CHAPTER 9. TRIAL STANDARD LEVELS

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CHAPTER 9. TRIAL STANDARD LEVELS

9.1 INTRODUCTION

Section 136(c) of EPACT 2005 amended section 342 of EPCA, in part, by adding new subsection 342(c)(4)(A), (42 U.S.C. 6313(c)(4)(A)) which directs the Secretary to issue, by rule, no later than January 1, 2009, energy conservation standards for the following equipment, manufactured on or after January 1, 2012: 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 equipment, which has never before been regulated at the Federal level, has a large number of equipment classes covered by this rulemaking. The U.S. Department of Energy (DOE) has, therefore, focused on conducting a thorough examination of the equipment classes with the greatest energy savings potential. DOE relied on industry-supplied shipment data and addressed those equipment classes which had the highest shipment values first. To address low-shipment equipment classes, DOE decided to develop correlations by conducting a "focused matched-pair analysis."[a] This methodology is described in further detail in Chapter 5 of the TSD.

DOE selected between four and eight energy consumption levels for each commercial refrigeration equipment (CRE) class for use in the LCC analysis. Based on the results of the LCC analysis, DOE selected a subset of four levels above the baseline level for each product for use in the more detailed analysis for the NOPR stage of the rulemaking. DOE refers to these as candidate standard levels (CSLs). The range of CSLs selected includes: the most energy efficient level or most energy efficient combination of design options, the combination of design options or efficiency level with the minimum LCC, and a combination of design options or efficiency level with a PBP of not more than 3 years. In addition, DOE selected two efficiency levels for analysis that filled in the large efficiency gap between the level 1 baseline and the minimum LCC level identified.

DOE presented a set of CSLs in the ANOPR for review based on consistent themes and using the results of the ANOPR LCC analysis. DOE did not receive specific comments on the levels selected, the methodology for selection, or alternative levels that would be of interest to stakeholders. After revising the ANOPR analysis, DOE used a similar selection process for the NOPR, but based on the NOPR LCC analysis results. In addition, DOE added one additional Trial Standard Level based on review of early results from the NES analysis.

Because of the size variation within each equipment class and the use of daily energy consumption as the efficiency metric, DOE presented a methodology to express efficiency standards in terms of a normalizing metric. DOE proposed the use of Total Display Area (TDA) as the normalizing metric for equipment with display area. For equipment without display capability (e.g., equipment with solid doors), DOE proposed the use of internal volume as the normalizing metric.

[a] The "focused matched-pair analysis" establishes a correlation between rating temperature levels and energy consumption by quantifying the differences in energy consumption for matched pairs of equipment classes that are very similar in features and dimensions, but have different operating temperatures.

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DOE expressed the ANOPR CSLs in terms of a normalized energy consumption using the normalization factor for each equipment class, and within each class the size analyzed. Each equipment class covers a range of equipment sizes. DOE proposed equations for final standards that would have maximum energy use standards set for equipment within each class varying linearly with the normalization metric (i.e., TDA or volume). Offset factors are used to adjust the energy efficiency requirement for smaller-sized equipment in each equipment class analyzed. These offset factors account for certain components of the refrigeration load (such as the conduction "end effects") that remain constant even when product sizes vary. These constant loads affect smaller cases disproportionately. The offset factors are intended to approximate these constant loads and provide a fixed end point, corresponding to a "zero TDA" or "zero volume" case, in an equation that describes the relationship between energy consumption and the corresponding TDA or volume metric. See Chapter 5 of the TSD for further details on the development of these offset factors for each equipment class.

DOE preserved the general methodology and themes it used for the selection of CSL levels in the NOPR in establishing the equipment class specific efficiency levels that make up the trial standard level (TSL) used in the final rule. However, the final rule TSLs are based on the results of the updated LCC analysis and NIA. Table 9.2.1 shows the TSL levels selected by DOE in terms of energy use for the specific equipment size analyzed in each class. TSL 5 is the maximum technologically feasible ("max tech") level for each equipment class. TSL 4 is the maximum efficiency level with a positive NPV at the seven-percent discount rate, except in the case of four equipment classes: VOP.RC.M, VOP.SC.M, SVO.RC.M, and SVO.SC.M where the minimal difference in energy efficiency between the minimum life cycle cost level, as determined by the LCC analysis, and the maximum efficiency level with positive NPV was less than one half of one percent daily energy consumption. For these equipment classes, DOE selected the minimum life-cycle cost level in preference to the maximum level with positive NPV. For a given equipment class, the efficiency levels selected for TSL 4 are either equivalent to that of TSL 3 or that of TSL 5. TSL 3 is the efficiency level that provided the minimum-life cycle cost as determined by the LCC analysis. TSL 2 and TSL 1 represent lower efficiency levels that fill in the gap between the baseline and the levels determined to result in the minimum LCC.

DOE characterized the TSL levels in terms of proposed equations that establish a maximum daily energy consumption (MEC) through a linear equation of the form:

MEC = A x TDA + B (for equipment classes that use TDA as the normalizing metric) or,

MEC = A x Volume + B (for equipment classes that use Volume as the normalizing metric)

The coefficients A and B are uniquely derived for each equipment class based on the calculated offset factors, B (see Chapter 5 of the TSD for offset factors) and the slope of the equation, A, that would be used to describe the efficiency requirements for equipment of different sizes within the same equipment class. Two points are needed to describe a linear relationship. In this case, the two points are the offset factor, calculated for equipment with either TDA = 0 or Volume = 0 as appropriate, and the energy consumption calculated for

Table 9.2.1 Trial Standard Levels for Analyzed Equipment Expressed in Terms of Daily Energy Consumption

Equipment Class	Test Metric	Trial Standard Level in Order of Efficiency						Trial Standard Levels for Equipment Analyzed Expressed in Terms of Energy Consumption (kWh/day)					
		Baseline	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	Baseline	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
VOP.RC.M	CDEC kWh/day	Level 1	Level 3	Level 4	Level 5	Level 5	Level 7	57.90	51.99	50.68	47.69	47.69	43.75
VOP.RC.L	CDEC kWh/day	Level 1	Level 3	Level 4	Level 6	Level 7	Level 7	133.60	118.44	113.28	112.00	108.40	108.40
VOP.SC.M	TDEC* kWh/day	Level 1	Level 3	Level 5	Level 6	Level 6	Level 8	39.60	35.95	33.38	30.70	30.70	29.33
VCT.RC.M	CDEC kWh/day	Level 1	Level 2	Level 3	Level 6	Level 7	Level 7	33.18	31.77	30.00	16.36	16.18	16.18
VCT.RC.L	CDEC kWh/day	Level 1	Level 3	Level 4	Level 6	Level 7	Level 7	69.31	65.73	46.90	39.60	39.18	39.18
VCT.SC.I	TDEC kWh/day	Level 1	Level 4	Level 5	Level 7	Level 8	Level 8	45.63	33.35	23.39	21.17	20.81	20.81
VCS.SC.I	TDEC kWh/day	Level 1	Level 3	Level 5	Level 8	Level 8	Level 8	27.13	24.31	21.64	19.07	19.07	19.07
SVO.RC.M	CDEC kWh/day	Level 1	Level 3	Level 4	Level 5	Level 5	Level 7	43.56	39.58	38.59	36.34	36.34	33.61
SVO.SC.M	TDEC kWh/day	Level 1	Level 3	Level 5	Level 6	Level 6	Level 8	33.11	30.66	28.87	26.74	26.74	25.74
SOC.RC.M	CDEC kWh/day	Level 1	Level 2	Level 3	Level 5	Level 5	Level 8	31.70	30.01	27.93	26.24	26.24	20.62
HZO.RC.M	CDEC kWh/day	Level 1	Level 2	Level 3	Level 4	Level 5	Level 5	19.63	17.89	15.73	14.69	14.54	14.54
HZO.RC.L	CDEC kWh/day	Level 1	Level 3	Level 4	Level 5	Level 5	Level 5	38.38	35.30	33.41	32.97	32.97	32.97
HZO.SC.M	TDEC kWh/day	Level 1	Level 3	Level 5	Level 7	Level 8	Level 8	19.23	17.85	16.51	14.93	14.81	14.81
HZO.SC.L	TDEC kWh/day	Level 1	Level 3	Level 5	Level 7	Level 8	Level 8	38.69	36.02	33.52	30.31	30.14	30.14
HCT.SC.I	TDEC kWh/day	Level 1	Level 3	Level 4	Level 5	Level 6	Level 6	7.25	6.37	3.70	3.53	3.32	3.32

* "TDEC" is total daily energy consumption of the case as measured for self-contained equipment. "CDEC" is calculated daily consumption of the case, used for remote-condensing equipment

the specific equipment analyzed as shown in Table 9.2.1. For a given equipment class at a given TSL

$$B = OffsetFactor_{class}$$

$$A = \frac{\left(EnergyUse_{Class,SizeAnalyzed}\, xSizeAnalyzed_{Class} - OffsetFactor_{Class}\right)}{SizeAnalyzed_{Class}}$$

where

$EnergyUse_{Class,SizeAnalyzed}$ = the energy use from the engineering analysis for a particular class and TSL

$SizeAnalyzed_{Class}$ = the size of equipment analyzed in terms of the normalization metric (TDA or Volume) for each equipment class

$OffsetFactor_{Class}$ = the offset factors calculated for each equipment class

Table 9.2.2 shows the resulting equations describing each TSL for the 15 equipment classes analyzed.

In addition to the 15 primary equipment classes analyzed, DOE worked to establish standards for the remaining 23 secondary equipment classes of CRE equipment covered in this rulemaking. DOE developed an extension approach to apply the standards developed for these

15 “primary” equipment classes to the remaining 23 “secondary” equipment classes. This approach involves extension multipliers developed using both the 15 primary equipment classes analyzed and a set of “focused matched-pair analyses”. In addition, DOE determined that standards for certain primary equipment classes can be directly applied to other similar secondary equipment classes. Chapter 5 of the TSD discusses the development of the extension multipliers and the set of focused matched-pair analyses. Using this approach, DOE developed an additional set of TSLs for these secondary equipment classes that corresponds to each of the equations shown in Table 9.2.2 at each TSL for the primary equipment classes. Table 9.2.3 shows this additional set of corresponding TSL levels. The levels shown in Table 9.2.3 do not necessarily reflect the same general themes (e.g. minimum life-cycle cost or max tech efficiency levels) for these equipment classes as the economics of these levels for secondary equipment classes were not explicitly analyzed. They do however represent TSLs for these equipment classes in the DOE rulemaking.

Table 9.2.2 Trial Standard Levels Expressed in Terms of Equations and Coefficients for Each Primary Equipment Class

Equipment Class	Test Metric	Trial Standard Levels for Primary Equipment Classes Analyzed*					
		Baseline	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
VOP.RC.M	CDEC kWh/day	1.01 x TDA + 4.07	0.9 x TDA + 4.07	0.87 x TDA + 4.07	0.82 x TDA + 4.07	0.82 x TDA + 4.07	0.74 x TDA + 4.07
VOP.RC.L	CDEC kWh/day	2.84 x TDA + 6.85	2.5 x TDA + 6.85	2.38 x TDA + 6.85	2.35 x TDA + 6.85	2.27 x TDA + 6.85	2.27 x TDA + 6.85
VOP.SC.M	TDEC kWh/day	2.34 x TDA + 4.71	2.09 x TDA + 4.71	1.92 x TDA + 4.71	1.74 x TDA + 4.71	1.74 x TDA + 4.71	1.65 x TDA + 4.71
VCT.RC.M	CDEC kWh/day	0.48 x TDA + 1.95	0.46 x TDA + 1.95	0.43 x TDA + 1.95	0.22 x TDA + 1.95	0.22 x TDA + 1.95	0.22 x TDA + 1.95
VCT.RC.L	CDEC kWh/day	1.03 x TDA + 2.61	0.97 x TDA + 2.61	0.68 x TDA + 2.61	0.57 x TDA + 2.61	0.56 x TDA + 2.61	0.56 x TDA + 2.61
VCT.SC.I	TDEC kWh/day	1.63 x TDA + 3.29	1.16 x TDA + 3.29	0.77 x TDA + 3.29	0.69 x TDA + 3.29	0.67 x TDA + 3.29	0.67 x TDA + 3.29
VCS.SC.I	TDEC kWh/day	0.55 x V + 0.88	0.49 x V + 0.88	0.43 x V + 0.88	0.38 x V + 0.88	0.38 x V + 0.88	0.38 x V + 0.88
SVO.RC.M	CDEC kWh/day	1.01 x TDA + 3.18	0.91 x TDA + 3.18	0.89 x TDA + 3.18	0.83 x TDA + 3.18	0.83 x TDA + 3.18	0.76 x TDA + 3.18
SVO.SC.M	TDEC kWh/day	2.23 x TDA + 4.59	2.04 x TDA + 4.59	1.9 x TDA + 4.59	1.73 x TDA + 4.59	1.73 x TDA + 4.59	1.65 x TDA + 4.59
SOC.RC.M	CDEC kWh/day	0.62 x TDA + 0.11	0.59 x TDA + 0.11	0.55 x TDA + 0.11	0.51 x TDA + 0.11	0.51 x TDA + 0.11	0.4 x TDA + 0.11
HZO.RC.M	CDEC kWh/day	0.51 x TDA + 2.88	0.45 x TDA + 2.88	0.39 x TDA + 2.88	0.36 x TDA + 2.88	0.35 x TDA + 2.88	0.35 x TDA + 2.88
HZO.RC.L	CDEC kWh/day	0.68 x TDA + 6.88	0.62 x TDA + 6.88	0.58 x TDA + 6.88	0.57 x TDA + 6.88	0.57 x TDA + 6.88	0.57 x TDA + 6.88
HZO.SC.M	TDEC kWh/day	1.14 x TDA + 5.55	1.03 x TDA + 5.55	0.91 x TDA + 5.55	0.78 x TDA + 5.55	0.77 x TDA + 5.55	0.77 x TDA + 5.55
HZO.SC.L	TDEC kWh/day	2.63 x TDA + 7.08	2.41 x TDA + 7.08	2.2 x TDA + 7.08	1.94 x TDA + 7.08	1.92 x TDA + 7.08	1.92 x TDA + 7.08
HCT.SC.I	TDEC kWh/day	1.33 x TDA + 0.43	1.16 x TDA + 0.43	0.64 x TDA + 0.43	0.6 x TDA + 0.43	0.56 x TDA + 0.43	0.56 x TDA + 0.43

*TSL Levels expressed in terms of Maximum Energy Consumption (MEC)

Table 9.2.3 Trial Standard Levels Expressed in Terms of Equations and Coefficients for each Secondary Equipment Class

Equipment Class	Test Metric	Trial Standard Levels for Secondary Equipment Classes Analyzed*					
		Baseline	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
SVO.RC.L	CDEC kWh/day	2.84 x TDA + 6.85	2.5 x TDA + 6.85	2.38 x TDA + 6.85	2.35 x TDA + 6.85	2.27 x TDA + 6.85	2.27 x TDA + 6.85
VOP.RC.I	CDEC kWh/day	3.6 x TDA + 8.7	3.17 x TDA + 8.7	3.03 x TDA + 8.7	2.99 x TDA + 8.7	2.89 x TDA + 8.7	2.89 x TDA + 8.7
SVO.RC.I	CDEC kWh/day	3.6 x TDA + 8.7	3.17 x TDA + 8.7	3.03 x TDA + 8.7	2.99 x TDA + 8.7	2.89 x TDA + 8.7	2.89 x TDA + 8.7
HZO.RC.I	CDEC kWh/day	0.87 x TDA + 8.74	0.78 x TDA + 8.74	0.73 x TDA + 8.74	0.72 x TDA + 8.74	0.72 x TDA + 8.74	0.72 x TDA + 8.74
VCT.RC.I	CDEC kWh/day	1.2 x TDA + 3.05	1.14 x TDA + 3.05	0.8 x TDA + 3.05	0.67 x TDA + 3.05	0.66 x TDA + 3.05	0.66 x TDA + 3.05
HCT.RC.M	CDEC kWh/day	0.39 x TDA + 0.13	0.34 x TDA + 0.13	0.19 x TDA + 0.13	0.18 x TDA + 0.13	0.16 x TDA + 0.13	0.16 x TDA + 0.13
HCT.RC.L	CDEC kWh/day	0.81 x TDA + 0.26	0.71 x TDA + 0.26	0.39 x TDA + 0.26	0.37 x TDA + 0.26	0.34 x TDA + 0.26	0.34 x TDA + 0.26
HCT.RC.I	CDEC kWh/day	0.95 x TDA + 0.31	0.83 x TDA + 0.31	0.46 x TDA + 0.31	0.43 x TDA + 0.31	0.4 x TDA + 0.31	0.4 x TDA + 0.31
VCS.RC.M	CDEC kWh/day	0.16 x V + 0.26	0.14 x V + 0.26	0.13 x V + 0.26	0.11 x V + 0.26	0.11 x V + 0.26	0.11 x V + 0.26
VCS.RC.L	CDEC kWh/day	0.33 x V + 0.54	0.3 x V + 0.54	0.26 x V + 0.54	0.23 x V + 0.54	0.23 x V + 0.54	0.23 x V + 0.54
VCS.RC.I	CDEC kWh/day	0.39 x V + 0.63	0.35 x V + 0.63	0.31 x V + 0.63	0.27 x V + 0.63	0.27 x V + 0.63	0.27 x V + 0.63
HCS.RC.M	CDEC kWh/day	0.16 x V + 0.26	0.14 x V + 0.26	0.13 x V + 0.26	0.11 x V + 0.26	0.11 x V + 0.26	0.11 x V + 0.26
HCS.RC.L	CDEC kWh/day	0.33 x V + 0.54	0.3 x V + 0.54	0.26 x V + 0.54	0.23 x V + 0.54	0.23 x V + 0.54	0.23 x V + 0.54
HCS.RC.I	CDEC kWh/day	0.39 x V + 0.63	0.35 x V + 0.63	0.31 x V + 0.63	0.27 x V + 0.63	0.27 x V + 0.63	0.27 x V + 0.63
SOC.RC.L	CDEC kWh/day	1.3 x TDA + 0.22	1.23 x TDA + 0.22	1.15 x TDA + 0.22	1.08 x TDA + 0.22	1.08 x TDA + 0.22	0.84 x TDA + 0.22
SOC.RC.I	CDEC kWh/day	1.52 x TDA + 0.26	1.44 x TDA + 0.26	1.34 x TDA + 0.26	1.26 x TDA + 0.26	1.26 x TDA + 0.26	0.99 x TDA + 0.26
VOP.SC.L	TDEC kWh/day	5.87 x TDA + 11.82	5.25 x TDA + 11.82	4.82 x TDA + 11.82	4.37 x TDA + 11.82	4.37 x TDA + 11.82	4.14 x TDA + 11.82
VOP.SC.I	TDEC kWh/day	7.45 x TDA + 15.02	6.67 x TDA + 15.02	6.13 x TDA + 15.02	5.55 x TDA + 15.02	5.55 x TDA + 15.02	5.26 x TDA + 15.02
SVO.SC.L	TDEC kWh/day	5.59 x TDA + 11.51	5.11 x TDA + 11.51	4.76 x TDA + 11.51	4.34 x TDA + 11.51	4.34 x TDA + 11.51	4.15 x TDA + 11.51
SVO.SC.I	TDEC kWh/day	7.11 x TDA + 14.63	6.5 x TDA + 14.63	6.05 x TDA + 14.63	5.52 x TDA + 14.63	5.52 x TDA + 14.63	5.27 x TDA + 14.63
HZO.SC.I	TDEC kWh/day	3.35 x TDA + 9.	3.06 x TDA + 9.	2.8 x TDA + 9.	2.46 x TDA + 9.	2.44 x TDA + 9.	2.44 x TDA + 9.
SOC.SC.I	TDEC kWh/day	2.13 x TDA + 0.36	2.02 x TDA + 0.36	1.88 x TDA + 0.36	1.76 x TDA + 0.36	1.76 x TDA + 0.36	1.38 x TDA + 0.36
HCS.SC.I	TDEC kWh/day	0.55 x V + 0.88	0.49 x V + 0.88	0.43 x V + 0.88	0.38 x V + 0.88	0.38 x V + 0.88	0.38 x V + 0.88

*TSL Levels expressed in terms of Maximum Energy Consumption (MEC)