This course is part funded by

Design, Print & Packaging Skillnet

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Design, Print & Packaging Skillnet

Diploma in Packaging Technology

HAZARDS OF THE SUPPLY CHAIN.

DISTRIBUTION PACKAGING.

1D & 1E

The Irish PACKAGING SOCIETY Affiliated with I•M3

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Programme for the Day

- Session 1: Introduction and Shock Hazards.
- Session 2: Vibration and Compression Hazards.
- Session 3: Puncture, Climatic and other Environmental Hazards.
- Session 4: Pallets and Palletizing, Video.
- Session 5: Cushioning, Materials, Testing.

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Unit 1
2. Structures and Interactions of the Supply Chain
Learning Outcome and Assessment Criteria

Learning Outcome (What you need to know/understand)

2. Understand the structure and interactions of elements in the packaging supply chain

Assessment Criteria (What you need to do)

2.1 Describe in detail the whole packaging supply chain in detail for a given packaged product

2.2 Assess how each part of the packaging supply chain interacts with other parts

2.3 Evaluate the role of packaging in mitigating the effects of hazards faced by packed products in the supply chain

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Unit 1
2. Structures and Interactions of the Supply Chain
Indicative Content

- Knowledge of the structure of the whole packaging supply chain
- The development, structure and inter-dependence of the various parts of the global packaging supply chain including, the final consumer and the different end of life options
- Packaging as a means of delivering cost effective solutions for moving goods from production to the final user
- Understand the complexity of the journey map for multiple handling and extended distribution systems taking account of packaging manufacturing processes and the storage and distribution of packaging materials and components.
- Use of coding and traceability systems e.g. bar codes; RFID

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Unit 1
2. Structures and Interactions of the Supply Chain
Indicative Content

- Defining product fragility and damage levels, e.g. breakage, scratching, scuffing, of both product and pack. Quantifying fragility and acceptable damage levels
- Identifying the main hazards, their causes and effects which may compromise the quality, hygiene, safety and legality of the packed product
- Measuring and monitoring the hazards
- Key performance properties of packaging and the process controls needed to minimise product damage and interference
- Linking hazard and risk management with potential spoilage
- Simulating journey hazards in the laboratory and carrying out actual transit trials

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Programme for the Day

- Session 1:
  Introduction and Shock Hazards

Some bumps and bangs of the supply chain!

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Structure of the Supply Chain

Breakout session

- Raw material manufacturers
  - supply raw materials to: Examples?
- Packaging converters
  - supply packaging materials and components to: Examples?
- Packer fillers
  - supply packaged products to: Examples?
- Sellers Examples?

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Other Members of the Packaging Supply Chain

- Machinery manufacturers and sellers
- Logistics companies which carry out storage and distribution and often much more, such as end of line packing activities
- Graphic and functional designers
- Research and Development laboratories
- Test laboratories
- Legal and other experts e.g. Dangerous goods

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Designing Packaging for Warehousing and Distribution

- Need to protect/preserve the product – e.g.?
- Need to protect/preserve the pack – e.g.?

i.e - need to mitigate hazards

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Distribution Damage

- **If we do not understand the distribution chain damage can easily occur**
- **£££££££ ?**
- **If we do not understand the distribution chain we will not have fit for purpose packaging at the lowest cost**

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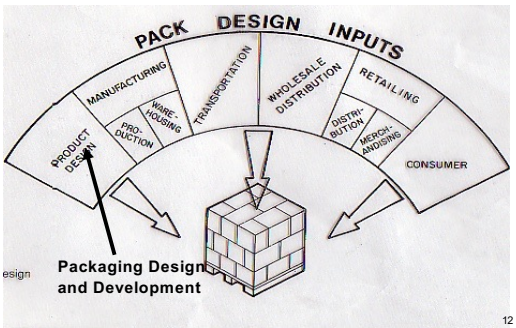
When Packaging Needs to be Involved

- Packaging for Protection



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Defining the Warehousing and Distribution Environment

- Map the journey
- Include all stages from packaging line to consumer
- List the handling methods
- How much control is there?
- What are the likely hazards?

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Designing Packaging for Warehousing and Distribution

- Process overview
  - Define the warehousing and distribution environment
  - Determine the packed product market needs
  - Define the product's critical factors
  - Investigate protective packaging
  - Test before implementation
  - Implement and monitor

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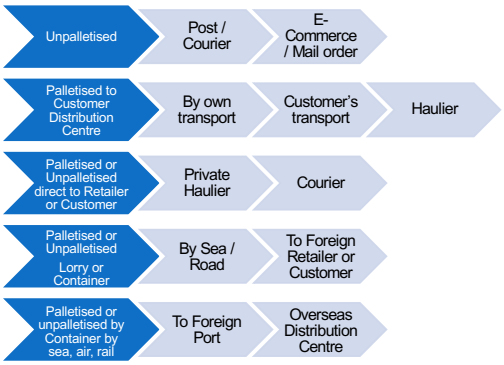
Examples of Distribution Models



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What are the Hazards of Warehousing and Distribution?

- Typical damage-causing conditions encountered - mechanical
  - Shock
  - Vibration
  - Compression
  - Puncture

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What are the Hazards of Warehousing and Distribution?

- Typical damage-causing conditions encountered - environmental
  - Climatic changes:
    - Temperature too high/too low
    - Humidity level too high/too low
    - Pressure level too high/too low
  - Contamination:
    - Birds, insects, rodents, dust, dirt, humans
  - Security:
    - Pilferage, tampering, counterfeiting

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The Shock Hazard

- Shock is defined as
  - A sudden and substantial change in velocity
  - (Newton's Laws of Motion)

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The Shock Hazard

- What causes shock damage?
  - Falls from conveyors, pallets, vehicles
  - Shunts on conveyors
  - Impacts in transit – including fork lift truck damage
  - Drops due to manual handling

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The Shock Hazard

- What are the effects?
  - Breakage of the product:
    - Catastrophic or minor
  - Packs breaking/bursting open:
    - Product spillage
    - Possible safety hazard
    - Contamination risk

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The Shock Hazard

- What are the effects?
  - Damage to the pack:
    - Dented cans
    - Crushed cases and cartons
  - Damage depends on how pack falls:
    - Edge/corner drops damage pack and contents

    Dependent on shape of primary pack
    - Flat drops may leave no visible pack damage, but contents may be damaged

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The Shock Hazard

- Protection against shock damage
  - Maintenance of equipment
    - Guide rails
    - Chutes
    - Fork Lifts
  - Stable pallet stacking to prevent falls
    - Good stacking pattern
    - Good stacking practices
    - Load restraint

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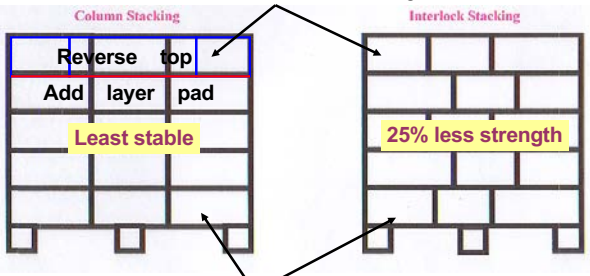
The Shock Hazard

Most vulnerable to shock damage



Most vulnerable to compression damage
Discuss later

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The Shock Hazard

- Protection against shock damage
  - Reduce manual handling:
    - As manual handling increases, so does potential for shock damage
    - The lighter the product, the more likely that it will be damaged during manual handling
  - Define the drop height:
    - Typically 0.8 to 1.0 metre

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The Shock Hazard

- Protection against shock damage
  - Training in good handling practices for all personnel
    - Internal
    - External contractors
  - Use cushioning materials to reduce the impact
  - Control of temperature and humidity

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Programme for the Day

- Session 2:
  Vibration and Compression Hazards.

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The Vibration Hazard

ISTA / ASTM Random Vibration Test conducted on a Pallet of Mayo Jar Packaging

https://youtu.be/oXgLlcf4Yt0

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The Vibration Hazard

- Vibration is defined as
  - An oscillation or motion about a fixed point
  - Oscillation frequency is the number of cycles per unit of time:
    - 1 Hertz = 1 cycle per second
  - Oscillation amplitude is the height or depth of the movement from the fixed point:
    - Higher amplitude = greater damage

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The Vibration Hazard

- What causes vibration damage?
  - Movement during transport
  - Natural frequencies specific to each type of transport:
    - Typically, the higher the frequency the lower the amplitude
    - Frequencies > 100 Hertz are of little concern
    - Frequencies < 30 Hertz are the most damaging are encountered in road transport

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The Vibration Hazard

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The Vibration Hazard

- What causes vibration damage?
  - Effects are made worse by:
    - Position on vehicle
    - Too much free space
    - Poorly secured loads
    - Poor road surfaces
    - Any imbalance in the load or vehicle

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The Vibration Hazard

- What are the effects?
  - Cracking/breaking of product
  - Scuffing/abrasion of product and pack
    - Plastic parts are scratched
    - Print rubs off bags, sacks and cartons
    - Edges of labels tear
    - Tuck-in flaps of cartons tear
    - Contamination risk

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The Vibration Hazard

- What are the effects?
  - Product settles and compacts:
    - Fine powders
    - Mixed particle sizes separate
  - Screw caps can work loose:
    - Leakage
    - Possible safety hazard
    - Contamination risk

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The Vibration Hazard

- What are the effects?
  - Resonance:
    - Occurs when vehicle frequency is the same as the natural frequency of the pack
    - Vibration is amplified - amplitude increases
    - Packs can bounce, resulting in severe damage to the contents

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The Vibration Hazard

- Protection against vibration damage
  - Isolate by cushioning:
  - Reduce movement:
    - Accurate sizing of cartons to contents
    - Accurate sizing of corrugated cases
    - Tight shrink wraps on secondary packs
    - Consider 'air ride' vehicles for critical products

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The Vibration Hazard

- Protection against vibration damage
  - Reduce contact points:
    - Consider at container design stage
    - Recesses for labels
  - Protect surfaces:
    - Scuff resistant lacquers
    - Film laminates
    - Reverse printing
    - Coextrusion

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Time for a Break!

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The Compression Hazard

- Static
  - Gradual compression
- Dynamic
  - Sudden application of load

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The Compression Hazard

- What causes compression damage?
  - Static compression happens over time due to weight resting on packs in stacking
  - Dynamic compression:
    - Handling materials with clamp trucks
    - Shunting
    - Resonance of a pallet stack

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The Compression Hazard

Compression damage caused by not understanding the distribution chain

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The Compression Hazard

- What are the effects?
  - Breakage of the product:
    - Catastrophic or minor
  - Breakage/damage of the pack:
    - Plastic bottles may crack
    - Corrugated cases may be crushed
  - Pallet load may collapse:
    - Loss of product
    - Potential safety hazard

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The Compression Hazard

- Protection against compression damage:
  - Design of primary and secondary pack for combined performance
  - Pallet type and design
  - Pallet stacking pattern
  - Define typical maximum compression load:
    - Pallet racking or block stacking?

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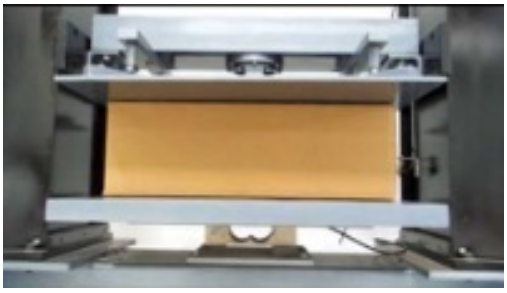
The Compression Testing



BCT - https://youtu.be/0-A5iDm-868
(ECT - https://youtu.be/ek9uTJd3LCM)

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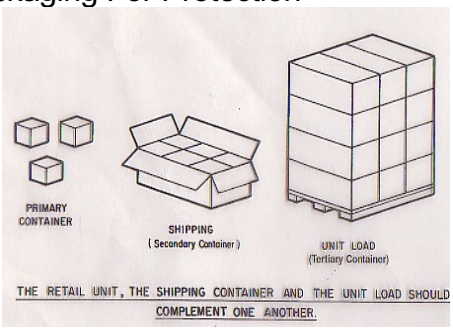
Combining Forces to Maximise Strength and Minimise Cost

- Packaging For Protection



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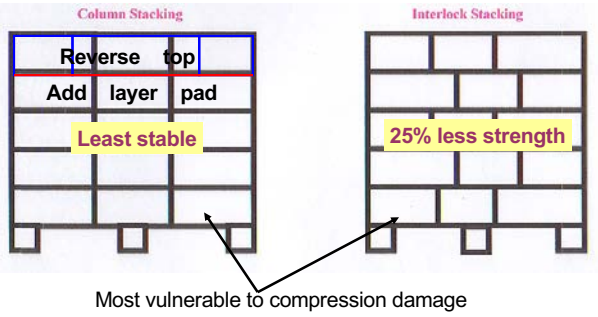
The Compression Hazard



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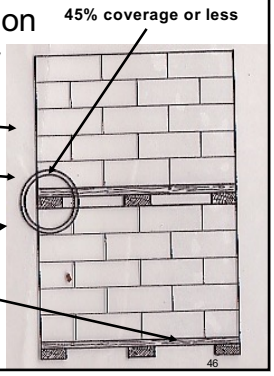
The Compression Hazard

- Packaging For Protection

Designing the packaging - Impropriety

- Multi Stacking
  - racking saves money
- Overhang
  - If overhangs - danger
  - If overhangs - damage
- Angled
  - If sloped - danger
  - If sloped - damage



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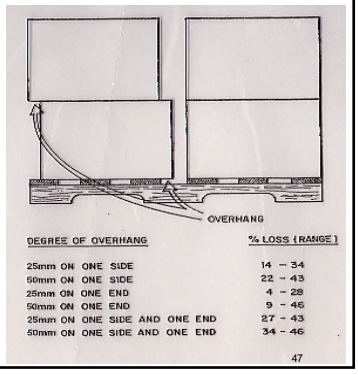
The Compression Hazard

- Packaging For Protection

Designing the packaging - Impropriety

- Overhang



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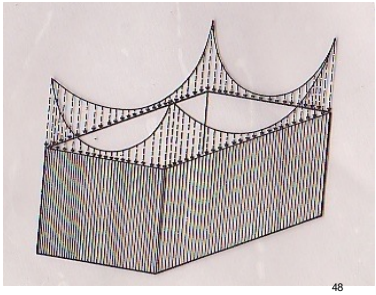
The Compression Hazard

- Packaging For Protection

Designing the packaging

60% of case strength is in its corners



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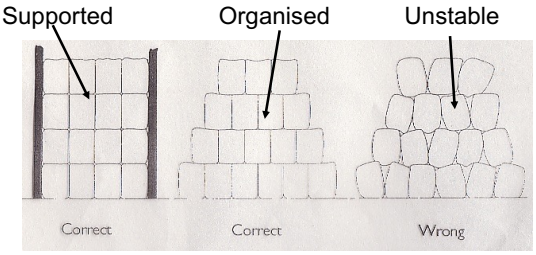
The Compression Hazard

- Packaging For Protection

Designing the packaging



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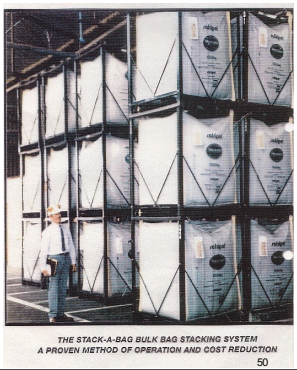
The Compression Hazard

- Packaging For Protection

Designing the packaging -

- Cost effective
- Efficient
- Safe



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The Compression Hazard

- Protection against compression damage:
  - Control of climatic conditions, especially for paper-based packs
  - Understanding the effect of stack height
  - Understanding the effect of pallet patterns
  - Understanding the effect of clamp trucks
  - Training in good handling practices

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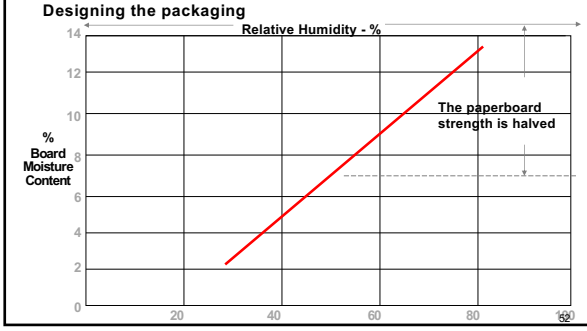
Climatic Conditions and Compression

- Packaging for Protection

Designing the packaging



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Break out session 2

Please break into groups and discuss:

- Shock Hazards
- Vibration
- Compression

In relation to how these hazards impact on the product, supply chain, distribution and what may be the solutions?

10 mins

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Programme for the Day

- Session 3:
  Puncture, Climatic and other Environmental Hazards.

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The Puncture Hazard

- Sudden piercing of a pack or product, in store or in transit
- Damage is often catastrophic

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The Puncture Hazard

- What causes puncture damage?
  - Careless handling of fork lift trucks
  - Nails and other sharp objects on pallets
  - Pallet overhang

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The Puncture Hazard

- What are the effects?
  - Product damage - usually severe
  - Packs bursting:
    - Product spillage
    - Potential safety hazard
    - Contamination risk
    - Collapse of palletised loads

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The Puncture Hazard

- Protection against puncture:
  - Training of all personnel
  - Specification and monitoring of pallet quality
  - Good pallet stacking patterns - avoid overhang

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Time for a Break!

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Climatic Hazards

- Changes in temperature
- and/or relative humidity
- and/or pressure
- and/or ultra-violet light
- Occur throughout warehousing and distribution
- Occur in both domestic and export markets

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Climatic Hazards

- Relative humidity
  - Concentration of moisture vapour in the air
  - Amount varies with temperature
  - Condensation occurs at dew point
- Conditions for condensation
  - Source of water vapour
  - Temperature differential
  - Clear path for movement of water vapour

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Relative Humidity

- The relative humidity is a measure of the amount of water vapour in the air (at a specific temperature) compared to the maximum amount of water vapour air could hold at that temperature, and is given as a percentage value.

e.g. RH = 90%

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Moisture Vapour

- The amount of moisture vapour in the air increases as temperature increases.
- The Dew Point is the maximum amount of moisture that the air can hold at any given temperature. For a certain amount of moisture in the air if the temperature falls below the dew point then condensation will occur.

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Condensation

- The conditions required for condensation are:
  - Source of water vapour
  - Temperature differential
  - Clear path for movement of water vapour
    - for example at 30ºC the maximum moisture level in the air will be 30g/m^3. If the air temperature cools down and the moisture stays the same then the dew point will be reached and condensation will occur.

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Climatic Hazards

- What causes changes in temperature and humidity?
  - Natural weather conditions
  - Poor storage conditions:
    - Damp warehouses
    - No heating/control of temperature
    - Use of gas fork lift trucks
    - Temperature of packaging as it arrives into production area.

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Climatic Hazards

- What causes changes in temperature and humidity?
  - Poor handling practices:
    - Warehouse doors left open
    - Air conditioning units
    - Goods left outside
    - Goods left out of refrigerated area

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Climatic Hazards

- What are the effects of temperature and humidity?
  - *Biotic and Abiotic deterioration:
    - Product spoilage
    - Reduced shelf life
    - Potential health hazard
    - Caking of powdered products
    - Product/pack failing

*Biotic = To do with living organisms
Abiotic = Non-living factors e.g. Light/Temp/Atmospheric gasses.

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Climatic Hazards

- What are the effects of humidity?
  - Loss of strength of paper-based packs:
    - Collapse of corrugated cases
  - Corrosion:
    - Metal products
    - Metal packs, e.g. cans
    - Potential health hazard

  Note – condensation can affect, for example heat sealing, gluing, CoF

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Climatic Hazards

'Ruckling'

Condensation from the bottles caused the case to lose compression strength

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UV Light and Pressure

- UV Light
  - Changes colour
  - Helps cause rancidity
  - Reduces physical properties of plastic packaging
- Pressure
  - Reduce pressure can cause bursting and leakage of packs
  - Increased pressure can distort packaging

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Climatic Hazards

- Protection against damage
  - Good storage conditions
  - Define and monitor actual temperature humidity, pressure and UV conditions
  - Training of all personnel
  - Use of insulation, vapour and UV barrier
  - Ensure you understand pressure differentials encountered – e.g. air transport

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Other Environmental Hazards

- Birds, insects, rodents, dust, dirt, humans
- Potential for packaging and product contamination
- Compromise product hygiene and safety

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Other Environmental Hazards

- What causes these hazards?
  - Poor hygiene practices
  - Poor housekeeping
  - Lack of understanding
  - *Throughout both packaging and product manufacture*

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Other Environmental Hazards

- Protection against damage
  - Pest control programme and monitoring
  - Good hygiene and housekeeping practices throughout the Supply Chain
  - For packaging materials, see:
    - BRC/IOP Global Standard for Packaging and Packaging Materials. Issue 4

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Other Environmental Hazards
Loss of Product Quality
Pilfering, Tampering & Counterfeiting

- What causes product security problems?
  - Human nature:
    - Inquisitiveness, malice, fraudulence
  - Lack of security measures:
    - Poor surveillance
    - Lack of effective tamper evident devices

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Other Environmental Hazards

- What are the effects?
  - Loss of product
  - Contamination
  - Damage to brand position
  - Potentially costly
  - May be lethal

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Other Environmental Hazards

- Protection against damage
  - Consider need for tamper evidence at all levels of packaging:
    - A tamper evident pack is one which shows a visible sign of an attempt to gain access to the product
    - It must be obvious that an attempt has been made to tamper
    - Consider the whole pack, not just the closure
    - Packs cannot be tamper proof

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Other Environmental Hazards

- Protection against damage
  - Surveillance
  - Product tracking – e.g. RFID
  - May need to consider anti-counterfeit measures:
    - Complexity of design
    - Control of component design and manufacture
    - Security printing and labelling

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Programme for the Day

- Session 4:
  Pallets and Palletizing, Video.

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The Role of Pallets and Palletisation

- Choosing the pallet
- Pallet stacking patterns
- Stabilising pallet loads

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The Role of Pallets and Palletisation

TEAM TASK

Are all pallets the same?

What are the key requirements and functions of a pallet?

What is overhang and is it an issue?

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Choosing the Pallet

- Consider
  - The load to be handled:
    - Product type, weight, weight distribution, shape and size
  - The expected life of the pallet:
    - Single or multi-trip
    - Conditions of use - internal or external

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Choosing the Pallet

- Consider
  - The usage environment:
    - Automatic or manual loading
    - Fully automatic or semi-automatic pallet handling throughout supply chain
    - Type of racking and stacking
    - How much access is needed
    - Vehicle size and loading method
    - Customer demand - standard pallets?
    - Industry norms

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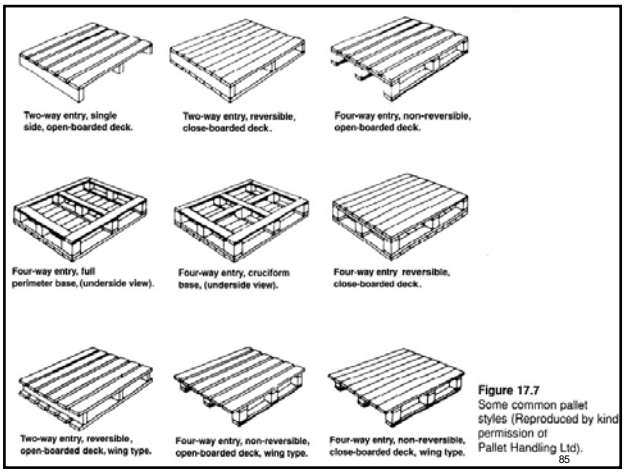

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Pallet Stacking Patterns

- Use of computer programmes to develop stacking patterns
- Need to carry out actual stacking trials
- Accuracy of placement on pallet:
  - Manual vs. automatic loading
- Column and interlock stacking

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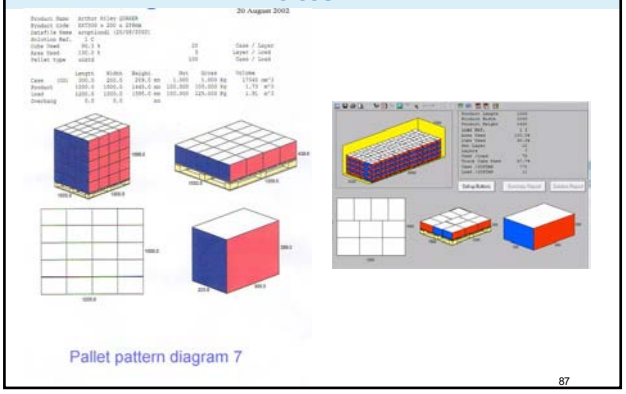
Determining the Ultimate Stacking Pattern



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Stabilising Pallet Loads

- Engineered in:
  - Coefficient of friction
  - Pallet stacking
- Strapping
- Stretch wrapping
- Shrink wrapping
- Adhesive

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Stabilising Pallet Loads

- Packaging For Protection
  Designing the packaging - fragility
- Holding it in place
  - Stretch
  - Shrink
  - Strapping

  → Correct choice is required
- Interlocking v Block
  - More stable
  - 25% less packaging required

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Identifying palletised loads

- Bar code labels for identification and traceability
- RFID
- Industry standards imposed

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Pallet Handling

Pallet handling do's and don'ts by CHEP

https://youtu.be/HEmD47jqqS4

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Understanding the Product

- What are the product's critical factors?
- What will cause it to become damaged?
  - Fragility
  - Damaging vibration frequency
  - Maximum compression strength
  - Temperature, Humidity, UV, Pressure tolerance

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Understanding the Product

- Value:
  - How much protection can we afford?
  - How attractive is it to the pilferer?
  - Is it likely to be counterfeited?
- Potential for tampering:
  - Food and drink, pharmaceuticals
- Specific legislation:
  - e.g. Dangerous Goods

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Product fragility

- Maximum tolerable acceleration which the object can stand

Fragility factor G

=

deceleration at which damage occurs

acceleration due to gravity

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Product fragility

G factor	Classification	Examples
15-25	Extremely fragile	Precision instruments
25-40	Fragile	Electronics
40-60	Stable	Desktop computers
60-85	Durable	TV sets
85-110	Rugged	Machinery

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Using Packaging for Protection

- Use packaging to provide
  - Cushioning against shock
  - Barrier to moisture
  - Barrier to light
  - Insulation
  - Resistance to pressure differentials
- *But remember the role of good practices and personnel training*

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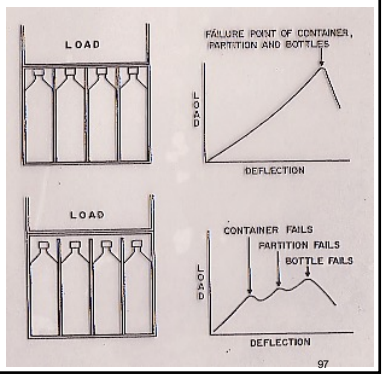
Using Packaging for Protection

- Packaging for Protection
  - Designing the packaging
    - All components can give strength
    - Synergies can be achieved
    - Cost effective packaging



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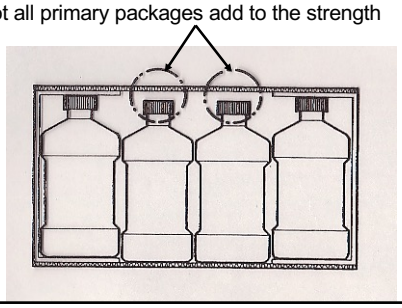
Using Packaging for Protection

- Packaging for Protection
  - Designing the packaging
    - Not all primary packages add to the strength



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Hydrostatic Pressure

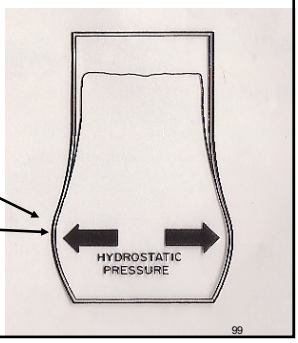
- Packaging For Protection
  - Designing the packaging

- Hydrostatic pressure causes bulge
- Bulge weakens the pack

The slosh factor

- Granules and powder can give the same effect

The bow factor



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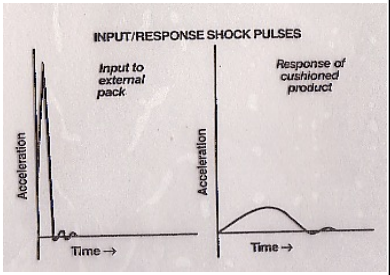
Cushioning Against Shock

- Fragility
  - Designing the packaging
    - Things break when dropped
    - Cushioning helps to slow down rate of deceleration



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Time for a Break!

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Protective Packaging Materials

- Cushioning against shock
  - Typical cushioning materials
    - Plastics
    - Paper-based
  - Four broad types

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Programme for the Day

- Session 5: Cushioning, Materials, Testing.

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EPS replacement

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EPS replacement

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End-caps and foam

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Bubble – Air – EPS – PU foam

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Cushioning Material Types

- Type A - Flexible cellular materials
  - Expanded polyethylene
  - Cross-linked expanded ethylene vinyl acetate
  - Expanded polystyrene - sheet or loose form
  - Urethane foam ester or ether - sheet/foam-in-place
  - Bonded polyurethane chipfoam - block, sheet

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Cushioning Material Types

- Type B - long fibres - tangled mass of long fibres, may be bonded to give even density
  - Bonded hair - sheets, mouldings
  - Wood wool - seasoned softwood, loose or enclosed in bolsters/pads
  - Rubberised hair - bonded with latex

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Cushioning Material Types

- Type C - Paper and pulp-based materials:
  - Bi-undulated paper
  - Cellulose wadding
  - Corrugated fibreboard
  - Moulded pulp
  - Shredded paper

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Moulded Pulp

HP 3D Printed Mounds

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Cushioning Material Types

- Type D - Miscellaneous materials:
  - Pneumatic bolsters (air cushions)
  - Air bubble film
  - Wood chips, sawdust, shavings
  - Mineral powders

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Cushioning Materials Properties for Selection

- Consider
  - Effectiveness:
    - Resilient vs. non-resilient
    - Cushioning factor
    - Effect of humidity and temperature changes
  - Need for special tooling/equipment
  - Cleanliness in use
  - Cost
  - Environmental impact

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Relative properties of cushioning materials

	Water retention	Corrosive effect	Mould growth	Dusting
Bonded PU chipfoam	high	low	mod	low
Expanded EVA	low	nil	low	nil
Expanded PE	low	nil	low	nil
Polystyrene sheets	low	low	low	mod
Corrugated board	high	low	high	low
Kraft paper cushioning	mod	low	high	mod

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Product fragility determines how much cushioning is needed

Fragility level G	Cushion Thickness mm	inches
15	200	8
30	100	4
45	76	3
60	51	2
75	44	1.75
90	38	1.5

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Protective packaging materials

- Barrier to moisture
  - Usually provided by the primary pack
  - May need to consider plastic coated paper/board
- Barrier to light
  - Usually provided by the primary pack
  - Most secondary packaging is opaque
  - May need to consider opaque pallet stretch wrap for product security

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Protective packaging materials

- Insulation against temperature
  - May be needed for specialist products e.g. blood products
  - Usually provided by expanded foamed plastics or metalised filmic material

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Protective Packaging Materials

- May also need to protect against
  - Grease and oil > Coatings
  - Static > Additives
  - Infestation > Seal Integrity
  - Acidity and alkalinity > Coatings

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Protective Packaging Materials

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Testing Solutions

- Test incoming materials and components
  - Specific to material type
- Test finished packs
  - Actual transit testing and laboratory testing
- Continuous monitoring of performance

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Finished Pack Testing

- Use actual product and packaging where possible
- Use conditions defined in the study of the journey from packaging line to consumer
- Allow sufficient time in the packaging development programme

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Finished Pack Testing

- Actual transit testing
  - Follow a prescribed route from packaging line to consumer
  - Use a product of known performance for comparison
  - Agree standards of acceptability for damage at each stage in the route

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Finished Pack Testing

- Actual transit testing
  - Does not measure conditions experienced
    - Unless data logger is used
  - Thus actual shock, vibration etc to which pack has been exposed is unknown
  - Relatively inexpensive, unless using data logger

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Finished Pack Testing
The Stacking (Safety) Factor

Therefore, the weight acting on bottom case = 10Kg

For a safety factor of 3.5

The compression strength of case must be = 35Kg

This is the lowest safety factor that is recommended

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Finished Pack Testing

- Laboratory testing
  - Simulates pack performance under known conditions as defined in the study of the warehousing and distribution environment

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Finished Pack Testing

- Laboratory testing
  - Typical tests:
    - Drop
    - Jolt
    - Vibration
    - Compression
    - Changes in temperature, humidity, pressure
    - Exposure to light

Bespoke ?

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Finished Pack Testing

- Laboratory testing
  - Usually means using an 'outside' laboratory
  - Shows the actual condition which causes damage
  - Can be expensive
  - Can be time consuming

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Finished Pack Testing

- It may be prudent to use a combination of transit and laboratory testing, especially for new products of unknown performance

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Dangerous Goods

See Unit on Legislation and Packaging

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Packaging in the Supply Chain Implementing Solutions

- Assess the risk
- Finalise the packaging specifications
- Monitor performance:
  - In warehousing
  - On display
  - In consumer use
- Monitor handling and hygiene practices
- Monitor training requirements

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Design, Print & Packaging Skillnet

Thank you for your attention.

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