Department has decided not to include this option in the analysis.

Location of Compressors. Whirlpool stated that for refrigerators with "forced air hi-side" design (which is the most common design used in the industry), there is no thermodynamic reason to expect energy savings from a change in location of the compressor and condenser. Such a change is also likely to decrease utility of the product by reducing the storage volume available at a convenient height off the floor. Whirlpool does not recommend this option. (Whirlpool, No. 36 at 9). Sub-Zero stated that it already mounts the compressors at the top of the unit; this allows easier servicing and theoretically should reduce the temperature differential. (Sub-Zero, No. 37 at 6). U-Line stated there are not many opportunities to relocate compressors and condensers for compact/under counter products. (U-Line, No. 11 at 7).

General Electric Appliances stated that the benefit of removing the evaporator fan from the refrigerated space diminishes as fan efficiencies improve. The feasibility of this option in large-scale production is questionable due to the need to seal the shaft without significantly increasing the frictional losses. Moisture migration, ice formation, and noise transfer to the cabinet are additional concerns. Moving the high-side components to the top of the refrigerator has marginal cabinet heat leakage benefits, but would require a fundamental redesign of the cabinet structure. Moving the high-side components would require the refrigerator to be completely redesigned to accommodate the option. It likely would require enhanced structural rigidity and deliberate means, such as low-placed weights, to prevent tipovers. General Electric Appliances concluded that, absent a total restructuring of the production line, or creation of new production capacity, the cost of introducing this design option is prohibitive. (GEA, No. 39 at 12-13)

The Department could find no data that showed that relocation of the compressor would save energy. After consideration of the comments discussed above, the Department has decided that even if there are small energy savings from this option, these savings would be insignificant compared to the costs of redesigning and manufacturing a refrigerator with the compressor on top. Therefore, this option has not been included in the engineering analysis.

Use of Natural Convection. Whirlpool stated this option is counterproductive for larger products (above about 14 cubic feet) since the wattage of

condenser fan motors has been reduced substantially in recent years. It does not recommend this option. (Whirlpool, No. 36 at 9). U-Line stated that except for frost-free models, all compact/ undercounter refrigerator-freezers use natural convection evaporators. Those units using forced air condenser systems are designed for built-in or recessed installations. (U-Line, No. 11 at 7).

Based on the comments discussed above, the Department has concluded that the industry is already using this option where it is practical and so has not included it in the engineering analysis.

Electrohydrodynamic Enhancement of Heat Exchangers. Whirlpool considers this to be a technology that is impractical, unsafe, and expensive to implement in products. It does not recommend this option. (Whirlpool, No. 36 at 9). U-Line stated that the compact/ undercounter AHAM subcommittee does not consider this option feasible. (U-Line, No. 11 at 7). Maytag stated that prototypes are not available for electrohydrodynamically enhanced evaporators or condensers. (Maytag, No. 20 at 6). General Electric Appliances stated this may be an inexpensive approach to obtaining marginal energy savings; however, the continuous use of an extremely high voltage field presents safety risks that simply are not acceptable, even if they could be addressed to some degree at a reasonable cost. (GEA, No. 39 at 13).

This concept has only been demonstrated in a laboratory, and no prototypes using this technology have been built. Since there is no cost or performance data for this design option in refrigerators, the Department has decided that this option is not well enough developed for consideration in this rulemaking.

Voltage Control Device. Whirlpool stated it has conducted tests on these devices and found that they save no energy on products which are designed to meet existing energy standards. It does not recommend this option. (Whirlpool, No. 36 at 9). U-Line stated these devices have not demonstrated measurable reductions in energy use when applied to refrigerators and freezers. (U-Line, No. 11 at 7). General Electric Appliances stated its testing indicates current high-efficiency compressors do not exhibit energy savings when used with devices that reduce line voltage and/or change phase angles. (GEA, No. 39 at 13).

Based upon data supplied to the Department,¹⁶ the Department believes

this option does not offer any potential for energy savings for new refrigerators and freezers.

(3) Other Comments.

a. Uncertainty Inherent in Data. The Joint Comments formulated a number of different approaches for quantifying the uncertainty and variance inherent in estimated energy savings and costs for individual design options. It said the basis for quantifying uncertainty lies not only in the estimates of energy savings and costs reasonable in the 1998 time frame, but also in the different economies of scales available to companies in the refrigerator-freezer industry. The impact of design options and associated costs affect these companies' products differently. (Joint Comments, No. 49 at 8).

An example from one of the uncertainty analyses demonstrates the variance in unit cost impacts on topmounted nondispenser automaticdefrost refrigerators. In this example, for a trial standard energy consumption 30 percent below the 1993 level, the increase in manufacturing unit costs runs from approximately \$65 up to \$145, depending on the specific energy saving options used. (Joint Comments, No. 49 at 8).

The Department is aware there are uncertainties in the estimated costs and energy savings of the various design options. Additionally, the Department recognizes other uncertainties that affect the feasibility of design options. including reliability, performance, and safety. The Department has asked manufacturers to supply the data needed to address the issue of the impact of uncertainties on life-cycle cost and payback periods. The Department has considered the uncertainties in costs and energy savings in developing the proposed standards for this rulemaking. The Department has also considered design feasibility and marketing utility uncertainties.

b. Simulation Model. The Joint Comments were critical of the accuracy of the ERA model, which calculates refrigerator energy use. The industry members of the Joint Comments assessed the accuracy of the ERA model in two phases. The first phase was to use current technology and currently available products to determine the accuracy of the ERA estimates versus actual energy data from refrigeratorfreezers. The second phase of this assessment was to determine how the ERA model handles nonconventional technologies, e.g., those technologies

¹⁶ Admiral Refrigerator Test Report for the Admiral Company; Izagulrre, F. L., Senior Engineer,

International Technical Services, Inc., August 25, 1993.