Specifications for Commercial Refrigeration

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ARB Workshop on Stationary Source High-GWP Early Action Items

February 15, 2008
• Background
• Data Sources, Emissions and Trends
• Existing Regulations & International Experience
• Potential Control Strategies
• Emission Reduction Projections
• Regulatory Concepts & Costs
• Data Gaps, Ongoing Research, Questions
• Working Group Formation
• Timeline & Contact Information
Types of Commercial Refrigeration Systems

- Direct expansion (DX) systems used in supermarkets, cold storage warehouses, industrial food processing

- Standalone equipment (open and closed display cases) and refrigerated vending machines
• Commercial Refrigeration Systems Emissions Sources
  – Direct refrigerant emissions occur during equipment manufacturing/charging, lifetime (from leaks, ruptures, maintenance), and end-of-life (EOL)
  – Indirect emissions ($\text{CO}_2\text{E}$ emissions resulting from energy use) occur during equipment manufacture, lifetime operation, and EOL
Existing Systems

• Direct Expansion (DX) Systems
  – Also called centralized or multiplex systems
    • Supermarkets, cold storage warehouses, built-up refrigeration/freezing systems for food processing, etc.
  – High direct emissions
    • Leaks result from vibration and thermal expansion of numerous pipes, threaded joints, fittings, and valves
    • Ruptures can result in huge refrigerant losses
  – High indirect emissions due to energy inefficient system components, designs
    • Lack of heat recovery in some systems, open cases, poor air curtains, inefficient lighting, use of anti-sweat heaters, etc.
• **Standalone Equipment and Vending Machines**
  – Low direct emissions (EOL), high indirect emissions
  – Large numbers of standalone cases and vending machines in CA
    • ~500,000 refrigerated vending machines in CA
    • Open and closed standalone cases yet to be enumerated
Data Sources, Emissions, and Trends: Rule 1415

- Rule 1415 Data
  - Reporting of annual ODS usage for RAC systems > 50 lbs in SCAQMD only
    - Leak rates exceed 35% for 11% of systems, 100% for 2.7% of systems
    - The top 15 SIC codes emit 80% of total

<table>
<thead>
<tr>
<th>SIC Code</th>
<th>Description</th>
<th>Emissions MTCO2E/year</th>
<th>Facilities</th>
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<tbody>
<tr>
<td>5400</td>
<td>FOOD STORE</td>
<td>94820</td>
<td>255</td>
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<tr>
<td>5490</td>
<td>GROCERY-RETAIL</td>
<td>54116</td>
<td>207</td>
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<td>2013</td>
<td>FOOD PROCESSOR</td>
<td>11001</td>
<td>5</td>
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<tr>
<td>4960</td>
<td>DISTRICT HEATING AND COOLING</td>
<td>6188</td>
<td>10</td>
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<tr>
<td>8700</td>
<td>OFFICE BUILDING</td>
<td>5137</td>
<td>141</td>
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<td>4810</td>
<td>TELEPHONE COMMUNICATION</td>
<td>5071</td>
<td>137</td>
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<tr>
<td></td>
<td>WHOLESALE TRADE NON-DURABLE</td>
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<tr>
<td>5142</td>
<td>GOODS/PACKAGED FROZEN FOODS</td>
<td>4643</td>
<td>1</td>
</tr>
</tbody>
</table>
Data Sources, Emissions, and Trends: ARMINES

- **Commercial RAC Inventory Development for California**
  - Contractor Denis Clodic/ARMINES
  - Preliminary estimates, DX systems

<table>
<thead>
<tr>
<th>Direct emissions or leaks</th>
<th>Indirect emissions or energy use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leak rates ~30% per year or ~2.7 MMTCO(_2)E</td>
<td>Indirect CO(_2) emissions ~2.3 MMTCO(_2)E</td>
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<tr>
<td>Typical CA DX system charge ~2800 lbs (large release potential)</td>
<td></td>
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<tr>
<td>Banked refrigerant in CA DX systems is ~7.5 MMTCO(_2)E</td>
<td></td>
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Data Sources, Emissions, and Trends: ARMINES (continued)

- **CA RAC Inventory: Preliminary Estimates, Continued**
  - Standalone systems, direct emissions
    - Emission rates estimated at 1% of the charge per year for stand-alone equipment, most of which are EOL emissions
  - Standalone systems, indirect emissions
    - More standalone systems in CA than anticipated; energy use ~50% of the commercial refrigeration total
Data Sources, Emissions, and Trends: USEPA Vintaging Model

- **Estimated CA Commercial/Industrial/Cold Storage Refrigeration Emissions**
  - HFC emissions ~2.5 MMTCO₂E
  - ODS emissions ~6 MMTCO₂E

**2006 CA Emission Sources**

- HFCs
- ODSs

- Domestic Refrigeration
- Commercial & Transport Refrigeration
- Industrial Process Refrigeration/Cold Storage
- Mobile Air Conditioning
- Large Commercial AC (chillers)
- Small Commercial AC
- Residential AC
- Fire Extinguishing
- Foams
Data Sources, Emissions, and Trends: USEPA Vintaging Model

- Estimated CA Commercial/Industrial/Cold Storage Refrigeration Banks
  - HFC Banks ~12.5 MMTCO$_2$E
  - ODS Banks ~35 MMTCO$_2$E

2006 CA Banks

HFCs

ODSs

- Domestic Refrigeration
- Commercial & Transport Refrigeration
- Industrial Process Refrigeration/Cold Storage
- Mobile Air Conditioning
- Large Commercial AC (Chillers)
- Small Commercial AC
- Residential AC
- Fire Extinguishing
- Foams
Existing Regulations

- ODSs Have Some Sales, Record-Keeping/Reporting, Technician Certification, and Emissions Restrictions
  - Section 608 of CAAAs and SCAQMD Rule 1415
- HFCs Subject to “No Venting” Provision of CAAAs, Section 608
• STEK Regulation
  – The Dutch regulation on leak-free refrigeration equipment, which includes the following:
    • Flared joints shall not be used
    • Pipes shall be joined by welded or brazed joints
    • Systems with a charge >3 kg shall be inspected annually
    • Systems with a charge of >1000 kg shall be under constant supervision
    • Logbooks must be kept for all systems with a charge >3 kg
    • Refill or top-off is only permitted if leaks are identified and repaired
International Experience (continued)

• EU F-Gas Regulation
  – Similar to, but more restrictive than, Section 608 of the CAAAs
    • Covers only Kyoto gases
    • Requires containment, record-keeping, recovery, training/certification, reporting, labeling, use control
    • Also specifies certain market prohibitions (shoes and tires containing SF$_6$, one-component foams, one-way cylinders, aerosols, etc.)
Potential Control Strategies

• DX Systems
  – Direct Emissions Reduction
    • Indirect or Secondary Loop (SL) Systems
      – Can utilize low-GWP refrigerants, or significantly reduced quantities of high-GWP refrigerants
        ▪ Charge reduction important to reduce emissions from ruptures
      – Automatic leak detection in machine rooms possible
        ▪ Benefits include easier leak detection/repair, fewer refrigerant purchases
Potential Control Strategies (continued)

• DX Systems, Continued
  – Indirect Emissions Reduction
    • Machine Room Technologies
      – Evaporative condensers
      – Floating head pressure controls
      – Heat recovery
    • Display Case Technologies
      – Add doors to display cases
      – Improved air curtains
      – Energy-efficient reach-ins, evaporator and condenser fan motors, compressor systems, lighting
      – Anti-sweat heater controls
      – Hot gas defrost
Potential Control Strategies (continued)

• Standalone Systems and Vending Machines
  – Direct Emissions Reduction
    • Alternative refrigerants currently possible (i.e. \( \text{CO}_2 \))
    • Future innovations may include thermoacoustic or magnetic refrigeration
Potential Control Strategies (continued)

- **Standalone Systems and Vending Machines**
  - Indirect Emissions Reduction
    - Compressor and component improvements (i.e. efficient lighting, fans, anti-sweat heaters, addition of doors)
    - USDOE is developing energy conservation standards for:
      - Self-contained and remote display cases (ASHRAE 72, 2005, for open and closed display cases)
      - Vending machines (ASHRAE 32.1, 2004)
      - Walk-in coolers and freezers (no test methods yet)
Emission Reduction Projections

• DX System Direct Emissions 2020 Forecast: BAU, SL, and SL With Low-GWP Refrigerants

Source: Interim Draft Report, ARMINES, Centre énergétique et procédés - CEP
http://www-cep.ensmp.fr/english/

Business As Usual

Secondary Loop (SL)

SL + Low-GWP
Energy Savings For CA Supermarkets
- 30% savings relative to BAU
- 0.7 TWh/year or 0.3 MMTCO$_2$E/year, in 2007; 3 MMTCO$_2$E by 2020

![Energy Savings in all Supermarkets in California](chart)
Regulatory Concepts

• **New Refrigeration Systems**
  – Limit direct emissions to X% for all new systems
    • Will likely require installation of indirect systems
  – Full accessibility to all piping
  – Automatic leak detection

• **Existing and New Retail Food Systems**
  – Increase energy efficiency by 30%
• First Approximation of Costs
  – Installation costs expected to dominate over energy saving device costs for new systems
    • USEPA and Oak Ridge National Lab estimate that for a SL system with HFC refrigerant, installation costs will be 20% higher than baseline DX system
      – Using ammonia refrigerant results in installation costs 75% higher than the baseline case
      – Maintenance costs are expected to be lower than for the baseline case
• First Approximation of Costs, Continued
  – Costs could largely be offset by maintenance, refrigerant, and energy savings benefits
  • Benefits depend largely on future refrigerant and energy costs
Data Gaps, Ongoing Research

• **Data Gaps**
  – Costs, benefits, and payback periods associated with installing new systems and upgrading existing systems

• **Ongoing Research**
  – RAC inventory and energy efficiency contract with Denis Clodic/ARMINES
Questions

- What should trigger the upgrading of existing systems (i.e. repair or future compliance date)?
- Should DOE test methods be adopted earlier for standalone equipment and vending machines?
Working Group Formation

- Focused Technical Group Formation
- Identify Key Stakeholders and Agency Partners
- Meet at Least Twice, Over Several Months
- First Meeting in March 2008
- If Interested, Please Provide Your Information
<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tr>
<td>March 2008</td>
<td>Working Group/Stakeholder Formation</td>
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<tr>
<td>Summer 2008</td>
<td>Working Group/Stakeholder Consultation Meeting</td>
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<tr>
<td>Winter 2008</td>
<td>1º Public Workshop to Discuss Proposed Control Strategies and Options</td>
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<tr>
<td>Spring 2009</td>
<td>2º Working Group/Stakeholder Consultation Meeting</td>
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<tr>
<td>Winter 2009</td>
<td>2º Public Workshop on Proposed Strategies</td>
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<tr>
<td>Summer 2010</td>
<td>Regulatory Language and ISOR Finalized</td>
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<tr>
<td>Winter 2010</td>
<td>Board Meeting on Action</td>
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- More Information
  • Visit: http://www.arb.ca.gov/cc/commref/commref.htm
  • Join list serve at:
    http://www.arb.ca.gov/listserv/listserv.php
Questions?