CHAPTER 4. SCREENING ANALYSIS

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4.1 INTRODUCTION

This document addresses the screening analysis that the U.S. Department of Energy (DOE) conducted in support of the energy conservation standards rulemaking for commercial refrigeration equipment (CRE), including commercial ice-cream freezers; self-contained commercial refrigerators, commercial freezers, and commercial refrigerator-freezers without doors; and remote condensing commercial refrigerators, commercial freezers, and commercial refrigerator-freezers. This rulemaking is mandated by the Energy Policy Act of 2005 (EPACT 2005), and are effective for equipment manufactured on or after January 1, 2012.

In the market and technology assessment (Chapter 3), DOE presented an initial list of technologies that can reduce the energy consumption of commercial refrigeration equipment. The goal of the screening analysis is to screen out technologies that will not be considered further in the rulemaking analyses. DOE understands that some of the technologies considered in Chapter 3 can reduce annual energy consumption under real-world conditions, but may not reduce calculated daily energy consumption (CDEC), as measured by the American National Standards Institute/American Society of Heating, Refrigerating and Air-Conditioning Engineers (ANSI/ASHRAE) Standard 72-2005, Method of Testing Commercial Refrigerators and Freezers. Therefore, DOE removed from consideration those technologies that have no effect or do not reduce CDEC. DOE evaluated the list of remaining technologies using the screening criteria set forth in the Energy Policy and Conservation Act (EPCA). (42 U.S.C. 6311-6317)

Section 325(o) of EPCA establishes criteria for prescribing new or amended standards that are designed to achieve the maximum improvement in energy efficiency. Further, EPCA directs the Secretary of Energy to determine whether a standard is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A), as directed by 42 U.S.C. 6316(a)(1)-(3). In addition, EPCA establishes guidelines for determining whether a standard is economically justified. (42 U.S.C. 6295(o)(2)(B)) In view of the EPCA requirements for determining whether a standard is technologically feasible and economically justified, Appendix A to subpart C of Title 10, Code of Federal Regulations, Part 430 (10 CFR Part 430), "Procedures, Interpretations, and Policies for Consideration of New or Revised Energy Conservation Standards for Consumer Products" (the Process Rule), sets forth procedures to guide DOE in its consideration and promulgation of new or revised efficiency standards. These procedures elaborate on the statutory criteria provided in 42 U.S.C. 6295(o) and, in part, eliminate problematic technologies early in the process of prescribing or amending an energy efficiency standard. In particular, sections 4(b)(4) and 5(b) of the Process Rule provide guidance to DOE in determining whether to eliminate from consideration any technology that presents unacceptable problems with respect to the following criteria:

Technological feasibility. Technologies incorporated in commercial equipment or in working prototypes will be considered technologically feasible.

Practicability to manufacture, install, and service. If mass production of a technology in commercial equipment and reliable installation and servicing of the technology could be achieved on the scale necessary to serve the relevant market at the time of the effective date of the standard, then that technology will be considered practicable to manufacture, install, and service.

Impacts on equipment utility or equipment availability. If DOE determines that a technology will have significant adverse impact on the utility of the equipment to significant sub-groups of consumers, or result in the unavailability of any covered equipment type with performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as equipment generally available in the United States at the time, DOE will not consider it further.

Adverse impacts on health or safety. If DOE determines that a technology will have significant adverse impacts on health or safety, DOE will not consider it further.

In sum, if DOE determines that a technology, or a combination of technologies, has unacceptable effects on the policies stated in section 5(b) of the Process Rule, it will be eliminated from consideration. If a particular technology fails to meet one or more of the four criteria, it will be screened out. The reasons for eliminating any technology are documented in section 4.3.

4.2 TECHNOLOGIES THAT DO NOT AFFECT CALCULATED DAILY ENERGY CONSUMPTION

The ANSI/ASHRAE Standard 72-2005 test procedure calls for a steady-state test. So, technologies that only reduce energy use under transient conditions will not affect the measured CDEC. Therefore, DOE removed the following technologies from consideration: higher efficiency expansion valves, condenser fan motor controllers, anti-sweat heater controllers, and liquid-suction heat exchangers (LSHXs).

4.2.1 Higher Efficiency Expansion Valves

Higher efficiency expansion valves can reduce the annual energy consumption of commercial refrigeration equipment by adapting to varying loads and ambient conditions. Because ANSI/ASHRAE Standard 72-2005 is a steady-state test (*i.e.*, there are no changes in refrigerated-product loading or ambient conditions), there is no opportunity for higher efficiency expansion valves to reduce CDEC. Consequently, DOE did not consider higher efficiency expansion valves in the engineering analysis.

4.2.2 Condenser Fan Motor Controllers

Condenser fan motor controllers can adapt condenser operation to changing ambient temperatures (effectively by creating floating head pressure), and thereby reduce annual energy consumption of self-contained commercial refrigeration equipment. However, because testing under the ANSI/ASHRAE Standard 72-2005 test procedure is conducted at a constant temperature, there is no opportunity to account for the adaptive technology of a condenser fan motor controller to reduce CDEC. Therefore, DOE did not consider condenser fan motor controllers in the engineering analysis.

4.2.3 Anti-Sweat Heater Controllers

A CRE manufacturer typically sizes anti-sweat heaters according to the maximum ambient temperature and humidity of a particular operating environment. The end-user must maintain that environment to prevent condensation (*i.e.,* fog) from forming on surfaces such as display case glass. Anti-sweat heater controllers modulate the operation of anti-sweat heaters by reducing anti-sweat heater power when humidity is low. Anti-sweat heater controllers operate most effectively when the dew point cannot be constantly maintained. Because the ANSI/ASHRAE Standard 72-2005 test procedure is conducted at a constant temperature and humidity, there is no opportunity to account for the adaptive technology of an anti-sweat heater controller to reduce CDEC. Therefore, DOE did not consider anti-sweat heater controllers in the engineering analysis.

4.2.4 Liquid-Suction Heat Exchangers

An LSHX is an indirect liquid-to-vapor heat transfer device that evaporates any residual liquid refrigerant that remains in the evaporator discharge line, and thereby minimizes the risk of liquid refrigerant carrying over to the compressor suction. Generally, LSHXs are installed in refrigeration systems to ensure proper system operation and increase system performance. However, the combination of refrigerant type, operating temperature, ambient conditions, and other factors determines whether an LSHX will increase or decrease the CDEC as measured by the ANSI/ASHRAE Standard 72-2005 test procedure. Because an LSHX does not consistently reduce CDEC, DOE did not consider this technology in the engineering analysis.

4.3 SCREENED-OUT TECHNOLOGIES

This section addresses the technologies that DOE screened out because they did not meet the requirements of sections 4(a) and 5(b) of the Process Rule. DOE considered the following four factors: (1) technological feasibility; (2) practicability to manufacture, install, and service; (3) adverse impacts on equipment utility to consumers; and (4) adverse impacts on health or safety. The technologies that were screened out are air curtain design, thermoacoustic refrigeration, magnetic refrigeration, electro-hydrodynamic (EHD) heat exchangers, and copper rotor motors.

4.3.1 Improved Air Curtains

An air curtain is a fan-powered device that creates a moving wall (curtain) of air, which separates two spaces of different temperatures. The curtain prevents the loss of refrigerated air from the display area of semivertical commercial refrigerators, for example, and prevents the entry of warm ambient air. Since improved air curtains are in the research stage, it would not be practicable to manufacture, install, and service this technology on the scale necessary to serve the relevant market at the time of the effective date of the standard. Also, because this technology is in the research stage, DOE cannot assess whether improved air curtains will have any adverse impacts on utility to significant sub-groups of consumers, result in the unavailability of any type of commercial refrigeration equipment, or present any significant adverse impacts on health or safety. Therefore, DOE screened out improved air curtains as a design option for improving the energy efficiency of commercial refrigeration equipment.

4.3.2 Thermoacoustic Refrigeration

Thermoacoustic refrigeration uses high-amplitude sound waves in a pressurized gas to pump heat from one place to another. This technology is in the research stage. Consequently, it would not be practicable to manufacture, install, and service on the scale necessary to serve the relevant market at the time of the effective date of the standard. DOE also cannot assess whether thermoacoustic refrigeration will have any adverse impacts on utility to significant sub-groups of consumers, result in the unavailability of any type of commercial refrigeration equipment, or present any significant adverse impacts on health or safety. Therefore, DOE screened out thermoacoustic refrigeration as a design option for improving the energy efficiency of commercial refrigeration equipment.

4.3.3 Magnetic Refrigeration

Magnetic refrigeration is a cooling technology based on the magnetocaloric effect in which a reversible change in temperature of a suitable material is caused by exposing the material to a changing magnetic field. Magnetic refrigeration can be used to attain extremely low temperatures and can be adapted to the cooling temperatures used in common commercial refrigeration equipment. However, magnetic refrigeration is in the research stage and, therefore, it would not be practicable to manufacture, install, and service this technology on the scale and in the timeframe necessary to serve the relevant market at the time of the effective date of the standard. DOE also cannot assess whether it will have any adverse impacts on utility to significant sub-groups of consumers, result in the unavailability of any type of commercial refrigeration equipment, or present any significant adverse impacts on health or safety. Therefore, DOE screened out magnetic refrigeration as a design option for improving the energy efficiency of commercial refrigeration equipment.

4.3.4 Electro-Hydrodynamic Enhanced Heat Transfer

EHD enhancement of heat transfer is the result of applying a high-voltage electrostatic potential field across a heat transfer fluid, such as a refrigerant or refrigerant mixture. The applied field destabilizes the thermal boundary layer, thereby producing better mixing of the bulk fluid flow and increasing the net heat transfer coefficient. This procedure appears to be more effective when applied to phase-change processes (*e.g.,* boiling and condensation). Because EHD enhanced heat transfer is in the research stage and is not used in commercially produced or sold commercial refrigeration equipment, it would not be practicable to manufacture, install, and service this technology on the scale necessary to serve the relevant market at the time of the effective date of the standard. Also, because this technology is in the research stage, DOE cannot assess whether it will have any adverse impacts on utility to significant sub-groups of consumers, result in the unavailability of any type of commercial refrigeration equipment, or present any adverse impacts on health or safety. Therefore, DOE screened out EHD enhanced heat transfer as a design option for improving the energy efficiency of commercial refrigeration equipment.

4.3.5 Copper Rotor Motors

Motor manufacturers have long known that substituting copper for die-cast aluminum in rotors would significantly reduce motor losses and improve electrical energy efficiency. However, manufacturing die-cast copper rotors requires specialized equipment, significant investment, and proprietary know-how that are not yet suitable for production of the millions of motors produced annually. DOE recognizes the advantages of this significant advance in motor technology, but it would not be practicable to manufacture, install, and service copper rotor motors on the scale necessary to serve the relevant market at the time of the effective date the standard. Further, DOE cannot assess whether the manufacture and use of copper rotor motors would have any adverse impacts on the utility of commercial refrigeration equipment to significant sub-groups of consumers, result in the unavailability of any type of commercial refrigeration equipment, or present any significant adverse impacts on health or safety. Therefore, DOE screened out copper rotor motors as a design option for improving the energy efficiency of commercial refrigeration equipment.

4.4 REMAINING TECHNOLOGIES

After eliminating those technologies that do not reduce CDEC and screening out technologies that do not meet the requirements of sections 4(a)(4) and 5(b) of the Process Rule, DOE is considering the following technologies:

- higher efficiency lighting
- higher efficiency lighting ballasts
- remote lighting ballast location
- higher efficiency evaporator fan motors
- evaporator fan motor controllers
- higher efficiency evaporator fan blades
- increased evaporator surface area
- low-pressure differential evaporators
- improved or thicker insulation
- defrost mechanisms
- defrost cycle controls
- higher efficiency compressors (self-contained equipment only)
- increased condenser surface area (self-contained equipment only)

- higher efficiency condenser fan motors (self-contained equipment only)
- higher efficiency condenser fan blades (self-contained equipment only)