The challenges of cold chain logistics
Ensuring temperature control along the total supply chain

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Summary of presentation

- Logistics operations for Life Science products
- Business and corporate responsibility drivers
- Packaging systems
- Temperature monitoring systems
- Containment systems (reusable containers and pallet systems)
- Transport systems: road, air, sea
PharmaLogistics

- Deals with the handling, movement and storage of pharma products from supplier to consumer

**Key Services:**
- Transportation
- Packaging
- Inventory
- Value-added services
- Site
- Warehousing/storage
- Orders
- Disposal
- Forecasting
- Service/support/maintenance
- Materials handling

Food Chain Intelligence
KNOWLEDGE...INNOVATION...ACTION
Temperature groups

**On the label**

- “Do not store over 30°C” from +2°C to +30°C
- “Do not store over 25°C” from +2°C to +25°C
- “Do not store over 15°C” from +2°C to +15°C
- “Do not store over 8°C” from +2°C to +8°C
- “Do not store below 8°C” from +8°C to +25°C
- “Protect from moisture” no more than 60% relative humidity in normal storage conditions; to be provided to the patient in a moisture-resistant container.
- “Protect from light” to be provided to the patient in a light-resistant container.

**Source:** WHO Technical report Series No. 908, 2003
Business drivers

- Of the greater than AUD$1,120 B of pharmaceutical product sold worldwide in 2005, about 10% biopharmaceuticals
- Biopharma prods are temperature sensitive
- Short time frame to realise profits
- Cost reduction (inventory)
- Global supply chain (manufacture site ≠ packaging site ≠ market)
- Expansion to new markets (eg. China, India)
- Expansion to urban operations
Overall…

- Re-inspection
- Delays
- Product written off
- Cash loss
- Breach in GMP, SOPs, GDP, 21 CFR Part 11, WHO, USP
CSR case

Indonesia: T<0 during vaccine transport (50% of freezing occurrences per year)

North Australia: T<0 in vaccines are detected 4 times more than heat exposure during transport & storage

South Australia: During 2001/2002, 9,700 vaccine doses ($128,500) were wasted due to cold chain issues

New Zealand: Temperature abuse of vaccines may have been the culprit in measles epidemics (1991)

Some products (epinephrine, diazepam, Lorazepam) show a reduction in potency after temperature abuse

Weakest links in the cold chain

- Lack of protocols (auditing/emergency/QA)
- Inadequate auditing/emergency systems
- Inadequate distribution routes
- Inadequate equipment/packaging
- Poor education and training
What is needed?

• Safe temperature guidelines for pharmaceutical products

• Systematic risk assessments of temperature abuse during the whole chain

• Define specific storage/transport guidelines and level of public intervention in regulatory matters

• Holistic regulations on the transport of pharmaceutical products. This is especially true for international trade regulations
Packaging systems

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Thermal Package

Should comprise:

1. Outer container
2. Insulation covering all 6 faces
3. Temperature control agent
4. Product located at the centre of the package
5. Temperature monitor
Characteristics of thermal packaging systems

- Normally used once, then discarded
- Stand-alone cooling system
- Usually, no means to add heat if required
- Able to travel by road, sea or air (40-120 hrs)
- Small capacities (e.g., less than 100 L)
- Can include embedded temperature control/recording means
- Suitable for integration with other technologies (e.g., RFID, high/low oxygen concentrations)
# Temperature Monitoring Technology

## Manufacturers/Suppliers
- **HOBO H8**: ONSET [http://www.onsetcomp.com/](http://www.onsetcomp.com/)
- **DS1923 THERMOCHRON I-BUTTON**: DALLAS SEMICONDUCTOR [http://www.maxim-ic.com](http://www.maxim-ic.com)

## Specifications

<table>
<thead>
<tr>
<th>Sensor type</th>
<th>ESCORT iLog</th>
<th>HOBO H8</th>
<th>JR RECORDER</th>
<th>NOMAD OM-41</th>
<th>DS1923 THERMOCHRON I-BUTTON</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement range (°C)</td>
<td>-40 to +70</td>
<td>-20 to +70</td>
<td>-45 to +125</td>
<td>-20 to +70</td>
<td>-20 to +85</td>
</tr>
<tr>
<td>Claimed accuracy (+/- °C)</td>
<td>0.3</td>
<td>0.7</td>
<td>0.5</td>
<td>0.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Resolution (°C)</td>
<td>0.1</td>
<td>0.4</td>
<td>0.5</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Capacity (memory)</td>
<td>32,000 samples</td>
<td>7,943 samples</td>
<td>64,000 samples</td>
<td>7,943 samples</td>
<td>8,192 samples</td>
</tr>
<tr>
<td>Sampling frequency</td>
<td>1 sec to 255 min</td>
<td>0.5 sec to 9 hrs</td>
<td>1 sec to 24 hrs</td>
<td>0.5 sec to 9 hrs</td>
<td>1 to 255 min</td>
</tr>
</tbody>
</table>
Temperature monitoring technology

VERITEC
KOOLTRACK
FOURIER SYSTEMS
LOGTAG
TINYTAG
TEMPTALE 4
COLE-PARMER

Food Chain Intelligence
Knowledge...Innovation...Action
## TI and TTI monitoring technology

<table>
<thead>
<tr>
<th>Name and type</th>
<th>Change in TTI noticed by user</th>
<th>Principle</th>
<th>Temperature or time limits</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>3M Monitor Mark® 9860A</td>
<td>Diffusing blue front along the length of a porous wick</td>
<td>Diffusion of coloured substance if temperature measured is higher than melting point of octyl octanoate</td>
<td>−15 °C</td>
<td>95 mm x 19 mm; thickness= 2 mm</td>
</tr>
<tr>
<td>VITSAB CheckPoint™ labels</td>
<td>Colour change of label, caused by a decrease in acidity of active substance</td>
<td>Enzymatic hydrolysis of a lipid substrate (occurs at −18 °C)</td>
<td>4 days</td>
<td>22 mm x 36 mm; thickness= 0.8 mm</td>
</tr>
<tr>
<td>WarmMark™ 51034</td>
<td>Colour change of label, caused by a decrease in acidity of active substance</td>
<td>Enzymatic hydrolysis of a lipid substrate (occurs at −18 °C)</td>
<td>12 hrs</td>
<td>19 mm x 46 mm; thickness= 1.5 mm</td>
</tr>
</tbody>
</table>
Wireless monitoring technology

**Electronic Track & Trace Technologies**

- RFID and wireless
- Wireless systems that allow for non-contact reading
## Wireless monitoring technology

<table>
<thead>
<tr>
<th>Company</th>
<th>Supply chain link</th>
<th>Application</th>
<th>Pilot trial year</th>
<th>Approximate Implementation Costs</th>
<th>Reason for RFID uptake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Envirotainer (Sweden)</td>
<td>Air freight</td>
<td>Tracking air shipments of temperature sensitive goods</td>
<td>2002</td>
<td>Unknown</td>
<td>Competitive advantage</td>
</tr>
<tr>
<td>DHL (Europe)</td>
<td>Delivery and logistics company</td>
<td>Monitoring temperatures of refrigerated vans</td>
<td>2007</td>
<td>Unknown</td>
<td>Quality assurance for pharmaceuticals</td>
</tr>
<tr>
<td>ASD Healthcare (US)</td>
<td>Pharmaceutical manufacturer</td>
<td>Monitoring of refrigerators and individual packages at hospitals</td>
<td>2007</td>
<td>Unknown</td>
<td>Quality assurance throughout the chain</td>
</tr>
<tr>
<td>TNT (The Netherlands)</td>
<td>Logistics and global express services</td>
<td>Tracking temperatures of health-care, pharmaceutical and chemical goods as they move along the supply chain (Asia only)</td>
<td>2006</td>
<td>$500,000</td>
<td>Supply chain of TNT's Life Science Regional DC in Singapore to a distribution hub in Bangkok, Thailand, plus shipments flown from the Singapore DC to a hub in Shanghai.</td>
</tr>
</tbody>
</table>
Packaging systems

- The Greenbox (Entropy Solutions, Inc)
- Pre-molded urethane and molded channels that disperse internal air more uniformly (Envirocooler)
- NanoCool™ (sorption cooling device)
- Radiant barrier + 2 PCM (2 phase changes at 2 different temperatures)
- Chip-vacua: 1st flexible VIP (Matsushita)
Containment systems
Containment systems

• Reusable
• Stand-alone/hybrid cooling system
• Able to travel by road, sea or air (120 or more hrs)
• Medium capacities (eg. less than 400 L)
• Can include embedded temperature control/recoding means
• Suitable for integration with other technologies (eg. RFID, high/low oxygen concentrations)
Containment systems

- Thermal container (Kodiak): Hard plastic casing enclosing foam-encased vacuum insulation panels
- **Thermo Chill™**: pallet insulated covers
- TCP Reliable: thermal control panels
- Cold Chain Technologies: **KoolTemp™** insulated pallet containers
- **ActivHeat®**: Lamina Medica (15 to 30°C)
- **Qpod™**: Refrigeration unit mounted into pallet
<table>
<thead>
<tr>
<th>TRANSPORT MODE</th>
<th>TYPICAL VOYAGE TIMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAN OR COMPARTMENT IN MULTI-TEMPERATURE TRUCK (URBAN/SHORT-DISTANCE DISTRIBUTION)</td>
<td>1 TO 12 HRS</td>
</tr>
<tr>
<td>TRUCK/TRAILER/SEMI-TRAILER (SHORT/LONG-DISTANCE DISTRIBUTION)</td>
<td>12 HRS TO 3 DAYS</td>
</tr>
<tr>
<td>RAIL (LONG-DISTANCE DISTRIBUTION)</td>
<td>3 TO 16 DAYS</td>
</tr>
<tr>
<td>AIRPLANE (LONG-DISTANCE DISTRIBUTION)</td>
<td>1 TO 100 HRS</td>
</tr>
<tr>
<td>SHIP (LONG-DISTANCE DISTRIBUTION)</td>
<td>3 DAYS TO 2 MONTHS</td>
</tr>
</tbody>
</table>
Road Transport

Refrigeration System

Doors
Multi-temperature trucks
Urban multi-temperature vehicles

- Multi-compartment distribution offers financial rewards for small shipments with different temperature requirements

- As shipments decrease in size, multi-compartment distribution benefits increase

- Global boost of online (internet) shopping
Containers
Container configuration

- Air delivery and return at one end
- Air delivery at floor
- Floors designed to distribute air
Rail Transport
Example: Field Trial with mixed loads

Tag layout for Field Trial 4
CSL Consignment / FCL transport
Melbourne (3 Jan) to Perth (6 Jan)
FCL Asset number FTA 3250682

Cebrion Smart-Trace Tag — Temperature Trace
CSL | Truck No: FCL | Tag: 197

Cebrion Smart-Trace Tag — Temperature Trace
CSL | Truck No: FCL | Tag: 212
Air freight systems
Innovation in service

FEDEX Temp-Assure Validated Air℠: validated airfreight process for temperature-sensitive shipments
Conclusion: a pharmaceutical supply chain…

- Requires more than just technology
- Entire change in culture and mindset
- Will consist of a verified and ‘in-specification’ supply chain
Thank you

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