What we mean by “Aerosol”

- Aerosol is a commonly used term for a pressurized container which releases a spray when actuated.
The Aerosol Package

- Convenient
- Easy to Use/Immediate Use
- Controlled Application
- Compact
- Portable
- Long Lasting
- Uniform Spray
- Recyclable (Regional)
History

• 1790 France: Self-Pressurized carbonated beverage introduced
History

This is the original drawing of a spray can done by Erik Rotheim in Norway ca 1926.
• 1943 USA: Department Of Agriculture researchers Goodhue & Sullivan develop a small aerosol can pressurized by a liquefied gas. Service men spray malaria infested mosquitoes.
History

• Post War Commercialization: Valve staked into a “Beer Can”
• 1949: The first one inch aerosol valve is introduced.
• Aerosols become inexpensive and practical.

Lindal North America
Function

• Release The Contents
• Permit Filling of Propellant
• Act As An Hermetic Seal
The Valve

Assembled Valve

Component Parts

Cross Section
Operation

“Headspace”
Contains propellant vapor
Exerts pressure in all directions

Product and Propellant
Propellants
Propellants

- HYDROCARBONS
  - A-17 (BUTANE) \( \text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_3 \)
  - A-31 (ISOBUTANE) \( (\text{CH}_3)_2\text{-CH-CH}_3 \)
  - A-108 (PROPANE) \( \text{CH}_3\text{-CH}_2\text{-CH}_3 \)
  - Liquid Under Pressure
  - Integral to the Formulation
Propellants

• Blends
• You can have other combinations of propellants:
  – Normal Butane + Propane
  – AB-46 (Aeropres)
  – NP-46 (Diversified)
  – B-46 (Technical)
Propellants

• Blends
  – Normal Butane + Isobutane + Propane
  – Aeropin-46 (Aeropres)
  – NIP-46 (Diversified)
  – T-46 (Technical)
Propellants

- DME (Dimethyl Ether) 63psig
- 152a (1, 1-Difluoroethane) 63psig
- 134a (1, 1, 1, 2-Tetrafluoroethane) 71psig
Propellants

• Safety
• With the Flammable Propellants, You Must Use Caution!
  – Utmost Importance
  – Heavier than air
  – Odorless
  – Colorless
Propellants

- COMPRESSED GASSES
  - CO2
  - N2
  - N20
  - Pressure Drops as Unit Empties
  - A Wet Spray
# Propellants

<table>
<thead>
<tr>
<th>Liquefied</th>
<th>Compressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>An integral part of the formula.</td>
<td>Acts like a piston. Large, wet particles.</td>
</tr>
<tr>
<td>Results in smaller, finer particles.</td>
<td>(However, there is some solubility with CO2)</td>
</tr>
<tr>
<td></td>
<td>Drop in pressure through life of can</td>
</tr>
<tr>
<td>Consistent pressure through life of can</td>
<td>Caution with CO2 + H2O! Carbonic acid formation.</td>
</tr>
<tr>
<td></td>
<td>Temperature changes have little effect on pressure. (Good for de-icers, e.g.)</td>
</tr>
<tr>
<td>Large temperature changes effect pressure.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost varies</td>
<td>Low cost</td>
</tr>
</tbody>
</table>
Operation

Pressure on the actuator moves the stem down.

This breaks the seal between the gasket and the stem.

The stem is exposed to the product/propellant in the container. (i.e. the valve is open)

Pressure inside the container pushes the product through the valve to the outside of the container.

By releasing the actuator, the spring returns the stem orifice to the sealed position (i.e. the valve is closed)
Operation

• **Product Flow Through The Valve**
  • 1. Dip Tube
  • 2. Housing
  • 3. Stem
  • 4. Actuator
Valve Components
Functions and Materials of Construction

- **Mounting Cup Gasket**: Seal between valve and can
- **Mounting Cup**: Link between can and valve
- **Stem**: Controls the flow
- **Stem Gasket**: The “On-Off” Switch
- **Spring**: Closes the Valve
- **Housing**: Encloses Stem, Gasket & Spring
- **Dip Tube**: Draws Product
Stems

• Control the flow
• Orifices
  – 1, 2, 3, or 4,
• Orifice sizes range from 1 x 0.010” to 4 x 0.027” x 0.045
• Usually made of nylon
• Acetal, brass, pp
Stem Gaskets

- Covers the Stem Orifice (The “On-Off” Switch)
- Different Materials for product compatibility
  - Buna N
  - Neoprene
  - Butyl
  - Viton
Stem Gaskets

• IMPORTANT POINTS TO REMEMBER
• The stem gasket seals the valve.
• It is made of rubber and will shrink or swell with different formulations.
• There is no universal stem gasket.
• *Testing is recommended/mandatory*!!!!
Stem Gaskets

- No standardized CSPA test method
- Tests methods differ between valve suppliers
- Looking for percentage of swell/shrinkage
- Change in durometer
Stem Gaskets

• Importance
  – By choosing the appropriate stem gasket you will avoid:

  • **High weight loss** (loss of propellant and/or product) which can result in:
    – Wet cartons in the warehouse
    – Consumer Returns (will consumer buy this again?)
    – Litigation?
Stem Gaskets

*How do I select the correct gasket for my product?*

- **Immersion Test**
  - In product (Bulk) only
  - OK for initial screening (and BOV and Compressed Gas systems)

- **Test in Packed Units**
  - More realistic condition. It includes the propellant
Stem Gaskets

Interpretation of Results

• Valve gaskets can tolerate up to ~10% swell (check with the individual valve suppliers)

• AVOID SHRINKAGE AT ALL COSTS!!
  – Shrinkage compromises the seal

• Red Flag if there is a big change in durometer
Springs

• Cause the valve to close

• Stainless Steel
  – 302
  – 316
Housing (Body)

- Encloses the Stem, Spring, and Gasket
- Can act as a secondary metering orifice
- Wide range of orifice sizes: 0.013” to 0.158”
Housing (Body)

- Vapor Tap (a hole in the side or bottom of the housing)
- 0.005” to 0.040”
- Produces a drier and warmer spray
- Reduces particle size
- Needs sufficient propellant to evacuate
- For intermittent inverted use
- Do not use with compressed gas
Dip Tubes

- Draw product into the valve
- Standard” 1/8” (0.122”) Inner Diameter
- Large: 3/16” (0.190”) I.D.
- Jumbo: Over ¼” (0.260”) I.D.
- Capillary” <0.060” I.D.
Dip Tubes

• Measurement
• CSPA (CSMA) Length
• The distance from the top of the mounting cup to the end of the dip tube
• International Marketers Beware:
  – There are different methods of measurement around the world (FSMS, FBOC, Visible Length)
Mounting Cups

- Hold the valve parts together
- Attaches valve to the can
- Tinplate or Aluminum
- Coatings
  - Uncoated (Tinplate only)
  - Epoxy (Tinplate and Alum)
  - PP Laminate Bottom (Tinplate Only)
  - PET (Tinplate Only)
  - Micoflex (Alum Only) Soon to be obsolete. Suppliers working on alternatives
Mounting Cup

- Gasket Materials
- Provide a seal between cup and can
- Cut Gasket
- PP Laminate (Coating and interface)
- PE Sleeve (PVC only)
Mounting Cups

Polyethylene Sleeve

Polypropylene Laminate  Lathe Cut Gasket
# Mounting Cups

*How do I choose the correct cup gasket? When do I use Laminate (and sleeve?)*

<table>
<thead>
<tr>
<th>Can</th>
<th>Mtg Cup Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tinplate (any size)</td>
<td>Laminate/PE Sleeve (cut gasket but $$$)</td>
</tr>
<tr>
<td>Aluminum &lt;50mm diameter non-machined can curl</td>
<td>Laminate/PE Sleeve (cut gasket but $$$ with piece of mind)</td>
</tr>
<tr>
<td>Aluminum 50mm or larger diameter machined or non-machined can curl</td>
<td>Cut Gasket</td>
</tr>
</tbody>
</table>
Crimp Considerations

• Crimp*: The method by which the valve is attached to the can
• Collets move into the mounting cup and spread to a specific diameter and depth

*Also known as “clinch” in the industry. Clarify your definitions when speaking with suppliers and fillers.
Crimp Considerations

Closed Collet

Closed Collet
Crimp Considerations

Open collet

Open collet in cup
Crimp Considerations

- Crimp dimensions will depend on:
  - Mounting cup material
  - Mounting cup gasket
  - Type of can

- Valve suppliers and contract packagers can give *starting point* dimensions
Crimp Considerations

A set of crimp gages and setting block are essential for the laboratory and production line.
Actuators
Actuators
Can Vary in Size…
Actuators

Spouts are actuators…
Actuators

…and so are Spray Thru Domes
Actuators

- Can be classified into two groups
  - Non-Mechanical Breakup (NMBU)
  - Mechanical Breakup (MBU)
Actuators

- MBU (Mechanical Break Up)
- Incorporates a “Swirl Chamber” inside the actuator
- Results in a discernable pattern size and shape
Actuators

- Detail of a mechanical break up insert
- Note the 4 tangential channels
- Some inserts can have 2 or 3 channels
Actuators

• Orifice size can range from 0.009” to wide open

• Typical sizes are
  – 0.013”, 0.016”, 0.018”, 0.020”, 0.022”, 0.024”, 0.030”, 0.040”

• Usually find “wide open” orifices in spouts
Actuators

• NMBU (Non-Mechanical Break Up)
• A direct flow through the actuator
• Usually results in a stream
Valve Types

• Vertical Valve
  – Vertical pressure on the actuator opens the valve

• Tilt Valve
  – Forward pressure on the actuator opens the valve
Valve Types

• Up/Down Valve
  – Uses a special housing for upright or inverted use
  – Not a true 360 degree valve
Valve Types

• 20mm Valve
• For use on bottles or small cans
• All internal parts are the same.
• Uses a ferrule instead of a mounting cup
Female Valve

Slotted stem molded into the actuator. Controls the flow.
Female Valve

- A = Mounting Cup
- B = Cup Gasket
- C = Stem Gasket
- D = Stem Seat
- E = Spring
- F = Housing
- G = Dip Tube
Male or Female

• Which valve do I need?
• The choice is yours
• Paint product considerations
• Actuator Assembly
• Inventory considerations
• One is not “better” than the other
Variable Valve

• For Variable Discharge
High Delivery Valves

- Used for viscous products
  - Caulking
  - Insulating Foams
  - Silicone
  - Cheese

- Consists of only three pieces
  - Stem/Gasket/Mounting Cup
Valve Types

- Metering Valves
- Delivery expressed in microliters:
  - 75mcl, 100mcl e.g.
- Has two gaskets
- Has a metering tank
- Available in 1” or 20mm
Valve Types

- Valves for powders/solids
  - A/P’s, Dry Shampoos, Glitter, etc.
- Special valve designs help to reduce seepage
- Clogging is formula related
Barrier Systems

- Bag In Can
- Product is kept separate from the propellant
- Propellant filled through bottom of can

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Barrier Systems

- Piston Can
- Product is kept separate from the propellant
- Propellant filled through bottom of can
Barrier Systems

- Bag On Valve (BOV)
- Bag is attached to the valve
- BOV is inserted into the can
- Propellant is Under Cup Gassed
- Valve is crimped to can
- Product is pressure filled Through the Valve into the bag
Barrier Systems

- Film pouch (Aptar, Coster, Lindal, Summit)
- PET (Power Container)
BOV-How It Works

• The pressurization agent – either compressed air or nitrogen – surrounds the product-filled pouch.

• When the actuator is depression, the air exerts pressure on the pouch, providing the force required to discharge the product.

• All the air remains in the container and is not released into the atmosphere.
BOV-How It Is Filled

1. Inserting of the BAG-On-Valve.
2. Under-The-Cup pregassing (UTC) and clinching the valve.
3. Pressure filling of product Through-The-Valve (TTV) into the bag.
4. Weight and/or pressure control and water bathing.
5. Actuator and cap fitting.
6. Dispensing of product.
BOV Product and Application
Range

Personal care:
• Post-foaming hair and shave gel, shampoo and conditioner.
• Liquid soap, hand and body creams and lotions. Sun creams and sprays, tanning creams, body oils, deo’s.
• Depilatory creams, facial scrub gels-lotions, facial mist.
• Toothpaste.

Animal care / veterinary:
• Medicines and animal care product.
• Insecticide, grooming sprays, shampoo etc.

Household products:
• Window cleaner, oven and ceramic plate cleaner.
• Shoe sprays.
• Insecticide sprays, citrus air fresheners.
• Plant sprays, furniture polish.
BOV Product and Application Range

Industrial / automotive:
- Personal fire extinguishers, automotive air conditioners.
- Lubricants, oils, waxes, fats, cleaners, toners.
- Leak detectors, PU-foam, anti-spatter weld sprays, surface cooling sprays for welding.

Food:
- Whipped cream, vegetable pan sprays, mustard, chocolate paste, puddings, toppings, cheeses, concentrated food flavors etc.

Pharma / medicine:
- Nasal sprays, syrups, vitamin gel.
- Based on enzymes odor removers
- Wound gels and sprays.
- Dental products.
- Eye contact lens products, ultrasonic gel.
BOV Technology

• Is BOV suitable for every product?
  No
  Certain formulations require liquefied propellant: Paint, Powders, Glitters.

Possibly
  If valves suppliers can make actuators that give maximum break up without the use of propellant. (100% olive oil can now be dispensed as a fan spray)

If formulators work with the “new” technology

If legislation mandates hard to attain VOC limits
THANK YOU

ANY QUESTIONS?
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mquint@lindalnorthamerica.com
Bonus Material Part 1

• We regret that time did not allow us to cover the following material regarding valve selection, testing and troubleshooting.

• It may be worth your while to have a look at the following slides to gain a better understanding of what it takes to select the proper valve for your product.
Valve Selection

• How Many Valve Combinations Are There?
  – Over 15,000 valve combinations (conservative estimate) not including gaskets and mounting cups
  – Include the gaskets and mounting cup, you have over a million combinations
Valve Selection

How Do I Decide?
• Gather as much information as possible
• Type of Propellant
• Product/Propellant Ratio
• Production Filling Method
• Can Size/Material
Valve Selection

Define The Parameters
• DRT, Pattern, Particle Size, Flammability
• Which are important for your product?
• Prioritize
• You may have to sacrifice!
Valve Selection

SOME CONSIDERATIONS

• DELIVERY CHARACTERISTICS
• DELIVERY RATE
• SPRAY PATTERN
• PARTICLE SIZE
• FLAMMABILITY
• SOUND
• WEIGHT LOSS
• CORROSION
• CLOGGING
• OFF ODOR
• APPEARANCE
• LEAKAGE
• LABEL WEIGHT
• DELIVERY (EVACUATION)
Valve Selection

• Get Valve Samples (free)
  – Valve suppliers can offer starting points for various products

• Determine correct stem gasket
Valve Selection

- Initiate Stability (weight loss) testing
  - Spray Weigh or Dead Storage
  - Test for six months at Room Temp and Oven (120 F)
  - At end of test check valve parts
  - Check for valve, container corrosion
Valve Selection

• Speak with your filler (What are their requirements/limitations?)
  – How Filled? (Pressure Fill? UTC?)
  – Button-on (Special Adapters Needed?)
  – Button-off (Special Tippers Required?)
    • Hand Tipped (Are Actuators hard to tip?)
  – Covercaps/Shrink wrap (Any Problems?)
Valve Selection

• Keep an eye out for:
  – Swelling, cracking of the plastic parts (actuators, stem, housing, dip tubing)
  – Coating integrity, pin holing, oxidation, corrosion of metal parts (mounting cups, springs)
  – Impingement using spray thru caps and accessories
  – Clogging with high solid products
Valve Selection

• Don’t assume lab samples will equal production units
• Perform a test run on the production line
  – Reveal equipment issues
  – Reveals bulk handling issues
  – Will show line speed
  – Includes process variations
• Evaluate production filled units
Troubleshooting

• Everything was going so well…
Troubleshooting

• Until one day…
Troubleshooting

• …something goes wrong
Troubleshooting

• Be Logical

• You know the process
Troubleshoot

UNIT DOES
DOES NOT
OPERATE
AS EXPECTED

NO PROPELLANT
AND/OR
NO
PRODUCT

NOT FILLED
LEAKAGE

THRU CAN

THRU VALVE

MTG CUP
CORROSION

GASKET
DETERIORATION

VALVE
IS
OPEN

INCORRECT
DIMENSIONS

WRONG
CUP GASKET
FOR
CAN

DEFECTIVE
OR
DAMAGED
CAN

FOREIGN
PARTICLES
DISRUPTING
SEAL

VALVE
DEFECT

DAMAGE
DURING
FILLING

NO
GASKET
COMPRESSION
(CUT GASKET)

CAN
BEAD
CONTAMINATION

CLOGGED/OR PARTIAL SPRAY
BUT
UNIT HAS
PRESSURE

IS
ACTUATOR
CLOGGED?

IS
VALVE
CLOGGED?

GASKET
SWELL

FOREIGN
PARTICLES
CLOGGING
VALVE

NOT REALLY
CLOGGED
BUT A
VALVE DEFECT

THRU CRIMP

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Bonus Material Part 2

• We regret that time did not allow us to cover the following material regarding Bag-On-Valve (BOV) technology
• It may be worth your while to have a look at the following slides to gain a better understanding of the BOV system and how it may be applicable to your products
BOV History

- In 1982, the first BOV design patent was filed in Europe.
- Early BOV packages used citric acid and sodium bicarbonate for pressurization.
- On July 25, 1985, NASA sent up a Pepsi® Aerosol Can on the Space Shuttle – Challenger (STS-51F). The special beverage can used a BOV from Enviro-Spray called the Growpak. (The astronauts did not like it.)
BOV History

- Eco-Pack (Belgium) was the first company to introduce the concept of using compressed air or nitrogen as the propellant. The propellant was filled by under-the-cup method.
- In 1987, CCL Container (Canada) began to develop a BOV system for the North American marketplace.
- Today, there are several valve companies around the World that manufacture a BOV.
Why Use BOV?

- You spray 100% product
- No liquefied propellant
- The propellant is Eco-Friendly/Non VOC /Non Green House Gas compressed air or Nitrogen ("Green")
- (Storing fish not recommended)
Why Use BOV?

- Continuous, quiet and non-chilling spray (no pumping required).
- Total evacuation of product. (Even with a dented can)
- Works at any angle (360° application). (Minimizes product misuse).
Why Use BOV?

- Ambient temperature has minimal effect on internal pressure
- Cannot bleed the propellant from the can (versus Bag In Can or Piston Can)
Why Use BOV?

- BOV’s are recyclable
- BOV’s are reusable (Marketing concerns)
- FDA compliant materials used in the construction.
BOV Technology

• Separate Filling Room Not Required
  – Flammable propellants are not used
• Still requires a Hot Bath
  – But…can get DOT exemption
• It is STILL an AEROSOL Package!
  – Some are calling it a “Non-Aerosol” and is being labeled as such.
BOV Types

• Male and Female BOV’s are available.
• Standard 1” valve components are used in the construction. (Can regulate flow with stem and actuator orifices)
• BOV’s use standard valve accessories.
The BOV Bag

- The flexible BOV bag film is made from 4 materials (Inside-PP, Nylon, Aluminum and PET-Outside).
- The BOV bag is heat-bonded to the polypropylene valve housing and has a gusseted bottom design for extra drop strength.
The BOV Bag

- The BOV bag fill range is 1 oz. to 24 oz. (Travel size to Industrial size)
- Each BOV bag is inkjet marked with lot traceability information.
- 100% QC pressure checked on assembly
Containers For BOV

- The BOV is now the “container”
- Aluminum-Straight Wall or Shaped
- Tinplate 2 or 3 Piece-Straight Wall or Shaped
- Plastic (PET) (Not commercially available)