California 2013 Title 24 Supermarket Refrigeration: Title 24 Requirements and Leak Reduction Measures

California Energy Commission and California Air Resources Board

Glenn Gallagher, California Air Resources Board
Doug Scott, VaCom Technologies

September 27, 2011

Presenters

- Glenn Gallagher
  - Glenn Gallagher is an Air Pollution Specialist at the California Air Resources Board. He currently works on regulations to reduce emissions of high-global warming potential greenhouse gases.
- Doug Scott
  - Doug Scott is the president of VaCom Technologies. VaCom Technologies assisted in the development of the CEC energy efficiency standards presented today. Doug, who has more than 30 years of experience in the refrigeration industry, will be presenting the standards on behalf of the CEC.

DISCLAIMER

- Note: There are federal regulations, state regulations, and local regulations.
- The topic of this webinar is state regulations (specifically, California).
- EPA does not write or enforce state regulations.
- EPA's regulations set the minimum standards that states must achieve. States have the option to develop more stringent requirements if they choose to do so.

CA Title 24 Requirements for Supermarket Refrigeration

Leak Reduction Measures

September 27, 2011

Glenn Gallagher,
California Air Resources Board

Topics

- Background and current practice
- Measure savings and economics
- Proposed Title 24 requirements

Background

- California building energy efficiency code (Title 24) reviewed periodically.
  - Current 2008 code– effective 1/1/2010
  - Proposed 2013 revision– to be effective 1/1/2014
- California Energy Commission (CEC) and California Air Resources Board (CARB) cooperated to evaluate supermarket refrigeration measures
  - CEC addressed energy savings
  - CARB addressed emissions and leak reduction measures
- First time Title 24 has included direct GHG emissions, using total CO_2 valuation

Objectives and Process

- Achieve significant energy savings through the development of reasonable, responsible, and cost-effective code change proposals for the 2013 code update and beyond
- Investor owned utilities (IOUs) completed initial process for CEC, including stakeholder meetings held to obtain industry input and feedback on code change proposals
- CEC holds public meetings to review and finalize code proposals

Title 24 Code Change Activities

- 2013 Base Code (Part 6 of Title 24)
- 2013 Reach Standard (Part 11 of Title 24)
  - Green Building Standard – i.e. CalGreen

- Identify topics for future codes
  - 2016 Title 24
  - Future Reach Standards

Types of Code Requirements

- Mandatory Measures:
  - All proposed supermarket refrigeration measures are mandatory measures
- Prescriptive Measures: N/A
- Performance Compliance Option: N/A
- *CEC would like a performance option for the 2016 code cycle, requiring:*
  - *Modeling software to define/apply energy budget*
  - *Equipment performance data*

Requirements for Base Code Measures

- A measure must be cost-effective:
  - Based on the standards-induced additional first cost, maintenance costs, measure life, and energy cost savings, according to the CEC Time Dependent Valuation (TDV) life-cycle costing methodology and weather data
- A measure must be possible to implement:
  - Using equipment that is available from multiple providers, or that is reasonably expected to be available following the code change

Background on Leak Reduction Measures

- Refrigerant leaks are a significant source of greenhouse gas emissions
- Current Air Board regulations cover leak checking and leak repair requirements
  - Refrigerant Management Program: www.arb.ca.gov/cc/reftrack/reftrack.htm
- Air Board regulations do not cover system design and installation practices, which can also significantly reduce refrigerant emissions

Basis of Draft Measures

- Measures address refrigeration system **design** and **installation** with the goal of minimizing refrigerant leaks
- Developed based on ANSI, ASHRAE, IMC, and stakeholder feedback
- Intended to set “floor”, not “ceiling” for stores ≥8,000 square feet
- Measures are applicable to new construction and major remodels starting in 2014

Types of Leak Reduction Measures

- 12 draft proposed measures
  - Piping & connection requirements (5 measures)
  - Valve requirements (3 measures)
  - Corrosion prevention (1 measure)
  - Leak testing & monitoring (3 measures)
- Full text available online at: www.arb.ca.gov/cc/commref/commref.htm

Cost Effectiveness

	Small Supermarket	Large Supermarket	Big Box Store
Cost of All Measures ($/Store)	$4,930	$6,780	$7,630
Annual GHG Reduction ($MTCO_2eq$/Store)	20	100	123
Lifetime Cost Savings ($/Store)	$14,159	$58,655	$70,704
Cost-Effectiveness ($ Saved/$MTCO_2eq$ Reduced)	$47.62	$39.08	$38.44
Simple payback (years)	3	1	1

- Analysis assumes an average leak rate reduction of 2% and an equipment lifetime of 15 years
- Cost savings are estimated based on reduced refrigerant usage (including associated carbon costs) and avoided repair costs

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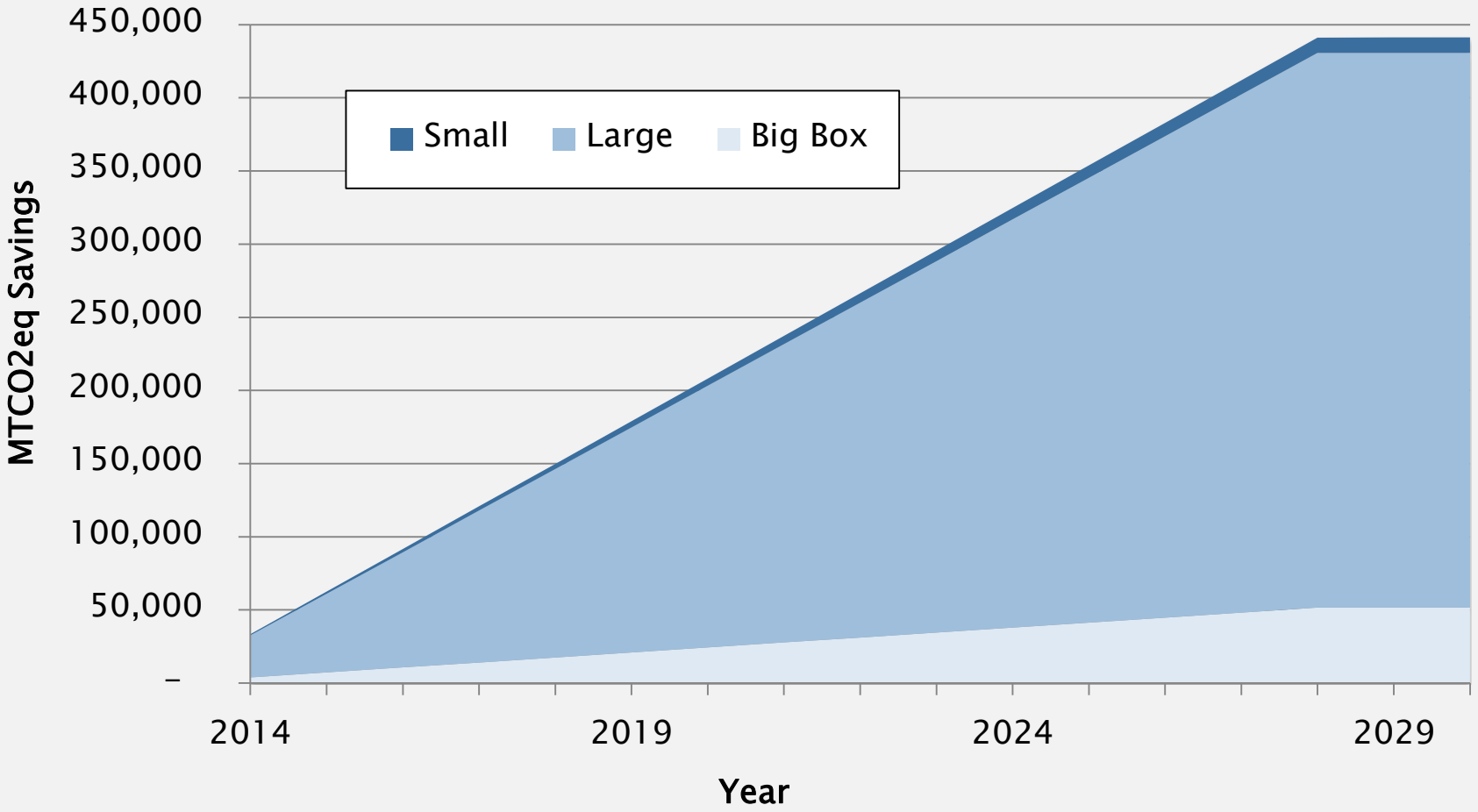
State-Wide Savings (California)



Regulatory Process

- Measures to be added to California's Green Building Standards Code, Title 24 Part 11
  - Nov-Dec 2011: Focus group meetings (additional meetings in 2012 as necessary)
  - Mid-2012: To Code Advisory Committee for approval or additional revisions
  - January 2013: To Building Commission
  - July 2013: Revised 2013 standards published
  - January 1, 2014: 2013 standards effective

Full Text of LRMs and Contact Info

LRMs and LRM cost-benefit at:

http://www.arb.ca.gov/cc/commref/commref.htm

Contact Information:

Glenn Gallagher – CA Air Resources Board

ggallagh@arb.ca.gov

Leak Reduction Measures (summary)

1. Welded refrigeration piping –not threaded
2. Copper tubing >= ¼" outside diameter (O.D.)
3. No flare fittings (with exceptions)
4. Pressure relief valves must have visual indicator for refrigerant release
5. Use only Schrader access valves with brass body
6. Valves shall have internal stem diaphragm or seal caps with chain tethers to fit over the stem
7. Evaporator coils must be coated when in cases w/ vinegar/salt food
8. Piping and components installed to protect from physical damage
9. Refrigerant piping shall be accessible for leak detection & repairs
10. Install level sensors on receivers with >= 200 pounds of refrigerant
11. Pressure test system during installation prior to evacuation & charging
12. Evacuate system following pressure testing & prior to charging

California 2013 Title 24 Supermarket Refrigeration

California Energy Commission

Consultants for California Statewide Utilities Group
Heschong Mahoney Group, Inc.
VaCom Technologies

Consultant for California Air Resources Board
ICF International

Presented by
Doug Scott
VaCom Technologies

September 27, 2011

Previous Process and Timeline

- Stakeholder meetings:
  - Meeting at CARB April, 2010
  - Three Codes and Standards Program meetings including FMI in Minneapolis September 2010
  - CEC public workshop April 2011
- CEC opens Rulemaking: September 2011
- Title 24 CEC Adoption: March 2012
- CBSC Publication: July 2013
- Title 24 Implementation: Jan 1, 2014

Typical Supermarket Refrig. Practice

- Typical new construction practice – common measures from 2001-2010 Savings By Design IOU incentive programs:
  - Floating head pressure to 70 F
  - Floating suction pressure control
  - Subcooling (at least on LT)
  - Variable speed condenser control (nearly 100% on evap condensers and ~50% on air-cooled)
  - History of condenser specific efficiencies

Analysis Methodology

- Energy analysis using DOE2.2R simulation
- Base case via Savings By Design experience
- Time dependent valuation (TDV)
  - Energy valuation based on time of day
- 15 years life for all refrigeration measures
- Measures evaluated with Benefit/Cost Ratio

BCR = total life-cycle TDV value / total incremental cost including discounted maintenance or replacement costs

Analysis Methodology (CO_2 value)

Year	Base Case Carbon Forecast ($/ton CO2eq)
2011	$ 13.98
2012	15.37
2013	16.89
2014	19.87
2015	22.85
2016	26.05
2017	29.26
2018	32.70
2019	36.14
2020	39.84
2021	43.67
2022	47.51
2023	51.62
2024	55.73
2025	60.13

- CEC developed economic value of direct and indirect carbon equivalent emissions
- Necessary to incorporate cost of direct HFC emissions for certain measures

Simulation Tool

- DOE 2.2R whole building hourly simulation
  - Fixtures loads disaggregated, balance space interactions (fixture, HVAC, building, etc.)
  - Mass-flow/component based refrigeration system modeling, explicit control strategies
  - Modeling of building envelope, HVAC, lighting, skylights, etc.

Base Case Assumptions

- Title 24 compliant building
  - Insulation, lighting power density, HVAC systems
  - Code level skylights and light level control
- Display cases
  - T-8 lights, EC motors, low watt glass door heaters
- Walk-ins
  - Federal Walk-in standard compliant
- Refrigeration systems
  - Partial floating head pressure, fixed suction, no subcooling
- Schedules: operations, occupancy, lighting, etc.

Store and System Analysis Types

Supermarket Prototype	Condenser Type	Compressor System	Designation
Small Supermarket (10,000 SF)	Air-cooled	Central	SAC
		Distributed	SAD
	Evaporative-cooled	Central	SEC
	Fluid cooler	Central	SFC
		Distributed	SFD
Large Supermarket (60,000 SF)	Air-cooled	Central	MAC
		Distributed	MAD
	Evaporative-cooled	Central	MEC
	Fluid cooler	Central	MFC
		Distributed	MFD
Big Box Store (150,000 SF)	Air-cooled	Central	LAC
		Distributed	LAD
	Evaporative-cooled	Central	LEC
	Fluid cooler	Central	LFC
		Distributed	LFD

Title 24 Base Code Measures

- Floating head pressure
- Remote condenser specific efficiency
- Floating suction pressure
- Mechanical subcooling
- Display case lighting control
- Prohibit open upright low temperature cases
- Heat recovery for space heating

Reach Code Measure

- CO_2 secondary (indirect) or cascade cooling

Proposed Code Language

- Primary source: April 2011 Draft CASE (Codes and Standards Enhancement) Report

  plus, subsequent changes by CEC based on stakeholder input
- Black text in following slides is based on proposed code language

Information is proposed not final and is subject to change

Applicability

Retail food stores with **8,000 square feet** or more of conditioned area or more, and that utilize either refrigerated display cases, or walk-in coolers or freezers connected to **remote** compressor units or condensing units, shall meet the requirements of this section.

- New construction:
  - Includes remodels and expansions with certain exceptions

Definitions

- **BUBBLE POINT** is the refrigerant liquid saturation temperature at a specified pressure.
- **DEW POINT** is the refrigerant vapor saturation temperature at a specified pressure.
- **COOLER** is a space greater than or equal to 28 F but less than 55 F.
- **FREEZER** is a space designed to maintain less than 28 F and space designed to be convertible between cooler and freezer operation.

Definitions

- **SATURATED CONDENSING TEMPERATURE (CONDENSING TEMPERATURE)** is the saturation temperature corresponding to the refrigerant pressure at the condenser entrance for single component and azeotropic refrigerants. For zeotropic refrigerants, the arithmetic **average of the Dew Point and Bubble Point** temperatures corresponding to the refrigerant pressure at the condenser entrance.

Definitions

- **CONDENSER SPECIFIC EFFICIENCY** is the condenser Total Heat of Rejection (THR) capacity divided by the input electric power at 100 percent fan speed (including spray pump electric input power for evaporative condensers) at standard conditions.
- **MICRO-CHANNEL CONDENSER** is an air-cooled condenser for refrigeration systems which utilizes multiple small parallel gas flow passages in a flat configuration with unitized fin surface between the gas passages, rather than round tubes arranged at a right angle to separate plate fins.

Definitions

- **TOTAL HEAT OF REJECTION** (THR) is the heat rejected by refrigeration system compressors at design conditions, consisting of the design cooling capacity plus the heat of compression added by the compressors.

And recently added:

- **GLOBAL WARMING POTENTIAL** ….
- **GLOBAL WARMING POTENTIAL VALUE** ….
- **LOW-GWP REFRIGERANT** …

Floating Head Pressure

- All condenser fans for air-cooled condensers, evaporative-cooled condensers, air- or water-cooled fluid coolers or cooling towers shall be continuously **variable speed**, with the speed of **all fans** serving a common condenser high side **controlled in unison**.

Floating Head Pressure

- The refrigeration system condenser controls for systems with **air-cooled** condensers shall use **variable-setpoint control** logic to reset the condensing temperature setpoint in response to ambient **drybulb** temperature.
- The refrigeration system condenser controls for systems with **evaporative-cooled** condensers shall use **variable-setpoint control** logic to reset the condensing temperature setpoint in response to ambient **wetbulb** temperature.

Floating Head Pressure

- EXCEPTION *[to ambient-following strategy]*: Condensing temperature control strategies approved by the Executive Director that have been demonstrated to provide equal energy savings.
- The minimum condensing temperature setpoint shall be **less than or equal to 70˚F**.

- Attractive economics in all locations and for all story types.

FHP – WBT Sensor Error Evaluation

- Investigated sensitivity of sensor error on evaporative condensers.
  - Concerns about RH sensor reading used for wetbulb temperature calculation.
- Analysis determined that evaporative condenser ambient-following control is cost-effective even with significant sensor error.

FHP – Charge Impact Evaluation

- Evaluated potential charge impacts
  - FHP methods could increase charge and/or increase potential for leakage
- Analysis determined that energy savings far outweigh potential direct GHG increase

Condenser Specific Efficiency

- Fan-powered condensers shall meet the (following) specific efficiency requirements:

Condenser Type	Minimum Specific Efficiency	Rating Condition
Evaporative-Cooled	160 (Btu/h)/W	100˚F Saturated Condensing Temperature (SCT), 70˚F Entering Wetbulb Temperature
Air-Cooled	65 (Btu/h)/W	105˚F Saturated Condensing Temperature (SCT), 95˚F Entering Drybulb Temperature

Condenser Specific Efficiency

- **EXCEPTION 1:** Condensers with a THR capacity of less than 150 MBH at the specific efficiency rating condition.
- **EXCEPTION 2:** Stores located in Climate Zone CTZ01.
- **EXCEPTION 3:** Existing condensers that are reused for an expansion or remodel.

- Air-cooled condensers shall have a fin density no greater than 10 fins per inch.
  - **EXCEPTION 1:** Micro-channel condensers.
  - **EXCEPTION 2:** Existing condensers that are reused for an expansion or remodel.

Condenser Specific Efficiency

- Required specific efficiencies are only slightly higher than the incentive program base case efficiencies since 2002.
  - 160 vs. 140 for evaporative condensers
  - 65 vs. 53 for air cooled condensers
- Observations:
  - Catalog capacities are not certified ratings
  - Motor ratings are nameplate ratings and applied power could be higher or lower
  - First generation condensers with EC motors had low efficiencies—better options are coming to market

Floating Suction Pressure

- Compressors and multiple-compressor suction groups shall include control systems that use **floating suction pressure** logic to reset the target saturated suction temperature based on the temperature requirements of the attached refrigeration display cases or walk-ins.
  - **EXCEPTION 1:** Single compressor systems that do not have continuously variable capacity capability.
  - **EXCEPTION 2:** Suction groups that have a design saturated suction temperature of 30˚F or higher, or suction groups that comprise the high stage of a two-stage or cascade system or that primarily serve chillers for secondary cooling fluids.

Floating Suction Pressure

- Standard practice in most stores
  - FSP logic standard in rack controllers
  - Temperature sensors in cases and walk-ins (needed for FSP) are standard practice
- Requires coordination with other controls such as electronic suction regulators
- Measure cost is primarily labor to program, fine-tune and maintain

Mechanical Subcooling

- Liquid subcooling shall be provided for all low temperature parallel compressor systems with a design saturated suction temperature of -10˚F or lower, with the subcooled liquid temperature maintained continuously at 50˚F or less at the exit of the subcooler, using compressor economizer port(s) or a separate parallel medium or high temperature suction group operating at a saturated suction temperature of 18˚F or higher.

Mechanical Subcooling

- **EXCEPTION 1:** Single compressor systems.
- **EXCEPTION 2:** Low temperature cascade systems that condense into another refrigeration system rather than condensing to ambient temperature.
- **EXCEPTION 3:** Existing compressors that are reused for an expansion or remodel.

Display Case Lighting Control

- Lighting in refrigeration display cases, and lights on glass doors installed on walk-in coolers and freezers shall be controlled by either A or B:
  A. Automatic time switch controls to turn off lights during non-business hours. Use of timed overrides to turn the lights for stocking shall not exceed one hour for any case line-up or walk-in and if manually imitated shall time-out automatically.
  B. Motion sensor controls on each case that reduce display case lighting power by at least 50% within 30 minutes after the area near the case is vacated.
  - **EXCEPTION 1:** Stores which are normally open for business 140 hours or more per week.

Prohibit Open Upright Frozen Food Cases

- Upright low temperature display cases that are designed for a supply air temperature of 5˚F or lower shall utilize reach-in glass doors.

- No incremental capital cost increase
- Energy impact: 12 ft. open case vs. 5 doors
  - 10,000 kWh annual savings

Heat Recovery for Space Heating

- HVAC systems shall utilize heat recovery from refrigeration system(s) for space heating, using no less than **25% of the sum of the design Total Heat of Rejection** of all refrigeration systems that have individual Total Heat of Rejection values of **150,000 BTU/Hr** or greater at design conditions.
  - **EXCEPTION 1:** Stores located in Climate Zone CTZ15.
  - **EXCEPTION 2:** HVAC systems that are reused for an expansion or remodel.

Heat Recovery for Space Heating

- The increase in HFC refrigerant charge associated with refrigeration heat recovery equipment and piping shall be no greater than 0.35 lbs per 1,000 BTU/Hr of heat recovery heating capacity.

Heat Recovery for Space Heating

- Analysis based on full heat recovery,
- Code requirement is only 25% of design THR to allow for many combinations of:
  - Refrigeration systems types
  - HVAC system types and configurations
  - Store sizes and layouts
  - New construction project types

CO^2 Secondary or Cascade Cooling

- Title 24 Part 11 Green Building Standards
  - Voluntary or "Reach" measure: easily adopted, standardized approach for jurisdictions wishing to implement a more stringent code
- Benefit is reduced direct GHG emissions
  - Measure with equal or slightly higher energy use, justified on lower total CO_2 emissions.
- Energy impacts neutral or negative
  - CO_2 indirect approximately equal to DX
  - CO_2 cascade slightly higher than CO_2 indirect
  - Glycol increases energy usage significantly

CO^2 Secondary or Cascade Cooling

- Cooling for all refrigerated display cases and walk-in coolers and freezers shall be provided using carbon dioxide (CO_2), connected to compressors as a direct expansion refrigerant, or as a phase-change indirect cooling fluid.
  - **EXCEPTION 1:** Stores with less than 20,000 square feet of sales area.
  - **EXCEPTION 2:** Existing compressor systems that are reused for an expansion or remodel.

CO^2 Secondary or Cascade Cooling

- **EXCEPTION 3:** For the medium temperature display cases and coolers use of indirect **glycol** cooling including the following:
  - Stores with a total medium temperature fixtures and walk-in cooling load of **360,000 BTU/Hr or greater** shall have at least one glycol chiller designed with a glycol supply temperature **no lower than 25˚F**.
  - Glycol supply **pump(s) equipped with variable speed** drives controlled based on glycol loop pressure differential and with two-way (no bypass) type control valves at cooling coils and display cases.
  - Variable **speed control on walk-in cooling coil fans**, utilizing speed control as primary temperature control before cycling glycol supply valves, with minimum fan speed no greater than 70%.

Recent added language to allow glycol with provisions to achieve minimum energy penalty vs. DX.

CO^2 Secondary or Cascade Cooling

Recent added language to allow low GWP option (e.g. HFO) when available

- **EXCEPTION 4:** Direct expansion systems using a Low-GWP refrigerant.

- **LOW-GWP REFRIGERANT** means a compound used as a heat transfer fluid or gas that is: (A) any compound or blend of compounds, with a **GWP Value less than 150**; and (B) U.S. EPA Significant New Alternatives Policy (SNAP)-approved; and (C) not an ozone depleting substance as defined in Title 40 of the Code of Federal Regulations, Part 82, §82.3 (as amended March 10, 2009).

- **EXCEPTION 5:** Self-contained refrigerated display cases.

Acceptance Testing

- Acceptance testing of control-related measures will be required as part of code compliance.
- Acceptance testing procedures will be developed once measures are adopted.

- Will contact chains to assist in “dry run” of acceptance testing procedures.

Rejected or Deferred Measures

- Evaporator coil specific efficiency
  - Large potential but too complex
  - Issue of no standard ratings or certification
- Display case LED lights
  - Federal preemption
- Display case night curtains
  - Not cost-effective

Rejected or Deferred Measures

- Prohibit hot gas defrost (reduced leakage)
  - Results too uncertain
- Walk-in variable speed fan control
  - Large potential but cost and performance concerns were not resolved
- Liquid-suction heat exchangers
  - Large potential savings but leakage concern was not resolved

QUESTIONS

Information:
www.energy.ca.gov/title24/2013standards/prerulemaking
www.calcodesgroup.com
www.h-m-g.com/T24/supermarket%20refrig/supermarketrefrig.htm

Martha Brook email: mbrook@energy.state.ca.us
Doug Scott email: dscott@vacomtech.com