Distribution Transformer Standards Rulemaking

Draft Report for Review

Engineering Analysis for Dry-type Distribution Transformers and Results on Design Line 9

Prepared for:

Building Technology Program
Office of Energy Efficiency and Renewable Energy
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Foreword

The U.S. Department of Energy is determining appropriate minimum efficiency levels for distribution transformers sold in the United States. As a part of the Department's study of the technology, this draft report presents preliminary findings of the Engineering Analysis which clarifies the relationship between the manufacturer's selling price and the unit's efficiency.

This draft report provides an overview of the engineering analysis for dry-type distribution transformers and presents the preliminary findings for the representative unit from design line nine, a 300 kVA, three-phase, dry-type transformer at 45kV BIL. A similar draft report on a liquid-type unit being studied was published by the Department on December 17th, 2001. The results in that draft report were modified following a public review and visits to several manufacturers around the country. The updated results from the December 17th draft report were presented in Appendix B of the Life Cycle Cost results for Design Line 1 published on June 6th, 2002. Both of these draft reports are available on the Department's web site:
http://www.eren.doe.gov/buildings/codes_standards/applbrf/dist_transformer.html

The Department requests public review and comment on the assumptions, methodology and results presented in this draft report. Comments will be entered into the docket for the distribution transformers rulemaking. Please submit comments by 4 p.m. September 13th, 2002, to:

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Please note that for all comments submitted, DOE requires that a signed, original document be mailed to the address above for inclusion in the docket. However, due to possible security screening delays in DOE's processing of mail sent through the U.S. Postal Service, DOE encourages stakeholders to also submit comments electronically (via email) to ensure timely receipt.

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List of Acronyms and Abbreviations

Al	Aluminum
ANN	Air cooled, natural circulation
ANOPR	Advance Notice of Proposed Rulemaking
ANSI	American National Standards Institute
BIL	Basic Impulse insulation Levels
CSA	Canadian Standards Association
Cu	Copper
DOE	United States Department of Energy
HO	Laser-scribed M3 core steel
Hz	Hertz
kV	Kilovolt
kVA	Kilovolt-Ampere (transformer size rating)
M*	M2, M3, M4, M6 - thickness of core steel
NEMA	National Electrical Manufacturers Association
NOPR	Notice of Proposed Rulemaking
OPS	Optimized Program Service, Inc.
ORNL	Oak Ridge National Laboratory
SEC	Securities and Exchange Commission
US	United States
Y	Wye-type transformer terminal connection
Φ	Phase

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1. Setting the Context

On November 1, 2000, the U.S. Department of Energy held a public meeting in Washington, D.C., to discuss the Framework Document for the Distribution Transformer Energy Conservation Standards Rulemaking. An electronic copy of this document is available on the Department's web site at http://www.eren.doe.gov/buildings/codes_standards/applbrf/dist_transformer.html

The Framework Document describes the procedural and analytical approaches the Department is using as it considers energy conservation standards for distribution transformers. The formal rulemaking process for developing energy conservation standards includes three Federal Register notices: the Advanced Notice of Proposed Rulemaking (ANOPR), the Notice of Proposed Rulemaking (NOPR), and the Notice of Final Rulemaking. With the release of this draft report, the Department is in what is commonly called the "pre-ANOPR" stage, which means that the Department is conducting the analysis that will be published for the ANOPR meeting next year.

This draft report provides background on the Engineering Analysis and includes a detailed cost-efficiency study of one of the dry-type units selected for study. The Engineering Analysis is an integral part of the rulemaking process, as described in the following excerpt from the Department's Framework Document:

> 3.4 ENGINEERING ANALYSIS
>
> After the screening analysis, the Department performs an engineering analysis on the options or efficiency levels that were not eliminated. The purpose of the engineering analysis is to estimate the relationship between transformer cost and energy efficiency levels, referred to as a cost-efficiency schedule.
>
> In consultation with outside experts, the Department selects the specific engineering analysis tools to be used in the evaluation. There are three general approaches for developing cost-efficiency schedules: the "efficiency level approach," the "design option approach," and the "cost assessment approach" (see Sect. 4.4). The critical inputs to the engineering analysis are data from manufacturers and/or experts in designing and costing transformers. This includes the cost-efficiency information available through retail prices of transformers and their existing efficiencies. However, information is also required to estimate, for some products, cost-efficiency tradeoffs that may not be available from current market information. This type of information may be developed by manufacturers, from simulation models and/or by design experts.
>
> The cost-efficiency schedules for each product class from the engineering analysis are used in evaluations of life-cycle cost and the calculation of simple payback periods.

The Department considered three possible methods of conducting the engineering analysis and decided on an approach that is a modified (and more transparent) efficiency level analysis. This approach involves contracting a transformer design company that specializes in distribution transformers. Their software tool is used to conduct literally thousands of design runs to create a database of designs and explore the cost-efficiency relationship. The results in this draft report represent those findings from one of the units being analyzed, a 300 kVA, three-phase, 45kV BIL, dry-type distribution transformer.

The Department recognizes that the results in this draft report are not the definitive answer to the question of the relationship between cost and efficiency. These results assume an ideal situation, where manufacturers do not incur any retooling or special handling costs associated with changing materials or core/coil dimensions. The Department requests that reviewers, and particularly manufacturers, submit comments on what additional costs they would incur other than for raw materials if DOE decides to introduce minimum efficiency standards.

2. Structuring the Engineering Analysis

2.1 Simplifying the Number of Units to Analyze

The National Electrical Manufacturers Association (NEMA) has seventy-three different standard kVA ratings in its TP-1-2002 document, spanning the range of liquid and dry-type distribution transformers. These kVA ratings are based on industry standard ratings outlined in the ANSI/IEEE C57.12.00 for liquid-type and C57.12.01 for dry-type. The Department recognizes that it would be impractical to conduct a detailed analysis of the cost-efficiency relationship on all seventy-three units, so it sought a method that simplified the analysis while retaining reasonable levels of accuracy. Through consultation with industry representatives and transformer design engineers, the DOE developed an understanding of the principles of construction for distribution transformers. It found that many of the units share similar designs and construction methods. Based on this knowledge, the DOE simplified the analysis by creating thirteen "design lines," which group together kVA ratings based on these similarities.

The thirteen"design lines" differentiated the transformers by type (liquid or dry), number of phases (one or three), and insulation levels (BIL level). Liquid transformers use a mineral oil or synthetic chemical as a cooling and insulating medium, while dry-type transformers use air for cooling. Basic Impulse Insulation Levels (BIL) refer to the level of insulation wound into a transformer, and dictate its design voltage. Generally, higher BIL levels will have lower transformer efficiencies because the additional winding insulation and clearances will increase the space between the core and coil, contributing to higher losses. For informational purposes, Table 2.1 provides a breakdown of the standard BIL levels typically associated with dry-type distribution transformer primary voltages.

Table 2.1 Primary voltages and corresponding BIL levels

Primary voltages	Dry-Type Voltage BIL
35 kV	150 kV BIL
25 kV	110-125 kV BIL
18 kV	95 kV BIL
15 kV	60 kV BIL
8.7 kV	45 kV BIL
5 kV	30 kV BIL
2.5 kV	20 kV BIL
1.2 kV	10 kV BIL
480 V	-

The DOE's thirteen "design lines" parceled together industry's seventy-three kVA ratings based on construction similarities and the type of transformer, number of phases and, where appropriate, BIL levels. Table 2.2 presents the design lines. For completeness sake, this table shows both the liquid and dry-type design lines; however, this draft report focuses only on dry-type and gives specific findings only on design line number nine.

Table 2.2 Design Lines and Representative Units for Analysis

Design Line	Type	# of Phases	KVA Range	Primary BIL Range	Primary Taps, Full Capacity	Secondary Voltage Range	Representative Unit for the Design Lines
1	Liquid Rect.	1	10-100	≤95-150 kV	±2-2.5%	240/120 to 600V	50kVA, 65˚C, ONAN, 1Φ, 60Hz, 24940GrdY/14400-240/120V, 125kV BIL
2	Liquid Round	1	10-100	≤95-150 kV	±2-2.5%	240/120 to 600V	25kVA, 65˚C, ONAN, 1F, 60Hz, 24940GrdY/14400-120/240V, 125kV BIL
3	Liquid	1	167-833	≤95-150 kV	±2-2.5%	240/120 to 600V	500kVA, 65˚C, ONAN, 1F, 60Hz, 14400/24940Y-120/240YV, 150kV BIL
4	Liquid	3	15-500	≤95 kV	±2-2.5%	208Y/120 to 600V	150kVA, 65˚C, ONAN, 3F, 60Hz, 12470Y/7200-208Y/120V, 95kV BIL
5	Liquid	3	750-2500	≤95-150 kV	±2-2.5%	208Y/120 to 600VY347	1500kVA, 65˚C, ONAN, 3F, 60Hz, 24940GrdY/14400-480Y/277V, 125kV BIL
6	Dry (LV)	1	15-333	10 kV	Universal*	120/240 to 600V	25 kVA, 150˚C, ANN, 1Φ, 60Hz, 480 - 120/240V, 10 kV BIL
7	Dry (LV)	3	15-150	10 kV	Universal*	208Y/120 to 600Y/347V	75 kVA, 150˚C, ANN, 3Φ, 60Hz, 480 – 208Y/120V, 10 kV BIL
8	Dry (LV)	3	225-1000	10 kV	Universal*	208Y/120 to 600Y/347V	300 kVA, 150˚C, ANN, 3Φ, 60Hz, 480 – 208Y/120V, 10 kV BIL
9	Dry (MV)	3	15-500	20-45 kV	±2-2.5%	208Y/120 to 600Y/347V	300 kVA, 150˚C, ANN, 3Φ, 60Hz, 4160 – 480Y/277V, 45 kV BIL
10	Dry (MV)	3	750-2500	20-45 kV	±2-2.5%	208Y/120 to 600Y/347V	1500 kVA, 150˚C, ANN, 3Φ, 60Hz, 4160 – 480Y/277V, 45 kV BIL
11	Dry (MV)	3	15-500	60-95 kV	±2-2.5%	208Y/120 to 600Y/347V	300 kVA, 150˚C, ANN, 3Φ, 60Hz, 12470 – 480Y/277V, 95 kV BIL
12	Dry (MV)	3	750-2500	60-95 kV	±2-2.5%	208Y/120 to 600Y/347V	1500 kVA, 150˚C, ANN, 3Φ, 60Hz, 12470 – 480Y/277V, 95 kV BIL
13	Dry (MV)	3	225-2500	110-150 kV	±2-2.5%	208Y/120 to 600Y/347V	2000 kVA, 150˚C, ANN, 3Φ, 60Hz, 12470 – 480Y/277V, 125 kV BIL

*Universal Taps are 2 above and 4 below 2.5%

Note: Design line one corresponds to liquid-type rectangular tank distribution transformers, either pad-mounted or submersible. Design line two covers the same kVA range, but it represents cylindrical tank designs, either pole-mounted or submersible.

In Table 2.2, the column labeled "Representative Unit for the Design Lines" describes the transformer from each design line that the DOE will study in its Engineering Analysis and Life-Cycle Cost Analysis. The findings of the analysis on this "representative unit" are then extrapolated to the other kVA ratings in a given design line, thus reducing the number of units studied from seventy-three to thirteen. The extrapolation technique employed is referred to as the "0.75 scaling rule." This rule states that for similarly designed transformers, cost of construction and losses scale to the ratio of kVA ratings raised to the 0.75 power. The relationship is valid where the optimum efficiency loading points of the two transformers being scaled are equal. The Department demonstrated the effectiveness of the 0.75 scaling rule by extrapolating from a few units to all the efficiency values in NEMA's TP-1 document. Appendix A of this report contains more detail on the derivation of the 0.75 scaling rule.

In Table 2.2, dry-type distribution transformers are broken into eight separate design lines, primarily according to their BIL levels. The Department believes this level of disaggregation is necessary to capture important differences in the cost-efficiency relationship between units as the BIL level varies. For example, a 500 kVA, three-phase, dry-type unit can appear in design lines 8, 9, 11, or 13 depending on whether the BIL level is 10 kV, 20-45 kV, 60-95 kV, or 110-150 kV.

For Design Lines 9 through 13, it should be noted that the representative units selected for some of the dry-type design lines are not the standard BIL levels shown in Table 2.1. A slightly higher BIL level was selected for the representative units from these design lines to ensure the minimum efficiency standard would not excessively penalize customers purchasing higher BIL levels. For example, a 300kVA with a 4160V primary is called a “5kV class” transformer and would normally be built with a 30kV BIL level. However, customers also order a 5kV class 300kVA with a 45kV or 60kV BIL. If the minimum efficiency standard were set at the 30kV BIL, it may be prohibitively difficult to achieve that same standard level for customers ordering 60kV BIL. Thus, the Department elected to evaluate the middle BIL level (in this example, 45kV BIL), making it slightly easier for the lower BIL levels to achieve compliance, and not too difficult for the higher BIL level.

2.2 Creating the Database of Transformer Designs

For all the representative units, the Engineering Analysis involves exploring the relationship between the manufacturing price and its corresponding efficiency. To explore this relationship, the Department selected a transformer design software company called Optimized Program Service, Inc. (OPS) to create a database of designs that span the range of efficiency levels for each of the units being analyzed. OPS has been performing this service for manufacturers for more than 30 years (information on OPS can be found in Appendix B of this draft report). Using its own software, OPS prepared a database of several thousand cost-optimized designs spanning a range of efficiencies (see Appendix C for list from design line nine).

OPS software produces an optimized, practical transformer design and bill of materials based on a series of inputs. The design specification report includes information about the core and coil design that would enable a manufacturer to build this unit, such as core dimensions, high and low voltage windings, insulation, cooling ducts and labor. The software generates an estimated cost to the manufacturer, which can then be converted to a manufacturer sales price using a predetermined mark-up.

The OPS software also generates an electrical analysis report estimating the design’s performance, including efficiency, at the following loading points: 25%, 35%, 50%, 65%, 75%, 100%, 125%, and 150% of nameplate load. The software provides a clear understanding of the relationship between cost and efficiency because it provides data on the design, the bill of materials, the labor costs and the efficiency. However, one shortcoming of this method is that the software cannot capture retooling costs associated with changing production designs for a specific manufacturer. Therefore, the preliminary results shown in this draft report may underestimate manufacturer costs by excluding retooling or necessary additional capital investment.

In order to create a database that incorporates transformer designs covering a broad spectrum of efficiencies, the Department decided to use an approach involving loss evaluation variables. Because the OPS software is structured to help manufacturers create economically optimized designs to meet their client needs, it has the capability to specify the customer's valuation of no-load (A-value) and load (B-value) losses. A and B values are expressed in dollars per watt, and represent the present value of all future core (A) and coil (B) losses the transformer will experience in its lifetime. The Department developed a matrix of A and B values:

A ranging from $0 to $12 by 0.5 increments
B ranging from $0 to $8 by 0.5 increments

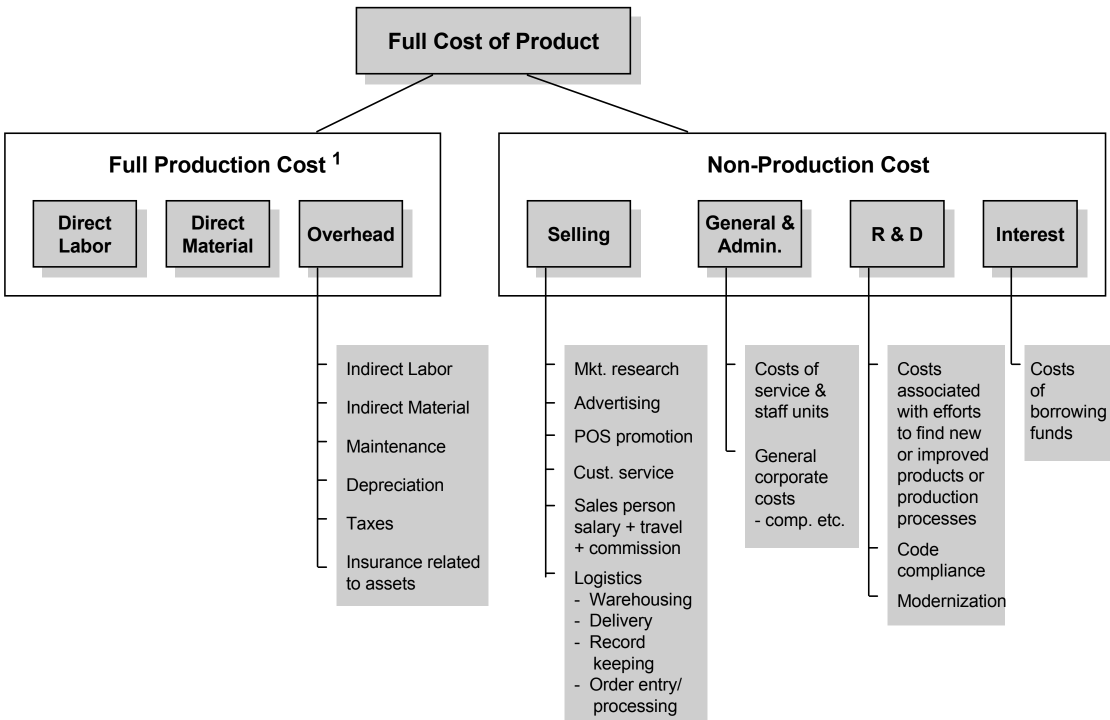
Because B is never greater than A, the complete matrix includes 289 combinations of A and B. The Department then used these combinations as inputs to the OPS software to create 289 different optimized transformer designs, cost-optimized to the matrix of A and B combinations.

3. Software Inputs to Generate the Design Database

3.1 Material and Labor Inputs

The Department of Energy uses a standard method of cost accounting to determine the costs associated with manufacturing. This methodology is illustrated in Figure 3.1, where production costs and non-production costs are combined to determine the full cost of a product.

Figure 3.1 Standard method of cost accounting for DOE Rulemaking



[1] Tax Reform Act of 1986, essentially, requires companies to measure cost of goods sold as the full production cost of the goods sold.

DOE developed estimates of the costs listed in Figure 3.1 from the U.S. Industry Census Data reports for 1992 and 1997, SEC 10-K reports for ACME Electric Corporation, Powell Industries, Inc., Magnetek, Inc., and Hammond Manufacturing Company Limited, and industry representatives. Note that this method of analysis does not include the profit margin associated with the product, which is generally a mark-up applied to the full cost of the product.

In consultations with OPS and manufacturers concerning the input cost of materials, the Department learned that when the optimizer program is running, inputs should reflect the final marked-up transformer sales price, not the direct material cost of the materials or labor to the manufacturer. For example, instead of having the input for core steel at $1.00 per pound as it arrives at the manufacturer's facility, it should be entered as $1.44 to reflect the scrap and handling factor, factory overhead, and non-production mark-up. Table 3.1 provides all the material prices entered into the OPS software.

Table 3.1 OPS software inputs for 300 kVA 3-phase 45 kV BIL

Type	Item	Description	Units	Direct Material		Factory Overhead[3]	Non-production Mark-up[4]	$ Input to OPS
				$ Cost [1]	Handling & Scrap[2]			
Variable Costs (change with design modifications)	Core Steel	HO steel (AK Steel laser-scribed)	lb.	1.15	1.025	1.125	1.25	**1.66**
	Core Steel	M3 steel	lb.	0.95	1.025	1.125	1.25	**1.37**
	Core Steel	M6 steel	lb.	0.64	1.025	1.125	1.25	**0.92**
	Core Steel	M19 steel	lb.	0.70	1.025	1.125	1.25	**1.01**
	Core Steel	M36 steel	lb.	0.46	1.025	1.125	1.25	**0.66**
	Copper Wire	Rectangular 0.1 x 0.2	lb.	1.60	1.025	1.125	1.25	**2.31**
	Aluminum Wire	Rectangular 0.1 x 0.2	lb.	2.00	1.025	1.125	1.25	**2.88**
	Copper Strip	Thickness Range 0.02 to 0.045	lb.	1.80	1.025	1.125	1.25	**2.59**
	Aluminum Strip	Thickness Range 0.02 to 0.045	lb.	1.20	1.025	1.125	1.25	**1.73**
	Insulation	P1, S1, Winding Form, Barrier: Nomex	lb.	17.50	1.025	1.125	1.25	**25.22**
	Spacers	0.5" dog-bone cooling duct spacer	ft.	0.24	1.025	1.125	1.25	**0.35**
	Varnish	Varnish impregnation	gal.	18.00	1.025	1.125	1.25	**25.94**
Fixed Costs (does not change)	Terminals	Start and finish terminals	set	75.00	-	1.125	1.25	**105.47**
	Busbar	Copper busbar for secondary, 10 feet	ft.	8.00	-	1.125	1.25	**11.25**
	Mounting Frame	Clamp core and mount inside enclosure	ea.	36.00	-	1.125	1.25	**50.63**
	Enclosure[5]	14 gauge steel enclosure, base & mounting feet	ea.	175.00	-	1.125	1.25	**246.09**
	Hardware	Miscellaneous hardware	ea.	25.00	-	1.125	1.25	**35.16**

[1]Purchasing price to manufacturers from suppliers of raw materials necessary for building a transformer. Source: Paul Goethe, OPS, 2001; Manufacturer interviews, 2002.
[2]Handling and scrap is a multiplier factor for the handling of material (loading into assembly and winding equipment). Source: Paul Goethe, OPS; Manufacturer interviews, 2002.
[3]Factory overhead includes all indirect costs associated with production, energy use (e.g., furnace), light bulbs, insurance on factory and equipment, etc. Source: US Industry Census Data for 1992 and 1997; SEC 10-K reports for Acme, Powell, Magnetek and Hammond; Manufacturer interviews, 2002.
[4]Material mark-up reflects non-production costs including sales and general administrative, R&D, interest payments and profit factor mark-ups. Source: US Industry Census Data for 1992 and 1997; SEC 10-K reports for Acme, Powell, Magnetek and Hammond; Manufacturer interviews, 2002.
[5]Enclosure is 60 inches high (fixed) with variable width and depth determined by the core-coil dimensions plus a fixed amount for clearance on all sides. To simplify the pricing, and because the primary cost is in the bending, painting and assembly of the steel, one cost was used for all enclosures.

OPS obtained the prices of core steel for a standard quantity order from a major U.S. core steel manufacturer. Due to current U.S. policy on steel import tariffs, the Department is conducting a sensitivity analysis on the resulting cost-efficiency relationship, to understand how significant changes in the cost of core steel may impact the rulemaking process. The Department will publish this sensitivity analysis next year in the ANOPR documentation.

Labor costs are another cost component in the manufacturing of a distribution transformer. The hourly cost of labor was developed along the same lines as the cost of materials; however, the mark-ups used were slightly different. The mark-ups shown in Table 3.2 were developed reviewing available literature and consulting with industry experts familiar with transformer manufacturing in the U.S.

Table 3.2 Manufacturing Labor Mark-ups

Item description	Percent change	Rate per hour
Labor cost per hour[1]		$ 14.31
Indirect Production[2]	33%	$ 19.03
Overhead[3]	30%	$ 24.74
Fringe[4]	21%	$ 29.93
Assembly Labor Up-time[5]	70%	$ 42.77
Non-Production Mark-up[6]	25%	$ 61.16
Cost of Labor Input to OPS		**$ 61.16**

[1] Cost per hour is from U.S. Census Bureau, 1997 Economic Census of Industry, published September 1999, Table 5, page 9. Data for NAICS code 3353111 "Power and distribution transformers, except parts" Production workers hours and wages.
[2] Indirect Production Labor (Production managers, quality control, etc.) as a percent of direct labor on a cost basis. NCI estimate.
[3] Overhead includes commissions, dismissal pay, bonuses, vacation, and sick leave, social security contributions. NCI estimate.
[4] Fringe includes pension contributions, group insurance premiums, workers compensation. Source: U.S. Census Bureau, 1997 Economic Census of Industry, published September 1999, Table 3, page 8. Data for NAICS code 335311 "Power, Distribution and Specialty Transformer Manufacturing", Total fringe benefits as a percent of total compensation for all employees (not just production workers).
[5] Assembly labor up-time - a factor applied to account for the time that workers are not assembling product and/or reworking unsatisfactory units. Multiply the rate by 100/70. NCI estimate.
[6] Non-production mark-up reflects non-production costs including sales and general administrative, R&D, interest payments and profit factor mark-ups. Source: US Industry Census Data for 1992 and 1997; SEC 10-K reports for Acme, Powell, Magnetek and Hammond; Manufacturer interviews, 2002.

3.2 Engineering Design Inputs

The purpose of this draft report is to present the methodology which the Department followed in its study of dry-type transformers. While there are eight design lines and thus eight units that were analyzed, design line nine was selected for presentation in this draft report. This unit is a common kVA rating, falls in the middle of the range of transformers that may be regulated, and is manufactured by several US companies. The results presented in this draft report on the representative unit from design line nine are intended to show the methodology and approach which the Department used for its Engineering Analysis.

As previously shown in Table 2.2, design line nine incorporates three-phase, dry-type, ventilated transformers from 15 kVA through 500 kVA at 45kV BIL (medium voltage). This design line has secondary voltages of 208Y/120 through 600Y/347V. The representative unit for this analysis utilizes the following design parameter inputs to the OPS software:

KVA rating: 300
Number of phases: 3
Primary voltage: 4160V at 60 Hz (45 kV BIL), Delta Connected
Secondary voltage: 480Y/277V
Temperature rise: 150˚C
Ambient temperature: 20˚C
Taps: 4-2.5% full capacity, 2 above normal, 2 below normal
Winding Configuration: Lo-Hi
Core configuration: 3-leg, stacked, butt-lap
Impedance Range: 3.0 - 6.0%

For all distribution transformers, the Department understands there are several different ways to build a transformer, even at the same kVA rating. Across the industry, manufacturers change core steels (e.g., M3, M6, M19), winding materials (e.g., aluminum or copper) and core construction methods (e.g., three (stacked) or five (wound) legs). The Department has to keep this kind of variability in mind, in order to ensure that the most common construction techniques are included in its analysis.

For the representative unit from design line nine, the Department selected six combinations of core steel and winding material for analysis as shown in Table 3.3. The core steels selected include M36, M19, M6, M3 and HO (laser-scribed M3). Although not commonly used by industry in this design, the Department included HO material because it enables the Department to identify the maximum efficiency level that is technically feasible, as HO is the best-performing core steel for this unit.

Table 3.3 Design Option Combinations for 300kVA 3-phase 45kV BIL

300 kVA Design Option #	Core Material	Conductor HV	Conductor LV	Design Type
1	M36, 26 gauge	AL (wire)	AL (wire)	3 - Leg Stacked
2	M19, 26 gauge	AL (wire)	AL (wire)	3 - Leg Stacked
3	M6, 29 gauge	AL (wire)	AL (wire)	3 - Leg Stacked
4	M6, 29 gauge	CU (wire)	CU (wire)	3 - Leg Stacked
5	M3	CU (wire)	AL (strip)	3 - Leg Stacked
6	HO	CU (wire)	CU (strip)	3 - Leg Stacked

The Department selected these six combinations of core and winding materials to cover the full range of efficiencies (i.e., M36 covering the lower end of the scale, and HO covering the high end). They also represent the most common design option combinations of 300kVA, three-phase, 45kV BIL, dry-type transformer sold in the United States.

The Department ran each of the six design option combinations presented in Table 3.3 through the OPS software using the matrix of 289 A and B value combinations (discussed in section 2.2) to create a database of over 1,700 designs. These designs, which include data about the manufacturing cost and performance of the units, are then used to evaluate the cost-efficiency relationship for the engineering analysis.

4. Results of Analysis on the 300 kVA, Three-phase, Dry-type

This chapter presents the aggregated findings of the six design-option combinations. The plots in this chapter show the range of prices, efficiencies, weights, and core and coil losses. Detailed design information on the six selected units from the database is in the next chapter.

The reader should be reminded that the range of designs in the database were generated using the aforementioned core and coil combinations and a range of evaluation formulas (A and B values). The resulting designs in the database are not intended to reflect what is most commonly built or sought after by installers. Rather, the database represents a range of technically feasible efficiency levels and prices, intended to cover the full range of possible efficiencies for a 300 kVA, three-phase, dry-type at 45kV BIL.

Figure 4.1 presents a plot of the manufacturer sales prices and efficiency levels for the full database of designs for this unit. The efficiency levels shown in this plot represent transformers at 50% of nameplate load. Several observations can be made about this scatter plot:

- The least expensive units employ the least expensive core steels, M36 and M19.
- Even though extremely high evaluation formulas are being applied to M36 and M19 steels (i.e., $12A and $8B), the efficiencies are unable to improve beyond 98%.
- NEMA's TP-1-2002 efficiency level for this unit is 98.6% efficient. This level cannot be achieved using the less expensive M36 and M19 core steels. This level can be achieved by using M6 or better core steels.
- Exponential growth in price is realized in the M3 and HO core steels, as the efficiency level increases. For example, moving a fraction of an efficiency level (e.g., from 99.00% to 99.25%) incurs an approximate doubling in price.
- The increased performance and higher price of all copper windings is shown when the M6AlAl design option combination is compared with the M6CuCu, although at several efficiency points, M3CuAl appears to be a lower-cost option than M6CuCu.

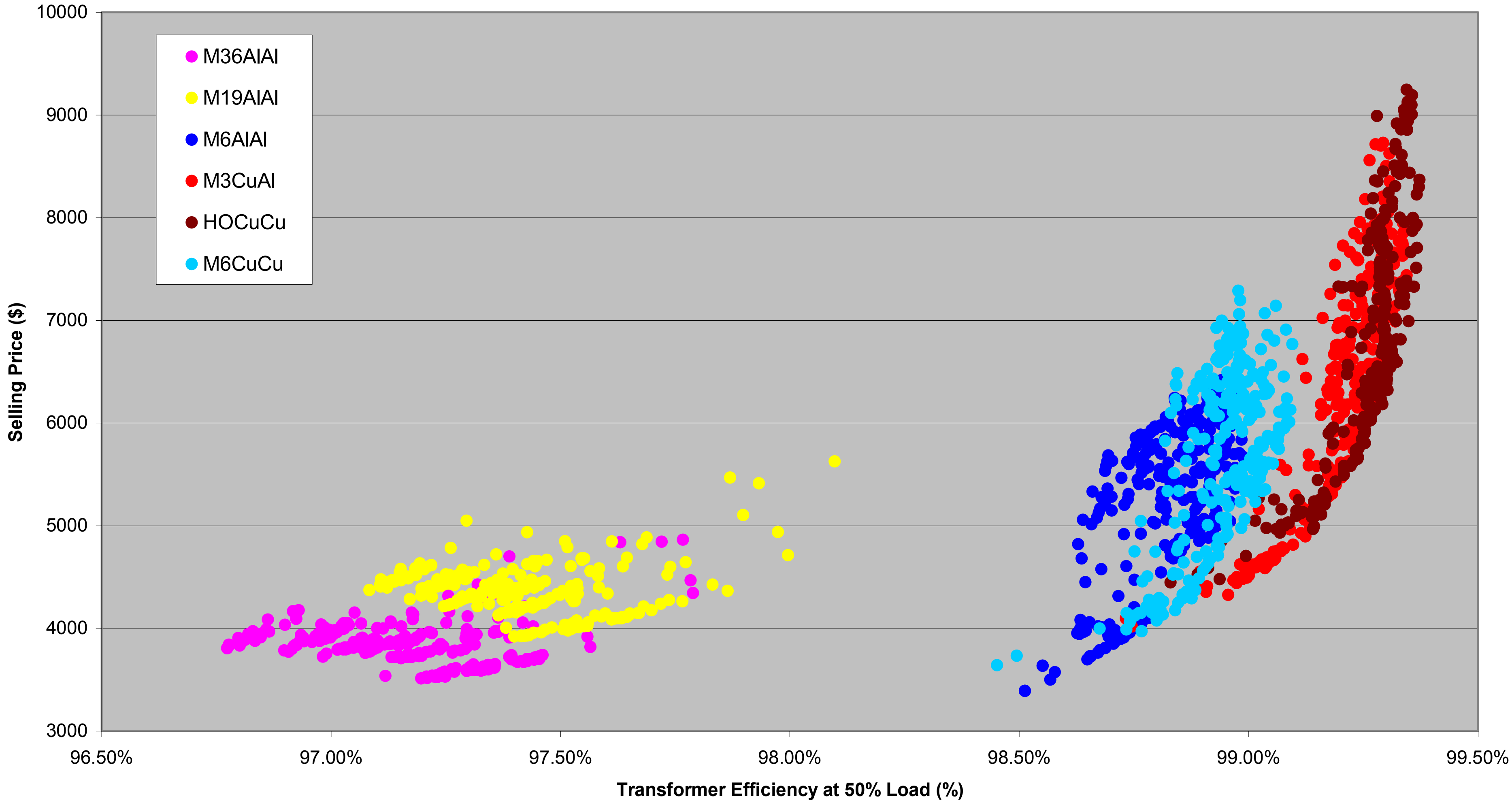


Figure 4.1 Scatter Plot of Selling Price and Efficiency for 300 kVA 3-phase dry-type

Figure 4.2 presents a plot of the manufacturer sales prices and core loss in watts for the full database of designs for this unit. Core losses are important because they occur whenever the transformer is energized, regardless of the load.

Several observations can be made about this scatter plot:

- The least expensive units using the lower-quality core steels (M36 and M19) have the highest level of core loss.

- A step improvement in core steels is apparent moving from M36 and M19 to M6 and the other core steels. The reduction in core steel losses is dramatic, from more than 3000 watts to approximately 1000 watts.

- Because of the different geometry enabled by the switch from aluminum windings to copper windings, M6 core steel, which is used in both M6AlAl and M6CuCu, has generally lower losses using copper windings.

- As expected, M3 and HO have the lowest core loss in the database of designs. The lowest losses for the core (about 500 watts) result from a $5000 design. Higher price units do not reduce the losses any further.

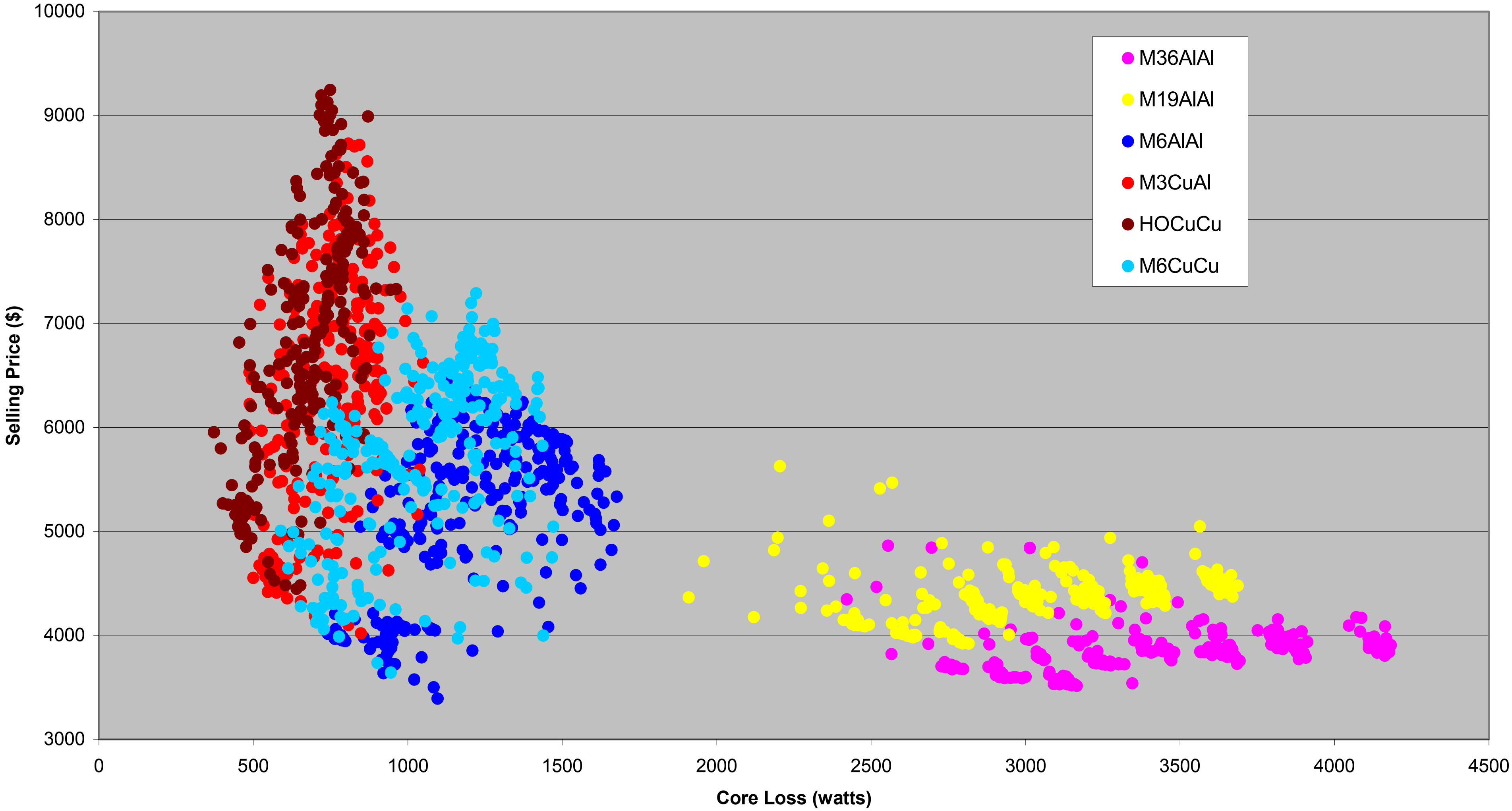


Figure 4.2 Scatter Plot of Selling Price and Core Loss for 300 kVA 3-phase dry-type

Figure 4.3 presents a plot of the manufacturer sales prices and coil loss in watts for the full database of designs for this unit. Coil losses are dependent on the transformer's load. The losses depicted in this plot are at 100% of nameplate load.

Several observations can be made about this scatter plot:

- The overall distribution of coil loss depicts steady improvement (reduction) in watts lost as price increases.

- As the designs approach their minimum watts of core loss (as demonstrated with the HO core material), the price appears to increase rapidly with little or no reduction in losses.

- M6, M3 and HO have designs that span the gamut of losses for this representative unit, ranging from approximately 7000 watts to 1000 watts, with the majority of designs under 3000 watts.

- The M36 and M19 core steels are more tightly grouped in terms of their watts of coil loss. With a few exceptions of M6 designs, these units tend to have the highest coil losses in the database.

- The most inexpensive M6 designs, which have selling prices comparable to M36 and M19 designs, have similar high levels of coil losses.

- The difference between M6AlAl and M6CuCu should be noted: M6CuCu generally has a higher selling price but slightly lower coil losses.

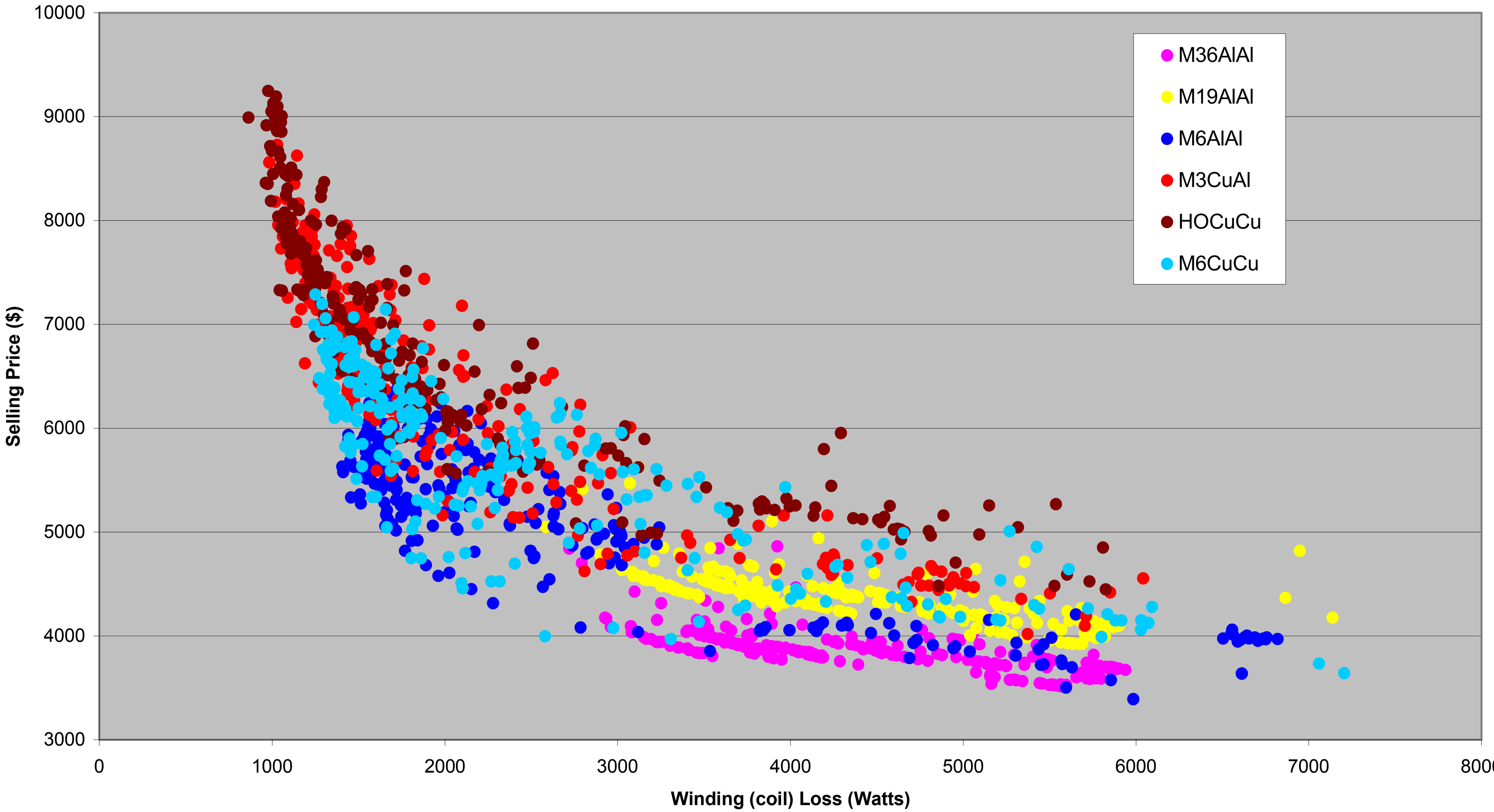


Figure 4.3 Scatter Plot of Selling Price and Coil Loss for 300 kVA 3-phase dry-type

Figure 4.4 presents a plot of the manufacturer sales prices and weights of finished transformers. The Department calculated these weights by summing the variable pounds of core steel, coil windings, insulation, and enclosure size, and then adding a fixed weight for core clamps, bushings and other fixed hardware.

Several observations can be made about this scatter plot:

- Overall, a strong linear trend between price and weight is evident. This is due to the fact that the sales price is driven primarily by the cost of input materials (see pie charts in Chapter 5).

- The slopes of the lines representing the various core steels are slightly different, with increasing slopes for the more expensive steels.

- Despite having the same evaluation formulas applied to create the designs, the M36 and M19 core steels do not achieve the same weight (and size) of the other core steels. These two are largely concentrated at the low-weight end of the spectrum.

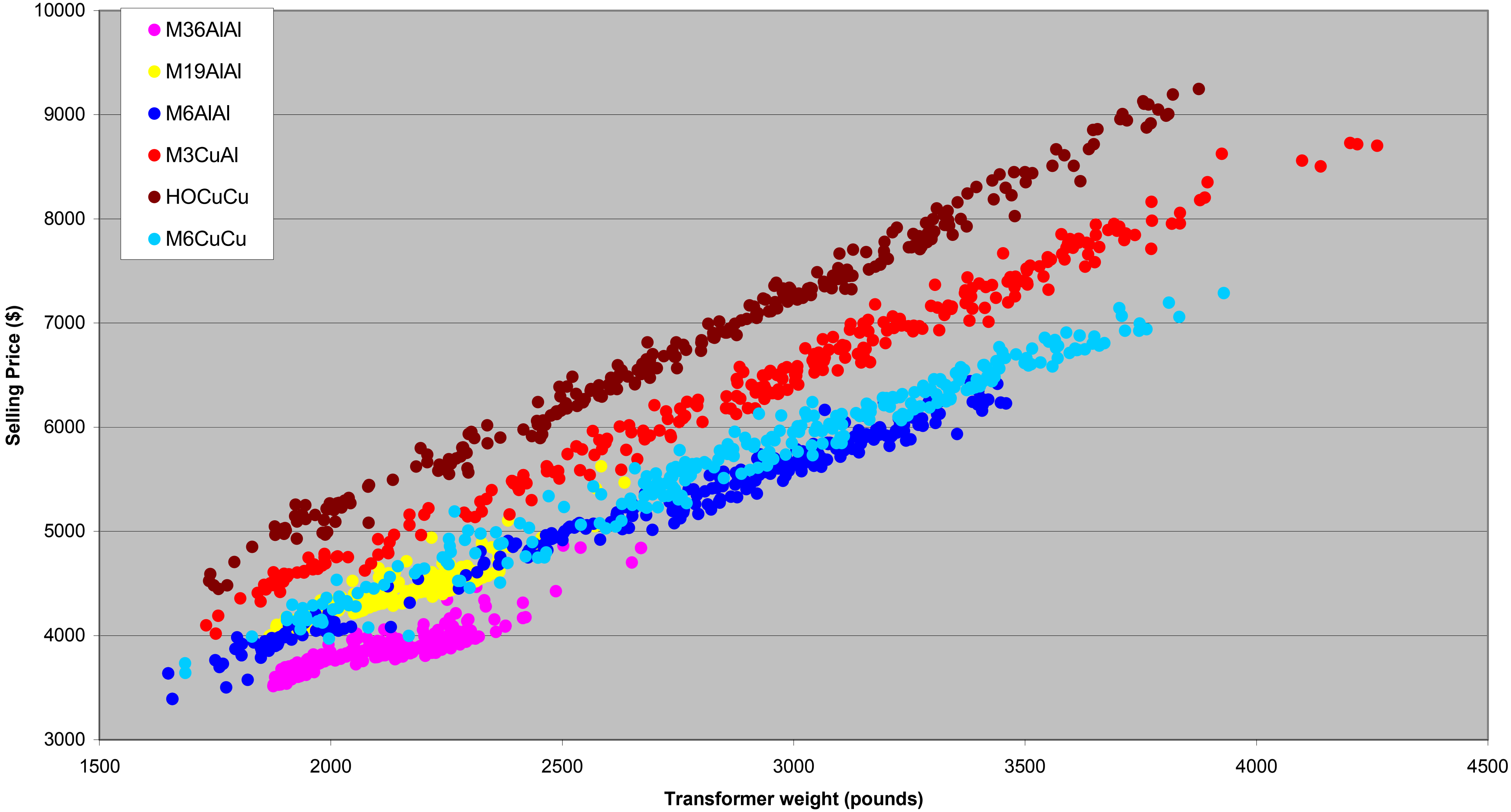


Figure 4.4 Scatter Plot of Selling Price and Finished Transformer Weight

5. Examples from the 300 kVA, Three-phase, 45kV BIL, Dry-type Design Database

In order to provide a high level of detail and establish credibility with its Engineering Analysis cost-efficiency database for design line nine, the Department selected six designs from its database to present in this chapter. Transformer engineers can review the OPS design detail reports, and assess the credibility of this database sample.

The six designs selected are the optimized designs for three of the core-coil combinations at two different A and B evaluation points. The design option combinations are:

- M36 core steel with primary and secondary aluminum windings (M36AlAl);
- M6 core steel with primary and secondary aluminum windings (M6AlAl); and
- M3 core steel with a copper primary winding and an aluminum secondary (M3CuAl).

The A and B evaluation points reported here are for $1.5A, $0.5B and $4A, $1B. The differences in design become evident when one compares the core dimensions, number of turns, and other physical attributes of the designs. Each design detail report is followed by a bill of materials showing the cost calculation and by a pie chart providing a breakdown of the final selling price.

5.1 OPS output for M36, Al-Al Design

The following design details report is for the $1.5A and $0.5B case for M36 core steel with an aluminum primary and secondary.

```
                       OPTIMIZED PROGRAM SERVICE

                   CLEVELAND OHIO            101800
                       2002- 5- 7    14:59:45
STRIP          3-PHASE TYPE TRANSFORMER                L9M36ALAL

FREQUENCY    60.0            KVA RATING    300.22 @ 100.00% DUTY CYCLE

CORE  5.376" STRP  STACK  8.010            GRADE M36    THICKNESS .0185

WINDOW:   7.206 X 20.974     EFF. AREA   41.550    WEIGHT  1481.845

WINDING FORM:INS. DIM.  5.501 X  8.510  THICKNESS  .060  LENGTH 18.973

                         COIL SPECIFICATIONS
                         -------------------

WNDG             WIRE             LENGTH   MEAN TURNS  MARGIN      WT
----------------------------------------------------------------------
S1     1X 8(.1133X  .4534)   AL      89.93     35.97   1.500      42.627
P1     1X 2(.0590X  .2360)   AL    2118.64     53.81   1.750      65.463

NUMBER OF COILS  3                TOTAL BARE CONDUCTOR WEIGHT   324.270
```

WNDG	TURNS	LO TAP	HI TAP	LAYRS	T/L	LAYR INS	SEC. INS	BUILD
S1	30.0			10	3.0	1(.01000)	1(.06000)	1.323
P1	450.0	427.5	472.5	17	29.0	3(.00500)	1(.00001)	1.413

TOTAL BUILD(%) 81.02

WNDG	TAPS: TURNS(VOLTS)		
P1	438.8(4056.00)	461.3(4264.00)	472.5(4368.00)

WNDG	INTERNAL DUCTS(90.00) %EFF	EXTERNAL DUCTS(90.00) %EFF
S1	3 .500 X .500 IN. END	
P1	3 .500 X .500 IN. END	.500 X .500 IN. END

WNDG	INT. DUCT AREA	EXT. DUCT AREA	TOTAL DUCT AREA
S1	1005.1800	207.2561	1212.4370
P1	1515.2910	1102.0520	2617.3430

ELECTRICAL ANALYSIS

WNDG	FULL-LOAD VOLTS	TAP VOLTS LOW	TAP VOLTS HIGH	TEST KV	LOAD CURRENT	RESIST. @20 C.	CURRNT DENS.	%REG
P1	4160.00 D	3952.00	4368.00	12.0	24.604	1.07353	933.	
S1	272.40 W			4.0	360.844	.00297	892.	1.7

	F.L.	N.L.		
FLUX DENS.	12.784	12.927	LEAKAGE INDUCTANCE MHYS	29.762
CORE LOSS	2368.199	2420.688	POWER FACTOR	.9999
COIL LOSS	4557.040	.858	IMPEDANCE %	6.79
EXCIT. VA	5253.045	5459.490	EFFICIENCY %	97.75
EXCIT. CURR.	.421	.437	OPEN ALT. DUCT 3	.00

AMBIENT TEMP.	20.00	NOMINAL LENGTH	37.74
TEMP.RISE	115.64	NOMINAL DEPTH	22.72
OPERATING TEMP.	135.64	NOMINAL HEIGHT	31.72

WINDING:	S1	P1
TEMP RISE:	116.	105.

COND. I^2R LOSS	=	4394.7800
COND. EDDY CURRENT LOSS	=	30.4158
OTHER STRAY LOSS	=	131.8434
K VALUE	=	1.0000

WIRE WRAP PER COIL

WNDG	THICKNESS	WEIGHT
P1	.00500	4.41291
S1	.00500	1.39537

%LOAD	%REG	%EFF	%IR	%IX	%IZ	COIL LOSS	TEMP. RISE
25	.32	96.59	.301	1.683	1.710	236.675	45.6
35	.45	97.34	.422	2.336	2.374	464.182	49.3
50	.67	97.81	.616	3.319	3.375	965.175	57.4
65	.93	97.95	.828	4.306	4.385	1686.616	69.1
75	1.12	97.96	.985	4.968	5.065	2313.542	79.3
100	1.70	97.75	1.457	6.637	6.795	4557.040	115.6
125	2.50	97.24	2.122	8.336	8.602	8295.920	175.8
150	3.82	96.27	3.223	10.100	10.602	15127.150	286.1

Table 5.1 provides a breakdown of costs, or the "bill of materials," associated with this design, M36 core steel, with an aluminum primary and secondary at $1.5A and $0.5B evaluation.

Table 5.1 Bill of Materials for M36AlAl at $1.5A and $0.5B

	A$ Input	$1.50		
	B$ Input	$0.50		
Material item	**Type**	**Quantity**	**$ each**	**$ total**
Winding Form (lb)	Nomex	3.16	$ 17.50	$ 55.27
Core Steel* (lb)	M36	1482	$ 0.46	$ 681.65
Primary winding* (lb)	Al, wire	196	$ 2.00	$ 392.78
Secondary winding* (lb)	Al, wire	128	$ 2.00	$ 255.76
Primary layer insulation* (lb)	Nomex	24.3	$ 17.50	$ 424.48
Secondary layer insulation* (lb)	Nomex	6.08	$ 17.50	$ 106.42
Barrier insulation* (lb)	Nomex	1.69	$ 17.50	$ 29.51
Duct Spacer* (ft)	0.5" dog-bone	199	$ 0.24	$ 47.81
Enclosure	14 gauge	1	$ 175.00	$ 175.00
Mounting Frame	-	1	$ 36.00	$ 36.00
Busbar (ft)	-	10	$ 8.00	$ 80.00
Start & finish terminals	HV & LV	-	$ 75.00	$ 75.00
Varnish impregnation (gal)		5.9	$ 18.00	$ 105.98
Misc. Hardware	-	1	$ 25.00	$ 25.00
Handling and Scrap Factor		2.5%		$ 48.46
Total Material Cost				$ 2,539.12
Labor item		**hours**	**rate**	**$ total**
Setup & wind primary (3 phase)		2.835	42.77	$ 121.25
Setup & wind secondary (3 phase)		1.813	42.77	$ 77.54
Stacking core metal		2.003	42.77	$ 85.65
Assembly (coils, yoke & clamping)		4.000	42.77	$ 171.08
Lead dressing (3 phase)		0.500	42.77	$ 21.39
Inspection		0.100	42.77	$ 4.28
Preliminary and Final Test		0.300	42.77	$ 12.83
Shipment Packing and Marking		1.100	42.77	$ 47.05
Miscellaneous (incl. VPI)		0.500	42.77	$ 21.39
Total Labor		13.150	42.77	$ 562.44
Manufacturing Cost (Material + Labor)				$ 3,101.56
Factory Overhead (Materials only)		12.5%		$ 317.39
Selling Factor		25.0%		$ 854.74
Manufacturer Selling Price				$ 4,273.69
* indicates those items to which the handling and scrap factor (2.5%) is applied				

Figure 5.1 provides a summary of the costs contributing to the total selling price of the transformer detailed above. Approximately 60% of the final selling price is material based - core, coil, insulation and other materials. Labor accounts for approximately 13% of the price, and overheads account for about 27%. For definitions of these categories, please see chapter 3 of this draft report.

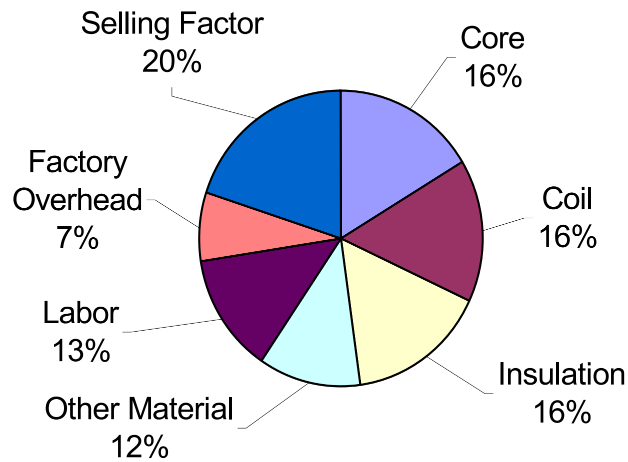


Figure 5.1 Cost breakdown for M36-AlAl Design at $1.5A and $0.5B

The following design details report is for the $4A and $1B case for M36 core steel with an aluminum primary and secondary.

```
                      OPTIMIZED PROGRAM SERVICE
                   CLEVELAND OHIO            101800
                       2002- 5- 7    15: 8:46

STRIP          3-PHASE TYPE TRANSFORMER                L9M36ALAL
FREQUENCY     60.0              KVA RATING    300.22 @ 100.00% DUTY CYCLE
CORE  5.750" STRP  STACK  6.872              GRADE M36    THICKNESS .0185
WINDOW:   6.386 X 18.319     EFF. AREA   38.129    WEIGHT  1261.145
WINDING FORM:INS. DIM.  5.875 X  7.372  THICKNESS  .060  LENGTH 16.319

                         COIL SPECIFICATIONS
                         -------------------

WNDG             WIRE            LENGTH   MEAN TURNS  MARGIN      WT
----------------------------------------------------------------------
S1     1X 8(.0991X  .3964)   AL      79.22     33.95   1.500     28.551
P1     1X 2(.0520X  .2079)   AL    1869.87     50.88   1.750     44.824

NUMBER OF COILS  3                 TOTAL BARE CONDUCTOR WEIGHT   220.124

WNDG  TURNS  LO TAP  HI TAP  LAYRS   T/L   LAYR INS   SEC. INS    BUILD
----------------------------------------------------------------------
S1      28.0                 10      3.0  1(.01000)  1(.06000)    1.181
P1     420.0   399.0   441.0 17     27.0  3(.00500)  1(.00001)    1.294

                                                TOTAL BUILD(%)  83.22

WNDG                TAPS: TURNS( VOLTS)
---------------------------------------------------------
P1     409.5(  4056.00)   430.5(  4264.00)   441.0(  4368.00)
```

WNDG	INTERNAL DUCTS(90.00) %EFF	EXTERNAL DUCTS(90.00) %EFF
S1	3 .500 X .500 IN. END	
P1	3 .500 X .500 IN. END	.500 X .500 IN. END

WNDG	INT. DUCT AREA	EXT. DUCT AREA	TOTAL DUCT AREA
S1	875.1730	175.1875	1050.3600
P1	1250.6590	872.9448	2123.6040

ELECTRICAL ANALYSIS

WNDG	FULL-LOAD VOLTS	TAP VOLTS LOW	TAP VOLTS HIGH	TEST KV	LOAD CURRENT	RESIST. @20 C.	CURRNT DENS.	%REG
P1	4160.00 D	3952.00	4368.00	12.0	24.745	1.22126	1210.	
S1	271.12 W			4.0	360.844	.00344	1173.	2.0

	F.L.	N.L.		
FLUX DENS.	14.879	15.069	LEAKAGE INDUCTANCE MHYS	27.746
CORE LOSS	2808.597	2901.739	POWER FACTOR	.9993
COIL LOSS	5703.644	6.427	IMPEDANCE %	6.49
EXCIT. VA	11433.560	13440.600	EFFICIENCY %	97.24
EXCIT. CURR.	.916	1.077	OPEN ALT. DUCT 3	.00

AMBIENT TEMP.	20.00	NOMINAL LENGTH	36.41
TEMP.RISE	149.48	NOMINAL DEPTH	20.76
OPERATING TEMP.	169.48	NOMINAL HEIGHT	29.82

WINDING:	S1	P1
TEMP RISE:	149.	133.

COND. I^2R LOSS = 5519.2450
COND. EDDY CURRENT LOSS = 18.8222
OTHER STRAY LOSS = 165.5773
K VALUE = 1.0000

WIRE WRAP PER COIL

WNDG	THICKNESS	WEIGHT
P1	.00500	3.45985
S1	.00500	1.07986

%LOAD	%REG	%EFF	%IR	%IX	%IZ	COIL LOSS	TEMP. RISE
25	.35	95.95	.356	1.598	1.637	279.974	49.8
35	.50	96.84	.498	2.201	2.257	546.163	54.6
50	.76	97.40	.728	3.115	3.199	1138.975	65.5
65	1.05	97.57	.990	4.037	4.156	2009.875	81.5
75	1.28	97.56	1.188	4.655	4.804	2782.728	95.6
100	2.01	97.24	1.827	6.222	6.485	5703.646	149.5
125	3.16	96.43	2.852	7.837	8.340	11134.580	247.9
150	5.61	94.44	5.070	9.592	10.850	23840.460	478.1

Table 5.2 provides a breakdown of costs, or the "bill of materials," associated with this design, M36 core steel, with an aluminum primary and secondary at $4A and $1B evaluation.

Table 5.2 Bill of Materials for M36AlAl at $4A and $1B

	A$ Input	$4.00		
	B$ Input	$1.00		
Material item	**Type**	**Quantity**	**$ each**	**$ total**
Winding Form (lb)	Nomex	2.57	$ 17.50	$ 44.94
Core Steel* (lb)	M36	1261	$ 0.46	$ 580.12
Primary winding* (lb)	Al, wire	134	$ 2.00	$ 268.94
Secondary winding* (lb)	Al, wire	86	$ 2.00	$ 171.31
Primary layer insulation* (lb)	Nomex	19.7	$ 17.50	$ 345.25
Secondary layer insulation* (lb)	Nomex	4.94	$ 17.50	$ 86.39
Barrier insulation* (lb)	Nomex	1.37	$ 17.50	$ 23.98
Duct Spacer* (ft)	0.5" dog-bone	171	$ 0.24	$ 41.12
Enclosure	14 gauge	1	$ 175.00	$ 175.00
Mounting Frame	-	1	$ 36.00	$ 36.00
Busbar (ft)	-	10	$ 8.00	$ 80.00
Start & finish terminals	HV & LV	-	$ 75.00	$ 75.00
Varnish impregnation (gal)		4.9	$ 18.00	$ 87.80
Misc. Hardware	-	1	$ 25.00	$ 25.00
Handling and Scrap Factor		2.5%		$ 37.93
Total Material Cost				$ 2,078.79
Labor item		**hours**	**rate**	**$ total**
Setup & wind primary (3 phase)		2.646	42.77	$ 113.17
Setup & wind secondary (3 phase)		1.711	42.77	$ 73.19
Stacking core metal		1.718	42.77	$ 73.48
Assembly (coils, yoke & clamping)		4.000	42.77	$ 171.08
Lead dressing (3 phase)		0.500	42.77	$ 21.39
Inspection		0.100	42.77	$ 4.28
Preliminary and Final Test		0.300	42.77	$ 12.83
Shipment Packing and Marking		1.100	42.77	$ 47.05
Miscellaneous (incl. VPI)		0.500	42.77	$ 21.39
Total Labor		12.575	42.77	$ 537.84
Manufacturing Cost (Material + Labor)				$ 2,616.63
Factory Overhead (Materials only)		12.5%		$ 259.85
Selling Factor		25.0%		$ 719.12
Manufacturer Selling Price				$ 3,595.60
* indicates those items to which the handling and scrap factor (2.5%) is applied				

Figure 5.2 provides a summary of the costs contributing to the total selling price of the transformer detailed above. Approximately 58% of the final selling price is material based - core, coil, insulation and other materials. Labor accounts for approximately 15% of the price, and overheads account for about 27%. For definitions of these categories, please see chapter 3 of this draft report.

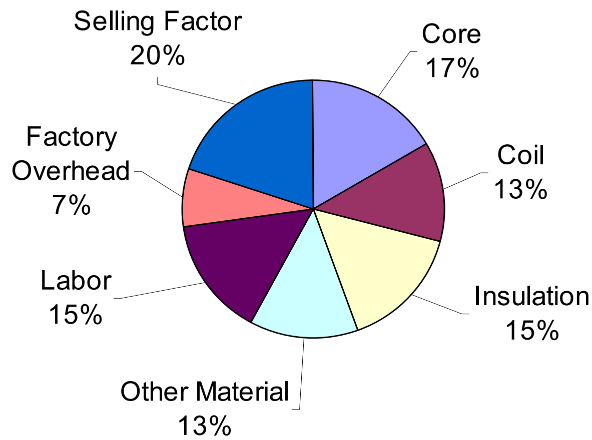


Figure 5.2 Cost breakdown for M36-AlAl Design at $4A and $1B

5.2 OPS output for M6, Al-Al Design

The following design details report is for the $1.5A and $0.5B case for M6 core steel with an aluminum primary and secondary.

```
                    OPTIMIZED PROGRAM SERVICE
                CLEVELAND OHIO            101800
                    2002- 5- 7    11:12:24
STRIP         3-PHASE TYPE TRANSFORMER                L9M6ALAL
FREQUENCY    60.0             KVA RATING    300.22 @ 100.00% DUTY CYCLE
CORE   5.273" STRP  STACK  7.228             GRADE M 6    THICKNESS .0140
WINDOW:   6.105 X 19.040     EFF. AREA   36.780    WEIGHT  1197.304
WINDING FORM:INS. DIM.  5.398 X  7.728  THICKNESS  .060  LENGTH 17.040

                     COIL SPECIFICATIONS
                     -------------------

WNDG             WIRE            LENGTH   MEAN TURNS  MARGIN      WT
----------------------------------------------------------------------
S1     1X 4(.2271X  .4542)    AL       71.52      33.01    1.500     33.457
P1         .1163X  .2326   AL    1671.69       48.99    1.750     51.364

NUMBER OF COILS  3                TOTAL BARE CONDUCTOR WEIGHT   254.464

WNDG  TURNS   LO TAP  HI TAP  LAYRS   T/L   LAYR INS    SEC. INS    BUILD
----------------------------------------------------------------------
S1      26.0                   4       6.5  1(.01000)  1(.06000)     .978
P1     390.0   370.5   409.5  8      53.0  6(.00500)  1(.00001)    1.220

                                                TOTAL BUILD(%)   78.01

WNDG               TAPS: TURNS( VOLTS)
----------------------------------------------------------
P1     380.3(  4056.00)   399.8(  4264.00)    409.5(  4368.00)
```

WNDG	INTERNAL DUCTS(90.00) %EFF	EXTERNAL DUCTS(90.00) %EFF
S1	3 .500 X .500 IN. END	
P1	3 .500 X .500 IN. END	.500 X .500 IN. END

WNDG	INT. DUCT AREA	EXT. DUCT AREA	TOTAL DUCT AREA
S1	808.1079	159.9111	968.0191
P1	1165.8540	869.4410	2035.2950

ELECTRICAL ANALYSIS

WNDG	FULL-LOAD VOLTS	TAP VOLTS LOW	TAP VOLTS HIGH	TEST KV	LOAD CURRENT	RESIST. @20 C.	CURRNT DENS.	%REG
P1	4160.00 D	3952.00	4368.00	12.0	24.433	.85182	932.	
S1	273.84 W			4.0	360.844	.00239	904.	1.2

	F.L.	N.L.		
FLUX DENS.	16.732	16.861	LEAKAGE INDUCTANCE MHYS	19.381
CORE LOSS	1190.857	1209.377	POWER FACTOR	1.0000
COIL LOSS	3593.059	.238	IMPEDANCE %	4.44
EXCIT. VA	3018.286	3247.553	EFFICIENCY %	98.43
EXCIT. CURR.	.242	.260	OPEN ALT. DUCT 3	.00

AMBIENT TEMP.	20.00	NOMINAL LENGTH	34.13
TEMP.RISE	106.40	NOMINAL DEPTH	20.83
OPERATING TEMP.	126.40	NOMINAL HEIGHT	29.59

WINDING:	S1	P1
TEMP RISE:	106.	99.

COND. I^2R LOSS	=	3402.9220
COND. EDDY CURRENT LOSS	=	88.0493
OTHER STRAY LOSS	=	102.0877
K VALUE	=	1.0000

WIRE WRAP PER COIL

WNDG	THICKNESS	WEIGHT
P1	.00500	2.03860
S1	.00500	.66317

%LOAD	%REG	%EFF	%IR	%IX	%IZ	COIL LOSS	TEMP. RISE
25	.24	98.18	.232	1.077	1.102	186.724	41.0
35	.34	98.53	.327	1.502	1.537	368.206	44.4
50	.50	98.71	.479	2.141	2.194	767.562	52.1
65	.68	98.72	.645	2.782	2.856	1340.671	63.1
75	.82	98.67	.767	3.211	3.302	1836.453	72.7
100	1.23	98.43	1.130	4.292	4.438	3593.059	106.4
125	1.79	98.00	1.633	5.387	5.629	6460.070	161.1
150	2.67	97.27	2.429	6.511	6.949	11478.180	256.8

Table 5.3 provides a breakdown of costs, or the "bill of materials," associated with this design, M6 core steel, with an aluminum primary and secondary at $1.5A and $0.5B evaluation.

Table 5.3 Bill of Materials for M6AlAl at $1.5A and $0.5B

	A$ Input	$1.50		
	B$ Input	$0.50		
Material item	**Type**	**Quantity**	**$ each**	**$ total**
Winding Form (lb)	Nomex	2.66	$ 17.50	$ 46.50
Core Steel* (lb)	M6	1197	$ 0.64	$ 760.29
Primary winding* (lb)	Al, wire	154	$ 2.00	$ 308.18
Secondary winding* (lb)	Al, wire	100	$ 2.00	$ 200.74
Primary layer insulation* (lb)	Nomex	17.4	$ 17.50	$ 303.70
Secondary layer insulation* (lb)	Nomex	1.67	$ 17.50	$ 29.24
Barrier insulation* (lb)	Nomex	1.38	$ 17.50	$ 24.21
Duct Spacer* (ft)	0.5" dog-bone	179	$ 0.24	$ 42.94
Enclosure	14 gauge	1	$ 175.00	$ 175.00
Mounting Frame	-	1	$ 36.00	$ 36.00
Busbar (ft)	-	10	$ 8.00	$ 80.00
Start & finish terminals	HV & LV	-	$ 75.00	$ 75.00
Varnish impregnation (gal)		4.6	$ 18.00	$ 81.97
Misc. Hardware	-	1	$ 25.00	$ 25.00
Handling and Scrap Factor		2.5%		$ 41.73
Total Material Cost				$ 2,230.50
Labor item		**hours**	**rate**	**$ total**
Setup & wind primary (3 phase)		2.457	42.77	$ 105.09
Setup & wind secondary (3 phase)		1.664	42.77	$ 71.16
Stacking core metal		1.807	42.77	$ 77.29
Assembly (coils, yoke & clamping)		4.000	42.77	$ 171.08
Lead dressing (3 phase)		0.500	42.77	$ 21.39
Inspection		0.100	42.77	$ 4.28
Preliminary and Final Test		0.300	42.77	$ 12.83
Shipment Packing and Marking		1.100	42.77	$ 47.05
Miscellaneous (incl. VPI)		0.500	42.77	$ 21.39
Total Labor		12.428	42.77	$ 531.53
Manufacturing Cost (Material + Labor)				$ 2,762.03
Factory Overhead (Materials only)		12.5%		$ 278.81
Selling Factor		25.0%		$ 760.21
Manufacturer Selling Price				$ 3,801.06

* indicates those items to which the handling and scrap factor (2.5%) is applied

Figure 5.3 provides a summary of the costs contributing to the total selling price of the transformer detailed above. Approximately 59% of the final selling price is material based - core, coil, insulation and other materials. Labor accounts for approximately 14% of the price, and overheads account for about 27%. For definitions of these categories, please see chapter 3 of this draft report.

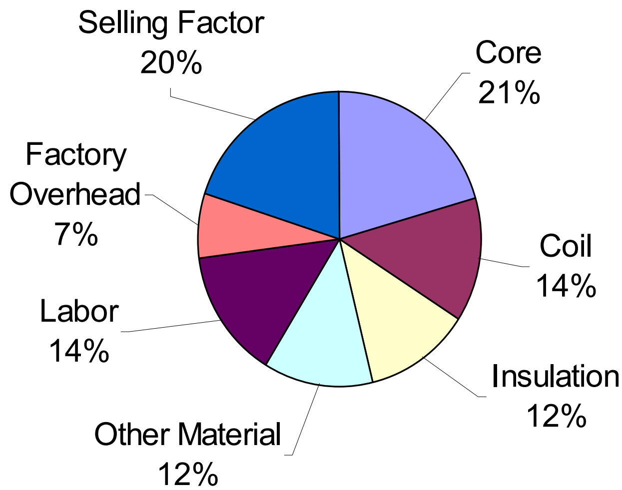


Figure 5.3 Cost breakdown for M6-AlAl Design at $1.5A and $0.5B

The following design details report is for the $4A and $1B case for M6 core steel with an aluminum primary and secondary.

```
                       OPTIMIZED PROGRAM SERVICE
                   CLEVELAND OHIO            101800
                       2002- 5- 7    11:20: 0
STRIP         3-PHASE TYPE TRANSFORMER                L9M6ALAL
FREQUENCY     60.0             KVA RATING    300.22 @ 100.00% DUTY CYCLE
CORE   5.398" STRP  STACK  8.256             GRADE M 6    THICKNESS .0140
WINDOW:    7.122 X 21.423     EFF. AREA   43.011    WEIGHT  1548.188
WINDING FORM:INS. DIM.  5.523 X  8.756  THICKNESS  .060  LENGTH 19.423

                         COIL SPECIFICATIONS
                         -------------------

WNDG             WIRE            LENGTH   MEAN TURNS  MARGIN      WT
----------------------------------------------------------------------
S1      1X 4(.2607X  .5214)    AL      85.75      36.75    1.500      53.290
P1          .1326X  .2652   AL    2023.86      55.07    1.750      81.410

NUMBER OF COILS   3                TOTAL BARE CONDUCTOR WEIGHT   404.101

WNDG  TURNS  LO TAP  HI TAP  LAYRS   T/L   LAYR INS   SEC. INS    BUILD
----------------------------------------------------------------------
S1      28.0                  5      6.0  1(.01000)  1(.06000)    1.393
P1     420.0   399.0   441.0  9     55.0  5(.00500)  1(.00001)    1.483

                                             TOTAL BUILD(%)  85.91

WNDG                 TAPS: TURNS( VOLTS)
----------------------------------------------------------
P1     409.5(  4056.00)   430.5(  4264.00)   441.0(  4368.00)
```

WNDG	INTERNAL DUCTS(90.00) %EFF	EXTERNAL DUCTS(90.00) %EFF
S1	3 .500 X .500 IN. END	
P1	3 .500 X .500 IN. END	.500 X .500 IN. END

WNDG	INT. DUCT AREA	EXT. DUCT AREA	TOTAL DUCT AREA
S1	1051.7610	218.4345	1270.1960
P1	1603.8220	1162.9140	2766.7350

ELECTRICAL ANALYSIS

WNDG	FULL-LOAD VOLTS	TAP VOLTS LOW	TAP VOLTS HIGH	TEST KV	LOAD CURRENT	RESIST. @20 C.	CURRNT DENS.	%REG
P1	4160.00 D	3952.00	4368.00	12.0	24.380	.78773	710.	
S1	274.14 W			4.0	360.844	.00216	681.	1.1

	F.L.	N.L.		
FLUX DENS.	13.291	13.391	LEAKAGE INDUCTANCE MHYS	25.770
CORE LOSS	973.530	988.263	POWER FACTOR	1.0000
COIL LOSS	3151.454	.052	IMPEDANCE %	5.77
EXCIT. VA	1601.564	1625.713	EFFICIENCY %	98.64
EXCIT. CURR.	.128	.130	OPEN ALT. DUCT 3	.00

AMBIENT TEMP.	20.00	NOMINAL LENGTH	37.56
TEMP.RISE	82.29	NOMINAL DEPTH	22.88
OPERATING TEMP.	102.29	NOMINAL HEIGHT	32.22

WINDING:	S1	P1
TEMP RISE:	82.	77.

COND. I^2R LOSS = 2899.5060
COND. EDDY CURRENT LOSS = 164.9629
OTHER STRAY LOSS = 86.9852
K VALUE = 1.0000

WNDG	WIRE WRAP PER COIL THICKNESS	WEIGHT
P1	.00500	2.79487
S1	.00500	.90941

%LOAD	%REG	%EFF	%IR	%IX	%IZ	COIL LOSS	TEMP. RISE
25	.22	98.48	.209	1.427	1.442	173.830	37.6
35	.32	98.75	.295	1.991	2.013	342.099	40.1
50	.47	98.89	.428	2.841	2.873	708.544	45.6
65	.64	98.88	.571	3.693	3.737	1225.014	53.4
75	.77	98.84	.673	4.263	4.315	1662.902	60.0
100	1.14	98.64	.963	5.694	5.775	3151.454	82.3
125	1.60	98.33	1.328	7.139	7.262	5389.323	115.9
150	2.22	97.88	1.819	8.605	8.795	8786.483	166.6

Table 5.4 provides a breakdown of costs, or the "bill of materials," associated with this design, M6 core steel, with an aluminum primary and secondary at $4A and $1B evaluation.

Table 5.4 Bill of Materials for M6AlAl at $4A and $1B

	A$ Input	$4.00		
	B$ Input	$1.00		
Material item	**Type**	**Quantity**	**$ each**	**$ total**
Winding Form (lb)	Nomex	3.29	$ 17.50	$ 57.66
Core Steel* (lb)	M6	1548	$ 0.64	$ 983.10
Primary winding* (lb)	Al, wire	244	$ 2.00	$ 488.46
Secondary winding* (lb)	Al, wire	160	$ 2.00	$ 319.74
Primary layer insulation* (lb)	Nomex	21.2	$ 17.50	$ 370.63
Secondary layer insulation* (lb)	Nomex	2.83	$ 17.50	$ 49.47
Barrier insulation* (lb)	Nomex	1.77	$ 17.50	$ 30.90
Duct Spacer* (ft)	0.5" dog-bone	204	$ 0.24	$ 48.95
Enclosure	14 gauge	1	$ 175.00	$ 175.00
Mounting Frame	-	1	$ 36.00	$ 36.00
Busbar (ft)	-	10	$ 8.00	$ 80.00
Start & finish terminals	HV & LV	-	$ 75.00	$ 75.00
Varnish impregnation (gal)		6.0	$ 18.00	$ 107.88
Misc. Hardware	-	1	$ 25.00	$ 25.00
Handling and Scrap Factor		2.5%		$ 57.28
Total Material Cost				$ 2,905.07
Labor item		**hours**	**rate**	**$ total**
Setup & wind primary (3 phase)		2.646	42.77	$ 113.17
Setup & wind secondary (3 phase)		1.852	42.77	$ 79.22
Stacking core metal		2.064	42.77	$ 88.28
Assembly (coils, yoke & clamping)		4.000	42.77	$ 171.08
Lead dressing (3 phase)		0.500	42.77	$ 21.39
Inspection		0.100	42.77	$ 4.28
Preliminary and Final Test		0.300	42.77	$ 12.83
Shipment Packing and Marking		1.100	42.77	$ 47.05
Miscellaneous (incl. VPI)		0.500	42.77	$ 21.39
Total Labor		13.062	42.77	$ 558.67
Manufacturing Cost (Material + Labor)				$ 3,463.74
Factory Overhead (Materials only)		12.5%		$ 363.13
Selling Factor		25.0%		$ 956.72
Manufacturer Selling Price				$ 4,783.59

* indicates those items to which the handling and scrap factor (2.5%) is applied

Figure 5.4 provides a summary of the costs contributing to the total selling price of the transformer detailed above. Approximately 60% of the final selling price is material based - core, coil, insulation and other materials. Labor accounts for approximately 12% of the price, and overheads account for about 27%. For definitions of these categories, please see chapter 3 of this draft report.

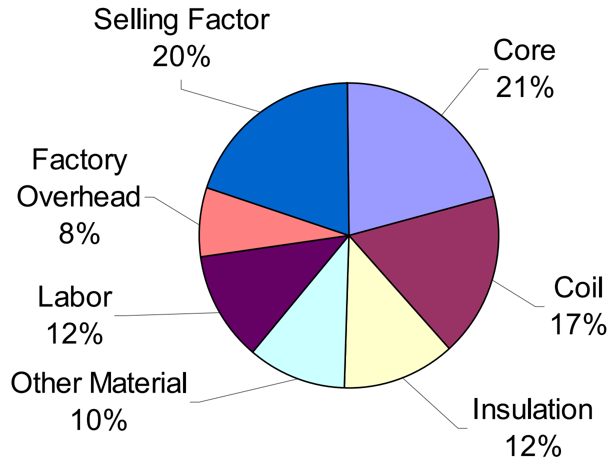


Figure 5.4 Cost breakdown for M6-AlAl design at $4A and $1B

5.3 OPS output for M3, Cu-Al Design

The following design details report is for the $1.5A and $0.5B case for M3 core steel with a copper primary and aluminum secondary.

```
                       OPTIMIZED PROGRAM SERVICE
                  CLEVELAND OHIO          101800
                       2002- 5- 8     8:45:32
STRIP          3-PHASE TYPE TRANSFORMER                L9M3CUAL
FREQUENCY    60.0             KVA RATING    300.22 @ 100.00% DUTY CYCLE
CORE  5.610" STRP  STACK  7.162             GRADE M 3    THICKNESS .0090
WINDOW:   6.187 X 16.817     EFF. AREA   38.173    WEIGHT  1195.203
WINDING FORM:INS. DIM.  5.735 X  7.662  THICKNESS  .060  LENGTH 14.817


                         COIL SPECIFICATIONS
                         -------------------

WNDG             WIRE            LENGTH   MEAN TURNS  MARGIN      WT
----------------------------------------------------------------------
S1         .0356X11.8168   AL      73.25      33.81    1.500    36.141
P1         .1028X  .2057   CU    1706.97      50.02    1.750   133.631

NUMBER OF COILS  3                TOTAL BARE CONDUCTOR WEIGHT   509.317

WNDG  TURNS  LO TAP  HI TAP  LAYRS   T/L   LAYR INS   SEC. INS    BUILD
----------------------------------------------------------------------
S1     26.0                  26      1.0  1(.00500)  1(.06000)    1.052
P1    390.0   370.5   409.5  9      50.0  5(.00500)  1(.00001)    1.216

                                                TOTAL BUILD(%)  79.20


WNDG                TAPS: TURNS( VOLTS)
----------------------------------------------------------
P1     380.3(  4056.00)   399.8(  4264.00)   409.5(  4368.00)
```

WNDG	INTERNAL DUCTS(90.00) %EFF	EXTERNAL DUCTS(90.00) %EFF
S1	3 .500 X .500 IN. END	
P1	3 .500 X .500 IN. END	.500 X .500 IN. END

WNDG	INT. DUCT AREA	EXT. DUCT AREA	TOTAL DUCT AREA
S1	738.3751	146.0320	884.4071
P1	1039.5030	749.1531	1788.6560

ELECTRICAL ANALYSIS

WNDG	FULL-LOAD VOLTS	TAP VOLTS LOW	TAP VOLTS HIGH	TEST KV	LOAD CURRENT	RESIST. @20 C.	CURRNT DENS.	%REG
P1	4160.00 D	3952.00	4368.00	12.0	24.349	.68451	1199.	
S1	274.28 W			4.0	360.844	.00232	857.	1.1

	F.L.	N.L.		
FLUX DENS.	16.142	16.248	LEAKAGE INDUCTANCE MHYS	23.036
CORE LOSS	751.479	768.364	POWER FACTOR	1.0000
COIL LOSS	2973.653	.070	IMPEDANCE %	5.17
EXCIT. VA	1921.907	1986.095	EFFICIENCY %	98.77
EXCIT. CURR.	.154	.159	OPEN ALT. DUCT 3	.00

AMBIENT TEMP.	20.00	NOMINAL LENGTH	35.39
TEMP.RISE	96.02	NOMINAL DEPTH	20.85
OPERATING TEMP.	116.02	NOMINAL HEIGHT	28.04

WINDING:	S1	P1
TEMP RISE:	96.	89.

COND. I^2R LOSS	=	2840.5150
COND. EDDY CURRENT LOSS	=	47.9218
OTHER STRAY LOSS	=	85.2155
K VALUE	=	1.0000

WIRE WRAP PER COIL

WNDG	THICKNESS	WEIGHT
P1	.00500	1.85361

%LOAD	%REG	%EFF	%IR	%IX	%IZ	COIL LOSS	TEMP. RISE
25	.21	98.79	.198	1.271	1.287	156.690	37.9
35	.30	98.99	.279	1.776	1.798	309.440	41.1
50	.44	99.07	.408	2.535	2.567	644.701	48.0
65	.60	99.04	.547	3.296	3.341	1123.315	57.9
75	.73	98.99	.649	3.805	3.859	1534.826	66.4
100	1.08	98.77	.945	5.083	5.170	2973.653	96.0
125	1.56	98.42	1.342	6.376	6.516	5263.746	143.4
150	2.24	97.88	1.925	7.692	7.929	9035.580	220.1

Table 5.5 provides a breakdown of costs, or the "bill of materials," associated with this design, M3 core steel, with a copper primary and aluminum secondary at $1.5A and $0.5B evaluation.

Table 5.5 Bill of Materials for M3CuAl at $1.5A and $0.5B

	A$ Input	$1.50		
	B$ Input	$0.50		
Material item	**Type**	**Quantity**	**$ each**	**$ total**
Winding Form (lb)	Nomex	2.36	$ 17.50	$ 41.27
Core Steel* (lb)	M3	1195	$ 0.95	$ 1,135.44
Primary winding* (lb)	Cu, wire	401	$ 1.60	$ 641.43
Secondary winding* (lb)	Al, strip	108	$ 1.20	$ 130.11
Primary layer insulation* (lb)	Nomex	14.7	$ 17.50	$ 256.81
Secondary layer insulation* (lb)	Nomex	6.20	$ 17.50	$ 108.48
Barrier insulation* (lb)	Nomex	1.23	$ 17.50	$ 21.52
Duct Spacer* (ft)	0.5" dog-bone	156	$ 0.24	$ 37.34
Enclosure	14 gauge	1	$ 175.00	$ 175.00
Mounting Frame	-	1	$ 36.00	$ 36.00
Busbar (ft)	-	10	$ 8.00	$ 80.00
Start & finish terminals	HV & LV	-	$ 75.00	$ 75.00
Varnish impregnation (gal)		4.5	$ 18.00	$ 80.60
Misc. Hardware	-	1	$ 25.00	$ 25.00
Handling and Scrap Factor		2.5%		$ 58.28
Total Material Cost				$ 2,902.28
Labor item		**hours**	**rate**	**$ total**
Setup & wind primary (3 phase)		2.457	42.77	$ 105.09
Setup & wind secondary (3 phase)		1.704	42.77	$ 72.87
Stacking core metal		1.791	42.77	$ 76.58
Assembly (coils, yoke & clamping)		4.000	42.77	$ 171.08
Lead dressing (3 phase)		0.500	42.77	$ 21.39
Inspection		0.100	42.77	$ 4.28
Preliminary and Final Test		0.300	42.77	$ 12.83
Shipment Packing and Marking		1.100	42.77	$ 47.05
Miscellaneous (incl. VPI)		0.500	42.77	$ 21.39
Total Labor		12.451	42.77	$ 532.55
Manufacturing Cost (Material + Labor)				$ 3,434.82
Factory Overhead (Materials only)		12.5%		$ 362.78
Selling Factor		25.0%		$ 949.40
Manufacturer Selling Price				$ 4,747.01

* indicates those items to which the handling and scrap factor (2.5%) is applied

Figure 5.5 provides a summary of the costs contributing to the total selling price of the transformer detailed above. Approximately 61% of the final selling price is material based - core, coil, insulation and other materials. Labor accounts for approximately 11% of the price, and overheads account for about 28%. For definitions of these categories, please see chapter 3 of this draft report.

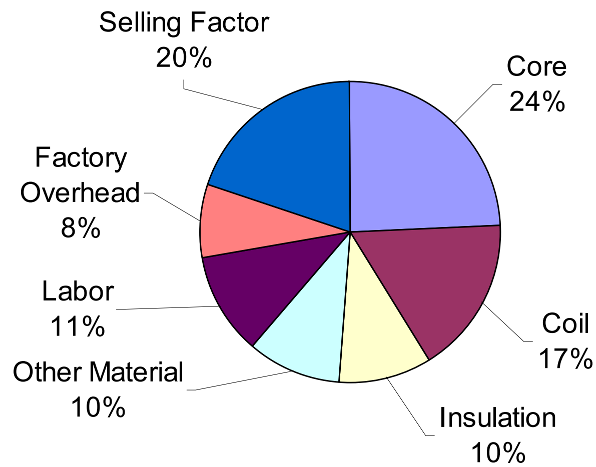


Figure 5.5 Cost breakdown for M3-CuAl Design at $1.5A and $0.5B

The following design details report is for the $4A and $1B case for M3 core steel with a copper primary and aluminum secondary.

```
                        OPTIMIZED PROGRAM SERVICE
                    CLEVELAND OHIO            101800
                        2002- 5- 8     8:53: 1
STRIP         3-PHASE TYPE TRANSFORMER                L9M3CUAL
FREQUENCY    60.0           KVA RATING    300.22 @ 100.00% DUTY CYCLE
CORE  5.459" STRP  STACK  7.586             GRADE M 3    THICKNESS .0090
WINDOW:   6.773 X 18.677     EFF. AREA   39.339    WEIGHT  1311.091
WINDING FORM:INS. DIM.  5.584 X  8.086  THICKNESS  .060  LENGTH 16.677

                          COIL SPECIFICATIONS
                          -------------------

WNDG             WIRE            LENGTH   MEAN TURNS  MARGIN      WT
----------------------------------------------------------------------
S1          .0374X13.6765   AL      77.97       34.65    1.500     46.689
P1          .1129X  .2258   CU    1824.37       51.48    1.750    173.293

NUMBER OF COILS  3                TOTAL BARE CONDUCTOR WEIGHT   659.946

WNDG  TURNS  LO TAP  HI TAP  LAYRS   T/L   LAYR INS    SEC. INS    BUILD
----------------------------------------------------------------------
S1     27.0                  27      1.0  1(.00500)  1(.06000)    1.139
P1    405.0   384.8   425.3  9      53.0  5(.00500)  1(.00001)    1.306

                                             TOTAL BUILD(%)  77.60

WNDG                  TAPS: TURNS( VOLTS)
----------------------------------------------------------
P1     394.9(  4056.00)   415.1(  4264.00)   425.3(  4368.00)
```

WNDG	INTERNAL DUCTS(90.00) %EFF	EXTERNAL DUCTS(90.00) %EFF
S1	3 .500 X .500 IN. END	
P1	3 .500 X .500 IN. END	.500 X .500 IN. END

WNDG	INT. DUCT AREA	EXT. DUCT AREA	TOTAL DUCT AREA
S1	844.1016	169.6575	1013.7590
P1	1228.3320	895.8640	2124.1960

ELECTRICAL ANALYSIS

WNDG	FULL-LOAD VOLTS	TAP VOLTS LOW	TAP VOLTS HIGH	TEST KV	LOAD CURRENT	RESIST. @20 C.	CURRNT DENS.	%REG
P1	4160.00 D	3952.00	4368.00	12.0	24.307	.60295	986.	
S1	274.71 W			4.0	360.844	.00204	706.	.9

	F.L.	N.L.
FLUX DENS.	15.097	15.184
CORE LOSS	680.575	690.620
COIL LOSS	2520.136	.039
EXCIT. VA	1586.851	1615.198
EXCIT. CURR.	.127	.129

LEAKAGE INDUCTANCE MHYS	22.954
POWER FACTOR	1.0000
IMPEDANCE %	5.12
EFFICIENCY %	98.95
OPEN ALT. DUCT 3	.00

AMBIENT TEMP.	20.00
TEMP.RISE	80.75
OPERATING TEMP.	100.75

NOMINAL LENGTH	36.69
NOMINAL DEPTH	21.86
NOMINAL HEIGHT	29.59

WINDING:	S1	P1
TEMP RISE:	81.	76.

COND. I^2R LOSS	=	2386.7360
COND. EDDY CURRENT LOSS	=	61.7981
OTHER STRAY LOSS	=	71.6021
K VALUE	=	1.0000

WIRE WRAP PER COIL

WNDG	THICKNESS	WEIGHT
P1	.00500	2.16286

%LOAD	%REG	%EFF	%IR	%IX	%IZ	COIL LOSS	TEMP. RISE
25	.18	98.91	.173	1.265	1.277	138.212	36.6
35	.26	99.09	.244	1.768	1.784	272.435	39.1
50	.39	99.17	.354	2.523	2.548	564.965	44.5
65	.53	99.16	.472	3.280	3.314	977.636	52.2
75	.63	99.11	.556	3.786	3.827	1327.832	58.7
100	.93	98.95	.794	5.057	5.119	2520.136	80.8
125	1.31	98.69	1.092	6.337	6.430	4316.851	114.1
150	1.80	98.32	1.490	7.632	7.776	7039.974	164.0

Table 5.6 provides a breakdown of costs, or the "bill of materials," associated with this design, M3 core steel, with a copper primary and aluminum secondary at $4A and $1B evaluation.

Table 5.6 Bill of Materials for M3CuAl at $4A and $1B

	A$ Input	$4.00		
	B$ Input	$1.00		
Material item	**Type**	**Quantity**	**$ each**	**$ total**
Winding Form (lb)	Nomex	2.71	$ 17.50	$ 47.40
Core Steel* (lb)	M3	1311	$ 0.95	$ 1,245.54
Primary winding* (lb)	Cu, wire	520	$ 1.60	$ 831.81
Secondary winding* (lb)	Al, strip	140	$ 1.20	$ 168.08
Primary layer insulation* (lb)	Nomex	17.0	$ 17.50	$ 297.49
Secondary layer insulation* (lb)	Nomex	7.44	$ 17.50	$ 130.16
Barrier insulation* (lb)	Nomex	1.42	$ 17.50	$ 24.89
Duct Spacer* (ft)	0.5" dog-bone	175	$ 0.24	$ 42.03
Enclosure	14 gauge	1	$ 175.00	$ 175.00
Mounting Frame	-	1	$ 36.00	$ 36.00
Busbar (ft)	-	10	$ 8.00	$ 80.00
Start & finish terminals	HV & LV	-	$ 75.00	$ 75.00
Varnish impregnation (gal)		5.1	$ 18.00	$ 92.48
Misc. Hardware	-	1	$ 25.00	$ 25.00
Handling and Scrap Factor		2.5%		$ 68.50
Total Material Cost				$ 3,339.36
Labor item		**hours**	**rate**	**$ total**
Setup & wind primary (3 phase)		2.552	42.77	$ 109.13
Setup & wind secondary (3 phase)		1.747	42.77	$ 74.70
Stacking core metal		1.896	42.77	$ 81.11
Assembly (coils, yoke & clamping)		4.000	42.77	$ 171.08
Lead dressing (3 phase)		0.500	42.77	$ 21.39
Inspection		0.100	42.77	$ 4.28
Preliminary and Final Test		0.300	42.77	$ 12.83
Shipment Packing and Marking		1.100	42.77	$ 47.05
Miscellaneous (incl. VPI)		0.500	42.77	$ 21.39
Total Labor		12.695	42.77	$ 542.94
Manufacturing Cost (Material + Labor)				$ 3,882.30
Factory Overhead (Materials only)		12.5%		$ 417.42
Selling Factor		25.0%		$ 1,074.93
Manufacturer Selling Price				$ 5,374.65

* indicates those items to which the handling and scrap factor (2.5%) is applied

Figure 5.6 provides a summary of the costs contributing to the total selling price of the transformer detailed above. Approximately 62% of the final selling price is material based - core, coil, insulation and other materials. Labor accounts for approximately 10% of the price, and overheads account for about 28%. For definitions of these categories, please see chapter 3 of this draft report.

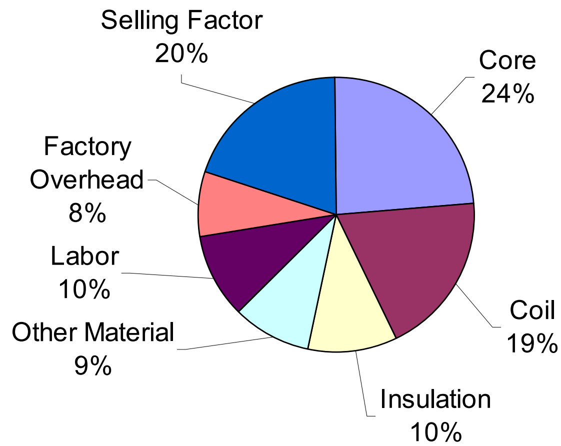


Figure 5.6 Cost breakdown for M3-CuAl Design at $4A and $1B

Appendix A. Scaling Relationships in Transformer Manufacturing[1]

There exist certain fundamental relationships between the ratings in kVA of transformers and their physical size and performance. A rather obvious such relationship is the fact that large transformers of the same voltage have lower percentage losses than small units, i.e., large transformers are more efficient. These size-versus-performance relationships arise from fundamental equations describing a transformer's voltage and kVA rating. For example, by fixing the kVA rating and voltage frequency, the product of the conductor current density, core flux density, core cross-sectional area, and total conductor cross-sectional area is constant.

To illustrate this point, consider a transformer with frequency, magnetic flux density, current density, and BIL all fixed. If one enlarges (or decreases) the kVA rating, then the only free parameters are the core cross-section and the core window area through which the windings pass. Thus, to increase (or decrease) the kVA rating, the dimensions for height width and depth of the core/coil assembly may be scaled equally in all directions. Careful examination reveals that linear dimensions vary as the ratio of kVA ratings to the ¼ power. Similarly, areas vary as the ratios of kVA ratings to the ½ power and volumes vary as the ratio of the kVA ratings to the ¾ or 0.75 power. Hence, there is the term "0.75 scaling rule". Table A.1 depicts the most common scaling relationships in transformers.

[1]This Appendix was drafted by Ben McConnell of Oak Ridge National Laboratory in Oak Ridge, Tennessee, and David Wiegand of Transformer Engineering Services in London, Ontario.

Table A.1 Common Scaling Relationships in Transformers

Parameter Being Scaled	**Relationship to kVA Rating (varies with ratio of kVA^x)**
Weight	$(kVA_1/kVA_0)^{3/4}$
Cost	$(kVA_1/kVA_0)^{3/4}$
Length	$(kVA_1/kVA_0)^{1/4}$
Width	$(kVA_1/kVA_0)^{1/4}$
Height	$(kVA_1/kVA_0)^{1/4}$
Total Losses	$(kVA_1/kVA_0)^{3/4}$
No-load Losses	$(kVA_1/kVA_0)^{3/4}$
Exciting Current	$(kVA_1/kVA_0)^{3/4}$
% Total Loss	$(kVA_1/kVA_0)^{-1/4}$
% No Load Loss	$(kVA_1/kVA_0)^{-1/4}$
% Exciting Current	$(kVA_1/kVA_0)^{-1/4}$
% R	$(kVA_1/kVA_0)^{-1/4}$
%X	$(kVA_1/kVA_0)^{1/4}$
Volts/Turn	$(kVA_1/kVA_0)^{1/2}$

The following three elements are true as the kVA rating increases or decreases if the following conditions are met: holding constant the type of transformer (distribution or power transformer, liquid-filled or dry-type, single-phase or three-phase), the primary voltage, the core configuration, the core material, the core flux density, and the current density (amperes per square inch of conductor cross-section) in both the primary and secondary windings.

1. The physical proportions are constant (same relative shape),
2. The eddy loss proportion is essentially constant, and
3. The insulation space factor (voltage or BIL) is constant.

In practical applications it is rare to find that all of the above are constant over even limited ranges; however, over a range of one order of magnitude in both directions (say from 50kVA to 5kVA or from 50kVA to 500kVA), the scaling rules shown in Table A.1 can be used to establish reasonable estimates of performance, dimensions, costs and losses. In practice, these rules can be applied over even wider ranges to estimate general performance levels. The same quantities are depicted graphically in Figure A.1 for reference.

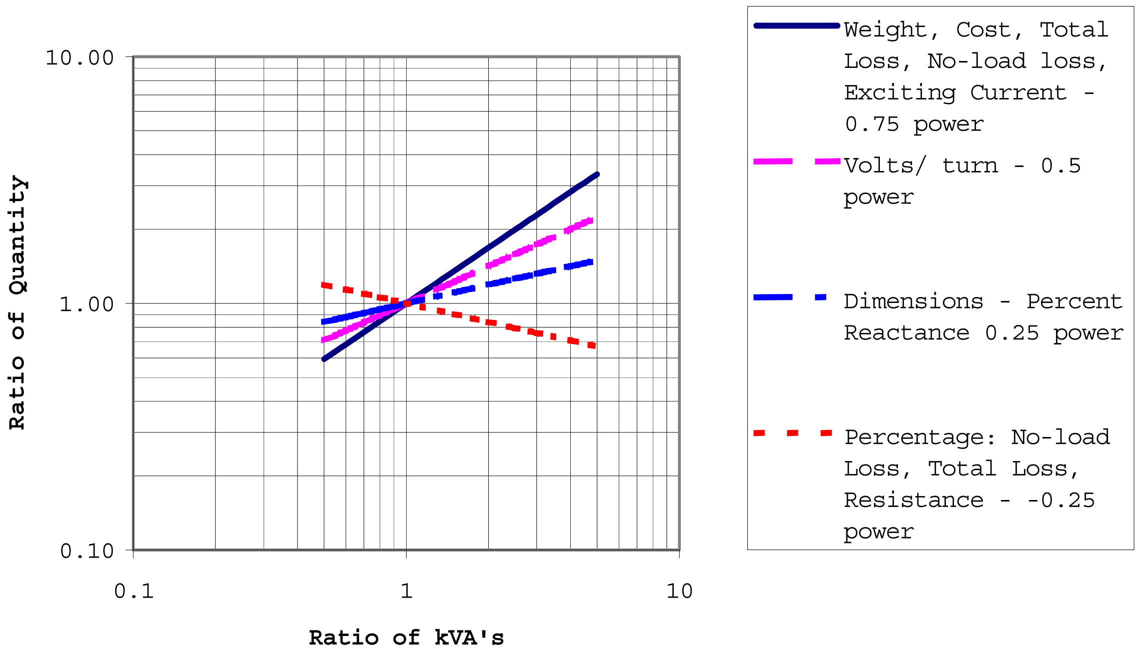


Figure A.1 Size and Performance Relationships by kVA Rating

To illustrate how the scaling laws are used, consider two transformers with kVA ratings of S_0 and S_1. The no-load losses (NL) and total losses (TL) of these two transformers would be depicted as NL_0 and TL_0, and NL_1 and TL_1. Then the relationships between the NL and TL of the two transformers could be shown as follows:

$$NL_1 = NL_0 \left(\frac{S_1}{S_0} \right)^{0.75} \qquad \text{and} \quad TL_1 = TL_0 \left(\frac{S_1}{S_0} \right)^{0.75}$$

These two equations can be manipulated algebraically to show that the load loss also varies to the 0.75 power. Starting with the concept that total losses equals no-load losses plus load losses, we can derive the relationship for load loss (LL), and show that it also scales to the 0.75 power. Specifically:

$$LL_1 = TL_1 - NL_1 \,.$$

Plugging the TL1 and NL1 terms into this equation, we find:

$$LL_1 = TL_0 \left(\frac{S_1}{S_0} \right)^{0.75} - NL_0 \left(\frac{S_1}{S_0} \right)^{0.75}$$

$$= \left(TL_0 - NL_0 \right) \left(\frac{S_1}{S_0} \right)^{0.75} .$$

That is,

$$LL_1 = LL_0 \left(\frac{S_1}{S_0} \right)^{0.75} .$$

In this way, the 0.75 scaling rule can be used to derive the losses of a transformer knowing the losses of a reference unit, if the specified type of transformer is held constant and key parameters are fixed such as the type of core material, core flux density, and conductor current density in the high and low voltage windings.

Theory and Basis for Scaling Rules

In order to understand the origins of winding and output coefficients and related scaling laws, it is necessary to review some basic equations and definitions. Most are lifted freely or derived from similar material in the text, *Modern Power Transformer Practice*, Wiley 1979, edited by R. Feinberg. No mathematics beyond elementary algebra is required, but a good deal of implied physics and electrical engineering is required to fully appreciate these derivations.

Power and Voltage Equations

The machine equation relates the induced volts, V, per phase to the number of turns (N) the frequency (f) in Hertz, the peak core flux density B_m in Tesla, and the cross-sectional area of the core steel (A_{Fe}) in square meters. The units are mixed to simplify the basic equations, a common practice in transformer design texts. The machine equation is derived from Faraday's law, which is expressed as

$$v = -N \frac{\partial \phi}{\partial t} ,$$

where v is the instantaneous value of V, and $\frac{\partial \phi}{\partial t}$ is the derivative of changing magnetic flux with respect to time.

Considering V as the root-mean-square (rms) value of a sine-wave alternating current voltage, the above equation can be converted into:

$$V/N = 4.44 \; f \; B_m \; A_{Fe} . \qquad \text{(equation 1)}$$

The voltage and turns may apply to either primary or secondary winding and, for the ideal transformer with no losses and no-leakage flux,

$$V_1/V_2 = N_1/N_2 = n = I_2/I_1 ,$$

where V_1 and V_2 represent primary and secondary voltages respectively, N_1 and N_2 primary and secondary turns, and I_1 and I_2 primary and secondary currents in amperes (amps). The quantity *n* is referred to as the "turns ratio." With the parameters defined, and using equation (1), the output or transformer capacity (S) in MVA per phase can be expressed as:

$$S = 4.44\ f\ B_m\ A_{Fe}\ N\ I\ . \qquad \text{(equation 1a)}$$

The overall cross-section of primary plus secondary conductors in square meters is

$$A_{Cu} = (N_1 a_1 + N_2 a_2) \times 10^{-6},$$

and, assuming current densities for primary and secondary windings to be equal, then

$$A_{Cu} = 2 \times 10^{-6}\ Na,$$

where "a" is the conductor cross-section in square millimeters (mm^2) of an individual turn referred to the winding with N turns and a_1 and a_2 are conductor cross-sections of primary and secondary turns respectively. As long as the winding current densities are equal, either winding may be used as reference, provided the choice of primary or secondary is consistent. Starting with (equation 1a), using the A_{Cu} relationship explained above, and letting J represent current density in amps per mm^2:

$$S = 2.22\ f\ B_m\ J\ A_{Fe}\ A_{Cu}\ . \qquad \text{(equation 2)}$$

Let A_w be the core window area in square meters, and k_w the window space factor, as given by 2 A_{Cu}/A_w. (Refer to Figure A.2 and note that in a three-phase transformer there are two coil phases occupying a given core window). This fraction is indicative of the insulation and cooling channel requirements. For distribution transformers, k_w is found to be about 0.3-0.4 for nominal 12 kV systems. Using these definitions,

$$S = 1.11\ f\ B_m\ J\ A_{Fe}\ k_w\ A_w\ . \qquad \text{(equation 2a)}$$

Note that, for a given MVA rating, and specified flux and current densities, the product of conductor and core cross-section is constant and inversely related; i.e. $A_{Fe} \propto 1/A_{Cu}$.

Losses

Ideally, if the values of energy loss in Watts per kilogram (W/kg) of unit mass of the core and windings are known, the total core and load losses (P_{Fe} and P_{Cu}) can be readily obtained. These results are accomplished by multiplying the W/kg for both core and windings by the core mass and the conductor mass respectively, (or by their volumes times material densities).

We use the convention that lower case corresponds to per-unit quantities and upper case corresponds to total or to total-per-phase quantities. Load losses consist of resistive (p_R) and eddy (p_i) components. Expressions can be derived that express each in terms of the conductor properties and geometry. The fraction of eddy losses plays an important role and can be expressed as

$$\%P_i = 100\ P_i/P_R, \text{ or } \quad P_i = P_R\left(\frac{\%P_i}{100}\right) \ .$$

Ignoring stray loss, (which is associated with eddy losses), let P_t represent total load loss for a three-phase transformer. That is,

$$P_t \ = 3P_{Cu}.$$

Also assume the same eddy loss fraction in primary and secondary windings.

$$P_{Cu} = P_R + P_i = P_R + \ P_R\left(\frac{\%P_i}{100}\right) = \left(1 + \frac{\%P_i}{100}\right)P_R = k_i P_R.$$

Closely associated with the load loss of a transformer is its impedance. When the load loss of a given transformer is determined by test (the wattmeter reading in the test circuit), that same test also provides the value of the impedance (the voltmeter reading in the test circuit). Impedance in a transformer is expressed in terms of the "impedance voltage," which is defined as "the voltage required to circulate rated current through one of two specified windings of a transformer when the other winding is short-circuited, with the windings connected as for rated voltage operation" (IEEE C57.12.80).

For convenience, "percent impedance," %Z, is used to describe the impedance voltage of a transformer. In accordance with the definition given above,

$$\%Z = \frac{IZ \times 100}{V} \ ,$$

that is, when related to the primary or secondary winding of a transformer, the percent impedance is the percent voltage drop due to impedance when rated current flows through the respective primary or secondary winding of the transformer.

The %Z may be represented by its resistive and reactive components, %R and %X, as

$$\%Z = \sqrt{(\%R)^2 + (\%X)^2} \ .$$

Therefore, we can express percent resistance (%R) as follows:

$$\%R = \frac{IR \times 10^2}{V}.$$

Note that R in the numerator must represent the total resistance in the transformer windings. Therefore, if the transformer is being viewed from the primary terminals, the value of R would be the total resistance of the primary winding, plus the total resistance of the secondary winding referred to the primary winding, $(R_2(N_1/N_2)^2)$.

Where the percent impedance, percent reactance, and percent resistance are related to the voltage across the primary or secondary winding of a transformer, the percent load loss ($\%I^2R$) is related to the MVA capacity of the transformer, stray loss being ignored as stated previously.

Multiplying numerator and denominator in the above equation by I, and letting P_t represent total load loss in watts and S represent the megavoltamperes (MVA per phase) rating, we determine the percent load loss as:

$$\text{Percent load loss} = \frac{I^2R\times10^2}{I\times V} = \frac{I^2R\times10^2}{3S\times10^6}$$

$$\therefore \%R = \frac{10^{-4}P_t}{3S} \;.$$

Thus, an expression of %R is equivalent to indicating the transformer's load loss.

From equation (2), it is evident that once the core flux density and current density are fixed, the transformer rating is dependent upon the core cross-section and window area. Next, we will derive information about the window shape.

In a detailed discussion of the reactance, the electrical characteristics would depend upon:

- the ratio of winding height (h) to the winding mean turn (s), and
- the ratio of the cross-sectional areas of the core and conductor (A_{Fe}/A_{Cu})

The mean value of s (a linear measurement, recording the circumference), is given by the equation $s = (s_1 + s_2)/2$, where s_1 is the mean turn of the primary winding and s_2 is the mean turn of the secondary winding.

These ratios, together with the necessary space factors for insulating and cooling clearances, establish the relative volumes of the core and conductor. Consequently, if fixed values for the specific loadings and therefore specific losses for core and conductor can be assumed, the ratios of core loss and load loss are established.

The following application of relationships derive an expression relating the flux and current densities. Starting with the simple expression of:

$$P_{Cu} = \left(1 + \frac{\%P_i}{100}\right) P_R = k_i P_R$$

$$P_{Cu} = (I_1^2 R_1 + I_2^2 R_2) k_i ,$$

where subscripts 1 and 2 indicate primary and secondary windings respectively. The resistance per phase of the primary winding is given by

$$R_1 = \frac{\rho N_1 s_1}{a_1} \text{ohms},$$

where a_1 is the cross-sectional area of the primary copper conductor, and ρ is the resistivity at full load operating temperature of the conductor, 21.4 x 10^{-3} ohm - meters. The value of R_2 is similarly obtained:

$$\therefore P_{Cu} = \left(\frac{I_1^2 \rho N_1 s_1}{a_1} + \frac{I_2^2 \rho N_2 s_2}{a_2} \right) k_i$$

$$\therefore P_{Cu} = IN \left(\frac{I_1 s_1}{a_1} + \frac{I_2 s_2}{a_2} \right) \rho k_i \quad ,$$

where IN is the ampere-turns in either winding. As before, the assumption of equal current densities in the windings is made, driven by the condition for minimum I^2R loss. Accordingly,

$$P_{Cu} = 2INJs\rho \, k_i$$

$$\therefore J = \frac{P_{Cu}}{2INs\rho k_i}$$, the current density equation.

Multiplying equation (1) by I and rearranging algebraically we get

$$IN = \frac{VI}{4.44 f B_m A_{Fe}} \quad .$$

It was established earlier that S is the rating per phase in MVA, that is VI = 10^6S. Thus:

$$\therefore IN = \frac{10^6 S}{4.44 f B_m A_{Fe}} \ .$$

Using the current density equation, substituting the resistivity value for ρ, and the above value for IN, we can derive that:

$$J = \frac{104 \times 10^{-6} f B_m A_{Fe} P_{Cu}}{k_i s S} \ .$$

The watts of conductor loss (for copper) can be expressed as a percentage of the transformer MVA rating:

$$\%P_{Cu} = \frac{P_{Cu} \times 10^2}{S} \ ,$$

or in kilowatts:

$$\%P_{Cu} = \frac{P_{Cu} \times 10^2}{S \times 10^3} = \frac{0.1 P_{Cu}}{S} \ .$$

By substituting in the revised equation for J (amperes per square meter), we get

$$J = \frac{104 \times 10^{-6} f B_m A_{Fe} S}{k_i s S} \times \frac{\%P_{Cu}}{0.1} = \frac{1040 \times 10^{-6} f B_m A_{Fe}}{k_i s} \times \%P_{Cu} \ . \qquad \text{(equation 3)}$$

If aluminum windings were used instead of copper, a value of 655 would be substituted for 1040. The expression assumes equal J in both windings and that both windings are made of the same material. The losses are expressed at operating temperature.

If J and B_m are chosen independently, the transformer will have a natural value of conductor loss depending upon the ratio A_{Fe}/s. Conversely, if losses are specified, the choice of J is determined by B_m and A_{Fe}/s. Note that this relationship gives no information about the other transformer dimensions. The impedance, voltage, and other space requirements provide the majority of this information.

Output and Winding Coefficients

Starting with the output or power equation (2), we can write:

$$S = 2.22\, f\, B_m\, J\, A_{Fe}\, A_{Cu} \quad \text{or} \quad A_{Fe} = \frac{S}{2.22\, f\, B_m J\, A_{Cu}} \ .$$

Then, without changing the value, we can state:

$$A_{Fe} = \sqrt{\frac{S^2}{\left(2.22 f\, B_m J\, A_{Cu}\right)^2}} = \sqrt{S}\sqrt{\frac{2.22 f\, B_m J (A_{Fe})(A_{Cu})}{\left(2.22 f\, B_m J\, A_{Cu}\right)^2}} \text{ , or}$$

$$A_{Fe} = \sqrt{S}\sqrt{\frac{A_{Fe}}{(2.22 f\, B_m J)(A_{Cu})}} \ . \qquad \text{(equation 4)}$$

Use K_{AS} to represent the portion of Equation (4) to the right of $\sqrt{S}$.

The expression K_{AS} is essentially constant for a wide range of transformer classes and is called the output coefficient. For three-phase liquid filled distribution transformers at 60 Hz, the value of K_{AS} ranges from 0.050-0.055 with a nominal median value of 0.052. For single phase, wound core, liquid filled units at 60 Hz the median value is about 0.040.

In a similar fashion making use of equation (4), we can restate equation (1) as follows

$$\frac{V}{N} = 4.44 f B_m A_{Fe} = \sqrt{\frac{(4.44 f B_m)^2 S A_{Fe}}{2.22 f B_m J A_{Cu}}}$$

$$= \sqrt{\left(\frac{8.88 f B_m}{J}\right)\left(\frac{A_{Fe}}{A_{Cu}}\right)(S)} = K_{VS}\sqrt{S} \ . \qquad \text{(equation 5)}$$

The expression K_{VS} is also essentially constant for a wide range of transformer classes and is called the winding coefficient. We can also express K_{VS} in terms of K_{AS}:

$K_{VS} = 4.44\ f\ B_m\ K_{AS}$.

For 60 Hz systems this may be rewritten as $K_{VS} = 266.4\ B_m\ K_{AS}$. Thus the median values for K_{VS} become 21.5 for three-phase and 17.0 for single-phase wound core distribution transformers at

60 Hz with B_m = 1.55 Tesla. Equations (4)-(6) provide initial estimates for transformer dimensions in studies. They are the starting basis for the scaling laws used to scale designs and performance. Typical values are given in Table A.2 for core type, liquid filled, 60 Hz distribution transformers at 12 kV, 95 kV BIL.

Table A.2 Nominal 60 Hz, core-type, liquid-filled, 12 kV distribution transformers

Class of Dist.	**J(A/mm²)**		**B_m (Tesla)**	**A_{Fe}/A_{Cu}**		**K_{AS}**		**K_{VS}**	**%X**
XFRM	Range	Nominal	Nominal	Range	Nominal	Range	Nominal		
3-Phase	2.4-3.2	2.7	1.55	1.4-2.8	1.6	0.050-0.055	0.052	21.5	4.75
1-Phase	2.0-2.5	2.3	1.55	0.65-0.85	0.8	0.038-0.043	0.041	17.0	4.75

Scaling Laws

Having established the output and winding coefficients, it is instructive to examine the origin of the 0.75 rules for scaling transformer losses. To illustrate, first of all, we need to set relationships as follows:

$$\frac{V}{N} = K_{VS}\sqrt{S}$$

$$A_{Fe} = K_{AS}\sqrt{S}$$

$$A_{Cu} = K_{CS}\sqrt{S} \text{ , (where } K_{CS} = \frac{1}{K_{AS}} \text{)}$$

$$s \sim (A_{Fe}^{0.5} + \frac{b_w}{4}) \sim S^{0.25}.$$

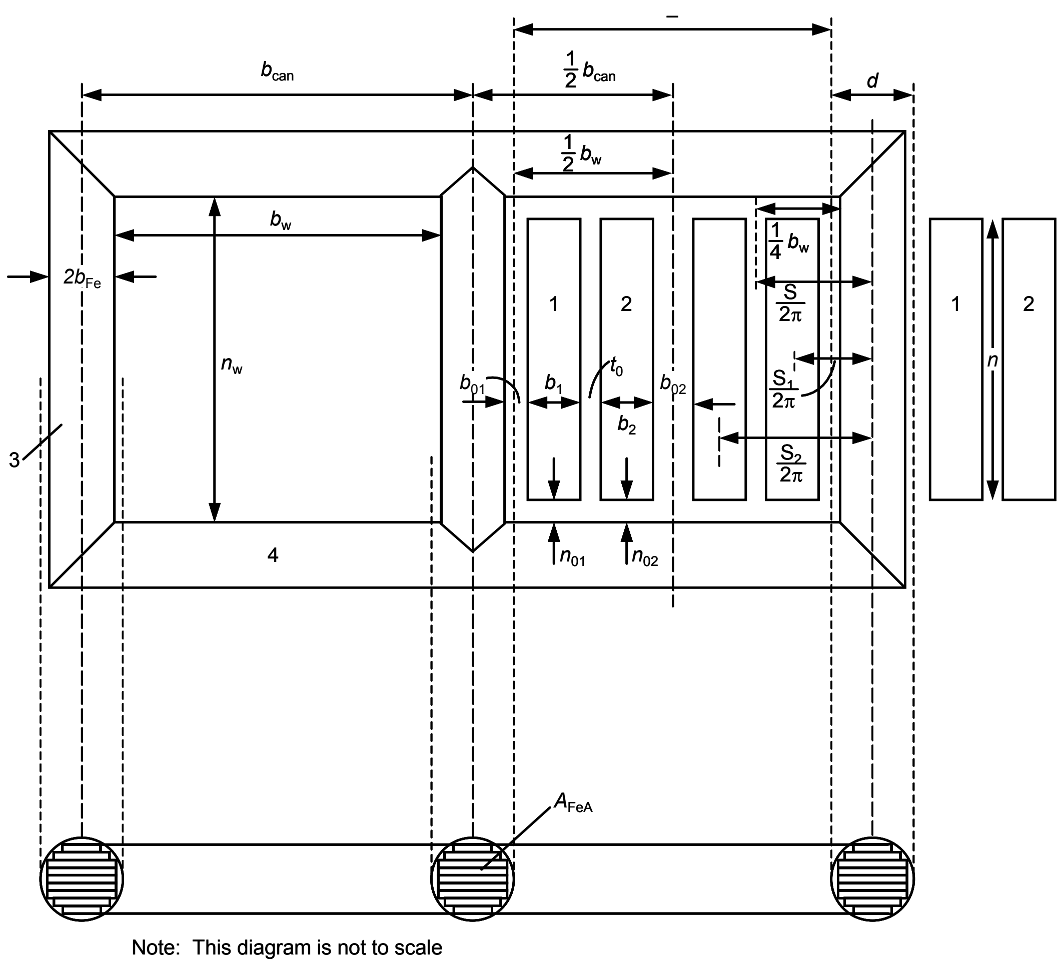
The shape of the window is set by voltage and the ratio h/s, which is essentially constant for a given voltage and size, thus setting b_w. Refer to Figure A.2 for dimensional definitions.

Now, we consider the load losses, P_{Cu} (in kW/phase):

$$P_{Cu} = \frac{I^2 R}{1000} = \left(\frac{S}{V}\right)^2 \frac{R}{1000} = \left(\frac{S}{V}\right)^2 \frac{R}{1000}$$

$$= \frac{4.28 \times 10^{-17} S^2 s N^2}{A_{Cu} V^2} = K\sqrt{S} \times s = K'S^{0.75}.$$

The other scaling laws are derived in a similar fashion.



Source: R. Feinberg, Modern Power Transformer Practice

Figure A.2 Basic three-phase transformer dimensions

Appendix B. Optimized Program Service, Inc.

DOE retained Optimized Program Service, Inc. (OPS) to conduct the computer modeling runs on the representative models from each of the design lines. This section provides some background on the company and its design software.

Company profile

OPS began in 1969 to provide comprehensive design tools for the transformer industry. OPS blends magnetic design theory with practical manufacturing experience, resulting in a series of software products that provide accurate and reliable transformer designs.

The OPS programming staff has over one hundred years of combined experience in transformer design and manufacturing. Present and past clientele include large and small transformer manufacturers, designers and specifiers all over the world - from small one-man companies to large international blue-chip corporations.

How the software works

Design requirements are submitted to the program, which directs the user through the entire design process, asking for all data necessary to develop a design that meets the specific requirements of the application. Multiple-choice questions and on-screen illustrations show alternatives that are available for each condition and provide a graphical representation of the selections. The designer can use preprogrammed default values or change the data to meet any special requirements of the design.

Design data are then submitted to the programs that will develop a practical design. Using modular architecture, specific routines are called in to achieve different levels of functionality. The programs can automatically select cores, wires or insulation, or the user can enter their own.

The format of the program's output includes physical characteristics, dimensions, material requirements, and mechanical clearances, as well as a complete and very comprehensive electrical analysis of the final design.

Software used for the Engineering Analysis

DOE used two OPS programs to generate the design database for the engineering analysis. These included 2TRANS and TOPT. The 2TRANS is a comprehensive design program used to design a wide range of linear transformers. For small linear transformers, 2TRANS will design a broad range of single or three-phase transformers with or without rectified outputs. For large transformers, 2TRANS will handle ratings upwards of 5000 kVA. Standard industry winding schemes such as barrel, disk and section winding are accommodated. Cooling methods available are air, forced-air and oil-filled. 2TRANS is used to design a range of transformers, including distribution transformers.

TOPT is a transformer design optimization program, which uses sophisticated mathematical routines to develop the best combination of materials to minimize cost, weight or size of a transformer. It is used when the designer has complete freedom to change core dimensions. TOPT works in tandem with 2TRANS to produce practical designs close to the true optimum.

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Appendix C. Engineering Analysis Database: Manufacturer Prices and Efficiencies

This appendix presents selected data fields from the engineering analysis database on all the transformer designs in design line nine. These data are shown graphically in the scatter plots in section 4 of this report. In this database extraction, the efficiency, the core and coil losses, and the manufacturer ex-factory price are shown for each record.

As discussed in this report, the engineering analysis design database was generated by OPS using its software described in Appendix B. While these tables in Appendix C present only five fields of data, the complete engineering analysis database contains a design details report on each of these records, containing all the design parameters and electrical analysis data shown in the example designs of Chapter 5.

The data in the following 30 tables has been ordered by efficiency level and then by price.

Table C.1 Engineering Analysis Database

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M36AIAI	96.77%	4162	838	3549	$ 3,806.17
DL9_M36AIAI	96.77%	4162	838	3549	$ 3,806.17
DL9_M36AIAI	96.78%	4177	818	3457	$ 3,840.29
DL9_M36AIAI	96.78%	4172	821	3473	$ 3,833.84
DL9_M36AIAI	96.80%	4183	780	3304	$ 3,905.51
DL9_M36AIAI	96.80%	4171	789	3350	$ 3,887.09
DL9_M36AIAI	96.80%	4138	819	3494	$ 3,833.99
DL9_M36AIAI	96.80%	4149	802	3414	$ 3,863.43
DL9_M36AIAI	96.81%	4150	787	3355	$ 3,888.52
DL9_M36AIAI	96.82%	4169	759	3227	$ 3,941.79
DL9_M36AIAI	96.82%	4168	759	3228	$ 3,941.71
DL9_M36AIAI	96.83%	4167	744	3165	$ 3,971.39
DL9_M36AIAI	96.83%	4111	792	3403	$ 3,879.00
DL9_M36AIAI	96.83%	4111	792	3403	$ 3,879.00
DL9_M36AIAI	96.83%	4111	792	3403	$ 3,879.00
DL9_M36AIAI	96.84%	4130	758	3244	$ 3,942.83
DL9_M36AIAI	96.85%	4125	759	3250	$ 3,941.85
DL9_M36AIAI	96.85%	4111	772	3315	$ 3,914.44
DL9_M36AIAI	96.86%	4129	736	3150	$ 3,988.59
DL9_M36AIAI	96.86%	4164	695	2960	$ 4,085.59
DL9_M36AIAI	96.86%	4110	745	3194	$ 3,969.84
DL9_M36AIAI	96.90%	3907	895	3903	$ 3,785.08
DL9_M36AIAI	96.90%	4083	716	3081	$ 4,034.94
DL9_M36AIAI	96.91%	3884	902	3950	$ 3,772.48
DL9_M36AIAI	96.91%	3890	885	3872	$ 3,799.63
DL9_M36AIAI	96.92%	4087	684	2933	$ 4,167.15
DL9_M36AIAI	96.92%	4087	684	2933	$ 4,167.15
DL9_M36AIAI	96.92%	3901	868	3792	$ 3,829.67
DL9_M36AIAI	96.92%	3876	886	3882	$ 3,840.40
DL9_M36AIAI	96.92%	4047	713	3076	$ 4,093.56
DL9_M36AIAI	96.92%	4047	713	3076	$ 4,093.56
DL9_M36AIAI	96.93%	3896	862	3766	$ 3,838.74
DL9_M36AIAI	96.93%	4070	682	2926	$ 4,175.25
DL9_M36AIAI	96.93%	3884	864	3780	$ 3,879.64
DL9_M36AIAI	96.93%	3912	832	3620	$ 3,936.28
DL9_M36AIAI	96.94%	3890	846	3696	$ 3,911.65
DL9_M36AIAI	96.94%	3881	853	3732	$ 3,897.61
DL9_M36AIAI	96.94%	3869	864	3785	$ 3,875.42
DL9_M36AIAI	96.96%	3832	872	3845	$ 3,866.74
DL9_M36AIAI	96.97%	3855	840	3681	$ 3,921.83
DL9_M36AIAI	96.97%	3857	827	3623	$ 3,946.37
DL9_M36AIAI	96.98%	3814	864	3813	$ 3,877.16
DL9_M36AIAI	96.98%	3893	780	3398	$ 4,038.66
DL9_M36AIAI	96.98%	3836	834	3661	$ 3,929.84
DL9_M36AIAI	96.98%	3821	848	3734	$ 3,910.38
DL9_M36AIAI	96.98%	3685	983	4392	$ 3,724.93
DL9_M36AIAI	96.99%	3867	795	3472	$ 4,010.17
DL9_M36AIAI	96.99%	3860	801	3504	$ 3,997.75
DL9_M36AIAI	96.99%	3814	846	3732	$ 3,911.17
DL9_M36AIAI	96.99%	3808	852	3760	$ 3,900.03
DL9_M36AIAI	96.99%	3851	807	3536	$ 3,987.19
DL9_M36AIAI	96.99%	3851	807	3536	$ 3,987.19
DL9_M36AIAI	96.99%	3694	962	4287	$ 3,754.15
DL9_M36AIAI	96.99%	3817	838	3689	$ 3,923.55
DL9_M36AIAI	96.99%	3813	842	3712	$ 3,917.54
DL9_M36AIAI	96.99%	3819	834	3671	$ 3,931.01
DL9_M36AIAI	96.99%	3833	815	3576	$ 3,967.59

Table C.2 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M36AIAI	97.00%	3838	808	3541	$ 3,985.97
DL9_M36AIAI	97.00%	3795	846	3739	$ 3,910.90
DL9_M36AIAI	97.00%	3802	840	3704	$ 3,922.84
DL9_M36AIAI	97.00%	3824	815	3583	$ 3,970.67
DL9_M36AIAI	97.00%	3822	817	3592	$ 3,974.95
DL9_M36AIAI	97.00%	3820	816	3589	$ 3,967.48
DL9_M36AIAI	97.00%	3802	830	3656	$ 3,940.52
DL9_M36AIAI	97.01%	3816	809	3553	$ 3,982.02
DL9_M36AIAI	97.01%	3812	812	3568	$ 3,974.55
DL9_M36AIAI	97.01%	3797	821	3618	$ 3,964.78
DL9_M36AIAI	97.01%	3680	937	4182	$ 3,791.12
DL9_M36AIAI	97.02%	3678	931	4152	$ 3,800.96
DL9_M36AIAI	97.02%	3812	792	3472	$ 4,019.66
DL9_M36AIAI	97.03%	3792	805	3544	$ 3,994.11
DL9_M36AIAI	97.03%	3669	929	4147	$ 3,806.00
DL9_M36AIAI	97.03%	3662	935	4179	$ 3,794.61
DL9_M36AIAI	97.03%	3818	778	3404	$ 4,050.51
DL9_M36AIAI	97.03%	3791	802	3527	$ 3,998.81
DL9_M36AIAI	97.03%	3667	924	4125	$ 3,812.83
DL9_M36AIAI	97.03%	3652	936	4190	$ 3,794.03
DL9_M36AIAI	97.03%	3651	933	4176	$ 3,798.71
DL9_M36AIAI	97.04%	3800	781	3426	$ 4,052.33
DL9_M36AIAI	97.04%	3788	789	3468	$ 4,033.15
DL9_M36AIAI	97.04%	3654	920	4112	$ 3,819.08
DL9_M36AIAI	97.05%	3649	917	4099	$ 3,823.53
DL9_M36AIAI	97.05%	3657	906	4045	$ 3,845.10
DL9_M36AIAI	97.05%	3635	926	4148	$ 3,810.38
DL9_M36AIAI	97.05%	3670	891	3964	$ 3,868.17
DL9_M36AIAI	97.05%	3651	908	4053	$ 3,841.23
DL9_M36AIAI	97.05%	3817	741	3228	$ 4,152.91
DL9_M36AIAI	97.05%	3634	920	4121	$ 3,820.63
DL9_M36AIAI	97.06%	3650	899	4017	$ 3,860.78
DL9_M36AIAI	97.06%	3631	917	4104	$ 3,826.78
DL9_M36AIAI	97.06%	3631	916	4098	$ 3,829.06
DL9_M36AIAI	97.07%	3663	873	3883	$ 3,900.75
DL9_M36AIAI	97.07%	3751	783	3443	$ 4,047.22
DL9_M36AIAI	97.07%	3604	929	4180	$ 3,809.91
DL9_M36AIAI	97.07%	3662	868	3861	$ 3,909.09
DL9_M36AIAI	97.07%	3608	922	4141	$ 3,821.38
DL9_M36AIAI	97.07%	3654	874	3896	$ 3,900.49
DL9_M36AIAI	97.07%	3624	904	4047	$ 3,848.26
DL9_M36AIAI	97.07%	3620	902	4039	$ 3,854.69
DL9_M36AIAI	97.07%	3472	1048	4795	$ 3,759.45
DL9_M36AIAI	97.08%	3624	887	3964	$ 3,878.33
DL9_M36AIAI	97.08%	3606	902	4045	$ 3,855.82
DL9_M19AIAI	97.08%	3671	836	3472	$ 4,372.69
DL9_M36AIAI	97.09%	3467	1036	4737	$ 3,776.24
DL9_M36AIAI	97.09%	3590	907	4076	$ 3,847.23
DL9_M36AIAI	97.09%	3615	878	3925	$ 3,894.34
DL9_M36AIAI	97.09%	3578	914	4114	$ 3,837.69
DL9_M36AIAI	97.09%	3611	880	3934	$ 3,891.13
DL9_M36AIAI	97.09%	3470	1021	4659	$ 3,797.83
DL9_M36AIAI	97.10%	3477	1008	4588	$ 3,818.12
DL9_M36AIAI	97.10%	3589	895	4013	$ 3,869.78
DL9_M36AIAI	97.10%	3566	914	4119	$ 3,839.30
DL9_M36AIAI	97.10%	3568	912	4106	$ 3,844.20
DL9_M36AIAI	97.10%	3592	887	3972	$ 3,885.28

Table C.3 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M36AIAI	97.10%	3630	849	3773	$ 3,995.14
DL9_M36AIAI	97.10%	3634	845	3750	$ 4,003.46
DL9_M36AIAI	97.10%	3481	996	4528	$ 3,835.36
DL9_M36AIAI	97.10%	3466	1012	4615	$ 3,813.15
DL9_M36AIAI	97.10%	3565	911	4105	$ 3,844.52
DL9_M19AIAI	97.11%	3657	812	3404	$ 4,410.53
DL9_M19AIAI	97.11%	3665	804	3366	$ 4,427.75
DL9_M19AIAI	97.11%	3654	814	3414	$ 4,408.01
DL9_M19AIAI	97.11%	3687	779	3252	$ 4,478.01
DL9_M19AIAI	97.11%	3663	797	3343	$ 4,439.40
DL9_M36AIAI	97.11%	3609	850	3779	$ 3,998.87
DL9_M19AIAI	97.11%	3658	800	3362	$ 4,431.20
DL9_M19AIAI	97.11%	3662	795	3334	$ 4,443.05
DL9_M19AIAI	97.12%	3657	798	3355	$ 4,440.18
DL9_M36AIAI	97.12%	3461	992	4519	$ 3,842.42
DL9_M36AIAI	97.12%	3346	1105	5163	$ 3,537.83
DL9_M19AIAI	97.12%	3627	818	3461	$ 4,396.83
DL9_M19AIAI	97.12%	3652	791	3332	$ 4,447.79
DL9_M36AIAI	97.13%	3444	994	4535	$ 3,847.20
DL9_M36AIAI	97.13%	3462	973	4421	$ 3,871.52
DL9_M36AIAI	97.13%	3607	825	3658	$ 4,051.67
DL9_M36AIAI	97.13%	3633	799	3525	$ 4,066.88
DL9_M36AIAI	97.13%	3441	989	4510	$ 3,851.31
DL9_M36AIAI	97.13%	3320	1109	5161	$ 3,720.05
DL9_M19AIAI	97.13%	3645	781	3298	$ 4,469.18
DL9_M19AIAI	97.14%	3632	788	3337	$ 4,455.51
DL9_M36AIAI	97.14%	3301	1113	5190	$ 3,721.23
DL9_M19AIAI	97.14%	3632	780	3309	$ 4,470.77
DL9_M36AIAI	97.14%	3428	984	4493	$ 3,858.09
DL9_M36AIAI	97.15%	3413	995	4550	$ 3,844.15
DL9_M19AIAI	97.15%	3630	778	3301	$ 4,474.23
DL9_M36AIAI	97.15%	3407	999	4577	$ 3,834.55
DL9_M36AIAI	97.15%	3302	1103	5137	$ 3,730.70
DL9_M36AIAI	97.15%	3410	994	4548	$ 3,844.18
DL9_M36AIAI	97.15%	3432	971	4422	$ 3,882.34
DL9_M36AIAI	97.15%	3299	1103	5139	$ 3,728.10
DL9_M19AIAI	97.15%	3655	746	3155	$ 4,543.66
DL9_M36AIAI	97.15%	3407	993	4545	$ 3,846.11
DL9_M19AIAI	97.15%	3665	732	3092	$ 4,578.25
DL9_M19AIAI	97.15%	3616	781	3326	$ 4,466.50
DL9_M36AIAI	97.15%	3275	1121	5250	$ 3,710.58
DL9_M36AIAI	97.15%	3548	847	3776	$ 4,019.21
DL9_M19AIAI	97.15%	3645	749	3173	$ 4,536.01
DL9_M19AIAI	97.16%	3626	764	3248	$ 4,505.19
DL9_M36AIAI	97.16%	3440	944	4278	$ 3,926.78
DL9_M36AIAI	97.16%	3391	987	4515	$ 3,856.54
DL9_M36AIAI	97.17%	3388	988	4521	$ 3,855.88
DL9_M36AIAI	97.17%	3258	1117	5241	$ 3,717.98
DL9_M19AIAI	97.17%	3612	762	3249	$ 4,504.04
DL9_M36AIAI	97.17%	3274	1098	5130	$ 3,747.90
DL9_M36AIAI	97.17%	3377	995	4559	$ 3,850.52
DL9_M19AIAI	97.17%	3600	771	3297	$ 4,487.61
DL9_M19AIAI	97.17%	3452	915	3920	$ 4,286.23
DL9_M36AIAI	97.18%	3249	1110	5208	$ 3,721.03
DL9_M36AIAI	97.18%	3575	784	3458	$ 4,153.32
DL9_M36AIAI	97.18%	3381	976	4459	$ 3,880.20
DL9_M36AIAI	97.18%	3539	817	3627	$ 4,088.55

Table C.4 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M36AIAI	97.18%	3562	792	3504	$ 4,138.10
DL9_M36AIAI	97.18%	3384	967	4410	$ 3,894.07
DL9_M36AIAI	97.18%	3252	1097	5136	$ 3,739.32
DL9_M19AIAI	97.18%	3618	729	3108	$ 4,581.35
DL9_M36AIAI	97.18%	3375	972	4442	$ 3,883.32
DL9_M19AIAI	97.18%	3609	737	3147	$ 4,556.43
DL9_M19AIAI	97.18%	3621	725	3091	$ 4,586.64
DL9_M19AIAI	97.18%	3595	750	3207	$ 4,533.79
DL9_M19AIAI	97.19%	3588	756	3240	$ 4,521.21
DL9_M19AIAI	97.19%	3593	750	3210	$ 4,534.66
DL9_M36AIAI	97.19%	3382	960	4377	$ 3,911.79
DL9_M19AIAI	97.19%	3606	731	3122	$ 4,575.65
DL9_M36AIAI	97.19%	3229	1105	5190	$ 3,729.32
DL9_M36AIAI	97.19%	3250	1084	5067	$ 3,757.61
DL9_M36AIAI	97.19%	3377	955	4351	$ 3,918.30
DL9_M19AIAI	97.19%	3621	710	3025	$ 4,632.74
DL9_M36AIAI	97.20%	3166	1161	5573	$ 3,513.57
DL9_M19AIAI	97.20%	3412	915	3968	$ 4,320.04
DL9_M36AIAI	97.20%	3391	936	4249	$ 3,943.70
DL9_M19AIAI	97.20%	3448	878	3775	$ 4,388.46
DL9_M36AIAI	97.20%	3237	1088	5094	$ 3,753.50
DL9_M36AIAI	97.20%	3220	1103	5183	$ 3,734.86
DL9_M19AIAI	97.20%	3435	889	3831	$ 4,323.10
DL9_M19AIAI	97.20%	3442	879	3785	$ 4,382.48
DL9_M19AIAI	97.20%	3451	868	3730	$ 4,363.22
DL9_M19AIAI	97.20%	3443	876	3770	$ 4,389.32
DL9_M19AIAI	97.20%	3581	735	3151	$ 4,573.38
DL9_M19AIAI	97.20%	3418	897	3885	$ 4,350.74
DL9_M36AIAI	97.21%	3233	1076	5027	$ 3,769.30
DL9_M36AIAI	97.21%	3160	1148	5498	$ 3,529.45
DL9_M19AIAI	97.21%	3584	723	3097	$ 4,599.35
DL9_M36AIAI	97.21%	3154	1152	5528	$ 3,525.45
DL9_M19AIAI	97.21%	3433	873	3767	$ 4,392.70
DL9_M19AIAI	97.21%	3431	874	3774	$ 4,389.93
DL9_M36AIAI	97.21%	3149	1156	5553	$ 3,518.53
DL9_M19AIAI	97.21%	3431	869	3755	$ 4,398.46
DL9_M19AIAI	97.21%	3436	864	3728	$ 4,411.25
DL9_M36AIAI	97.21%	3370	928	4212	$ 3,964.15
DL9_M19AIAI	97.22%	3426	871	3771	$ 4,398.11
DL9_M19AIAI	97.22%	3425	871	3768	$ 4,395.02
DL9_M36AIAI	97.22%	3218	1077	5035	$ 3,775.18
DL9_M19AIAI	97.22%	3573	718	3084	$ 4,614.67
DL9_M19AIAI	97.22%	3573	718	3084	$ 4,614.67
DL9_M19AIAI	97.22%	3573	718	3084	$ 4,614.67
DL9_M19AIAI	97.22%	3391	898	3921	$ 4,307.74
DL9_M36AIAI	97.22%	3351	938	4262	$ 3,951.48
DL9_M36AIAI	97.22%	3149	1139	5457	$ 3,539.97
DL9_M36AIAI	97.22%	3137	1150	5523	$ 3,531.66
DL9_M36AIAI	97.23%	3134	1146	5508	$ 3,529.65
DL9_M36AIAI	97.23%	3223	1049	4880	$ 3,814.82
DL9_M19AIAI	97.23%	3404	867	3770	$ 4,405.64
DL9_M36AIAI	97.23%	3136	1135	5443	$ 3,544.37
DL9_M19AIAI	97.23%	3439	832	3596	$ 4,477.07
DL9_M36AIAI	97.23%	3110	1159	5597	$ 3,528.14
DL9_M36AIAI	97.24%	3201	1062	4959	$ 3,795.41
DL9_M36AIAI	97.24%	3108	1153	5566	$ 3,534.10
DL9_M19AIAI	97.24%	3425	836	3620	$ 4,465.68

Table C.5 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M19AIAI	97.24%	3408	852	3704	$ 4,428.84
DL9_M19AIAI	97.24%	3402	857	3732	$ 4,418.06
DL9_M36AIAI	97.24%	3233	1026	4754	$ 3,848.73
DL9_M19AIAI	97.24%	3421	837	3628	$ 4,459.31
DL9_M36AIAI	97.24%	3138	1119	5343	$ 3,564.34
DL9_M19AIAI	97.24%	3396	860	3751	$ 4,416.20
DL9_M36AIAI	97.24%	3206	1043	4851	$ 3,827.31
DL9_M19AIAI	97.25%	3258	990	4353	$ 4,213.94
DL9_M36AIAI	97.25%	3139	1106	5270	$ 3,577.74
DL9_M19AIAI	97.25%	3394	850	3706	$ 4,435.66
DL9_M19AIAI	97.25%	3408	836	3632	$ 4,461.02
DL9_M19AIAI	97.25%	3408	836	3632	$ 4,461.02
DL9_M36AIAI	97.25%	3091	1152	5563	$ 3,530.12
DL9_M19AIAI	97.25%	3420	823	3569	$ 4,489.81
DL9_M19AIAI	97.25%	3432	810	3510	$ 4,526.28
DL9_M19AIAI	97.25%	3414	826	3589	$ 4,484.49
DL9_M36AIAI	97.25%	3353	887	3996	$ 4,053.35
DL9_M19AIAI	97.25%	3389	849	3707	$ 4,436.24
DL9_M19AIAI	97.25%	3389	849	3707	$ 4,436.24
DL9_M36AIAI	97.25%	3127	1111	5306	$ 3,575.18
DL9_M19AIAI	97.26%	3251	983	4336	$ 4,224.08
DL9_M36AIAI	97.26%	3122	1111	5307	$ 3,574.60
DL9_M36AIAI	97.26%	3493	740	3252	$ 4,316.07
DL9_M19AIAI	97.26%	3418	811	3520	$ 4,521.21
DL9_M36AIAI	97.26%	3390	840	3748	$ 4,162.84
DL9_M19AIAI	97.26%	3378	850	3716	$ 4,435.91
DL9_M19AIAI	97.26%	3549	675	2901	$ 4,782.60
DL9_M19AIAI	97.26%	3250	973	4297	$ 4,236.18
DL9_M36AIAI	97.26%	3131	1090	5183	$ 3,602.54
DL9_M19AIAI	97.26%	3367	852	3731	$ 4,435.50
DL9_M19AIAI	97.26%	3382	836	3650	$ 4,463.03
DL9_M36AIAI	97.27%	3064	1154	5481	$ 3,771.22
DL9_M36AIAI	97.27%	3059	1159	5514	$ 3,762.68
DL9_M19AIAI	97.27%	3382	835	3645	$ 4,465.21
DL9_M36AIAI	97.27%	3062	1155	5491	$ 3,774.03
DL9_M19AIAI	97.27%	3387	827	3609	$ 4,481.03
DL9_M19AIAI	97.27%	3390	822	3581	$ 4,494.58
DL9_M36AIAI	97.27%	3103	1109	5297	$ 3,578.53
DL9_M19AIAI	97.27%	3351	860	3783	$ 4,423.34
DL9_M36AIAI	97.27%	3059	1151	5466	$ 3,782.04
DL9_M19AIAI	97.27%	3243	967	4279	$ 4,243.51
DL9_M36AIAI	97.27%	3122	1085	5156	$ 3,611.40
DL9_M19AIAI	97.27%	3381	823	3593	$ 4,488.44
DL9_M19AIAI	97.27%	3250	952	4204	$ 4,270.50
DL9_M19AIAI	97.28%	3390	812	3537	$ 4,515.39
DL9_M19AIAI	97.28%	3373	829	3623	$ 4,479.45
DL9_M19AIAI	97.28%	3242	952	4210	$ 4,268.89
DL9_M19AIAI	97.28%	3380	814	3551	$ 4,510.98
DL9_M36AIAI	97.28%	3042	1148	5456	$ 3,785.47
DL9_M19AIAI	97.29%	3257	927	4088	$ 4,310.27
DL9_M19AIAI	97.29%	3396	788	3432	$ 4,570.94
DL9_M19AIAI	97.29%	3363	819	3585	$ 4,501.47
DL9_M19AIAI	97.29%	3239	942	4171	$ 4,287.11
DL9_M19AIAI	97.29%	3351	827	3630	$ 4,489.67
DL9_M36AIAI	97.29%	3036	1139	5404	$ 3,800.20
DL9_M19AIAI	97.29%	3345	829	3639	$ 4,479.92
DL9_M36AIAI	97.29%	3173	1000	4621	$ 3,904.70

Table C.6 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M19AIAI	97.29%	3360	812	3555	$ 4,515.94
DL9_M36AIAI	97.30%	3196	974	4474	$ 3,949.28
DL9_M19AIAI	97.30%	3564	606	2586	$ 5,048.07
DL9_M19AIAI	97.30%	3239	931	4124	$ 4,304.65
DL9_M36AIAI	97.30%	2988	1181	5736	$ 3,585.52
DL9_M36AIAI	97.30%	3217	952	4355	$ 3,990.73
DL9_M36AIAI	97.30%	3049	1120	5294	$ 3,818.42
DL9_M19AIAI	97.30%	3341	827	3637	$ 4,488.84
DL9_M36AIAI	97.30%	3000	1168	5655	$ 3,600.14
DL9_M19AIAI	97.30%	3235	933	4138	$ 4,301.06
DL9_M36AIAI	97.30%	3300	866	3894	$ 4,117.72
DL9_M36AIAI	97.30%	2988	1177	5716	$ 3,591.62
DL9_M19AIAI	97.30%	3359	805	3521	$ 4,532.72
DL9_M19AIAI	97.30%	3365	798	3489	$ 4,546.97
DL9_M36AIAI	97.30%	3076	1083	5156	$ 3,621.73
DL9_M19AIAI	97.31%	3241	912	4033	$ 4,334.34
DL9_M19AIAI	97.31%	3241	911	4029	$ 4,337.06
DL9_M19AIAI	97.31%	3219	931	4138	$ 4,305.41
DL9_M36AIAI	97.31%	2969	1178	5727	$ 3,594.93
DL9_M36AIAI	97.31%	3078	1069	5075	$ 3,648.13
DL9_M36AIAI	97.31%	3169	976	4494	$ 3,942.45
DL9_M19AIAI	97.31%	3343	800	3507	$ 4,548.65
DL9_M36AIAI	97.31%	3036	1106	5216	$ 3,843.88
DL9_M36AIAI	97.32%	2961	1176	5717	$ 3,595.61
DL9_M36AIAI	97.32%	3153	982	4524	$ 3,941.17
DL9_M19AIAI	97.32%	3073	1059	4800	$ 4,214.93
DL9_M36AIAI	97.32%	3424	708	3098	$ 4,425.89
DL9_M36AIAI	97.32%	2951	1181	5749	$ 3,592.26
DL9_M36AIAI	97.33%	2937	1184	5772	$ 3,593.14
DL9_M19AIAI	97.33%	3188	932	4167	$ 4,307.63
DL9_M36AIAI	97.33%	2932	1188	5796	$ 3,588.28
DL9_M19AIAI	97.33%	3209	909	4042	$ 4,345.61
DL9_M19AIAI	97.33%	3212	902	4011	$ 4,356.52
DL9_M36AIAI	97.33%	2932	1182	5762	$ 3,593.11
DL9_M36AIAI	97.33%	3308	805	3582	$ 4,278.50
DL9_M36AIAI	97.33%	2932	1180	5752	$ 3,595.49
DL9_M36AIAI	97.33%	2926	1186	5780	$ 3,626.14
DL9_M36AIAI	97.33%	2928	1182	5759	$ 3,599.21
DL9_M19AIAI	97.33%	3338	771	3377	$ 4,618.90
DL9_M19AIAI	97.34%	3237	868	3836	$ 4,422.83
DL9_M36AIAI	97.34%	2923	1174	5718	$ 3,605.29
DL9_M36AIAI	97.34%	2921	1175	5717	$ 3,643.16
DL9_M36AIAI	97.34%	2915	1180	5756	$ 3,599.09
DL9_M36AIAI	97.34%	2915	1180	5756	$ 3,599.09
DL9_M19AIAI	97.34%	3047	1045	4762	$ 4,239.40
DL9_M19AIAI	97.35%	3225	861	3810	$ 4,439.84
DL9_M19AIAI	97.35%	3167	913	4093	$ 4,343.43
DL9_M36AIAI	97.36%	3011	1064	4983	$ 3,956.75
DL9_M19AIAI	97.36%	3164	911	4081	$ 4,346.32
DL9_M36AIAI	97.36%	2904	1169	5682	$ 3,618.23
DL9_M36AIAI	97.36%	2902	1169	5691	$ 3,650.28
DL9_M36AIAI	97.36%	3012	1057	4939	$ 3,973.14
DL9_M19AIAI	97.36%	3333	735	3210	$ 4,719.42
DL9_M19AIAI	97.36%	3189	877	3906	$ 4,407.09
DL9_M36AIAI	97.36%	3273	792	3510	$ 4,339.41
DL9_M19AIAI	97.36%	3217	848	3754	$ 4,469.49
DL9_M36AIAI	97.36%	3001	1061	4964	$ 3,964.51

Table C.7 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M36AIAI	97.36%	3164	897	4070	$ 4,106.51
DL9_M19AIAI	97.36%	2917	1143	5311	$ 4,127.47
DL9_M36AIAI	97.37%	3022	1033	4803	$ 3,976.62
DL9_M19AIAI	97.37%	3159	892	3994	$ 4,426.04
DL9_M19AIAI	97.37%	2920	1129	5237	$ 4,147.65
DL9_M19AIAI	97.37%	3191	856	3803	$ 4,454.35
DL9_M19AIAI	97.37%	3024	1021	4663	$ 4,278.83
DL9_M19AIAI	97.37%	3206	839	3718	$ 4,534.15
DL9_M19AIAI	97.38%	3081	961	4323	$ 4,370.19
DL9_M19AIAI	97.38%	3021	1015	4638	$ 4,286.49
DL9_M19AIAI	97.38%	2913	1122	5211	$ 4,154.59
DL9_M19AIAI	97.38%	2946	1087	5041	$ 4,007.04
DL9_M19AIAI	97.38%	3038	991	4506	$ 4,324.98
DL9_M19AIAI	97.39%	3157	870	3888	$ 4,430.21
DL9_M19AIAI	97.39%	2901	1122	5226	$ 4,157.12
DL9_M19AIAI	97.39%	2922	1101	5102	$ 4,180.48
DL9_M36AIAI	97.39%	2909	1114	5354	$ 3,721.30
DL9_M36AIAI	97.39%	2883	1139	5425	$ 3,912.33
DL9_M36AIAI	97.39%	3377	645	2792	$ 4,701.16
DL9_M36AIAI	97.39%	2900	1115	5356	$ 3,739.83
DL9_M36AIAI	97.39%	2880	1135	5484	$ 3,697.99
DL9_M19AIAI	97.39%	2911	1103	5118	$ 4,187.60
DL9_M19AIAI	97.40%	3187	824	3651	$ 4,576.23
DL9_M19AIAI	97.40%	3050	957	4327	$ 4,391.64
DL9_M19AIAI	97.40%	3013	994	4534	$ 4,325.04
DL9_M19AIAI	97.40%	2816	1190	5677	$ 3,921.43
DL9_M19AIAI	97.40%	3047	956	4321	$ 4,391.16
DL9_M19AIAI	97.40%	2881	1119	5231	$ 4,157.23
DL9_M19AIAI	97.40%	2902	1095	5090	$ 4,191.89
DL9_M36AIAI	97.41%	2797	1198	5878	$ 3,676.64
DL9_M19AIAI	97.41%	2924	1071	4943	$ 4,221.76
DL9_M19AIAI	97.41%	2998	996	4552	$ 4,322.65
DL9_M19AIAI	97.41%	3025	968	4394	$ 4,371.06
DL9_M36AIAI	97.41%	2799	1193	5852	$ 3,676.40
DL9_M19AIAI	97.41%	2898	1089	5060	$ 4,201.10
DL9_M19AIAI	97.41%	2874	1111	5193	$ 4,179.64
DL9_M19AIAI	97.41%	3022	962	4363	$ 4,375.81
DL9_M19AIAI	97.41%	3131	852	3809	$ 4,519.32
DL9_M19AIAI	97.41%	2796	1186	5689	$ 3,923.51
DL9_M36AIAI	97.41%	2786	1195	5863	$ 3,680.16
DL9_M19AIAI	97.41%	2807	1174	5606	$ 3,928.01
DL9_M19AIAI	97.42%	3035	944	4273	$ 4,412.20
DL9_M19AIAI	97.42%	3023	954	4324	$ 4,394.08
DL9_M36AIAI	97.42%	2952	1024	4762	$ 4,055.89
DL9_M36AIAI	97.42%	2762	1211	5939	$ 3,673.13
DL9_M19AIAI	97.42%	2795	1177	5636	$ 3,925.30
DL9_M19AIAI	97.42%	2883	1087	5063	$ 4,205.21
DL9_M19AIAI	97.42%	3005	964	4382	$ 4,382.14
DL9_M36AIAI	97.42%	3107	861	3881	$ 4,212.61
DL9_M36AIAI	97.43%	2761	1201	5901	$ 3,685.78
DL9_M36AIAI	97.43%	2772	1189	5825	$ 3,701.23
DL9_M36AIAI	97.43%	2764	1197	5880	$ 3,681.51
DL9_M19AIAI	97.43%	3274	687	2994	$ 4,937.33
DL9_M19AIAI	97.43%	2789	1171	5608	$ 3,929.59
DL9_M19AIAI	97.43%	3153	807	3584	$ 4,625.47
DL9_M19AIAI	97.43%	2794	1165	5564	$ 3,937.79
DL9_M19AIAI	97.43%	3020	937	4241	$ 4,424.82

Table C.8 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M36AIAI	97.43%	2763	1193	5851	$ 3,703.00
DL9_M19AIAI	97.43%	2785	1170	5606	$ 3,934.21
DL9_M36AIAI	97.43%	2773	1181	5789	$ 3,694.43
DL9_M19AIAI	97.44%	2855	1091	5100	$ 4,207.12
DL9_M19AIAI	97.44%	3030	915	4128	$ 4,475.53
DL9_M19AIAI	97.44%	2884	1059	4911	$ 4,248.70
DL9_M19AIAI	97.44%	2850	1090	5102	$ 4,202.19
DL9_M36AIAI	97.44%	2866	1074	5056	$ 4,017.24
DL9_M19AIAI	97.44%	2787	1151	5502	$ 3,956.33
DL9_M19AIAI	97.44%	3143	795	3526	$ 4,657.15
DL9_M19AIAI	97.44%	2980	956	4356	$ 4,397.68
DL9_M36AIAI	97.44%	2741	1196	5875	$ 3,693.97
DL9_M19AIAI	97.44%	2990	944	4293	$ 4,418.84
DL9_M19AIAI	97.44%	2997	937	4250	$ 4,434.47
DL9_M36AIAI	97.44%	2750	1184	5807	$ 3,696.25
DL9_M36AIAI	97.44%	2759	1174	5743	$ 3,715.68
DL9_M19AIAI	97.44%	3116	817	3643	$ 4,604.48
DL9_M19AIAI	97.45%	3118	813	3619	$ 4,621.76
DL9_M19AIAI	97.45%	2853	1072	5004	$ 4,230.85
DL9_M19AIAI	97.45%	3125	798	3547	$ 4,653.83
DL9_M19AIAI	97.45%	2976	944	4295	$ 4,422.00
DL9_M36AIAI	97.45%	2740	1180	5790	$ 3,711.56
DL9_M36AIAI	97.45%	2743	1177	5750	$ 3,725.79
DL9_M36AIAI	97.45%	2727	1191	5857	$ 3,702.04
DL9_M19AIAI	97.46%	2981	933	4240	$ 4,442.64
DL9_M19AIAI	97.46%	2765	1147	5496	$ 3,962.59
DL9_M36AIAI	97.46%	2738	1170	5714	$ 3,741.77
DL9_M19AIAI	97.46%	2857	1049	4878	$ 4,265.69
DL9_M19AIAI	97.46%	2837	1067	4982	$ 4,246.24
DL9_M19AIAI	97.47%	2774	1125	5366	$ 3,986.27
DL9_M19AIAI	97.47%	2976	923	4191	$ 4,460.78
DL9_M19AIAI	97.47%	2844	1049	4884	$ 4,269.62
DL9_M19AIAI	97.47%	3095	798	3553	$ 4,666.65
DL9_M19AIAI	97.48%	2845	1034	4806	$ 4,296.00
DL9_M19AIAI	97.48%	2766	1109	5282	$ 4,007.98
DL9_M19AIAI	97.49%	2845	1012	4687	$ 4,333.27
DL9_M19AIAI	97.50%	2827	1022	4744	$ 4,325.58
DL9_M19AIAI	97.50%	2836	1003	4642	$ 4,358.93
DL9_M19AIAI	97.51%	2838	999	4621	$ 4,364.61
DL9_M19AIAI	97.51%	2646	1191	5793	$ 3,994.03
DL9_M19AIAI	97.51%	2834	1000	4626	$ 4,361.00
DL9_M19AIAI	97.51%	2738	1092	5207	$ 4,035.03
DL9_M19AIAI	97.51%	3091	740	3265	$ 4,848.17
DL9_M19AIAI	97.51%	2642	1183	5756	$ 4,003.57
DL9_M19AIAI	97.52%	3065	758	3356	$ 4,791.88
DL9_M19AIAI	97.52%	2635	1185	5770	$ 3,979.42
DL9_M19AIAI	97.52%	2628	1192	5814	$ 3,992.26
DL9_M19AIAI	97.52%	2630	1189	5795	$ 3,993.84
DL9_M19AIAI	97.52%	2721	1097	5245	$ 4,031.25
DL9_M19AIAI	97.52%	2637	1179	5734	$ 4,004.26
DL9_M19AIAI	97.52%	2816	998	4619	$ 4,369.33
DL9_M19AIAI	97.52%	2945	867	3910	$ 4,606.96
DL9_M19AIAI	97.52%	2832	978	4509	$ 4,413.91
DL9_M19AIAI	97.52%	2707	1103	5200	$ 4,298.03
DL9_M19AIAI	97.52%	2616	1192	5821	$ 3,996.36
DL9_M19AIAI	97.53%	2722	1082	5157	$ 4,049.37
DL9_M19AIAI	97.53%	2668	1132	5384	$ 4,264.58

Table C.9 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M19AIAI	97.53%	2680	1117	5296	$ 4,266.05
DL9_M19AIAI	97.53%	2814	980	4522	$ 4,408.89
DL9_M19AIAI	97.53%	2724	1067	5076	$ 4,077.02
DL9_M19AIAI	97.54%	2820	969	4462	$ 4,430.27
DL9_M19AIAI	97.54%	2803	985	4552	$ 4,393.26
DL9_M19AIAI	97.54%	2689	1098	5184	$ 4,335.60
DL9_M19AIAI	97.54%	2601	1184	5786	$ 4,011.80
DL9_M19AIAI	97.55%	2936	838	3762	$ 4,680.31
DL9_M19AIAI	97.55%	2930	842	3785	$ 4,667.56
DL9_M19AIAI	97.55%	2594	1171	5704	$ 4,021.42
DL9_M19AIAI	97.55%	2927	838	3764	$ 4,682.10
DL9_M19AIAI	97.56%	2580	1174	5737	$ 4,023.98
DL9_M36AIAI	97.56%	2685	1069	5094	$ 3,918.29
DL9_M19AIAI	97.56%	2602	1149	5568	$ 4,058.72
DL9_M36AIAI	97.57%	2566	1178	5756	$ 3,818.99
DL9_M19AIAI	97.57%	2946	797	3523	$ 4,558.47
DL9_M19AIAI	97.58%	2602	1125	5428	$ 4,125.14
DL9_M19AIAI	97.58%	2784	933	4279	$ 4,509.85
DL9_M19AIAI	97.58%	2664	1050	4925	$ 4,399.01
DL9_M19AIAI	97.58%	2815	899	4096	$ 4,584.53
DL9_M19AIAI	97.59%	2567	1138	5521	$ 4,115.59
DL9_M19AIAI	97.60%	2643	1049	5002	$ 4,145.34
DL9_M19AIAI	97.60%	2547	1137	5441	$ 4,337.70
DL9_M19AIAI	97.61%	2493	1179	5790	$ 4,102.76
DL9_M19AIAI	97.61%	2479	1191	5870	$ 4,086.64
DL9_M19AIAI	97.61%	2878	792	3537	$ 4,846.50
DL9_M19AIAI	97.62%	2465	1194	5889	$ 4,095.32
DL9_M19AIAI	97.62%	2457	1195	5901	$ 4,097.12
DL9_M19AIAI	97.62%	2457	1195	5901	$ 4,097.12
DL9_M19AIAI	97.62%	2462	1189	5861	$ 4,100.95
DL9_M19AIAI	97.63%	2456	1189	5866	$ 4,098.07
DL9_M36AIAI	97.63%	3014	627	2720	$ 4,839.95
DL9_M36AIAI	97.63%	3014	627	2720	$ 4,839.95
DL9_M19AIAI	97.63%	2446	1190	5876	$ 4,097.04
DL9_M19AIAI	97.64%	2455	1178	5801	$ 4,111.53
DL9_M19AIAI	97.64%	2441	1191	5887	$ 4,105.78
DL9_M19AIAI	97.64%	2450	1182	5823	$ 4,107.81
DL9_M19AIAI	97.64%	2660	971	4486	$ 4,604.63
DL9_M19AIAI	97.64%	2438	1181	5821	$ 4,110.00
DL9_M19AIAI	97.64%	2752	866	3934	$ 4,689.59
DL9_M19AIAI	97.65%	2458	1150	5615	$ 4,145.44
DL9_M19AIAI	97.65%	2435	1172	5758	$ 4,137.83
DL9_M19AIAI	97.67%	2422	1158	5673	$ 4,149.31
DL9_M19AIAI	97.67%	2411	1166	5725	$ 4,148.06
DL9_M19AIAI	97.68%	2186	1380	6949	$ 4,818.93
DL9_M19AIAI	97.68%	2446	1115	5410	$ 4,212.11
DL9_M19AIAI	97.69%	2729	821	3697	$ 4,886.46
DL9_M19AIAI	97.70%	2120	1414	7138	$ 4,175.41
DL9_M19AIAI	97.72%	2357	1145	5602	$ 4,238.04
DL9_M36AIAI	97.72%	2695	804	3585	$ 4,843.66
DL9_M19AIAI	97.73%	2364	1116	5327	$ 4,524.45
DL9_M19AIAI	97.74%	2386	1087	5250	$ 4,276.47
DL9_M19AIAI	97.74%	2448	1022	4789	$ 4,598.12
DL9_M19AIAI	97.77%	2272	1156	5685	$ 4,264.38
DL9_M36AIAI	97.77%	2555	872	3925	$ 4,862.83
DL9_M19AIAI	97.77%	2343	1074	5073	$ 4,644.49
DL9_M36AIAI	97.78%	2517	883	4032	$ 4,466.81

Table C.10 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M36AlAl	97.79%	2421	971	4537	$ 4,344.62
DL9_M19AlAl	97.83%	2271	1054	5058	$ 4,425.71
DL9_M19AlAl	97.86%	1910	1363	6865	$ 4,365.56
DL9_M19AlAl	97.87%	2568	696	3071	$ 5,468.97
DL9_M19AlAl	97.90%	2363	857	3893	$ 5,103.82
DL9_M19AlAl	97.93%	2528	638	2797	$ 5,412.05
DL9_M19AlAl	97.97%	2197	905	4162	$ 4,939.29
DL9_M19AlAl	98.00%	1958	1110	5356	$ 4,712.80
DL9_M19AlAl	98.10%	2205	705	3122	$ 5,626.21
DL9_M6-CuCu	98.45%	945	1414	7206	$ 3,642.64
DL9_M6-CuCu	98.49%	902	1391	7060	$ 3,734.46
DL9_M6-AlAl	98.51%	1097	1169	5986	$ 3,391.84
DL9_M6-AlAl	98.51%	1097	1169	5986	$ 3,391.84
DL9_M6-AlAl	98.55%	922	1284	6614	$ 3,637.61
DL9_M6-AlAl	98.55%	922	1284	6614	$ 3,637.61
DL9_M6-AlAl	98.57%	1083	1096	5596	$ 3,500.77
DL9_M6-AlAl	98.58%	1021	1144	5855	$ 3,573.49
DL9_M6-AlAl	98.63%	787	1303	6706	$ 3,952.00
DL9_M6-AlAl	98.63%	1660	427	1770	$ 4,820.31
DL9_M6-AlAl	98.63%	776	1308	6738	$ 3,974.35
DL9_M6-AlAl	98.63%	798	1284	6589	$ 3,945.29
DL9_M6-AlAl	98.63%	763	1317	6820	$ 3,970.05
DL9_M6-AlAl	98.63%	784	1295	6643	$ 4,000.85
DL9_M6-AlAl	98.63%	784	1295	6643	$ 4,000.85
DL9_M6-AlAl	98.63%	1455	623	2785	$ 4,081.86
DL9_M6-AlAl	98.63%	792	1287	6605	$ 3,962.71
DL9_M6-AlAl	98.63%	775	1303	6727	$ 3,967.81
DL9_M6-AlAl	98.63%	769	1309	6758	$ 3,985.65
DL9_M6-AlAl	98.64%	1624	450	1891	$ 4,680.66
DL9_M6-AlAl	98.64%	780	1294	6654	$ 3,975.01
DL9_M6-AlAl	98.64%	774	1299	6688	$ 3,985.63
DL9_M6-AlAl	98.64%	1667	404	1655	$ 5,058.74
DL9_M6-AlAl	98.64%	780	1290	6629	$ 3,985.43
DL9_M6-AlAl	98.64%	764	1304	6751	$ 3,966.87
DL9_M6-AlAl	98.64%	1559	503	2154	$ 4,451.19
DL9_M6-AlAl	98.64%	791	1270	6504	$ 3,975.66
DL9_M6-AlAl	98.65%	941	1114	5630	$ 3,696.32
DL9_M6-AlAl	98.65%	767	1281	6557	$ 4,060.01
DL9_M6-AlAl	98.65%	959	1088	5449	$ 3,720.96
DL9_M6-AlAl	98.65%	942	1105	5574	$ 3,728.49
DL9_M6-AlAl	98.66%	954	1090	5466	$ 3,725.94
DL9_M6-AlAl	98.66%	1624	417	1717	$ 5,014.69
DL9_M6-AlAl	98.66%	1676	362	1456	$ 5,333.66
DL9_M6-AlAl	98.67%	1610	413	1696	$ 5,077.98
DL9_M6-AlAl	98.67%	915	1105	5569	$ 3,763.43
DL9_M6-AlAl	98.67%	751	1269	6552	$ 4,020.25
DL9_M6-AlAl	98.67%	1609	408	1670	$ 5,125.87
DL9_M6-CuCu	98.68%	1439	575	2580	$ 3,997.49
DL9_M6-AlAl	98.68%	1044	969	4689	$ 3,787.18
DL9_M6-AlAl	98.68%	1606	407	1660	$ 5,167.69
DL9_M6-AlAl	98.68%	741	1268	6562	$ 4,014.38
DL9_M6-AlAl	98.68%	1544	464	1962	$ 4,577.70
DL9_M6-AlAl	98.68%	1634	373	1514	$ 5,275.88
DL9_M6-AlAl	98.69%	1588	408	1665	$ 5,209.44
DL9_M6-AlAl	98.69%	1617	378	1520	$ 5,534.67
DL9_M6-AlAl	98.69%	931	1064	5304	$ 3,809.88
DL9_M6-AlAl	98.69%	931	1064	5304	$ 3,809.88

Table C.11 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M6-AlAl	98.69%	1640	353	1412	$ 5,576.11
DL9_M6-AlAl	98.69%	1619	369	1473	$ 5,627.18
DL9_M6-AlAl	98.69%	1614	374	1510	$ 5,362.77
DL9_M6-AlAl	98.69%	1618	367	1453	$ 5,685.09
DL9_M6-AlAl	98.69%	904	1081	5308	$ 3,934.16
DL9_M6-AlAl	98.69%	886	1098	5466	$ 3,919.64
DL9_M6-AlAl	98.70%	1292	689	3118	$ 4,038.02
DL9_M6-AlAl	98.70%	1570	405	1649	$ 5,281.51
DL9_M6-AlAl	98.70%	1550	423	1747	$ 5,148.32
DL9_M6-AlAl	98.70%	1619	352	1405	$ 5,630.52
DL9_M6-AlAl	98.70%	1209	762	3534	$ 3,853.59
DL9_M6-AlAl	98.70%	878	1093	5438	$ 3,870.89
DL9_M6-AlAl	98.70%	878	1093	5438	$ 3,870.89
DL9_M6-AlAl	98.71%	939	1029	5038	$ 3,849.99
DL9_M6-AlAl	98.71%	857	1105	5511	$ 3,980.94
DL9_M6-AlAl	98.71%	947	1012	4944	$ 3,880.20
DL9_M6-AlAl	98.72%	1425	526	2279	$ 4,313.89
DL9_M6-AlAl	98.72%	927	1016	4954	$ 3,900.20
DL9_M6-AlAl	98.72%	1547	394	1593	$ 5,466.33
DL9_M6-AlAl	98.73%	1499	434	1808	$ 4,916.70
DL9_M6-AlAl	98.73%	936	996	4825	$ 3,911.18
DL9_M6-AlAl	98.73%	1501	430	1772	$ 5,204.25
DL9_M6-AlAl	98.73%	950	979	4712	$ 3,932.06
DL9_M3-CuAl	98.73%	808	1118	5704	$ 4,098.50
DL9_M6-CuCu	98.73%	777	1148	5800	$ 3,988.32
DL9_M6-AlAl	98.73%	1448	477	2027	$ 4,606.37
DL9_M6-CuCu	98.73%	722	1202	6031	$ 4,150.03
DL9_M6-AlAl	98.74%	1534	387	1561	$ 5,620.95
DL9_M6-AlAl	98.74%	1492	427	1745	$ 5,258.00
DL9_M6-AlAl	98.74%	1496	421	1718	$ 5,309.21
DL9_M6-AlAl	98.74%	1526	390	1571	$ 5,600.47
DL9_M6-AlAl	98.74%	1088	826	3823	$ 4,047.67
DL9_M6-CuCu	98.74%	728	1185	6029	$ 4,059.89
DL9_M6-AlAl	98.74%	930	983	4732	$ 3,959.80
DL9_M6-CuCu	98.74%	721	1189	6073	$ 4,124.57
DL9_M6-AlAl	98.74%	917	992	4729	$ 4,094.37
DL9_M3-CuAl	98.74%	848	1058	5373	$ 4,017.98
DL9_M6-AlAl	98.75%	1077	827	3829	$ 4,063.85
DL9_M6-AlAl	98.75%	1514	389	1564	$ 5,703.74
DL9_M6-AlAl	98.75%	1072	829	3844	$ 4,053.96
DL9_M6-AlAl	98.75%	1508	391	1577	$ 5,671.03
DL9_M6-AlAl	98.75%	764	1134	5653	$ 4,205.31
DL9_M6-CuCu	98.75%	1467	430	1805	$ 4,749.70
DL9_M6-AlAl	98.75%	1308	589	2567	$ 4,473.10
DL9_M6-AlAl	98.75%	1064	832	3856	$ 4,084.32
DL9_M6-AlAl	98.75%	1064	832	3856	$ 4,084.32
DL9_M6-CuCu	98.75%	703	1192	6069	$ 4,123.92
DL9_M6-AlAl	98.75%	1516	377	1511	$ 5,858.30
DL9_M6-AlAl	98.75%	952	940	4466	$ 4,027.46
DL9_M6-AlAl	98.75%	1508	384	1543	$ 5,775.30
DL9_M6-AlAl	98.76%	928	962	4601	$ 4,003.98
DL9_M6-AlAl	98.76%	1471	416	1689	$ 5,447.79
DL9_M6-CuCu	98.76%	725	1157	5881	$ 4,149.45
DL9_M6-AlAl	98.76%	1460	422	1721	$ 5,406.60
DL9_M6-AlAl	98.76%	1023	858	3995	$ 4,055.31
DL9_M6-AlAl	98.76%	828	1049	5148	$ 4,153.26
DL9_M6-AlAl	98.76%	1495	382	1524	$ 5,886.26

Table C.12 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M6-CuCu	98.76%	1471	405	1665	$ 5,045.44
DL9_M6-CuCu	98.76%	708	1168	5917	$ 4,148.25
DL9_M6-AlAl	98.77%	1435	441	1843	$ 4,921.18
DL9_M6-AlAl	98.77%	989	885	4152	$ 4,046.42
DL9_M6-AlAl	98.77%	989	885	4152	$ 4,046.42
DL9_M6-AlAl	98.77%	1467	407	1636	$ 5,600.38
DL9_M6-AlAl	98.77%	992	883	4133	$ 4,078.36
DL9_M6-AlAl	98.77%	992	883	4133	$ 4,078.36
DL9_M6-CuCu	98.77%	1162	712	3308	$ 3,971.08
DL9_M6-AlAl	98.77%	1490	383	1547	$ 5,513.96
DL9_M6-AlAl	98.77%	1512	361	1440	$ 5,872.47
DL9_M6-CuCu	98.77%	1383	487	2104	$ 4,458.58
DL9_M6-AlAl	98.77%	1456	415	1698	$ 5,539.79
DL9_M6-AlAl	98.77%	983	887	4152	$ 4,085.08
DL9_M6-AlAl	98.77%	1507	362	1443	$ 5,821.54
DL9_M6-AlAl	98.77%	1468	400	1605	$ 5,666.97
DL9_M6-AlAl	98.77%	1501	361	1441	$ 5,883.12
DL9_M6-AlAl	98.77%	1483	379	1518	$ 5,592.39
DL9_M6-AlAl	98.78%	1476	384	1535	$ 5,849.91
DL9_M6-AlAl	98.78%	1462	397	1590	$ 5,701.81
DL9_M6-AlAl	98.78%	969	889	4166	$ 4,097.02
DL9_M6-AlAl	98.78%	969	889	4166	$ 4,097.02
DL9_M6-CuCu	98.78%	708	1149	5836	$ 4,208.61
DL9_M6-AlAl	98.78%	965	891	4188	$ 4,130.20
DL9_M6-AlAl	98.78%	899	957	4572	$ 4,123.10
DL9_M6-AlAl	98.78%	899	957	4572	$ 4,123.10
DL9_M6-AlAl	98.78%	1473	383	1530	$ 5,562.96
DL9_M6-CuCu	98.78%	1366	488	2097	$ 4,507.41
DL9_M6-AlAl	98.78%	940	914	4299	$ 4,100.59
DL9_M6-AlAl	98.78%	940	914	4299	$ 4,100.59
DL9_M6-AlAl	98.78%	1458	395	1577	$ 5,778.32
DL9_M6-AlAl	98.78%	934	918	4327	$ 4,126.32
DL9_M6-AlAl	98.78%	1438	413	1670	$ 5,581.97
DL9_M6-AlAl	98.78%	1466	384	1542	$ 5,569.83
DL9_M6-CuCu	98.78%	654	1195	6094	$ 4,279.17
DL9_M6-AlAl	98.78%	1448	401	1632	$ 5,403.17
DL9_M6-AlAl	98.78%	929	918	4333	$ 4,101.91
DL9_M6-AlAl	98.78%	1460	385	1533	$ 5,904.41
DL9_M6-AlAl	98.79%	1452	393	1574	$ 5,794.83
DL9_M6-AlAl	98.79%	1440	402	1627	$ 5,741.43
DL9_M6-AlAl	98.79%	1456	384	1536	$ 5,930.94
DL9_M6-CuCu	98.79%	797	1042	5191	$ 4,157.12
DL9_M6-CuCu	98.79%	789	1047	5216	$ 4,149.01
DL9_M6-AlAl	98.79%	1338	497	2068	$ 5,035.09
DL9_M6-AlAl	98.79%	888	946	4495	$ 4,212.21
DL9_M6-CuCu	98.79%	693	1139	5723	$ 4,264.01
DL9_M6-AlAl	98.79%	1470	360	1441	$ 5,934.85
DL9_M6-AlAl	98.80%	1442	387	1549	$ 5,964.51
DL9_M6-CuCu	98.80%	823	1005	4983	$ 4,182.60
DL9_M6-AlAl	98.80%	1329	498	2074	$ 5,021.23
DL9_M6-CuCu	98.80%	1385	442	1862	$ 4,746.71
DL9_M6-AlAl	98.80%	1424	400	1604	$ 5,791.02
DL9_M6-AlAl	98.80%	1424	400	1604	$ 5,791.02
DL9_M6-CuCu	98.80%	1170	653	2975	$ 4,076.71
DL9_M3-CuAl	98.80%	698	1117	5710	$ 4,188.67
DL9_M6-AlAl	98.80%	1407	408	1646	$ 5,486.70
DL9_M6-CuCu	98.80%	733	1082	5411	$ 4,296.11

Table C.13 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M6-AlAl	98.81%	1425	388	1570	$ 5,552.02
DL9_M6-CuCu	98.81%	824	986	4859	$ 4,186.31
DL9_M6-AlAl	98.81%	1422	389	1555	$ 5,976.05
DL9_M6-AlAl	98.81%	1423	387	1548	$ 5,961.78
DL9_M6-AlAl	98.81%	1366	443	1832	$ 5,181.12
DL9_M6-AlAl	98.81%	1213	595	2605	$ 4,544.78
DL9_M6-AlAl	98.81%	1423	385	1545	$ 5,700.97
DL9_M6-AlAl	98.81%	1365	442	1841	$ 5,261.66
DL9_M6-AlAl	98.81%	1370	434	1779	$ 5,327.75
DL9_M6-AlAl	98.81%	1318	485	2002	$ 5,193.24
DL9_M6-CuCu	98.81%	1056	746	3471	$ 4,135.66
DL9_M6-CuCu	98.81%	719	1081	5441	$ 4,261.32
DL9_M6-AlAl	98.81%	1360	440	1808	$ 5,287.04
DL9_M6-AlAl	98.81%	1388	412	1681	$ 5,476.84
DL9_M6-AlAl	98.82%	1286	509	2172	$ 4,809.10
DL9_M6-AlAl	98.82%	1391	404	1636	$ 5,842.09
DL9_M6-AlAl	98.82%	1307	488	2018	$ 5,195.75
DL9_M6-CuCu	98.82%	1436	358	1423	$ 5,824.68
DL9_M6-AlAl	98.82%	1349	445	1808	$ 5,529.81
DL9_M6-AlAl	98.82%	1404	389	1560	$ 6,057.63
DL9_M6-AlAl	98.82%	1301	492	2052	$ 5,154.78
DL9_M6-AlAl	98.82%	1330	460	1931	$ 5,060.36
DL9_M6-CuCu	98.82%	1396	390	1580	$ 5,337.73
DL9_M6-AlAl	98.82%	1391	395	1570	$ 6,022.52
DL9_M6-AlAl	98.83%	1383	400	1621	$ 5,614.08
DL9_M6-AlAl	98.83%	1191	589	2519	$ 4,765.96
DL9_HOCuCu	98.83%	639	1137	5825	$ 4,447.24
DL9_M6-AlAl	98.83%	1315	462	1889	$ 5,413.82
DL9_M6-AlAl	98.83%	1387	390	1571	$ 5,963.91
DL9_M6-AlAl	98.83%	1095	681	2951	$ 4,697.97
DL9_M6-CuCu	98.83%	1427	349	1362	$ 6,098.97
DL9_M6-AlAl	98.83%	1187	588	2515	$ 4,749.17
DL9_M6-AlAl	98.83%	1290	479	1996	$ 5,346.61
DL9_M6-AlAl	98.83%	1344	425	1720	$ 5,485.66
DL9_M6-CuCu	98.83%	1246	523	2269	$ 4,523.89
DL9_M6-AlAl	98.84%	1074	693	3023	$ 4,682.35
DL9_M6-CuCu	98.84%	709	1056	5216	$ 4,535.41
DL9_M6-CuCu	98.84%	1393	372	1489	$ 5,511.18
DL9_M6-AlAl	98.84%	1372	390	1565	$ 6,243.76
DL9_M6-CuCu	98.84%	1328	434	1811	$ 5,028.62
DL9_M6-AlAl	98.84%	1368	393	1578	$ 6,217.60
DL9_M6-CuCu	98.84%	782	979	4867	$ 4,176.40
DL9_M6-AlAl	98.84%	1108	653	2819	$ 4,793.39
DL9_M6-AlAl	98.84%	1375	386	1548	$ 5,910.00
DL9_M6-AlAl	98.84%	1177	584	2496	$ 4,820.53
DL9_M6-CuCu	98.84%	1417	343	1332	$ 6,232.20
DL9_M6-CuCu	98.84%	1423	336	1293	$ 6,379.71
DL9_M6-CuCu	98.84%	1419	338	1310	$ 6,367.88
DL9_M6-CuCu	98.84%	1409	347	1361	$ 6,170.81
DL9_M6-AlAl	98.84%	1270	484	2017	$ 5,302.95
DL9_M6-CuCu	98.84%	1280	474	2023	$ 4,758.69
DL9_M6-CuCu	98.84%	1421	333	1272	$ 6,483.02
DL9_M6-CuCu	98.85%	1219	532	2318	$ 4,524.72
DL9_M6-AlAl	98.85%	1352	399	1629	$ 5,688.62
DL9_M6-CuCu	98.85%	960	790	3697	$ 4,249.58
DL9_M6-CuCu	98.85%	1256	495	2118	$ 4,796.98
DL9_M6-CuCu	98.85%	1354	394	1602	$ 5,339.43

Table C.14 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M6-AlAl	98.85%	1108	638	2738	$ 4,870.60
DL9_M6-AlAl	98.85%	1332	413	1676	$ 5,674.41
DL9_M6-AlAl	98.85%	1350	394	1579	$ 6,129.25
DL9_M6-AlAl	98.85%	1350	393	1572	$ 6,217.95
DL9_M6-AlAl	98.85%	1055	686	2984	$ 4,753.09
DL9_M6-AlAl	98.85%	1357	383	1540	$ 5,908.75
DL9_M6-AlAl	98.85%	1264	475	1969	$ 5,418.02
DL9_M6-CuCu	98.86%	783	953	4675	$ 4,289.03
DL9_M6-CuCu	98.86%	849	887	4205	$ 4,329.87
DL9_M6-AlAl	98.86%	1334	400	1614	$ 5,879.91
DL9_M6-AlAl	98.86%	1346	388	1556	$ 6,024.25
DL9_M6-AlAl	98.86%	1321	413	1652	$ 5,758.05
DL9_M6-CuCu	98.86%	613	1120	5612	$ 4,642.77
DL9_M6-AlAl	98.86%	1218	514	2137	$ 5,248.98
DL9_M6-AlAl	98.86%	1085	647	2833	$ 4,806.59
DL9_M6-CuCu	98.86%	759	973	4797	$ 4,302.14
DL9_M6-CuCu	98.86%	1294	437	1830	$ 5,102.49
DL9_M6-CuCu	98.86%	615	1115	5426	$ 4,857.61
DL9_M6-AlAl	98.86%	1315	415	1680	$ 5,717.35
DL9_M6-AlAl	98.86%	1251	477	1963	$ 5,448.14
DL9_M6-CuCu	98.86%	1348	377	1521	$ 5,631.97
DL9_M6-AlAl	98.86%	1167	556	2375	$ 5,079.50
DL9_M6-CuCu	98.87%	871	851	4004	$ 4,358.90
DL9_M6-CuCu	98.87%	731	988	4898	$ 4,357.23
DL9_M6-AlAl	98.87%	1325	394	1570	$ 5,969.29
DL9_M6-AlAl	98.87%	1095	624	2657	$ 5,027.76
DL9_M6-AlAl	98.87%	1325	393	1568	$ 6,023.05
DL9_M6-AlAl	98.87%	1266	452	1859	$ 5,727.64
DL9_M6-CuCu	98.87%	1350	366	1455	$ 5,765.57
DL9_M6-CuCu	98.87%	756	960	4668	$ 4,464.63
DL9_M6-AlAl	98.87%	1287	427	1769	$ 5,648.50
DL9_M6-AlAl	98.87%	1309	402	1610	$ 5,919.65
DL9_M6-AlAl	98.87%	1092	619	2630	$ 5,053.98
DL9_M6-AlAl	98.87%	1313	397	1623	$ 5,918.64
DL9_M6-AlAl	98.87%	1041	668	2878	$ 4,927.09
DL9_M6-AlAl	98.87%	1315	394	1576	$ 6,083.10
DL9_M6-AlAl	98.88%	1037	669	2881	$ 4,936.53
DL9_M6-AlAl	98.88%	1243	463	1898	$ 5,653.62
DL9_M6-AlAl	98.88%	1189	517	2150	$ 5,279.82
DL9_M6-CuCu	98.88%	909	796	3739	$ 4,291.93
DL9_M6-AlAl	98.88%	1208	496	2043	$ 5,421.71
DL9_M6-AlAl	98.88%	1139	564	2378	$ 5,063.10
DL9_M6-CuCu	98.88%	1350	352	1368	$ 6,228.04
DL9_M6-CuCu	98.88%	758	943	4644	$ 4,361.14
DL9_M6-CuCu	98.88%	840	861	4055	$ 4,407.85
DL9_M6-CuCu	98.88%	1339	362	1446	$ 5,903.08
DL9_M6-CuCu	98.88%	1350	350	1336	$ 6,316.21
DL9_M6-CuCu	98.88%	838	861	4033	$ 4,451.27
DL9_M6-AlAl	98.88%	1214	482	2035	$ 5,275.74
DL9_M6-AlAl	98.88%	1253	441	1819	$ 5,525.88
DL9_M6-AlAl	98.88%	1076	618	2628	$ 5,157.31
DL9_M6-CuCu	98.88%	754	940	4586	$ 4,371.91
DL9_M3-CuAl	98.89%	547	1143	5850	$ 4,418.44
DL9_M6-AlAl	98.89%	1035	654	2797	$ 5,037.46
DL9_M6-CuCu	98.89%	1341	348	1336	$ 6,384.36
DL9_M6-CuCu	98.89%	1137	552	2404	$ 4,696.04
DL9_M6-AlAl	98.89%	1070	618	2632	$ 5,180.98

Table C.15 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M6-AlAl	98.89%	1275	412	1674	$ 5,948.42
DL9_HOCuCu	98.89%	568	1118	5731	$ 4,525.56
DL9_HOCuCu	98.89%	604	1082	5528	$ 4,482.38
DL9_M6-AlAl	98.89%	1290	395	1590	$ 6,124.34
DL9_M6-AlAl	98.89%	986	699	3023	$ 4,961.62
DL9_M6-AlAl	98.89%	1276	409	1653	$ 6,039.34
DL9_M6-AlAl	98.89%	1222	461	1886	$ 5,738.72
DL9_M6-CuCu	98.89%	1314	369	1471	$ 5,843.44
DL9_M6-CuCu	98.89%	838	844	3926	$ 4,485.90
DL9_M6-AlAl	98.89%	988	692	3041	$ 4,851.11
DL9_M6-AlAl	98.89%	941	738	3227	$ 4,881.89
DL9_M6-AlAl	98.89%	999	680	2992	$ 4,908.56
DL9_M3-CuAl	98.89%	500	1177	6041	$ 4,553.35
DL9_M6-AlAl	98.89%	1221	456	1872	$ 5,874.10
DL9_M6-AlAl	98.89%	1178	499	2062	$ 5,512.77
DL9_M6-AlAl	98.89%	1074	603	2541	$ 5,220.03
DL9_M6-CuCu	98.89%	1328	348	1322	$ 6,457.81
DL9_M6-AlAl	98.90%	979	697	3012	$ 4,980.88
DL9_M6-AlAl	98.90%	1180	494	2043	$ 5,572.90
DL9_M6-AlAl	98.90%	1173	497	2042	$ 5,568.98
DL9_M6-AlAl	98.90%	1227	444	1786	$ 5,999.17
DL9_M6-CuCu	98.90%	1230	440	1839	$ 5,307.33
DL9_M6-CuCu	98.90%	1327	342	1328	$ 6,355.62
DL9_M6-CuCu	98.90%	760	908	4330	$ 4,561.96
DL9_M6-CuCu	98.90%	1215	450	1890	$ 5,270.55
DL9_M6-AlAl	98.90%	974	691	2978	$ 5,065.14
DL9_M6-CuCu	98.90%	1286	377	1524	$ 5,847.94
DL9_M6-AlAl	98.90%	970	693	2987	$ 5,031.70
DL9_M6-CuCu	98.91%	787	872	4098	$ 4,597.95
DL9_M6-CuCu	98.91%	890	768	3446	$ 4,748.54
DL9_M3-CuAl	98.91%	609	1049	5336	$ 4,355.11
DL9_M6-AlAl	98.91%	1264	394	1592	$ 6,157.90
DL9_M6-AlAl	98.91%	1140	515	2149	$ 5,555.00
DL9_M3-CuAl	98.91%	576	1078	5502	$ 4,409.84
DL9_M6-CuCu	98.91%	1306	348	1337	$ 6,527.33
DL9_M6-CuCu	98.91%	1302	351	1366	$ 6,278.37
DL9_M6-AlAl	98.91%	1226	426	1700	$ 6,246.20
DL9_M6-AlAl	98.91%	1252	400	1606	$ 6,230.19
DL9_M6-CuCu	98.91%	589	1063	5268	$ 5,006.92
DL9_HOCuCu	98.91%	554	1097	5602	$ 4,589.81
DL9_M6-CuCu	98.91%	898	753	3404	$ 4,631.45
DL9_M6-CuCu	98.91%	1295	355	1385	$ 6,266.95
DL9_M6-AlAl	98.91%	940	710	3091	$ 4,883.74
DL9_M6-AlAl	98.91%	1175	474	1913	$ 5,837.33
DL9_M6-CuCu	98.91%	756	892	4259	$ 4,665.28
DL9_M6-AlAl	98.91%	1091	557	2344	$ 5,309.03
DL9_M6-AlAl	98.91%	1164	483	1980	$ 5,750.08
DL9_M6-AlAl	98.91%	1099	547	2293	$ 5,384.46
DL9_M6-CuCu	98.91%	1286	360	1420	$ 6,127.76
DL9_M6-CuCu	98.91%	1292	354	1393	$ 6,267.85
DL9_M6-CuCu	98.91%	1289	356	1398	$ 6,248.33
DL9_M6-AlAl	98.92%	1178	467	1909	$ 5,929.05
DL9_M6-AlAl	98.92%	1102	543	2260	$ 5,433.50
DL9_M6-CuCu	98.92%	1298	346	1338	$ 6,395.46
DL9_M6-CuCu	98.92%	1296	348	1357	$ 6,392.04
DL9_M6-AlAl	98.92%	1151	493	2063	$ 5,497.03
DL9_M6-CuCu	98.92%	1109	534	2202	$ 5,402.94

Table C.16 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M6-CuCu	98.92%	1281	362	1431	$ 6,113.00
DL9_M6-CuCu	98.92%	741	901	4273	$ 4,683.49
DL9_M6-AlAl	98.92%	1248	394	1590	$ 6,234.67
DL9_M6-CuCu	98.92%	1281	359	1422	$ 6,189.80
DL9_M6-CuCu	98.92%	1227	413	1701	$ 5,611.75
DL9_M6-CuCu	98.92%	1176	462	1943	$ 5,226.55
DL9_M6-AlAl	98.92%	1119	518	2138	$ 5,573.63
DL9_M6-AlAl	98.92%	1219	418	1704	$ 6,014.26
DL9_M6-AlAl	98.92%	962	675	2921	$ 4,984.54
DL9_M6-AlAl	98.92%	1210	426	1704	$ 6,345.87
DL9_M6-AlAl	98.92%	1181	455	1859	$ 6,092.72
DL9_M6-AlAl	98.92%	917	719	3153	$ 4,945.06
DL9_M6-CuCu	98.92%	1248	387	1498	$ 6,433.53
DL9_M6-CuCu	98.92%	1266	366	1450	$ 6,113.95
DL9_M6-CuCu	98.92%	1221	412	1686	$ 5,588.93
DL9_M6-CuCu	98.92%	1212	419	1721	$ 5,731.43
DL9_M6-CuCu	98.92%	1233	397	1567	$ 6,211.17
DL9_M6-AlAl	98.92%	1044	586	2527	$ 5,086.61
DL9_M6-AlAl	98.93%	1106	522	2201	$ 5,546.45
DL9_M6-CuCu	98.93%	1277	351	1361	$ 6,381.79
DL9_M6-CuCu	98.93%	1254	372	1493	$ 6,067.01
DL9_M6-AlAl	98.93%	1135	489	2041	$ 5,603.30
DL9_M6-CuCu	98.93%	1223	401	1622	$ 5,735.38
DL9_M6-CuCu	98.93%	1218	406	1654	$ 5,694.24
DL9_M6-CuCu	98.93%	1273	350	1345	$ 6,617.46
DL9_M6-AlAl	98.93%	1046	577	2477	$ 5,147.88
DL9_M6-CuCu	98.93%	1281	342	1312	$ 6,925.89
DL9_M6-CuCu	98.93%	912	711	3155	$ 4,803.10
DL9_M6-AlAl	98.93%	1003	619	2668	$ 5,271.15
DL9_M6-AlAl	98.93%	925	697	3015	$ 5,000.05
DL9_M6-AlAl	98.93%	1223	398	1605	$ 6,228.64
DL9_M6-CuCu	98.93%	1240	381	1453	$ 6,633.19
DL9_M6-AlAl	98.93%	955	665	2867	$ 5,073.55
DL9_M6-CuCu	98.93%	1150	471	1964	$ 5,341.34
DL9_M6-AlAl	98.93%	1093	524	2166	$ 5,611.89
DL9_M6-CuCu	98.93%	687	931	4464	$ 4,711.70
DL9_M6-CuCu	98.93%	681	936	4442	$ 4,874.78
DL9_M6-CuCu	98.93%	1238	376	1493	$ 6,070.94
DL9_M6-CuCu	98.94%	1119	496	2056	$ 5,262.53
DL9_M6-CuCu	98.94%	1235	380	1458	$ 6,594.95
DL9_M6-CuCu	98.94%	1221	393	1539	$ 6,357.42
DL9_M6-CuCu	98.94%	653	961	4638	$ 4,790.17
DL9_M6-CuCu	98.94%	1231	383	1471	$ 6,596.56
DL9_HOCuCu	98.94%	653	960	4858	$ 4,480.90
DL9_M6-CuCu	98.94%	1201	411	1683	$ 5,847.78
DL9_M6-CuCu	98.94%	1274	338	1295	$ 6,753.44
DL9_M6-CuCu	98.94%	1269	341	1316	$ 6,662.48
DL9_M6-AlAl	98.94%	1134	474	1920	$ 5,989.49
DL9_M6-CuCu	98.94%	1266	342	1308	$ 6,739.45
DL9_M6-CuCu	98.94%	1096	511	2189	$ 5,076.57
DL9_M6-AlAl	98.94%	1184	423	1706	$ 6,239.67
DL9_M6-AlAl	98.94%	1201	406	1639	$ 6,264.98
DL9_M6-AlAl	98.94%	1176	431	1731	$ 6,417.02
DL9_HOCuCu	98.94%	476	1130	5809	$ 4,850.38
DL9_M6-CuCu	98.94%	1276	328	1243	$ 6,995.92
DL9_M6-CuCu	98.94%	1265	339	1317	$ 6,743.60
DL9_M6-AlAl	98.94%	1169	434	1787	$ 6,122.57

Table C.17 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M6-CuCu	98.94%	1099	504	2080	$ 5,253.24
DL9_M6-CuCu	98.94%	1254	345	1335	$ 6,621.00
DL9_M6-AlAl	98.95%	1017	581	2422	$ 5,691.42
DL9_M6-CuCu	98.95%	1180	419	1637	$ 6,198.34
DL9_M6-CuCu	98.95%	1250	348	1327	$ 6,762.09
DL9_M6-AlAl	98.95%	1015	582	2416	$ 5,700.95
DL9_M6-CuCu	98.95%	1256	341	1312	$ 6,714.29
DL9_M6-CuCu	98.95%	649	947	4541	$ 4,887.93
DL9_M6-AlAl	98.95%	1071	523	2171	$ 5,767.84
DL9_M6-CuCu	98.95%	1058	535	2205	$ 5,423.45
DL9_M6-CuCu	98.95%	1099	495	1976	$ 5,906.21
DL9_M6-CuCu	98.95%	1086	507	2151	$ 5,246.82
DL9_M6-CuCu	98.95%	942	650	2781	$ 5,034.57
DL9_M6-AlAl	98.95%	1079	513	2120	$ 5,790.46
DL9_M6-AlAl	98.95%	1148	443	1796	$ 6,084.73
DL9_M6-AlAl	98.95%	1112	479	1955	$ 6,113.36
DL9_M6-CuCu	98.95%	1141	450	1795	$ 5,956.36
DL9_M6-CuCu	98.95%	873	717	3132	$ 5,076.66
DL9_M6-CuCu	98.95%	974	616	2717	$ 4,897.35
DL9_M6-CuCu	98.95%	1210	380	1501	$ 6,192.20
DL9_M6-CuCu	98.95%	629	961	4656	$ 4,991.81
DL9_M6-AlAl	98.95%	972	618	2589	$ 5,572.30
DL9_M6-CuCu	98.95%	1169	419	1638	$ 6,268.65
DL9_M6-AlAl	98.95%	1098	489	2017	$ 6,050.83
DL9_M6-CuCu	98.95%	1178	409	1583	$ 6,398.25
DL9_M6-CuCu	98.95%	768	818	3743	$ 4,926.88
DL9_M6-CuCu	98.95%	1209	377	1438	$ 6,822.83
DL9_M6-CuCu	98.95%	1205	382	1472	$ 6,699.94
DL9_M6-CuCu	98.95%	1193	392	1532	$ 6,494.60
DL9_M6-CuCu	98.95%	1205	380	1476	$ 6,666.19
DL9_M6-CuCu	98.95%	773	812	3728	$ 4,918.13
DL9_M6-AlAl	98.95%	972	613	2605	$ 5,406.14
DL9_M3-CuAl	98.96%	653	931	4701	$ 4,326.78
DL9_M6-CuCu	98.96%	1249	335	1283	$ 6,925.74
DL9_M6-CuCu	98.96%	781	802	3633	$ 5,190.99
DL9_M6-AlAl	98.96%	1171	411	1664	$ 6,268.59
DL9_M6-CuCu	98.96%	1055	527	2186	$ 5,470.38
DL9_M6-AlAl	98.96%	1064	517	2132	$ 5,848.72
DL9_M6-CuCu	98.96%	1045	535	2210	$ 5,460.86
DL9_M6-AlAl	98.96%	887	692	2993	$ 5,232.90
DL9_M6-CuCu	98.96%	1235	344	1341	$ 6,747.53
DL9_M6-CuCu	98.96%	1238	341	1326	$ 6,807.08
DL9_M6-CuCu	98.96%	1162	417	1632	$ 6,289.14
DL9_M6-AlAl	98.96%	847	730	3241	$ 5,044.32
DL9_M6-CuCu	98.96%	1166	409	1581	$ 6,459.34
DL9_M6-CuCu	98.96%	1157	418	1667	$ 5,987.82
DL9_M6-AlAl	98.96%	1072	503	2055	$ 5,970.55
DL9_M6-AlAl	98.96%	1126	446	1787	$ 6,441.08
DL9_M6-AlAl	98.96%	1112	459	1898	$ 6,090.28
DL9_M6-CuCu	98.96%	1117	453	1809	$ 6,004.99
DL9_M6-AlAl	98.96%	1028	542	2209	$ 6,047.62
DL9_M6-CuCu	98.97%	1125	444	1759	$ 6,107.64
DL9_M6-AlAl	98.97%	1035	531	2251	$ 5,543.00
DL9_M3-CuAl	98.97%	569	998	5064	$ 4,468.51
DL9_M6-CuCu	98.97%	1195	371	1448	$ 6,445.53
DL9_M6-CuCu	98.97%	1185	380	1461	$ 6,836.58
DL9_M6-CuCu	98.97%	1180	384	1483	$ 6,755.73

Table C.18 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M6-AlAl	98.97%	1041	522	2198	$ 5,697.43
DL9_M6-CuCu	98.97%	1118	445	1754	$ 6,126.65
DL9_M6-CuCu	98.97%	1023	538	2225	$ 5,524.12
DL9_M6-CuCu	98.97%	1184	377	1500	$ 6,347.82
DL9_M6-AlAl	98.97%	1013	547	2317	$ 5,562.25
DL9_M6-AlAl	98.97%	881	680	2943	$ 5,362.49
DL9_M6-AlAl	98.97%	944	616	2664	$ 5,384.50
DL9_M6-CuCu	98.97%	1185	374	1464	$ 6,440.70
DL9_M6-CuCu	98.97%	1023	536	2218	$ 5,538.84
DL9_M6-CuCu	98.97%	1139	420	1689	$ 6,025.03
DL9_M6-AlAl	98.97%	1077	481	1975	$ 6,238.75
DL9_M6-CuCu	98.97%	1119	439	1729	$ 6,226.48
DL9_M6-CuCu	98.97%	1146	410	1624	$ 6,147.41
DL9_M6-CuCu	98.97%	1196	360	1375	$ 6,880.27
DL9_M6-CuCu	98.97%	1196	360	1375	$ 6,880.27
DL9_M3-CuAl	98.97%	596	960	4858	$ 4,441.85
DL9_M6-CuCu	98.97%	1146	410	1579	$ 6,549.02
DL9_M3-CuAl	98.97%	580	975	4917	$ 4,499.90
DL9_M6-CuCu	98.97%	1049	506	2107	$ 5,429.74
DL9_M6-CuCu	98.97%	1050	504	2103	$ 5,394.58
DL9_M6-CuCu	98.97%	1203	351	1373	$ 6,783.08
DL9_M6-CuCu	98.98%	1141	412	1600	$ 6,520.45
DL9_M6-CuCu	98.98%	1140	411	1597	$ 6,538.25
DL9_M6-CuCu	98.98%	1140	410	1629	$ 6,197.13
DL9_M6-CuCu	98.98%	1221	329	1251	$ 7,288.71
DL9_M6-AlAl	98.98%	927	622	2629	$ 5,538.08
DL9_M6-CuCu	98.98%	1182	367	1424	$ 6,604.93
DL9_M6-CuCu	98.98%	1170	377	1501	$ 6,427.72
DL9_M6-CuCu	98.98%	1180	368	1438	$ 6,592.55
DL9_M3-CuAl	98.98%	561	987	5016	$ 4,478.24
DL9_M3-CuAl	98.98%	575	972	4919	$ 4,486.71
DL9_M6-CuCu	98.98%	1147	400	1566	$ 6,363.79
DL9_M6-CuCu	98.98%	1208	339	1310	$ 7,059.68
DL9_M6-AlAl	98.98%	1010	536	2268	$ 5,707.84
DL9_M6-CuCu	98.98%	1172	373	1447	$ 6,663.29
DL9_M3-CuAl	98.98%	937	607	2809	$ 4,623.72
DL9_M6-CuCu	98.98%	1199	345	1345	$ 6,941.30
DL9_M6-CuCu	98.98%	1205	338	1290	$ 7,195.32
DL9_M6-CuCu	98.98%	988	555	2298	$ 5,527.26
DL9_M6-CuCu	98.98%	1140	403	1588	$ 6,337.09
DL9_M6-CuCu	98.98%	1010	532	2290	$ 5,232.41
DL9_M6-CuCu	98.98%	1106	436	1786	$ 5,962.80
DL9_M6-CuCu	98.98%	982	559	2307	$ 5,520.05
DL9_M6-CuCu	98.98%	1172	369	1423	$ 6,780.30
DL9_M6-CuCu	98.98%	736	804	3696	$ 4,977.42
DL9_M6-AlAl	98.98%	1032	507	2083	$ 5,838.66
DL9_M6-CuCu	98.99%	1031	507	2133	$ 5,490.82
DL9_M6-CuCu	98.99%	1108	429	1742	$ 5,914.81
DL9_M3-CuAl	98.99%	590	946	4756	$ 4,482.81
DL9_M6-AlAl	98.99%	997	537	2244	$ 5,669.42
DL9_M3-CuAl	98.99%	583	950	4802	$ 4,484.99
DL9_M6-CuCu	98.99%	1180	353	1365	$ 6,869.32
DL9_M6-CuCu	98.99%	1089	443	1759	$ 6,278.56
DL9_M3-CuAl	98.99%	547	986	5018	$ 4,604.18
DL9_M6-CuCu	98.99%	975	557	2314	$ 5,578.86
DL9_M3-CuAl	98.99%	552	980	4981	$ 4,505.49
DL9_M6-CuCu	98.99%	1144	386	1547	$ 6,582.43

Table C.19 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M6-AlAl	98.99%	1011	519	2131	$ 6,166.05
DL9_M6-CuCu	98.99%	878	651	2882	$ 5,063.72
DL9_M6-CuCu	98.99%	1134	393	1520	$ 6,610.94
DL9_M6-CuCu	98.99%	752	775	3457	$ 5,337.74
DL9_M6-CuCu	98.99%	987	539	2306	$ 5,403.46
DL9_HOCuCu	98.99%	548	976	4957	$ 4,706.20
DL9_M6-CuCu	99.00%	1061	461	1863	$ 6,134.05
DL9_M3-CuAl	99.00%	593	928	4653	$ 4,493.98
DL9_M6-CuCu	99.00%	1116	403	1581	$ 6,403.59
DL9_M3-CuAl	99.00%	586	928	4685	$ 4,516.95
DL9_M6-CuCu	99.00%	1054	460	1824	$ 6,030.58
DL9_M6-CuCu	99.00%	950	563	2332	$ 5,611.78
DL9_M6-CuCu	99.00%	950	563	2332	$ 5,611.78
DL9_M6-CuCu	99.00%	1116	397	1540	$ 6,574.32
DL9_M6-CuCu	99.00%	1099	413	1679	$ 6,200.56
DL9_M3-CuAl	99.00%	539	973	4943	$ 4,564.17
DL9_M6-CuCu	99.00%	1081	430	1673	$ 6,575.65
DL9_M6-CuCu	99.00%	647	864	3969	$ 5,433.15
DL9_M6-CuCu	99.00%	936	574	2382	$ 5,640.32
DL9_M6-CuCu	99.00%	953	557	2315	$ 5,649.66
DL9_M6-CuCu	99.00%	931	579	2398	$ 5,644.63
DL9_M6-CuCu	99.01%	1047	458	1813	$ 6,062.75
DL9_M6-CuCu	99.01%	815	689	3052	$ 5,315.08
DL9_M6-CuCu	99.01%	942	559	2324	$ 5,688.75
DL9_M3-CuAl	99.01%	537	963	4875	$ 4,620.03
DL9_M6-CuCu	99.01%	1104	396	1562	$ 6,481.71
DL9_M3-CuAl	99.01%	559	940	4742	$ 4,607.75
DL9_M6-CuCu	99.01%	968	530	2266	$ 5,551.77
DL9_M6-CuCu	99.01%	1005	493	2068	$ 5,728.43
DL9_M6-CuCu	99.01%	916	582	2412	$ 5,662.92
DL9_M6-CuCu	99.01%	934	561	2336	$ 5,723.11
DL9_M6-CuCu	99.01%	773	723	3169	$ 5,355.69
DL9_HOCuCu	99.01%	450	1044	5317	$ 5,047.19
DL9_M6-CuCu	99.01%	1032	461	1856	$ 6,262.33
DL9_M6-CuCu	99.01%	701	792	3592	$ 5,233.26
DL9_M6-CuCu	99.02%	1048	443	1751	$ 6,459.84
DL9_M3-CuAl	99.02%	552	939	4737	$ 4,592.76
DL9_M6-CuCu	99.02%	1034	456	1800	$ 6,165.87
DL9_M6-CuCu	99.02%	896	592	2482	$ 5,648.26
DL9_M6-CuCu	99.02%	886	602	2493	$ 5,663.33
DL9_M6-CuCu	99.02%	748	737	3282	$ 5,446.70
DL9_M3-CuAl	99.02%	529	955	4832	$ 4,635.02
DL9_M6-CuCu	99.02%	924	559	2336	$ 5,744.22
DL9_M6-CuCu	99.02%	924	559	2336	$ 5,744.22
DL9_M3-CuAl	99.02%	1031	451	1987	$ 5,161.86
DL9_HOCuCu	99.02%	401	1080	5537	$ 5,268.23
DL9_M6-CuCu	99.02%	1014	465	1870	$ 6,106.92
DL9_M6-CuCu	99.02%	715	763	3406	$ 5,462.58
DL9_M6-CuCu	99.02%	918	560	2333	$ 5,812.20
DL9_M6-CuCu	99.03%	1067	408	1622	$ 6,424.58
DL9_M6-CuCu	99.03%	1043	431	1688	$ 6,720.50
DL9_M6-CuCu	99.03%	771	702	3029	$ 5,580.42
DL9_M6-CuCu	99.03%	771	702	3029	$ 5,580.42
DL9_M6-CuCu	99.03%	894	578	2411	$ 5,788.77
DL9_M6-CuCu	99.03%	694	778	3472	$ 5,529.26
DL9_M3-CuAl	99.03%	520	952	4815	$ 4,671.45
DL9_M6-CuCu	99.03%	769	701	3126	$ 5,337.76

Table C.20 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M6-CuCu	99.03%	797	673	2894	$ 5,555.26
DL9_M6-CuCu	99.03%	866	602	2496	$ 5,773.77
DL9_M6-CuCu	99.03%	1018	450	1810	$ 6,493.78
DL9_M6-CuCu	99.03%	1039	426	1733	$ 6,377.27
DL9_M6-CuCu	99.03%	801	664	2846	$ 5,618.92
DL9_M6-CuCu	99.03%	965	499	1991	$ 6,282.12
DL9_M6-CuCu	99.03%	1010	454	1803	$ 6,282.45
DL9_M6-CuCu	99.03%	1077	385	1472	$ 7,069.23
DL9_M3-CuAl	99.04%	609	852	4239	$ 4,587.34
DL9_M6-CuCu	99.04%	752	708	3156	$ 5,355.49
DL9_HOCuCu	99.04%	458	998	5093	$ 4,976.67
DL9_M3-CuAl	99.04%	596	860	4247	$ 4,603.89
DL9_M6-CuCu	99.04%	998	458	1824	$ 6,287.68
DL9_M3-CuAl	99.04%	832	623	2901	$ 4,691.76
DL9_M6-CuCu	99.04%	1018	434	1690	$ 6,859.25
DL9_M6-CuCu	99.04%	879	573	2406	$ 5,874.83
DL9_M6-CuCu	99.04%	741	711	3094	$ 5,602.77
DL9_M6-CuCu	99.04%	996	455	1814	$ 6,334.35
DL9_M6-CuCu	99.04%	868	580	2481	$ 5,614.76
DL9_M6-CuCu	99.04%	993	455	1809	$ 6,317.30
DL9_M3-CuAl	99.04%	639	808	3918	$ 4,641.77
DL9_M3-CuAl	99.05%	591	855	4216	$ 4,652.04
DL9_M6-CuCu	99.05%	992	449	1818	$ 6,564.44
DL9_M6-CuCu	99.05%	904	534	2244	$ 5,847.64
DL9_M6-CuCu	99.05%	816	622	2671	$ 5,839.62
DL9_M6-CuCu	99.05%	705	729	3226	$ 5,605.73
DL9_M3-CuAl	99.05%	536	897	4503	$ 4,747.00
DL9_M3-CuAl	99.05%	573	858	4229	$ 4,664.38
DL9_M3-CuAl	99.06%	577	854	4188	$ 4,691.60
DL9_M6-CuCu	99.06%	766	664	2868	$ 5,834.13
DL9_HOCuCu	99.06%	418	1012	5151	$ 5,255.30
DL9_M6-CuCu	99.06%	1029	401	1603	$ 6,802.02
DL9_M6-CuCu	99.06%	806	623	2668	$ 5,867.80
DL9_M3-CuAl	99.06%	557	870	4331	$ 4,681.89
DL9_M6-CuCu	99.06%	998	426	1659	$ 7,141.96
DL9_M6-CuCu	99.06%	762	661	2830	$ 5,779.96
DL9_M3-CuAl	99.06%	650	774	3706	$ 4,750.09
DL9_HOCuCu	99.06%	474	950	4813	$ 4,967.76
DL9_M3-CuAl	99.06%	562	860	4206	$ 4,752.28
DL9_M6-CuCu	99.06%	827	591	2478	$ 5,836.48
DL9_M6-CuCu	99.06%	822	594	2555	$ 5,761.94
DL9_M6-CuCu	99.07%	749	666	2873	$ 5,896.79
DL9_M6-CuCu	99.07%	717	698	3021	$ 5,955.53
DL9_M6-CuCu	99.07%	788	627	2707	$ 5,747.82
DL9_M6-CuCu	99.07%	828	585	2472	$ 6,109.43
DL9_HOCuCu	99.07%	494	917	4641	$ 4,931.01
DL9_M3-CuAl	99.07%	1038	371	1606	$ 5,592.08
DL9_M3-CuAl	99.07%	549	860	4254	$ 4,759.84
DL9_M3-CuAl	99.07%	696	711	3367	$ 4,751.73
DL9_HOCuCu	99.07%	442	964	4886	$ 5,160.45
DL9_HOCuCu	99.07%	461	945	4800	$ 5,010.38
DL9_M3-CuAl	99.07%	552	853	4250	$ 4,782.73
DL9_M6-CuCu	99.07%	777	627	2661	$ 6,111.78
DL9_M3-CuAl	99.07%	768	634	2942	$ 4,789.46
DL9_M6-CuCu	99.08%	766	634	2647	$ 6,103.25
DL9_M6-CuCu	99.08%	834	565	2390	$ 5,962.75
DL9_M6-CuCu	99.08%	926	472	1920	$ 6,452.29

Table C.21 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M3-CuAl	99.08%	744	653	3057	$ 4,775.83
DL9_M6-CuCu	99.08%	802	595	2491	$ 5,949.98
DL9_HOCuCu	99.08%	473	922	4660	$ 5,003.22
DL9_M6-CuCu	99.08%	800	594	2517	$ 5,965.69
DL9_M6-CuCu	99.08%	759	635	2668	$ 6,142.18
DL9_M6-CuCu	99.08%	950	441	1711	$ 6,908.87
DL9_M3-CuAl	99.08%	1002	389	1688	$ 5,541.68
DL9_M6-CuCu	99.08%	798	590	2476	$ 6,002.42
DL9_M6-CuCu	99.08%	755	633	2666	$ 6,239.54
DL9_HOCuCu	99.08%	470	917	4637	$ 5,023.55
DL9_HOCuCu	99.09%	469	914	4621	$ 5,031.33
DL9_M6-CuCu	99.09%	790	593	2493	$ 6,014.56
DL9_HOCuCu	99.09%	472	911	4598	$ 5,024.37
DL9_M6-CuCu	99.09%	782	597	2519	$ 6,009.44
DL9_M3-CuAl	99.09%	773	604	2770	$ 4,963.74
DL9_M6-CuCu	99.09%	728	648	2764	$ 6,130.39
DL9_M6-CuCu	99.10%	904	466	1874	$ 6,768.48
DL9_M3-CuAl	99.10%	708	660	3100	$ 4,815.46
DL9_M3-CuAl	99.10%	902	458	2016	$ 5,298.45
DL9_HOCuCu	99.10%	461	896	4524	$ 5,095.39
DL9_HOCuCu	99.10%	455	901	4543	$ 5,145.27
DL9_M3-CuAl	99.11%	818	533	2395	$ 5,141.80
DL9_HOCuCu	99.11%	441	908	4575	$ 5,251.26
DL9_HOCuCu	99.11%	453	893	4508	$ 5,119.72
DL9_M3-CuAl	99.11%	837	505	2263	$ 5,190.39
DL9_HOCuCu	99.11%	464	877	4416	$ 5,122.27
DL9_M3-CuAl	99.11%	579	762	3652	$ 4,925.83
DL9_M3-CuAl	99.12%	1049	287	1190	$ 6,623.09
DL9_HOCuCu	99.12%	467	869	4364	$ 5,133.21
DL9_M3-CuAl	99.12%	795	540	2432	$ 5,138.16
DL9_M3-CuAl	99.12%	533	796	3817	$ 5,060.19
DL9_M3-CuAl	99.12%	476	853	4213	$ 5,159.81
DL9_M3-CuAl	99.12%	611	715	3421	$ 4,896.24
DL9_M3-CuAl	99.12%	1021	304	1270	$ 6,441.58
DL9_M3-CuAl	99.13%	918	398	1716	$ 5,691.80
DL9_M3-CuAl	99.13%	899	416	1815	$ 5,587.56
DL9_M3-CuAl	99.13%	598	714	3402	$ 4,966.65
DL9_M3-CuAl	99.13%	502	807	3962	$ 5,160.56
DL9_HOCuCu	99.14%	717	588	2758	$ 5,082.31
DL9_HOCuCu	99.14%	646	655	3138	$ 4,969.18
DL9_HOCuCu	99.14%	473	827	4134	$ 5,156.04
DL9_HOCuCu	99.14%	626	673	3228	$ 4,985.34
DL9_HOCuCu	99.14%	632	665	3192	$ 4,992.82
DL9_HOCuCu	99.14%	462	836	4144	$ 5,236.00
DL9_M3-CuAl	99.14%	742	554	2509	$ 5,179.33
DL9_HOCuCu	99.14%	655	640	3026	$ 5,092.49
DL9_M3-CuAl	99.15%	838	450	1973	$ 5,579.97
DL9_HOCuCu	99.15%	430	855	4237	$ 5,444.36
DL9_HOCuCu	99.15%	470	810	3996	$ 5,245.47
DL9_HOCuCu	99.16%	464	813	4031	$ 5,255.94
DL9_HOCuCu	99.16%	483	793	3909	$ 5,213.38
DL9_M3-CuAl	99.16%	931	344	1460	$ 6,181.95
DL9_M3-CuAl	99.16%	901	374	1600	$ 6,078.98
DL9_HOCuCu	99.16%	524	750	3670	$ 5,108.29
DL9_HOCuCu	99.16%	493	780	3824	$ 5,217.03
DL9_M3-CuAl	99.16%	631	642	2976	$ 5,223.44
DL9_HOCuCu	99.16%	486	787	3860	$ 5,228.76

Table C.22 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M3-CuAl	99.16%	992	277	1140	$ 7,023.23
DL9_HOCuCu	99.16%	461	805	3977	$ 5,321.98
DL9_HOCuCu	99.17%	483	779	3821	$ 5,267.46
DL9_HOCuCu	99.17%	505	757	3693	$ 5,205.65
DL9_HOCuCu	99.17%	510	753	3640	$ 5,230.46
DL9_HOCuCu	99.17%	478	784	3836	$ 5,294.00
DL9_HOCuCu	99.17%	482	779	3817	$ 5,274.02
DL9_HOCuCu	99.17%	810	449	2014	$ 5,604.80
DL9_HOCuCu	99.17%	800	459	2063	$ 5,565.56
DL9_HOCuCu	99.17%	476	782	3850	$ 5,270.72
DL9_M3-CuAl	99.17%	892	365	1562	$ 6,126.18
DL9_M3-CuAl	99.17%	913	340	1440	$ 6,327.68
DL9_M3-CuAl	99.17%	911	342	1451	$ 6,327.00
DL9_M3-CuAl	99.17%	905	347	1472	$ 6,298.05
DL9_M3-CuAl	99.17%	757	495	2192	$ 5,505.94
DL9_M3-CuAl	99.17%	909	342	1446	$ 6,334.45
DL9_M3-CuAl	99.17%	760	490	2172	$ 5,576.00
DL9_M3-CuAl	99.17%	904	346	1468	$ 6,320.62
DL9_HOCuCu	99.17%	860	389	1711	$ 5,895.87
DL9_M3-CuAl	99.17%	668	581	2646	$ 5,285.44
DL9_M3-CuAl	99.17%	846	402	1737	$ 5,904.57
DL9_M3-CuAl	99.17%	900	348	1475	$ 6,272.98
DL9_M3-CuAl	99.18%	718	529	2370	$ 5,397.90
DL9_M3-CuAl	99.18%	718	529	2370	$ 5,397.90
DL9_M3-CuAl	99.18%	901	345	1455	$ 6,321.45
DL9_M3-CuAl	99.18%	906	339	1435	$ 6,360.41
DL9_M3-CuAl	99.18%	976	267	1091	$ 7,257.61
DL9_M3-CuAl	99.18%	691	551	2479	$ 5,427.44
DL9_M3-CuAl	99.18%	691	551	2479	$ 5,427.44
DL9_M3-CuAl	99.18%	901	341	1440	$ 6,409.03
DL9_HOCuCu	99.18%	858	382	1680	$ 5,932.53
DL9_HOCuCu	99.18%	858	382	1680	$ 5,932.53
DL9_M3-CuAl	99.18%	913	328	1383	$ 6,524.26
DL9_M3-CuAl	99.18%	896	343	1448	$ 6,357.85
DL9_M3-CuAl	99.18%	807	431	1886	$ 5,734.31
DL9_M3-CuAl	99.18%	891	347	1468	$ 6,330.05
DL9_M3-CuAl	99.18%	632	605	2764	$ 5,311.39
DL9_HOCuCu	99.18%	395	841	4195	$ 5,798.01
DL9_M3-CuAl	99.18%	701	534	2386	$ 5,460.26
DL9_M3-CuAl	99.18%	833	402	1736	$ 5,923.72
DL9_HOCuCu	99.18%	372	861	4292	$ 5,953.39
DL9_HOCuCu	99.18%	372	861	4292	$ 5,953.39
DL9_M3-CuAl	99.19%	902	329	1368	$ 6,668.43
DL9_M3-CuAl	99.19%	807	422	1817	$ 5,918.78
DL9_M3-CuAl	99.19%	955	272	1113	$ 7,542.23
DL9_M3-CuAl	99.19%	899	328	1380	$ 6,549.36
DL9_M3-CuAl	99.19%	643	584	2628	$ 5,460.86
DL9_M3-CuAl	99.19%	896	331	1370	$ 6,704.19
DL9_HOCuCu	99.19%	495	731	3511	$ 5,430.73
DL9_M3-CuAl	99.19%	791	434	1897	$ 5,782.39
DL9_M3-CuAl	99.19%	625	601	2732	$ 5,395.73
DL9_M3-CuAl	99.19%	900	325	1341	$ 6,756.72
DL9_M3-CuAl	99.19%	891	333	1395	$ 6,542.29
DL9_M3-CuAl	99.19%	845	378	1617	$ 6,176.79
DL9_M3-CuAl	99.19%	703	519	2324	$ 5,538.98
DL9_M3-CuAl	99.19%	703	519	2324	$ 5,538.98
DL9_M3-CuAl	99.19%	703	519	2324	$ 5,538.98

Table C. 23 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M3-CuAl	99.19%	861	360	1513	$ 6,396.08
DL9_M3-CuAl	99.19%	839	381	1634	$ 6,242.17
DL9_M3-CuAl	99.19%	827	393	1692	$ 6,049.31
DL9_M3-CuAl	99.19%	912	308	1273	$ 6,927.93
DL9_M3-CuAl	99.19%	894	325	1340	$ 6,760.92
DL9_M3-CuAl	99.20%	893	324	1350	$ 6,674.82
DL9_HOCuCu	99.20%	963	254	1044	$ 7,329.96
DL9_M3-CuAl	99.20%	837	380	1608	$ 6,295.77
DL9_M3-CuAl	99.20%	822	394	1693	$ 6,049.29
DL9_M3-CuAl	99.20%	900	314	1287	$ 6,973.07
DL9_M3-CuAl	99.20%	855	356	1488	$ 6,505.36
DL9_M3-CuAl	99.20%	699	509	2264	$ 5,614.97
DL9_M3-CuAl	99.20%	866	342	1430	$ 6,668.83
DL9_M3-CuAl	99.20%	927	280	1160	$ 7,318.27
DL9_M3-CuAl	99.20%	581	625	2887	$ 5,470.50
DL9_M3-CuAl	99.20%	875	330	1366	$ 6,750.51
DL9_M3-CuAl	99.20%	593	610	2783	$ 5,481.81
DL9_M3-CuAl	99.20%	593	610	2783	$ 5,481.81
DL9_M3-CuAl	99.20%	593	610	2783	$ 5,481.81
DL9_M3-CuAl	99.21%	944	258	1052	$ 7,728.86
DL9_HOCuCu	99.21%	944	257	1058	$ 7,323.58
DL9_M3-CuAl	99.21%	839	361	1513	$ 6,493.57
DL9_M3-CuAl	99.21%	735	465	2029	$ 5,790.38
DL9_HOCuCu	99.21%	799	400	1764	$ 5,914.58
DL9_M3-CuAl	99.21%	882	316	1287	$ 7,147.51
DL9_HOCuCu	99.21%	514	685	3242	$ 5,495.71
DL9_M3-CuAl	99.21%	792	406	1742	$ 6,106.88
DL9_HOCuCu	99.21%	701	497	2250	$ 5,583.78
DL9_HOCuCu	99.21%	691	506	2293	$ 5,551.20
DL9_M3-CuAl	99.21%	554	644	2961	$ 5,567.64
DL9_M3-CuAl	99.21%	849	349	1450	$ 6,635.89
DL9_M3-CuAl	99.21%	804	393	1688	$ 6,178.99
DL9_M3-CuAl	99.21%	753	443	1924	$ 5,883.38
DL9_M3-CuAl	99.21%	884	312	1287	$ 6,953.29
DL9_M3-CuAl	99.21%	872	322	1339	$ 6,770.98
DL9_M3-CuAl	99.21%	892	302	1262	$ 6,996.17
DL9_M3-CuAl	99.21%	860	333	1407	$ 6,641.51
DL9_M3-CuAl	99.21%	864	328	1364	$ 6,935.52
DL9_HOCuCu	99.21%	848	341	1463	$ 6,475.38
DL9_HOCuCu	99.22%	866	320	1361	$ 6,567.38
DL9_M3-CuAl	99.22%	904	281	1169	$ 7,145.57
DL9_M3-CuAl	99.22%	808	377	1627	$ 6,180.14
DL9_HOCuCu	99.22%	857	328	1405	$ 6,546.03
DL9_M3-CuAl	99.22%	606	578	2599	$ 5,626.15
DL9_M3-CuAl	99.22%	857	324	1354	$ 6,780.12
DL9_M3-CuAl	99.22%	729	453	1964	$ 5,936.97
DL9_M3-CuAl	99.22%	854	328	1380	$ 6,742.63
DL9_M3-CuAl	99.22%	843	336	1391	$ 6,806.64
DL9_M3-CuAl	99.22%	901	278	1132	$ 7,668.40
DL9_M3-CuAl	99.22%	834	344	1457	$ 6,606.47
DL9_M3-CuAl	99.22%	567	609	2739	$ 5,815.32
DL9_M3-CuAl	99.22%	567	609	2739	$ 5,815.32
DL9_HOCuCu	99.22%	638	538	2453	$ 5,582.83
DL9_M3-CuAl	99.22%	861	314	1308	$ 6,921.69
DL9_HOCuCu	99.22%	876	298	1251	$ 6,885.47
DL9_HOCuCu	99.23%	897	274	1146	$ 7,334.65
DL9_M3-CuAl	99.23%	834	335	1423	$ 6,621.14

Table C.24 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M3-CuAl	99.23%	690	479	2104	$ 5,888.13
DL9_HOCuCu	99.23%	506	662	3119	$ 5,622.73
DL9_M3-CuAl	99.23%	866	302	1269	$ 6,930.26
DL9_M3-CuAl	99.23%	530	637	2913	$ 5,741.51
DL9_M3-CuAl	99.23%	530	637	2913	$ 5,741.51
DL9_HOCuCu	99.23%	757	409	1802	$ 6,024.26
DL9_M3-CuAl	99.23%	765	399	1726	$ 6,205.03
DL9_M3-CuAl	99.23%	901	262	1062	$ 7,846.07
DL9_M3-CuAl	99.23%	761	401	1727	$ 6,274.32
DL9_M3-CuAl	99.23%	761	401	1727	$ 6,274.32
DL9_M3-CuAl	99.23%	788	372	1595	$ 6,385.07
DL9_M3-CuAl	99.23%	869	291	1212	$ 7,241.71
DL9_HOCuCu	99.23%	553	607	2807	$ 5,640.97
DL9_HOCuCu	99.23%	627	532	2415	$ 5,701.00
DL9_HOCuCu	99.23%	516	642	3004	$ 5,736.62
DL9_M3-CuAl	99.23%	839	320	1336	$ 7,062.49
DL9_M3-CuAl	99.23%	878	279	1148	$ 7,610.51
DL9_HOCuCu	99.23%	599	558	2548	$ 5,693.46
DL9_M3-CuAl	99.24%	788	368	1574	$ 6,506.99
DL9_HOCuCu	99.24%	627	529	2401	$ 5,720.37
DL9_M3-CuAl	99.24%	778	377	1614	$ 6,426.53
DL9_HOCuCu	99.24%	601	553	2533	$ 5,650.14
DL9_M3-CuAl	99.24%	686	467	2020	$ 6,152.18
DL9_M3-CuAl	99.24%	883	269	1107	$ 7,584.34
DL9_HOCuCu	99.24%	507	645	3049	$ 5,664.96
DL9_M3-CuAl	99.24%	775	377	1597	$ 6,464.19
DL9_M3-CuAl	99.24%	872	279	1142	$ 7,586.34
DL9_M3-CuAl	99.24%	550	601	2735	$ 5,786.71
DL9_HOCuCu	99.24%	627	522	2366	$ 5,754.26
DL9_M3-CuAl	99.24%	685	464	2044	$ 5,964.66
DL9_M3-CuAl	99.24%	490	658	3032	$ 5,963.47
DL9_M3-CuAl	99.24%	892	253	1035	$ 7,956.88
DL9_HOCuCu	99.24%	862	283	1181	$ 7,284.03
DL9_M3-CuAl	99.24%	633	512	2249	$ 5,952.24
DL9_M3-CuAl	99.24%	851	293	1212	$ 7,334.59
DL9_M3-CuAl	99.24%	760	384	1655	$ 6,372.40
DL9_M3-CuAl	99.24%	476	668	3074	$ 6,007.26
DL9_M3-CuAl	99.24%	610	534	2392	$ 5,849.25
DL9_M3-CuAl	99.24%	876	267	1093	$ 7,797.63
DL9_M3-CuAl	99.24%	580	561	2512	$ 5,876.26
DL9_M3-CuAl	99.24%	847	295	1233	$ 7,198.62
DL9_M3-CuAl	99.25%	835	306	1271	$ 7,190.89
DL9_HOCuCu	99.25%	823	318	1356	$ 6,732.67
DL9_M3-CuAl	99.25%	852	288	1194	$ 7,399.74
DL9_HOCuCu	99.25%	767	372	1626	$ 6,292.51
DL9_M3-CuAl	99.25%	814	325	1370	$ 6,920.85
DL9_HOCuCu	99.25%	624	515	2320	$ 5,844.52
DL9_M3-CuAl	99.25%	768	370	1585	$ 6,543.92
DL9_HOCuCu	99.25%	855	282	1183	$ 7,327.93
DL9_M3-CuAl	99.25%	836	301	1258	$ 7,138.39
DL9_HOCuCu	99.25%	686	450	2002	$ 5,976.45
DL9_HOCuCu	99.25%	505	631	2960	$ 5,807.05
DL9_M3-CuAl	99.25%	692	441	1898	$ 6,262.41
DL9_M3-CuAl	99.25%	609	524	2310	$ 6,018.78
DL9_M3-CuAl	99.25%	799	333	1401	$ 6,909.60
DL9_HOCuCu	99.25%	462	669	3155	$ 5,895.99
DL9_HOCuCu	99.25%	675	456	2016	$ 6,059.30

Table C.25 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_M3-CuAl	99.25%	526	604	2779	$ 5,966.96
DL9_HOCuCu	99.25%	617	512	2306	$ 5,899.26
DL9_HOCuCu	99.25%	815	314	1334	$ 6,862.43
DL9_HOCuCu	99.25%	478	651	3035	$ 5,933.06
DL9_HOCuCu	99.25%	505	623	2931	$ 5,803.10
DL9_M3-CuAl	99.25%	876	251	1019	$ 8,180.63
DL9_HOCuCu	99.25%	767	361	1559	$ 6,412.34
DL9_M3-CuAl	99.25%	627	500	2194	$ 6,085.93
DL9_M3-CuAl	99.25%	746	380	1634	$ 6,539.33
DL9_M3-CuAl	99.26%	785	340	1448	$ 6,752.02
DL9_HOCuCu	99.26%	749	375	1630	$ 6,366.93
DL9_HOCuCu	99.26%	695	429	1889	$ 6,179.08
DL9_HOCuCu	99.26%	715	409	1792	$ 6,229.33
DL9_M3-CuAl	99.26%	791	331	1387	$ 7,008.62
DL9_M3-CuAl	99.26%	831	291	1212	$ 7,346.43
DL9_M3-CuAl	99.26%	801	321	1340	$ 7,078.26
DL9_M3-CuAl	99.26%	839	282	1151	$ 7,809.39
DL9_HOCuCu	99.26%	697	424	1856	$ 6,237.82
DL9_M3-CuAl	99.26%	819	300	1193	$ 7,894.50
DL9_HOCuCu	99.26%	858	262	1084	$ 7,781.20
DL9_HOCuCu	99.26%	852	267	1109	$ 7,681.58
DL9_M3-CuAl	99.26%	821	297	1226	$ 7,440.48
DL9_HOCuCu	99.26%	471	645	3044	$ 6,019.17
DL9_M3-CuAl	99.26%	731	384	1653	$ 6,576.08
DL9_M3-CuAl	99.26%	685	429	1831	$ 6,406.17
DL9_M3-CuAl	99.26%	869	245	983	$ 8,558.99
DL9_HOCuCu	99.26%	654	458	2023	$ 6,148.69
DL9_HOCuCu	99.26%	656	455	2009	$ 6,162.99
DL9_M3-CuAl	99.26%	605	505	2244	$ 6,212.33
DL9_HOCuCu	99.27%	653	457	2020	$ 6,157.99
DL9_HOCuCu	99.27%	653	457	2020	$ 6,157.99
DL9_M3-CuAl	99.27%	684	426	1851	$ 6,333.12
DL9_HOCuCu	99.27%	858	252	1035	$ 8,038.10
DL9_HOCuCu	99.27%	632	477	2124	$ 6,027.01
DL9_HOCuCu	99.27%	792	317	1350	$ 6,920.80
DL9_HOCuCu	99.27%	653	456	2018	$ 6,150.96
DL9_HOCuCu	99.27%	648	461	2043	$ 6,127.12
DL9_HOCuCu	99.27%	691	417	1823	$ 6,315.78
DL9_HOCuCu	99.27%	638	470	2089	$ 6,065.00
DL9_M3-CuAl	99.27%	822	286	1183	$ 7,522.00
DL9_HOCuCu	99.27%	653	455	2010	$ 6,143.04
DL9_HOCuCu	99.27%	646	462	2046	$ 6,113.60
DL9_HOCuCu	99.27%	646	462	2046	$ 6,113.60
DL9_M3-CuAl	99.27%	764	343	1450	$ 6,975.57
DL9_M3-CuAl	99.27%	567	540	2434	$ 6,182.90
DL9_M3-CuAl	99.27%	743	363	1541	$ 6,866.08
DL9_HOCuCu	99.27%	844	261	1074	$ 7,855.24
DL9_HOCuCu	99.27%	736	369	1602	$ 6,486.54
DL9_HOCuCu	99.27%	837	266	1094	$ 7,847.98
DL9_M3-CuAl	99.27%	711	391	1646	$ 6,716.44
DL9_M3-CuAl	99.27%	781	321	1337	$ 7,403.15
DL9_HOCuCu	99.27%	858	243	993	$ 8,189.06
DL9_M3-CuAl	99.27%	488	613	2784	$ 6,225.38
DL9_HOCuCu	99.27%	653	448	1978	$ 6,296.94
DL9_HOCuCu	99.27%	794	306	1298	$ 7,094.10
DL9_HOCuCu	99.27%	656	444	1951	$ 6,270.35
DL9_M3-CuAl	99.27%	815	285	1156	$ 7,858.83

Table C.26 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_HOCuCu	99.27%	787	312	1327	$ 7,023.74
DL9_HOCuCu	99.27%	685	415	1800	$ 6,408.24
DL9_M3-CuAl	99.27%	804	295	1225	$ 7,501.50
DL9_M3-CuAl	99.27%	797	301	1237	$ 7,924.78
DL9_M3-CuAl	99.27%	773	325	1348	$ 7,387.79
DL9_HOCuCu	99.27%	685	413	1800	$ 6,364.33
DL9_M3-CuAl	99.27%	806	291	1177	$ 7,886.28
DL9_M3-CuAl	99.27%	783	313	1303	$ 7,444.30
DL9_HOCuCu	99.27%	827	270	1105	$ 7,849.14
DL9_HOCuCu	99.27%	856	239	963	$ 8,361.65
DL9_HOCuCu	99.27%	624	471	2096	$ 6,126.72
DL9_HOCuCu	99.27%	624	471	2096	$ 6,126.72
DL9_M3-CuAl	99.28%	744	350	1489	$ 6,834.14
DL9_HOCuCu	99.28%	824	270	1105	$ 7,846.80
DL9_M3-CuAl	99.28%	843	250	1012	$ 8,715.88
DL9_M3-CuAl	99.28%	769	324	1339	$ 7,447.83
DL9_M3-CuAl	99.28%	659	434	1872	$ 6,579.01
DL9_HOCuCu	99.28%	708	385	1670	$ 6,510.80
DL9_HOCuCu	99.28%	667	425	1863	$ 6,302.71
DL9_HOCuCu	99.28%	820	272	1117	$ 7,817.74
DL9_HOCuCu	99.28%	696	395	1717	$ 6,468.93
DL9_HOCuCu	99.28%	822	269	1102	$ 7,879.80
DL9_M3-CuAl	99.28%	745	345	1467	$ 6,969.60
DL9_M3-CuAl	99.28%	806	283	1168	$ 7,770.47
DL9_HOCuCu	99.28%	658	432	1899	$ 6,365.71
DL9_HOCuCu	99.28%	822	268	1102	$ 7,833.49
DL9_HOCuCu	99.28%	644	446	1966	$ 6,270.54
DL9_HOCuCu	99.28%	833	256	1052	$ 7,928.32
DL9_HOCuCu	99.28%	815	273	1122	$ 7,808.22
DL9_HOCuCu	99.28%	871	217	863	$ 8,991.29
DL9_HOCuCu	99.28%	820	268	1104	$ 7,881.98
DL9_M3-CuAl	99.28%	558	530	2356	$ 6,371.74
DL9_HOCuCu	99.28%	782	305	1282	$ 7,205.73
DL9_HOCuCu	99.28%	847	240	975	$ 8,353.12
DL9_HOCuCu	99.28%	699	388	1676	$ 6,548.71
DL9_HOCuCu	99.28%	817	269	1107	$ 7,859.14
DL9_M3-CuAl	99.28%	754	331	1385	$ 7,253.03
DL9_HOCuCu	99.28%	811	274	1128	$ 7,793.24
DL9_HOCuCu	99.28%	657	428	1875	$ 6,349.21
DL9_M3-CuAl	99.28%	598	486	2106	$ 6,495.99
DL9_HOCuCu	99.28%	659	425	1857	$ 6,369.22
DL9_HOCuCu	99.28%	803	279	1151	$ 7,739.73
DL9_M3-CuAl	99.28%	712	370	1569	$ 6,945.79
DL9_M3-CuAl	99.28%	782	299	1246	$ 7,544.72
DL9_HOCuCu	99.28%	785	297	1244	$ 7,329.79
DL9_HOCuCu	99.28%	789	292	1221	$ 7,422.44
DL9_HOCuCu	99.28%	800	281	1159	$ 7,725.97
DL9_M3-CuAl	99.28%	663	417	1808	$ 6,586.16
DL9_HOCuCu	99.29%	812	267	1102	$ 7,941.69
DL9_HOCuCu	99.29%	789	290	1207	$ 7,559.98
DL9_M3-CuAl	99.29%	751	328	1357	$ 7,364.72
DL9_HOCuCu	99.29%	801	279	1151	$ 7,806.42
DL9_M3-CuAl	99.29%	717	362	1530	$ 7,029.31
DL9_HOCuCu	99.29%	810	269	1111	$ 7,885.14
DL9_HOCuCu	99.29%	790	289	1200	$ 7,573.53
DL9_HOCuCu	99.29%	789	289	1207	$ 7,479.03
DL9_HOCuCu	99.29%	786	293	1218	$ 7,514.63

Table C.27 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_HOCuCu	99.29%	786	293	1218	$ 7,514.63
DL9_HOCuCu	99.29%	779	299	1252	$ 7,353.37
DL9_HOCuCu	99.29%	786	293	1232	$ 7,487.54
DL9_HOCuCu	99.29%	787	292	1213	$ 7,541.59
DL9_HOCuCu	99.29%	798	280	1156	$ 7,726.89
DL9_M3-CuAl	99.29%	805	273	1120	$ 7,983.54
DL9_M3-CuAl	99.29%	710	367	1583	$ 7,012.58
DL9_HOCuCu	99.29%	795	282	1162	$ 7,771.34
DL9_M3-CuAl	99.29%	782	295	1218	$ 7,807.48
DL9_HOCuCu	99.29%	784	294	1229	$ 7,412.73
DL9_HOCuCu	99.29%	782	295	1230	$ 7,451.80
DL9_M3-CuAl	99.29%	754	323	1357	$ 7,315.36
DL9_HOCuCu	99.29%	557	519	2326	$ 6,241.50
DL9_M3-CuAl	99.29%	827	248	1007	$ 8,702.44
DL9_HOCuCu	99.29%	651	425	1859	$ 6,402.59
DL9_HOCuCu	99.29%	731	344	1469	$ 7,039.30
DL9_HOCuCu	99.29%	793	282	1163	$ 7,778.67
DL9_HOCuCu	99.29%	804	271	1119	$ 7,867.18
DL9_HOCuCu	99.29%	796	279	1165	$ 7,691.10
DL9_HOCuCu	99.29%	809	266	1093	$ 7,971.93
DL9_HOCuCu	99.29%	663	411	1789	$ 6,507.85
DL9_M3-CuAl	99.29%	730	344	1458	$ 7,164.33
DL9_HOCuCu	99.29%	493	581	2678	$ 6,204.37
DL9_M3-CuAl	99.29%	775	298	1238	$ 7,610.90
DL9_HOCuCu	99.29%	694	379	1633	$ 6,681.08
DL9_M3-CuAl	99.29%	662	412	1761	$ 6,843.24
DL9_HOCuCu	99.29%	789	283	1168	$ 7,757.25
DL9_M3-CuAl	99.29%	495	576	2583	$ 6,462.09
DL9_M3-CuAl	99.29%	587	484	2108	$ 6,701.35
DL9_HOCuCu	99.29%	783	288	1190	$ 7,724.14
DL9_HOCuCu	99.29%	578	492	2214	$ 6,183.69
DL9_HOCuCu	99.29%	789	281	1162	$ 7,800.16
DL9_M3-CuAl	99.29%	805	265	1083	$ 8,203.79
DL9_M3-CuAl	99.29%	487	583	2625	$ 6,530.10
DL9_M3-CuAl	99.29%	713	356	1520	$ 6,969.73
DL9_HOCuCu	99.29%	692	377	1627	$ 6,676.27
DL9_HOCuCu	99.29%	742	327	1386	$ 7,078.49
DL9_HOCuCu	99.29%	650	419	1828	$ 6,473.66
DL9_HOCuCu	99.29%	823	245	1006	$ 8,449.57
DL9_M3-CuAl	99.29%	767	302	1245	$ 7,765.40
DL9_M3-CuAl	99.29%	767	302	1245	$ 7,765.40
DL9_M3-CuAl	99.29%	767	302	1245	$ 7,765.40
DL9_HOCuCu	99.29%	718	350	1493	$ 6,904.01
DL9_HOCuCu	99.29%	718	350	1493	$ 6,904.01
DL9_HOCuCu	99.29%	700	367	1580	$ 6,742.38
DL9_M3-CuAl	99.29%	807	260	1031	$ 8,728.36
DL9_M3-CuAl	99.29%	768	299	1241	$ 7,662.05
DL9_HOCuCu	99.29%	726	340	1449	$ 6,947.10
DL9_M3-CuAl	99.29%	691	375	1581	$ 6,991.36
DL9_HOCuCu	99.29%	800	266	1092	$ 7,987.38
DL9_HOCuCu	99.30%	743	322	1354	$ 7,242.53
DL9_M3-CuAl	99.30%	583	482	2113	$ 6,502.31
DL9_M3-CuAl	99.30%	776	288	1193	$ 7,954.45
DL9_HOCuCu	99.30%	771	293	1230	$ 7,459.53
DL9_HOCuCu	99.30%	743	321	1352	$ 7,267.60
DL9_M3-CuAl	99.30%	724	340	1439	$ 7,157.74
DL9_M3-CuAl	99.30%	781	282	1153	$ 8,164.50

Table C.28 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_HOCuCu	99.30%	706	357	1524	$ 6,909.10
DL9_HOCuCu	99.30%	740	323	1359	$ 7,224.43
DL9_HOCuCu	99.30%	734	329	1396	$ 7,111.06
DL9_M3-CuAl	99.30%	766	297	1228	$ 7,721.81
DL9_HOCuCu	99.30%	706	357	1524	$ 6,916.83
DL9_HOCuCu	99.30%	773	289	1197	$ 7,733.72
DL9_HOCuCu	99.30%	698	365	1577	$ 6,791.45
DL9_HOCuCu	99.30%	753	310	1293	$ 7,436.77
DL9_HOCuCu	99.30%	753	310	1293	$ 7,436.77
DL9_HOCuCu	99.30%	705	357	1527	$ 6,909.00
DL9_HOCuCu	99.30%	701	361	1547	$ 6,858.13
DL9_HOCuCu	99.30%	734	328	1392	$ 7,113.61
DL9_HOCuCu	99.30%	728	334	1419	$ 7,047.93
DL9_HOCuCu	99.30%	801	261	1073	$ 8,076.81
DL9_HOCuCu	99.30%	698	364	1566	$ 6,833.45
DL9_HOCuCu	99.30%	741	320	1354	$ 7,237.32
DL9_M3-CuAl	99.30%	707	354	1506	$ 7,167.01
DL9_HOCuCu	99.30%	695	366	1571	$ 6,809.15
DL9_HOCuCu	99.30%	792	269	1107	$ 8,025.37
DL9_M3-CuAl	99.30%	765	295	1216	$ 7,944.70
DL9_HOCuCu	99.30%	774	286	1192	$ 7,650.87
DL9_HOCuCu	99.30%	741	319	1354	$ 7,200.43
DL9_HOCuCu	99.30%	732	328	1391	$ 7,140.11
DL9_M3-CuAl	99.30%	584	476	2082	$ 6,558.57
DL9_M3-CuAl	99.30%	735	324	1370	$ 7,369.16
DL9_M3-CuAl	99.30%	800	258	1051	$ 8,503.58
DL9_HOCuCu	99.30%	523	535	2426	$ 6,388.23
DL9_HOCuCu	99.30%	656	401	1736	$ 6,649.98
DL9_HOCuCu	99.30%	511	547	2464	$ 6,390.25
DL9_M3-CuAl	99.30%	739	318	1330	$ 7,713.46
DL9_M3-CuAl	99.30%	713	344	1441	$ 7,342.33
DL9_HOCuCu	99.30%	642	415	1808	$ 6,566.84
DL9_M3-CuAl	99.30%	759	297	1224	$ 7,940.42
DL9_HOCuCu	99.30%	771	285	1192	$ 7,709.05
DL9_HOCuCu	99.30%	672	384	1661	$ 6,677.61
DL9_HOCuCu	99.30%	748	307	1293	$ 7,454.21
DL9_HOCuCu	99.30%	609	447	1969	$ 6,426.69
DL9_HOCuCu	99.30%	501	554	2497	$ 6,484.47
DL9_HOCuCu	99.30%	755	300	1264	$ 7,526.36
DL9_HOCuCu	99.30%	549	504	2259	$ 6,320.38
DL9_M3-CuAl	99.30%	694	358	1530	$ 7,098.29
DL9_M3-CuAl	99.30%	615	437	1863	$ 6,788.09
DL9_HOCuCu	99.30%	741	311	1307	$ 7,397.08
DL9_M3-CuAl	99.30%	612	439	1908	$ 6,756.00
DL9_M3-CuAl	99.30%	748	303	1244	$ 8,056.83
DL9_HOCuCu	99.30%	736	315	1318	$ 7,454.35
DL9_HOCuCu	99.30%	666	385	1655	$ 6,811.30
DL9_HOCuCu	99.30%	788	262	1081	$ 8,242.24
DL9_M3-CuAl	99.31%	768	280	1145	$ 8,625.23
DL9_M3-CuAl	99.31%	770	277	1130	$ 8,352.20
DL9_HOCuCu	99.31%	552	492	2172	$ 6,544.06
DL9_HOCuCu	99.31%	637	405	1753	$ 6,738.43
DL9_M3-CuAl	99.31%	744	296	1230	$ 7,845.19
DL9_HOCuCu	99.31%	759	279	1157	$ 8,101.79
DL9_HOCuCu	99.31%	626	412	1797	$ 6,701.30
DL9_HOCuCu	99.31%	768	270	1120	$ 8,159.94
DL9_HOCuCu	99.31%	736	301	1254	$ 7,616.78

Table C.29 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_HOCuCu	99.31%	583	454	1995	$ 6,607.73
DL9_M3-CuAl	99.31%	634	401	1714	$ 7,040.28
DL9_HOCuCu	99.32%	607	427	1867	$ 6,637.98
DL9_M3-CuAl	99.32%	704	329	1376	$ 7,660.05
DL9_M3-CuAl	99.32%	690	342	1434	$ 7,551.19
DL9_M3-CuAl	99.32%	645	387	1615	$ 7,367.67
DL9_HOCuCu	99.32%	776	255	1047	$ 8,509.15
DL9_HOCuCu	99.32%	649	379	1629	$ 7,016.19
DL9_HOCuCu	99.32%	763	265	1089	$ 8,306.65
DL9_HOCuCu	99.32%	782	245	999	$ 8,670.85
DL9_M3-CuAl	99.32%	635	392	1687	$ 7,137.02
DL9_M3-CuAl	99.32%	586	441	1909	$ 6,989.92
DL9_HOCuCu	99.32%	783	243	990	$ 8,716.71
DL9_HOCuCu	99.32%	772	253	1035	$ 8,668.48
DL9_HOCuCu	99.32%	628	397	1702	$ 6,994.31
DL9_HOCuCu	99.32%	606	418	1814	$ 6,815.49
DL9_HOCuCu	99.32%	763	261	1076	$ 8,448.33
DL9_HOCuCu	99.32%	784	239	968	$ 8,917.07
DL9_HOCuCu	99.32%	488	534	2417	$ 6,596.18
DL9_M3-CuAl	99.33%	679	337	1398	$ 7,771.65
DL9_M3-CuAl	99.33%	618	397	1681	$ 7,288.30
DL9_HOCuCu	99.33%	721	291	1224	$ 8,000.65
DL9_HOCuCu	99.33%	649	364	1561	$ 7,168.62
DL9_HOCuCu	99.33%	747	265	1093	$ 8,425.54
DL9_HOCuCu	99.33%	662	349	1500	$ 7,240.12
DL9_HOCuCu	99.33%	455	556	2511	$ 6,815.26
DL9_HOCuCu	99.33%	663	347	1487	$ 7,356.63
DL9_HOCuCu	99.33%	757	252	1029	$ 8,860.62
DL9_HOCuCu	99.33%	662	345	1474	$ 7,337.35
DL9_M3-CuAl	99.33%	521	486	2100	$ 7,179.62
DL9_HOCuCu	99.33%	752	255	1048	$ 8,609.51
DL9_HOCuCu	99.33%	736	270	1112	$ 8,509.73
DL9_M3-CuAl	99.33%	658	346	1453	$ 7,754.06
DL9_HOCuCu	99.33%	641	363	1569	$ 7,224.42
DL9_M3-CuAl	99.34%	632	372	1563	$ 7,630.73
DL9_M3-CuAl	99.34%	632	372	1563	$ 7,630.73
DL9_M3-CuAl	99.34%	605	398	1692	$ 7,380.69
DL9_M3-CuAl	99.34%	659	343	1432	$ 7,950.80
DL9_HOCuCu	99.34%	649	353	1516	$ 7,298.14
DL9_HOCuCu	99.34%	649	353	1507	$ 7,331.62
DL9_M3-CuAl	99.34%	658	343	1451	$ 7,722.61
DL9_M3-CuAl	99.34%	653	348	1457	$ 7,853.53
DL9_HOCuCu	99.34%	755	244	996	$ 9,049.46
DL9_HOCuCu	99.34%	631	368	1581	$ 7,235.78
DL9_HOCuCu	99.34%	609	389	1667	$ 7,157.57
DL9_HOCuCu	99.34%	699	299	1255	$ 7,959.95
DL9_HOCuCu	99.34%	749	249	1014	$ 9,004.84
DL9_HOCuCu	99.34%	742	252	1032	$ 8,956.48
DL9_HOCuCu	99.34%	599	392	1667	$ 7,386.20
DL9_HOCuCu	99.34%	738	253	1026	$ 8,878.00
DL9_HOCuCu	99.34%	738	253	1026	$ 8,878.00
DL9_M3-CuAl	99.34%	548	442	1881	$ 7,438.15
DL9_HOCuCu	99.34%	749	241	977	$ 9,246.36
DL9_HOCuCu	99.34%	732	257	1055	$ 8,854.55
DL9_HOCuCu	99.35%	740	248	1008	$ 9,127.95
DL9_HOCuCu	99.35%	738	249	1008	$ 9,104.16
DL9_HOCuCu	99.35%	729	257	1052	$ 8,945.39

Table C.30 Engineering Analysis Database (continued)

ID	Efficiency (%)	Core Loss (watts)	Coil Loss (watts)	Coil Loss (watts)	Price (US$)
DL9_HOCuCu	99.35%	617	368	1579	$ 7,335.33
DL9_HOCuCu	99.35%	490	494	2198	$ 6,992.92
DL9_HOCuCu	99.35%	706	274	1142	$ 8,437.84
DL9_HOCuCu	99.35%	625	351	1488	$ 7,666.09
DL9_HOCuCu	99.36%	720	254	1032	$ 9,097.90
DL9_HOCuCu	99.36%	715	258	1056	$ 9,005.74
DL9_HOCuCu	99.36%	720	252	1023	$ 9,193.66
DL9_HOCuCu	99.36%	643	329	1399	$ 7,871.15
DL9_HOCuCu	99.36%	652	317	1344	$ 7,998.36
DL9_HOCuCu	99.36%	558	408	1765	$ 7,326.37
DL9_HOCuCu	99.36%	625	336	1426	$ 7,916.05
DL9_HOCuCu	99.36%	547	412	1775	$ 7,512.20
DL9_HOCuCu	99.37%	651	306	1283	$ 8,227.33
DL9_HOCuCu	99.37%	624	333	1409	$ 7,934.56
DL9_HOCuCu	99.37%	591	365	1555	$ 7,705.41
DL9_HOCuCu	99.37%	642	308	1287	$ 8,298.59
DL9_HOCuCu	99.37%	639	309	1302	$ 8,369.05