before the work is undertaken. (10)

1. It is unreasonable to make the equipment dead - unavoidable
2. It is reasonable to work on it whilst it is live
3. Suitable protection –
   - Distribution panels – test points – do not allow hands t access – tools only
   - Test probes / tools – insulated and fused
   - Test meter checked prior to use
   - Area cordoned off
   - Insulating mats, hats, gloves if required
   - Live working = PTW system

Competent persons or supervised by competent
Recognised qualifications and experience of similar work

Cabinet should be earthed

Sufficient working space
Lighting
Access
X-ray radiography is a non-destructive testing (NDT) technique that is sometimes used to examine the internal structure of fuel tanks in the wings of large passenger aircraft.

(a) Outline the principles of operation when using X-ray radiography for this application. (4)
Radiation generated by portable machine
Focussed into a beam by lead shielding
Directed to penetrate surface, to reach film placed on other side / inside
Image created on film after processing
Defects revealed by contrast between light / dark areas
Darker areas = more radiation passed through due to defects

(b) Other than visual inspection, explain why different forms of NDT might not be appropriate for this application. (4)

Gamma –
Impractical and too expensive

Eddy current –
Only for surfaces
No permanent record

Dye Penetration –
Only indication of presence of defects – not depth / severity
Only for surfaces – not internal / tanks

MPI (magnetic particle imaging) –
Does not work on non-ferrous material
Access to internal would be impossible

(c) Identify TWO disadvantages in the application of X-ray radiography. (2)
Expensive
Manual handling of equipment
Training of operators
Exposure to x-rays
Outline the key safety features of a facility that is to be used for the storage of highly flammable solvents in 200 litre drums. (10)

- Building to be safe distance from other buildings
- Constructed of fire resistant materials, including doors
- Erected on an impermeable base
- Bunding to contain spills
- Collection and disposal of spillages
- Light-weight roof / blast panels
- Low and high level ventilation
- Ramp for access / egress and movement of barrels
- Sprinklers / fire extinguishers for use in emergency
- Provision of spill kits
- Locks and warning signs
- Clearance of vegetation around the area

The use of a tower crane on a construction site must be notified to the Health and Safety Executive before it is brought into first use.

Outline the safety concerns in relation to the use of tower cranes on construction sites that have influenced the introduction of this legal requirement. (10)

- Initial erection – mis-assembly of structural components, undetected component defects
- Failure to carry out pre-use inspection- identify correct specification of parts for intended use
- Extension / dismantling – inadequate support of components, compromised stability, poor communication with ground
- Clearing zones – inadequate where more than one tower crane, over areas outside of construction site
- Access – vertical ladders, high standard of fitness
- Welfare – inside cab – heating, breaks = human error
A storage tank requires inspection, cleaning and repair. It is 6 metres in diameter and 10 metres high and was previously used for storing leaded petrol.

Outline the arrangements that should be considered in order to comply with the Confined Spaces Regulations 1997. (20)

**Entry** –
Only if not reasonably practicable to achieve purpose without entry

Can any of the work be done without entering the tank –
Cameras for inspection
Robotic inspection systems
Cleaning lance operated from outside

**SSOW** –
Related to any of the risks present
Fire, explosion, loss of consciousness to due asphyxiation or high temperatures
Full risk assessment – consider previous contents of tank – flammable atmospheres
Air contamination from cleaning products – need for ventilation and BA
Lead = toxic
Working from height – access / egress
Escape and rescue arrangements

Purging with inert gas
Forced ventilation
Atmospheric testing before entry
Electrical equipment – safe and earthed

Job rotation and fluid intake

**Procedural** –
Establish well defined SSOW
Entry permit system
Limit number of people
Communication with stand by personnel (outside tank)
Emergency arrangements

**Emergency arrangements** –
Provision and maintenance of cutting equipment
Hoists for rescue
Fire-fighting equipment
PPE / BA
First aid facilities including resuscitation
Liaison with emergency services

Training –
For all, including rescue teams
Work methods
Emergency
Precautions

(a) With reference to the Pressure Systems Safety Regulations 2000, explain what is meant by a ‘pressure system’. (4)
(a) One or more pressure vessels of rigid construction, associated pipe-work and protective devices.
(b) Pipework, with its protective devices, to which a transportable pressure receptacle is, or is intended to be, connected.
(c) A pipeline and its protective devices
…which contain a relevant fluid (eg. Steam)

(b) Outline FOUR examples of the mechanisms of mechanical failure in pressure systems. (8)

Water hammer –
Condensate builds up from obstructions (seals, flanges etc,)
Steam pushes the water around the system
Water builds up, finds a weak point in the system and explodes

Ductile fracture –
Slow crack growth due to overloading

Brittle fracture –
Rapid crack growth with no prior visible deformation. Due to overloading / stress

Thermal fatigue –
Excessive heat over time. Causes cracks. Incorrectly specified materials / insulation.

(c) Outline the technical AND procedural measures to minimise the likelihood of failures in pressure systems. (8)
Correct design specification
System is fit for purpose
Appropriate safety features (pressure release valves, level sensors)
QC during manufacture
Inspection and maintenance procedures prepared by competent person
Non-destructive testing
Ensure system operates within parameters
Water – filtered / treated

(a) Describe the effects of a fire in a workplace on the following structural materials:
(i) steel; (4)
Expands when heated
Loses strength and buckles
Regains strength on cooling but may have different properties

(ii) concrete; (4)
Limited expansion
Cracks
If steel reinforced – concrete will crack as steel expands
Strength lost on cooling – loses integrity

(iii) wood. (4)
Thin sections burn
Thicker timber will char on outside
Generates smoke and fumes
Will retain integrity

(b) Outline the precautions that could be taken to prevent failure of these materials in the event of fire. (8)
Steel –
Sprayed with concrete
Fibre board of appropriate rating

Concrete –
Selection of fire-resistant mix
Greater depth of concrete before steel reinforcement

Wood –
Fire resistant timber
Increasing thickness – allows for charring of outer layer only
Impregnate with fire retardant

General –
Compartmentalisation – prevent heat transfer
Automatic application of water to structural members in a fire
Fire resistant surface claddings

Part 4 of the Construction (Design and Management) Regulations 2007 require that certain places of construction work are to be inspected by a competent person.

(a) Identify:
(i) when statutory inspections of supported excavations must be carried out; (3)
Start of every shift before work
After an event that may affect stability of excavation
Following unintentional fall of material

(ii) the information that should be recorded in a statutory excavation inspection report. (5)
Name and position of person making the report
Name and address of person who report is for
Description of place of work, including the plant and equipment in use
Date and time of inspection
Details of anything identified that could lead to risk
Actions taken to prevent risk
Details of any further action

(b) Outline the particular features of an excavation that could result in it being considered unsafe. (12)
Proximity to adjoining structures
Poor support of soil
Damage to / dislodgement of supports
Presence of excess water (pipes or land drains)
Damaged services
Presence of fallen rock, earth or other materials
Inadequate means of access / egress
Presence of gas, fumes, biological or chemical hazards
Inadequate barriers / warning signs to prevent persons falling in
(a) With respect to UK mains voltage electricity, outline the factors that determine the severity of the effects of an electric shock. (6)

Voltage
Current – DC or AC
Resistance of individual – age, gender, amount of moisture on the body, footwear worn
Route of entry
Speed of action of any protective measures (RCD etc.)
Floor material
Presence of water

(b) For EACH of the following protective devices, describe their principles of operation:

(i) residual current devices; (3)
Shock limiting device – not system protection
Detects differential in current
Operates switch to cut off supply
Prevents severe shock

(ii) fuses; (3)
Placed in live side of circuit
Automatic cut off of supply
Supply exceeds given value and produces enough heat to melt fuse
Slow reaction for shock prevention
System protection NOT person

(iii) 110v centre tapped to earth reduced voltage systems. (3)
Step down transformer
Earthed to centre = max voltage in shock = 55v
240v in
110 v out divided 2

(c) Outline other design features of electrical systems intended to improve safety. (5)
Selection and colour coding of cables
Effective means of isolation
Earthed systems
Circuit breakers
Double insulation
Outline the arrangements in a motor fleet policy that will minimise the risk to a company sales force in which the sales personnel are expected to spend around 150 days a year travelling around their respective sales areas. (10)

Individual competence, fitness, behaviour
Vehicle selection / maintenance
Incident reporting
Emergency procedures
Journey planning
Keeping in touch - checking into office – phone, email.
Provision and monitor of breaks
Training in legal requirements and other safety arrangements

(a) Define the following terms:
(i) flash point; (2)
The lowest temperature at which a volatile material can vaporize to form an ignitable mixture in the air.

(ii) auto-ignition temperature. (2)
The lowest temperature at which a substance will spontaneously ignite in a normal atmosphere without an external source of ignition.

(b) Flammable limit data, provided by a UK solvent manufacturer, as part of their safety data sheet, is given as the upper and lower flammable limits as percentages of vapour in air at standard air pressure and 20°C temperature.

Outline the way in which this data should be interpreted to give practical guidance on the prevention of fire and explosion. (6)
Data will specify upper and lower limits of mixture of a substance with air needed for the substance to burn.

Use of LFL sensors to monitor / detect increase in vapour concentration
Removal of oxygen in the air (inerting) would prevent combustion
Operating at an ambient temperature well below the flash point would prevent flammable atmosphere being generated

(a) Outline the hazards associated with the use of steam in industrial power and heat generation systems. (5)
Heat
Pressure
Noise from leaks / application of steam
Steam hammer in pipework
Static electricity generation
Heated pipework as a source of ignition

(b) Outline causes and effects of the event known as a “steam explosion”. (5)

Fukushima – molten core contacted with coolant sea water, rapid steam generation as water boils, increase in pressure with increase in volume of steam.

Effect = vessel will weaken and explode, contents (steam, water, other molten materials) ejected, missiles from parts of machinery, vessel.

A 150 year-old four-storey brick built brewery with a pitched slate roof is to be converted into executive apartments.

(a) Outline the causes of structural damage that a building surveyor might discover. (5)

Adverse weather
Loss of roof materials, exposed timber
Damage to windows, cladding
Heavy snow – weakened roof

Previous industrial use
Impact from vehicles, fit’s etc.
Damaged door edges, flooring
Corrosion from substances used, seepage
Temperature changes – expansion and weakening of building
Vibration from machinery – cracks, subsidence

Over time
Subsidence
Damp, rotten wood / timber due to age, inadequate care and protection
Vegetation roots – damage to foundations

(b) Outline the ways in which the conversion activities may give rise to structural failures. (5)

Removal of load bearing walls would weaken the structure
Overloading existing structure – beyond its original designed limitations
Excavations – near to foundations
Vibrations from plant
During a fire drill exercise at a large multi-storey office premises, the majority of the occupants evacuated the building in less than three minutes. However, all of the people based in one area of the building failed to leave the building until a further four minutes had elapsed.

(a) Explain the issues that may have contributed to the delay in evacuation. (15)

Distance from alarm sounders
Volume of alarm / clarity
Complex escape routes, procedures
Phased alarm?
Lack of fire marshals to guide evacuees
Disabled workers
Stairs / not using lifts
Awaiting assistance at safe refuges
Lack of training
No clear responsibilities
Doubt as to whether it was a false alarm or not – frequent false alarms

(b) Outline the advantages of undertaking regular fire drills in workplaces. (5)

To comply with legislation / insurance requirements
To familiarise occupants with procedures / duties
To test current systems and seek areas to improve
For communication of procedure – particularly if high turnaround of staff / casual workers

(a) Describe the following hazards associated with an abrasive wheel:

(i) mechanical; (5)
Contact / entanglement / cuts / grazes
Bursting wheels – ejection of materials
Failure to wear eye protection / protective screens
Vibration – HAVS
Noise generated

(ii) non-mechanical. (5)
Ergonomic hazards – poor posture with hand held grinders
Trips over cables
Fire and explosions caused by dust
Inhaling harmful dusts or fumes generated by operation
Items being ground may be hot to touch
(b) Describe the protective devices and guards that would be found on an abrasive wheel to minimise the risk of injury from mechanical hazards. (4)

Tool rests – minimum gap and no more than 5mm
Eye guards must be fitted and used
Fixed guard on hand held grinders, all fixings must be fastened tightly
PPE – eye protection, goggles must always be worn. Gloves to protect hands
E-stops for fixed grinders
Pedestal grinders – exclusion zone marked on floor

(c) Explain the risks associated with an abrasive wheel arising from its deterioration. (3)

(d) Explain why employees require training for activities involving an abrasive wheel. (3)

A company is planning a change of premises from one containing a “manual” warehouse to one which contains automated order picking and automated guided vehicle (AGV) goods transfer facilities.

(a) Outline the risks which might be reduced by the move. (10)

Manual handling
Working at height
FLT / Pedestrian interaction
FLT collisions
FLT emissions
FLT static electricity, ignition sparks
Noise – less people in the area = less affected by hazard
WBV from FLT
Avoidance of human error
Reduction in heating and lighting costs

(b) Outline the risks which might arise from the move. (10)
A road haulage company intends to transport significant quantities of bulk flammable materials in tank containers. They are advised that they require a “Dangerous Goods Safety Adviser”.

(a) Outline the criteria under which a „Dangerous Goods Safety Adviser“ must be appointed. (4)

Appoint DGSA if organisation transports dangerous goods.

Unless:
- Only occasionally (i.e. breakdown services)
- Only receiving the goods
- In limited quantities (specified in part 3 of ADR)
- Moving very short distances
- Using private vehicles

(b) Outline the particular duties of a „Dangerous Goods Safety Adviser“. (6)

Monitor compliance with rules
Advise employer on compliance
Prepare annual report to management on transport of DG
Monitor procedures and controls
Investigate and report – incidents, including property / environmental damage
Advise on potential security aspects of transport

(c) Outline the procedures and practices that a „Dangerous Goods Safety Adviser“ should be monitoring in the event that the tender is successful. (10)

Compliance requirements – ID of goods
Advice on purchasing new transport
Procedures for checking equipment – carriage, unload, load
Trainings and records
Emergency procedures – implementation
Investigating serious incidents
Implementation of corrective actions
Consider legal requirements when using 3rd part contractors
Ensure all employees have detailed instructions
Training – risks
Ensure load carries documents, safety equipment, as required
Implement and monitor loading and unloading procedures
Detailed security plan
Under the Confined Spaces Regulation 1997, an enclosed space where work is undertaken is designated a confined space ‘by virtue of its enclosed nature’, in addition to where ‘there arises a reasonably foreseeable specified risk’.

Outline the range of reasonably foreseeable specified risks that, if present, would cause the enclosed space to be designated a ‘confined space’ AND, in EACH case, outline a practical example of the specified risk. (10)

**Serious injury to any person at work from fire or explosion**
Cleaning the flammable residue from the internals of a tank / chamber, with scraping tools, and steam / heat tools. Increase in oxygen levels due to cleaning process, presence of flammable atmosphere, ignition source (scraping – friction).

**Loss of consciousness from increase in body temperature**
Carrying out maintenance tasks inside an enclosed tank, with no adequate forced ventilation or air cooled breathing apparatus.

**Loss of consciousness from gas, fumes, vapour, lack of oxygen**
Carrying out welding repairs inside a tank, build-up of welding fume (toxic)

**Drowning from increase in liquid levels**
Carrying out work in a sewer, without precautions taken against water ingress through the system.

**Asphyxiation / unable to move from free-flowing solid**
Working inside a grain silo, without a proper PTW system, inadvertent filling of silo.

**(a) breakdown maintenance;**
Repairing breakdowns as they occur. Unpredictable, difficult to plan for / hold parts for. If it ain’t broke, don’t fix it.

**(b) condition-based maintenance.**
Monitoring performance of parts, reactive maintenance based on evidence. deterioration.
If it ain’t broke, and you can prove it, don’t fix it.
Requires expensive equipment for data analysing. Can be costly just to investigate / gather data.

**Preventative maintenance**
Carrying out maintenance on safety critical parts before they fail, based on manufacturers and historical data / failure rates. Requires stock to be held in advance. Regular intervals.
Cost effective
Easy to plan
More reliable
Describe the principles of safety integration that must be followed by manufacturers who supply new machinery into the European Economic Area. (10)

**Principles of safety integration**

1. Designed and constructed fit for purpose. Eliminate or reduce risks.
2. Apply principles in order, eliminate, reduce etc. as far as possible. Take necessary protective measures. Inform users of residual risk
3. Consider use and misuse
4. Take account of operator constraints due to PPE
5. Supply with all essentials (tools etc.) to adjust, maintain, use safely

**CE Marking**

Visible declaration of conformity with Machinery Directive

Entitles free circulation in Europe.

The owners of a large distribution warehouse business have secured a contract from a stationery manufacturer. Their insurers have recommended that the proposed storage facility is sprinkler protected.

Outline the factors to be considered in providing an adequate sprinkler system for the storage facility. (10)

Each head opens independently at set temps

- **Wet system** – where no risk of frost
- **Dry system** – where risk of frost. Water held back by valve.
- **Pre-action** – detection at lower temps, water supplied to pipes ready to extinguish
- Bulb or soldered head type
- Siting in accordance with risk assessments
- **Maintenance** – daily, weekly, quarterly 6m, 1y etc.
- Sufficient water supply
- Back up pumps in case of power cut
- Cope with run off

(a) Outline the range of information that should be included on an organisation’s standard form for the internal reporting of work related road traffic incidents. (7)

Incidents, location, times, passengers, 3rd part details, recovery costs and details, police details, witness details, diagrams, photographs, damage to car or other property, personal injury details, ALSO NEAR MISSES

**RISKS = DRIVER / VEHICLE / JOURNEY**
(b) Outline the likely content of an ‘in-vehicle response kit’ for use by a driver involved in a work-related road traffic incident. (3)

First aid kit
Emergency numbers – recovery etc.
Shovel for snow
Blanket for shock

Outline specific causes of:
(a) lateral instability; (5)

Sideways tip over
Excessive speed, loads at height, potholes…

(b) longitudinal instability (5) in counterbalanced forklift trucks.

Heavy loads – tip forward
Too much weight
Load on end of forks – reduced lifting capability
Too much tilt
Too fast, hard braking
Slopes – forward with load in front
INVESTIGATIONS

TASK
INDIVIDUAL
MACHINERY
ENVIRONMENT

CONSIDERATIONS

DESIGN
USE
MAINTENANCE
DECOMMISSIONING

CONTROL OF HAZARDS
POPIMAR