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COO-4954-3

PHASE III FINAL REPORT

AND

THIRD UPDATE

OF THE

ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

PREPARED FOR

THE U.S. DEPARTMENT OF ENERGY

UNDER CONTRACT NUMBER DE-AC02-78ET33020
(FORMERLY CONTRACT NUMBER EN-78-C-02-4954)

VOLUME I OF I

BY

united engineers
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JULY 1981

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September 3, 1981
UE&C/DOE-EEDB-IV-19

ET 33020, M007

Mr. Howard H. Rohm
Senior Program Assistant
Division of Nuclear Alternative
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U. S. Department of Energy
Mailing Station B-107 GTN
Washington, DC 20545

Dear Mr. Rohm:

SUBJECT: Replacement Pages for the
Final Report & Third Update of
Energy Economic Data Base (EEDB) Program-Phase III

We are transmitting herewith twenty-five (25) copies of replacement pages for the "Phase III Final Report and Third Update of the Energy Economic Data Base (EEDB) Program", dated July, 1981. By copy of this letter, ten (10) of these copies are distributed as indicated below.

Please insert these pages in your EEDB Phase III Final Report and destroy the old pages.

Very truly yours,

R. E. Allen
EEDB Program Project Manager

REA/rmh
Enclosures

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July 31, 1981

Mr. Howard H. Rohm
Senior Program Assistant
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U.S. Department of Energy
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Washington, DC 20545

Dear Mr. Rohm:

Subject: U.S. Department of Energy
Energy Economic Data Base (EEDB) Program-Phase III
Contract No. DE-AC02-78ET33020
(formerly EN-78-C-02-4954)

We are transmitting herewith twenty-five (25) copies of "Phase III Final Report and Third Update of the Energy Economic Data Base (EEDB) Program", dated July, 1981. By copy of this letter, ten (10) of these copies are distributed as indicated below.

This document is the final report for work done under Phase III of the subject contract. The report discusses the Energy Economic Data Base and presents the results of the Third Update of the data base, for the effective cost and regulation date of January 1, 1980. Section 4 in general, and Tables 4-1, 4-2, and 4-4, in particular, summarize the technical features and the capital, fuel and operating and maintenance costs of the 11 nuclear and alternative power generating stations in the data base.

This final report contains all of the deliverables required under the subject contract, with the exception of the CONCICE and PEGASUS cost, commodity and equipment computer printouts. CONCICE/PEGASUS cost/equipment and commodity computer printouts are bound separately because of their bulk. One (1) copy of each of 29 volumes of printouts were forwarded to Mr. Kermit Laughon under cover of transmittal letter UE&C/DOE-EEDB-III-17, dated June 29, 1981.

Very truly yours,

R. E. Allen
EEDB Program Project Manager

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CONTENTS

PHASE III FINAL REPORT AND THIRD UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

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PHASE III FINAL REPORT AND THIRD UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

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TABLE LIST

PHASE III FINAL REPORT AND THIRD UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

Sheet 2 of 6

TABLE LIST

PHASE III FINAL REPORT AND THIRD UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

TABLE LIST

PHASE III FINAL REPORT AND THIRD UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

TABLE LIST

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TABLE LIST

PHASE III FINAL REPORT AND THIRD UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

TABLE LIST

PHASE III FINAL REPORT AND THIRD UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

FIGURE LIST

PHASE III FINAL REPORT AND THIRD UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

SECTION 1

1.0 INTRODUCTION

1.1 AUTHORIZATION

The Energy Economic Data Base (EEDB) Program, which deals with the development of cost data for nuclear and comparison electric power generating stations, is authorized by the U.S. Department of Energy (USDOE) and funded under their Contract No. DE-AC02-78ET33020 (formerly EN-78-C-02-4945) with United Engineers & Constructors, Inc.

1.2 OBJECTIVE

The objective of the USDOE EEDB Program is to provide periodic updates of technical and cost (capital, fuel and operating and maintenance) information of significance to the U.S. Department of Energy. This information is intended to be used by USDOE in evaluating and monitoring U.S. Civilian nuclear power programs, and to provide them with a consistent means of evaluating the nuclear option and proposed alternatives.

1.3 THE THIRD UPDATE

In achieving the objective of the EEDB Program, the first-order task of assembling the data base itself and of providing the Initial Update (1978) is complete. The second order task of providing periodic updates is initiated with the Second Update (1979). This report presents the Third Update of the EEDB for a cost and regulation date of January 1, 1980, prepared during Phase III of the EEDB Program.

The intent of the format and structure of this and future reports is to provide a historical record of the evolution of the data base cost estimates and to provide convenience to the user. Therefore, the organization of the first report is retained and the important descriptive and tutorial information, concerning the structure and use of the EEDB, is repeated. This should minimize the necessity to refer to previous reports in the use of this report, but simplify such reference when it is required.

The data tables, which make up the bulk of the report, are updated to January 1, 1980. The data in these tables and in the backup data file, described in Section 2, supercede the information presented in the Second Update (1979). Where required, new descriptive information is added in the text to supplement the data tables.

1.4 CHANGES TO THE DATA BASE FOR THE THIRD UPDATE

Major changes are made to the data base during the Third Update. These changes are initiated by ongoing evaluations of the USDOE EEDB Program objective, relative to the prevailing conditions pertinent to that objective. Specifically, the changes are enumerated as follows:

a. The six loop, 3360 MWt, 1330 MWe HTGR Nuclear Power Generating Station (NPGS) is replaced with a four loop, 2240 MWt, 858 MWe HTGR-Steam Cycle NPGS to reflect the decision by developers of the HTGR concept to concentrate development efforts on the smaller plant.

b. The three loop, 3800 MWt, 1162 MWe CANDU type PHWR NPGS is replaced with a two loop, 3800 MWt, 1260 MWe PHWR NPGS, in order to provide the data base with a PHWR NPGS specifically designed for U.S. siting.

c. The Gas Cooled Fast Breeder Reactor NPGS is deleted from the data base, because the current technical model is outdated and resources for the required revisions are not available within the priorities of the Third Update.

d. An 1170 MWt, 150 MWe HTGR-Process Steam NPGS is added to the data base in order to provide it with a nuclear cogeneration alternative.

e. The LMFBR NPGS is revised to reflect the current developments in the USDOE LMFBR Conceptual Design Study.

f. The wet scrubbers on both of the High Sulfur Coal-Fired Fossil Power Generating Stations (FPGS) are upgraded to current technology and costs.

g. Baghouses and dry scrubbers are added to both of the Low Sulfur Coal-Fired FPGS to meet the New Source Performance Standards, promulgated in early 1979.

h. Construction site labor manhours for the nuclear power generating stations are increased from 11½ to 17 manhours per kilowatt to reflect late 1980 industry acknowledgement that these manhours were being grossly understated. (Additional discussion on this subject may be found in Section 5.5.1).

i. The simplified methodology for determining fuel cycle costs, introduced in the Second Update, is expanded and refined in the Third Update.

j. The general effort to check major cost drivers and to improve data base consistency is continued in the Third Update.

A more detailed discussion of each of these changes appears at the appropriate place in the text of this report.

1.5 DATA BASE COMPONENTS

Currently, the EEDB contains six nuclear electrical generating plant technical models and five comparison coal-fired electrical generating plant technical models. Each of these technical plant models is a complete, detailed, conceptual design for a single unit, steam electric power generating station located on a standard, hypothetical "Middletown" site. Tables 1-1 and 1-2 list respectively the six nuclear and five comparison electrical power generating stations and their associated capabilities. A description of the "Middletown" site is provided in Appendix A-1 for nuclear plants, and Appendix A-2 for coal-fired plants.

Technical models and capital costs for these plants are based on evaluation of related capital cost studies prepared for the Department of Energy and its predecessor agencies, the Energy Research and Development Administration (ERDA) and the Atomic Energy Commission (AEC), and for the Nuclear Regulatory Commission, (NRC) and its predecessor agency, the Atomic Energy Commission, over the last 15 years. In addition, other studies, prepared for various government agencies and other organizations, also contribute to the development of the capital, fuel, and operating and maintenance (O&M) cost data presented in this report. The Base Studies and Reports from which this Third Update has evolved for the technical and capital, fuel and O&M cost data, are tabulated in Tables 1-3, 1-4, and 1-5. These and other associated studies and reports are tabulated more specifically in the list of references included in Section 8.

1.6 ORGANIZATION OF THE REPORT

Section 2 of this report provides a description of the current Data Base, as of September 30, 1980. In Section 3, assumptions and groundrules for this cost update are identified. Section 4 summarizes the Third Cost Update, with cost results summarized in Tables 4-4, 4-5, and 4-6. Section 5 presents the details of the Third Update of the technical conceptual design, the capital cost, the quantities of commodities and their unit costs, and the craft labor manhours and costs for each EEDB Program model. Section 6 and 7 describe the details of the Fuel Cost Third Update and the Operating and Maintenance Costs Third Update, respectively. Section 8 contains a glossary of acronyms and abbreviations used in this report, as well as the complete list of references cited above.

Effective Date - 1/1/80

TABLE 1-1

ENERGY ECONOMIC DATA BASE

THIRD UPDATE
NUCLEAR POWER GENERATING STATIONS

EEDB Model Number	Plant Type	Net Capacity
A1	Boiling Water Reactor Plant (BWR)	1190 MWe
A2	High Temperature Gas Cooled Reactor Plant - Steam Cycle (HTGR-SC)	858 MWe
A3	Pressurized Water Reactor Plant (PWR)	1139 MWe
A4	Pressurized Heavy Water Reactor Plant (PHWR)	1260 MWe
B1	High Temperature Gas Cooled Reactor Plant - Process Steam (HTGR-PS)	150 MWe
A5	Liquid Metal Fast Breeder Reactor Plant (LMFBR)	1457 MWe

Effective Date - 1/1/ 80

TABLE 1-2

ENERGY ECONOMIC DATA BASE

THIRD UPDATE
COMPARISON POWER GENERATING STATIONS

EEDB Model Number	Plant Type	Net Capacity
C1	Comparison High Sulfur Coal Plant (HS12)	1232 MWe
C2	Comparison High Sulfur Coal Plant (HS8)	795 MWe
C3	Comparison Low Sulfur Coal Plant (LS12)	1236 MWe
C4	Comparison Low Sulfur Coal Plant (LS8)	795 MWe
D1	Comparison Coal Gasification Combined Cycle Plant (CGCC)	630 MWe

TABLE 1-3

ENERGY ECONOMIC DATA BASE

TECHNICAL AND CAPITAL COST MODELS BASE DATA STUDIES AND REPORTS

EEDB Model Number	Model Type	Base Data Study or Report*
A1	BWR	Commercial, Electric Power Cost Studies - Capital Cost - Boiling Water Reactor Plant (NUREG-0242, COO-2477-6)
A2	HTGR-SC	The HTGR for Electric Power Generation - Design and Cost Evaluation (Gas Cooled Reactor Associates - GCRA/AE/78-1)
A3	PWR	Commercial Electric Power Cost Studies - Capital Cost - Pressurized Water Reactor Plant (NUREG-0241, COO-2477-5)
A4	PHWR	Conceptual Design of a Large HWR for U.S. Siting (Combustion Engineering, Inc. - CEND-379)
B1	HTGR-PS	1170 MWt HTGR Steamer Cogeneration Plant - Design and Cost Study (UE&C/DOE - 800716)
A5	LMFBR	NSSS Capital Costs for a Mature LMFBR Industry and Addendum (Combustion Engineering, Inc. - CE-FBR-78-532 & CE-ADD-80-310)
C1	HS12	Commercial Electric Power Cost Studies - Capital Cost - High and Low Sulfur Coal Plants - 1200 MWe (Nominal) (NUREG-0243, COO-2477-7)
C2	HS8	Commercial Electric Power Cost Studies - Capital Cost - Low and High Sulfur Coal Plants - 800 MWe (Nominal) (NUREG-0244, COO-2477-8)
C3	LS12	Same as EEDB Model C1
C4	LS8	Same as EEDB Model C2
D1	CGCC	Study of Electric Plant Applications for Low Btu Gasification of Coal for Electric Power Generation (FE-1545-59)

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* Refer to Section 8.1 for additional details

TABLE 1-4

ENERGY ECONOMIC DATA BASE

FUEL COST MODELS BASE DATA STUDIES AND REPORTS

EEDB Model Number	Model Type	Base Data Study or Report*
A1	BWR	a. Commercial Electric Power Cost Studies - Fuel Supply Investment Cost: Coal and Nuclear (NUREG-0246, COO-2477-10) b. Commercial Electric Power Cost Studies - Total Generating Costs: Coal and Nuclear Plants (NUREG-0248, COO-2477-12) c. Fuel Cost Projections (NUREG/CR-1041) d. Fuel Cost Estimates for LWR, HTGR CANDU Type HWR, LMFBR and GCFR (NUS-3190)
A2	HTGR-SC	
A3	PWR	
A4	PHWR	
B1	HTGR-PS	
A5	LMFBR	
C1	HS12	
C2	HS8	
C3	LS12	
C4	LS8	
D1	CGCC	Study of Electric Plant Applications for Low Btu Gassification of Coal for Electric Power Generation (FE-1545-59)

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* Refer to Section 8.1 for additional details

TABLE 1-5

ENERGY ECONOMIC DATA BASE

OPERATING AND MAINTENANCE COST MODELS
BASE DATA STUDIES AND REPORTS

EEDB Model Number	Model Type	Base Data Study or Report*
A1	BWR	A Procedure for Estimating Nonfuel Operating and Maintenance Costs for Large Steam-Electric Power Plants; ORNL/TM-6467
A2	HTGR-SC	Guidelines for Estimating Nonfuel Operating and Maintenance Costs for Alternative Nuclear Power Plants; ORNL/TM-6860
A3	PWR	Same as Model A1
A4	PHWR	Same as Model A2
B1	HTGR-PS	Same as Model A2
A5	LMFBR	Same as Model A2
C1	HS12	Same as Model A1
C2	HS8	Same as Model A1
C3	LS12	Same as Model A1
C4	LS8	Same as Model A1
D1	CGCC	Same as Model A1

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[*] Refer to Section 8.1 for additional details

SECTION 2

2.0 DESCRIPTION OF THE ENERGY ECONOMIC DATA BASE

2.1 PURPOSE, CONTENTS AND USE OF THE DATA BASE

The economics of the nuclear option have been examined for years and many comparisons have been attempted. Some investigators have demonstrated that the nuclear option can compete with alternatives, while others have concluded the opposite. It is difficult to draw broad conclusions about the nuclear option and its alternatives from these studies, because it is often not clear under what circumstances the nuclear option is or is not competitive with alternatives. This uncertainty occurs because of conflicting claims, low visibility of study groundrules and assumptions, and differences or inconsistencies in what is included in the costs of the options that are compared.

In order to assess the economic viability of the nuclear option in a reasonable manner, relative energy costs must be evaluated for a variety of nuclear and alternative power generating stations on a common and consistent basis. The Energy Economic Data Base (EEDB) Program meets this objective for nuclear and comparison coal alternatives.

The EEDB contains capital, fuel and operating and maintenance costs for different types of nuclear and comparison coal-fired power generating stations. Each cost estimate is based upon a detailed technical model which includes system design descriptions for over 400 systems, a detailed equipment list containing over 1250 mini-specifications and up to 10,000 lines of commodity, material and equipment quantities, labor hours and costs. The technical models are based on actual power plant designs and over 50 years of power plant design and construction experience. Site related factors are normalized by locating each technical model on a common hypothetical "Middletown" site, for which there is a detailed written, geological and environmental description.

Costs are given in constant (inflation-free) dollars of the date of the estimate. The EEDB user may make credible cost comparisons among alternatives based on the data as presented. Additionally, the baseline data may be used to develop comparable and reliable life cycle costs and cash flow requirements, through the uniform application of the required factors, such as contingency and allowance for funds used during construction.

The EEDB approach promotes greater understanding and acceptance of comparisons, because all components of "bottom-line" numbers in the different estimates are readily identified. Consequently, differences or similiarities in compared alternatives may be identified as controllable or uncontrollable costs, as inflationary costs or as discretionary costs. The depth of detail furnished is the key to providing the necessary consistency to allow comparison of commodities and components among diverse alternatives and, thereby, to determine the reasons for cost differences.

2.2 SELECTION OF TECHNICAL MODELS FOR THE DATA BASE

Selection of power generating station types and associated fuel cycles to be included in the EEDB is based on the USDOE objectives discussed in Section 1 and the availability of existing cost information.

Nuclear power generating station types are selected to provide a cross-section of current and developing technology experience in the United States. Current technology experience is represented by light water reactor (LWR) power generating stations of intermediate capacity. Converters and breeders are included to represent high potential developing technologies.

Cross Section of Nuclear Technology Experience (See Table 1-1)

Current Technology Light Water Reactors	Developing Technology Converters	Developing Technology Breeder
PWR	HTGR	LMFBR
BWR	PHWR	

Other plant types are selected to provide alternatives for comparison with the nuclear plant types. Current technology experience is represented by coal-fired power generating stations of appropriate size, including plants which burn either high sulfur or low sulfur coals. A coal gasification combined cycle plant is included to provide a basis for comparison to developing technologies.

Cross Section of Comparison Technology Experience (See Table 1-2)

Current Technology High Sulfur Coal	Current Technology Low Sulfur Coal	Developing Technology
800 MWe	800 MWe	Coal Gasification Combined Cycle
1200 MWe	1200 MWe	

Fuel cycles are selected for the nuclear power generating stations that represent current technology and policies. The LWR's and converters are provided with "throwaway" fuel cycles, while the breeders are provided with plutonium recycle fuel cycles.

2.3 COMPOSITION OF THE DATA BASE

The data base is composed of the following five elements for each of the power generating stations listed in Tables 1-1 and 1-2:

a. A Technical (Conceptual Design) Model

b. A Capital Cost Model

c. A Fuel Cycle Cost Model

d. An Operating and Maintenance Cost Model

e. A Back-up Data File

2.3.1 Technical Models

The Technical Models are detailed conceptual descriptions of the plants in the data base, and appear in the Base Data Studies and Reports referenced in Table 1-3. They provide the basis for the level of detail found in the capital cost models and, consequently, to the degree of accuracy for the comparative results reported in the data base.

Each Technical Model is composed of:

a. Heat Cycle Diagram

b. Major System Flow Diagrams

c. Electrical One Line Diagram

d. Plot Plan

e. Major Building and Equipment Arrangement Drawings

f. Detailed Equipment List

Revision of the detailed equipment lists is the means for updating the technical models in the data base. The diagrams, plans and drawings in the base data studies and reports serve as resources for support of the equipment list revisions.

2.3.1.1 Equipment Lists

The detailed equipment lists are developed from PEGASUS (Power Plant Economic

Generator and Scale-Up System), a proprietary computer program of United Engineers & Constructors Inc. of Philadelphia, PA. PEGASUS utilizes an expanded Code-of-Accounts derived from "Guide for Economic Evaluation of Nuclear Reactor Plant Design," USAEC Report NUS-531 (1969), developed for the U.S. Atomic Energy Commission (now Department of Energy and Nuclear Regulatory Commission) by NUS Corporation of Rockville, MD.

The PEGASUS program tabulates engineering data, which describes the equipment and material used in the plant design and their quantities. This is accomplished through use of a mini-specification of standardized format developed for each account in the equipment listing. Mini-specifications are not used for material (e.g., concrete) listings. Samples of two mini-specifications, one for a circulating water pump and its motor and one for medium voltage electrical switchgear, are provided in Tables 2-1 and 2-2.

Additionally, the PEGASUS program contains unit cost data for material and equipment and associated labor data, such as craft manhours, composite craft mixes and craft labor rates. PEGASUS also has the capability of developing technical models for various capacity plants by scaling a known plant capacity model, in accordance with the procedure described in Section 4.

PEGASUS, as the basic Technical Model in the Data Base, directly supports the Capital Cost Models as discussed in Section 2.3.2.

2.3.1.2 Maturity of Technical Models

The structure of the expanded cost Code-of-Accounts, used in the Equipment List, permits the degree of detail entered in the model to vary according to the amount of information that is available. Consequently, mature models, where considerable information is available, are detailed to the "nine-digit" level, whereas less mature models are detailed to the "three-digit" or summary level. Table 2-3 shows the significance of the various levels of detail, as related to the information provided. Nuclear power generating station models detailed to the "nine-digit" level, contain approximately 10,000 lines of information, while comparison power generating station models detailed to the same level, contain approximately 5,000 lines of information. The difference is primarily due to the greater complexity and redundancy of systems in the nuclear power generating station models.

The current update of the EEDB contains technical models of varying degrees of detail. In Tables 1-1 and 1-2, the "A" and "C" models are detailed to the "five-digit" to "nine-digit" levels, and the "B" and "D" models to the "three-digit" or summary level.

2.3.2 Capital Cost Models

The Capital Cost Models for the plants in the data base are developed from CONCICE (CONceptual Construction Investment Cost Estimate), a proprietary computer program of United Engineers & Constructors Inc. of Philadelphia, PA. The CONCICE program utilizes extensive technical and unit cost data from PEGASUS, by means of an interface program, to develop capital cost models. Consequently, the more detailed the Technical Model in PEGASUS, the more detailed the Capital Cost Model developed by CONCICE can be. CONCICE is similar to and compatible with the U.S. Department of Energy CONCEPT code, as illustrated in Table 2-4.

CONCICE contains information for each account in the Technical Model in terms of Factory Equipment, Site Labor and Site Material costs. It categorizes these accounts into Direct and Indirect capital costs, and sums them into a total Base Construction Cost. Table 2-5 illustrates a typical CONCICE Capital Cost Model for a Boiling Water Reactor Plant at the "two-digit" level. When required, the CONCICE computer program can provide a number of economic analyses of the cost models in the data base, as follows:

a. Comparative Economics

b. Cost Projections

c. Cost Analysis

d. Cash Flow Analysis

e. Trend Analysis

f. Parametric Analysis

2.3.3 Fuel Cost Models

Two different fuel cost models are utilized in the EEDB; the Nuclear Fuel Cycle Cost Model and the Coal Fuel Cost Model. The two models are structured differently, as follows:

a. The nuclear fuel cycle model covers a complete reactor fuel cycle from mining of uranium ore through reprocessing of irradiated fuel, recovery of uranium, plutonium or thorium from spent fuel and shipment of high level waste to permanent storage.

b. The coal fuel model includes only the mining of coal and transportation to its point of use. Storage and disposal of wastes are accounted for in the coal plant Operating & Maintenance Cost models.

2.3.3.1 Nuclear Fuels

Development of the nuclear fuel cycle costs generally follows the methodology presented in "Guide for Economic Evaluation of Nuclear Reactor Plant Designs," USAEC Report NUS-531 (1969). Costs are developed and reported in a Code-of-Accounts derived from that report.

Nuclear fuel cycle costs for the EEDB Initial Update are based on cost analyses performed by NUS Corporation (NUS) of Rockville, Maryland, under contract to United Engineers. The current update of the nuclear fuel cycle costs extends the work done in the initial and succeeding updates by following a similar methodology, but utilizing data from more recent reports. Recent market costs are taken from "Fuel Cycle Cost Projections", NUREG/CR-1041 published by Batelle Pacific Northwest Laboratory in December, 1979. Mass flow data are taken from "Nuclear Proliferation and Civilian Nuclear Power Report of the Non-Proliferation Alternative Assessment Program (NASAP)", DOE/NE-0001/9, Volume IX, published by USDOE in June, 1980.

The utility economics of using nuclear fuel for the generation of electricity is simulated by:

a. Providing <u>Direct</u> costs for materials, processes, and services as input.

b. Estimating <u>Indirect</u> costs by an "interest rate" approach which is derivable from a discounted cash flow approach.

The input values for direct costs are selected and adjustments are made to reflect the time-value of money spent before and after utilization of the fuel in the reactor. The net direct costs are amortized in proportion to the amount of energy generated over a fixed calendar time (usually one year). Indirect costs are treated like an interest cost on borrowed money. Such an interest rate may be considered as the composite cost of money, including such parameters as borrowing costs and the rate of return on equity and taxes.

The fuel cycle costs, both direct and indirect, are levelized over a 30-year period using an appropriate discount rate, as stated in the groundrules.

The input nuclear fuel cost components are given with appropriate account designations as unit costs by calendar years, shown typically in Table 2-6. The output nuclear fuel costs are given as 30-year levelized costs in cost per energy unit for appropriate account designations, shown typically in Table 2-7.

2.3.3.2 Coal

The costs of coal as fuel are based on a number of complicating factors which strongly affect the costs to the user. The preponderant coal cost factors are mine-mouth costs and transportation costs.

The quality of coal, as regards both heating value and sulfur content, influences the cost of use, but is so dependent on site specific factors that generalizations are not attempted. Typical costs for high and low sulfur content coals shipped to the representative "Middletown" site are derived, with the extraction and the transportation costs given explicity. The reagent cost for desulfurization products, are traditionally charged against operation and maintenance rather than attributed to the fuel costs. In the EEDB, these costs are included in the appropriate Operating and Maintenance Cost Models.

2.3.4 Operating and Maintenance Cost Models

The Operating and Maintenance (O&M) Cost Models in the EEDB are based on the Oak Ridge National Laboratory report ORNL/TM-6467, "A Procedure for Estimating Nonfuel Operation and Maintenance Costs for Large Steam-Electric Power

Plants." The cost estimating procedure involves the application of empirical functions that represent historical cost experience plus new factors arising from regulatory and economic considerations.

Oak Ridge National Laboratory (ORNL) provides O&M data in the form of staffing and material requirements for each of the EEDB technical models. The O&M costs are generated by OMCOST, a digital computer program developed by ORNL, based on the procedures given in report ORNL/TM-6467.

Although the intent is not to reflect specific operating philosophy or experience, data from published and private sources are examined to insure that the reference plants are realistic. Factors considered in formulating guidelines are plant design, staff training, personnel motivation, outage planning, regulatory provisions, operating load, hours of service, and number of outages and startups.

Tables 2-8 and 2-9 are typical outputs from the OMCOST program with a standard set of accounts for nuclear and fossil power generating stations.

2.3.5 EEDB Back-up Data File

The Back-up Data File contains all of the information and documentation acquired or developed, including the documents listed in Tables 1-3 through 1-5, for the successive updates to produce the data contained in the Data Base Reports. In the interest of keeping the EEDB reports to a manageable size, the following information is omitted from the reports, but is included in the Back-up Data File:

a. Technical Data, including the detailed Equipment Lists, other than the Base Parameter Summaries.

b. Capital Cost Data below the three-digit level.

c. Inflated Operating and Maintenance Cost Data.

d. Resource Data, including all of the documents listed in Tables 1-3, 1-4, and 1-5 and in Section 8.1.

Questions concerning information contained in the Back-up Data File may be addressed to:

United Engineers & Constructors Inc.
30 South 17th Street
P.O. Box 8223
Philadelphia, PA 19101

Attention: R. E. Allen
EEDB Program Project Manager
(215) 422-3734

2.4 APPROACH TO PRESENTATION OF COST DATA

The capital, fuel and operating and maintenance costs developed and presented in the EEDB reports are in constant January 1 dollars of the year covered by the report. The objective is to present comparable baseline costs in the three cost areas of interest that are unencumbered by controversial factors, such as the effects of future inflation, and non-uniform factors, such as costs arising from owner options or utility system configuration. The user of this data may add whatever factors may be desired to the base costs, in order to make reliable comparisons based on unique requirements. This approach promotes greater understanding and acceptance of disputed comparisons, because all components of "bottom-line" numbers are readily identified. Consequently, differences or similarities in compared alternatives may be identified as base costs, inflationary costs or preferential costs. Where comparisons are made of the capital costs of the various alternatives, unit costs, based on tabulated quantities of commodities, can be compared as credibility checks.

2.4.1 Items Not Included in Capital Cost Data

Preferential and utility system related cost components that are NOT included in the capital cost data presented in this report are tabulated in Table 2-10. Many of these non-uniform cost factors are dependent on the choice of the owner rather than on the intrinsic characteristics of the plant. These cost factors, especially those which are related to the time-value of money, are significant fractions of the total costs involved. Because of the variability of these cost factors, they are deliberately excluded from the costs presented herein.

The user of the EEDB may include these costs by making a consistent application of the necessary adders and multiplying factors to the Base Construction Costs for the alternatives of interest. Information related to owner's costs appear in NUREG-0248, "Commercial Electric Power Cost Studies - Total Generating Costs: Coal and Nuclear Plants."

2.4.2 Inflation, Escalation and Discount Rates

Certain time-value terms are used in the EEDB Program. These terms are defined as follows in accordance with their usage in the EEDB:

Inflation Rate (i) - the rate at which the average price of all goods and services in the economy increases.

Escalation Rate (e) - the rate at which the price of a commodity or service increases, independent of any changes due to inflation.

Real Interest Rate (r) - the rate above inflation that is required to attract investment.

Discount Rate (d) - the opportunity cost of capital seen by a firm when used in finding the present value of a series of future cash flows, where $d = (1 + i)(1 + r)$.

Levelized Cost (C_L) - the uniform annual cost of a commodity or service over the lifetime of a facility, in which the commodity or service is utilized, whose stream of payments has the same present value as the stream of the annual predicted costs of the commodity or service over that period.

The capital, fuel and operating and maintenance costs are developed on an inflation-free (constant dollar) basis for the EEDB. Therefore, the inflation rate is zero ($i = 0$) for these cost components. The scarcity of material is negligible for capital and operating and maintenance costs, but may be significant for the cost of coal and nuclear fuels. Therefore, escalation for scarcity is considered to be zero ($e = 0$) for capital and operating and maintenance costs, but equal to or greater than zero ($e \geq 0$) for coal and nuclear fuel costs.

2.4.3 Total Generating Costs and Life Cycle Costs

The base capital, fuel and operating and maintenance costs in this report cannot be summed directly to obtain Total Generating and Life Cycle Costs. A simple summation of the capital, fuel, and operating and maintenance constant dollar unit costs can only give cost data which are useful for comparison of the relative costs of alternatives. These totals are not intended to represent the Total Generating or Life Cycle Costs.

To prepare Total Generating and Life Cycle Costs from data in this report, the excluded items described in paragraph 2.4.1 and the effects of inflation discussed in paragraph 2.4.2, must be combined with the base costs presented herein, in accordance with consistent and documented groundrules and assumptions. Preparation of Total Generating Costs and Life Cycle Costs is beyond the scope of the EEDB Program.

TABLE 2-1

ENERGY ECONOMIC DATA BASE

Effective Date - 1/1/80

MINI-SPECIFICATION - CIRCULATING WATER PUMP

(Cost Basis 01/80)

```
PROG. CM-711 *PEGO3O*

EQUIPMENT LIST - REPORT 1

         MODEL 148 - 1139 MWE/3425 MWT  PWR  -    2.5 IN HG AV - MIDDLETOWN,USA

          ACCOUNT                                                                    DESCRIPTION
           NUMBER             ITEM



         262.1211    CIRCULATING WATER PUMP+MTR

         262.12111   CIRC WATER PUMP                                        QUANTITY         4 X 25 PCT
                                                                            TYPE            MIXED FLOW
                                                                            ORIENTATION     VERTICAL
                                                                            FLOW RATE       147,500 GPM
                                                                            SPEED               320 RPM
                                                                            TDH                 105 FT
                                                                            BHP               4,414 HP
                                                                            NPSH                 30 FT
                                                                            EFFICIENCY           88.6 PCT
                                                                            DESIGN PRESS        150 PSIA
                                                                            DESIGN TEMP         100 F
                                                                            MATERIAL        NI-RESIST COL. AND BOWL
                                                                                            S.S. IMPELLER     .
                                                                            SAFETY CLASS         NNS
                                                                            SEISMIC CAT.         NONE
                                                                            DESIGN CODE

         262.12112   CIRC WATER PUMP MOTOR                                  QUANTITY -       4 X 25 PCT
                                                                            TYPE -          AC INDUCTION
                                                                            HORSEPOWER        5,000 HP
                                                                            SPEED               320 RPM
                                                                            VOLTAGE         13.2 KV, 3 PHASE, 60 HZ
```

TABLE 2-2

ENERGY ECONOMIC DATA BASE

Effective Date - 1/1/80

MINI-SPECIFICATION - CIRCULATING WATER PUMP SWITCHGEAR

(Cost Basis 01/80)

PROG. CM-711 *PEG030*

EQUIPMENT LIST - REPORT 1

MODEL 148 - 1139 MWE/3425 MWT PWR - 2.5 IN HG AV - MIDDLETOWN,USA

ACCOUNT NUMBER	ITEM	DESCRIPTION
241.2131	NON-CLASS 1E 4.16 KV	TWO 4.16 KV BUSES CONSISTING OF INDOOR METAL CLAD SWITCHGEAR : NOMINAL VOLTAGE : 5 KV NOMINAL MVA CLASS : 350 MVA CONTINUOUS CURRENT - INCOMING LINE ACB : 1200 A FEEDER ACB : 1200 A BUS : 1200 A RATED SHORT CIRCUIT CURRENT: 41000 A, RMS@4.76 KV INTERRUPTING TIME : 5 CYCLES CLOSING AND LATCHING CAPABILITY : 78000 A, RMS QUANTITIES - INCOMING LINE : 4 FEEDER : 17 SPACE : 2 PT COMP'TS : 2 EACH BUS IS COMPLETE WITH METERING, PROTECTIVE RELAYING, AND CONTROL LOGIC

TABLE 2-3

ENERGY ECONOMIC DATA BASE

CODE OF ACCOUNTS
EXAMPLE OF LEVELS OF DETAIL

No. of Digits	No. of Account	Name of Account	Function/Level
2	26	Main Condenser Heat Rejection System	Name/Account
3	262	Mechanical Equipment	Name/Sub-Account
4	262.1	Heat Rejection System	Name/System
5	262.15	Main Cooling Twoer Make-up and Blowdown System	Name/Sub-System
6	262.151	Make-up Water System	Name/Sub-Sub-System
7	262.1511	Rotating Machinery	Class/Equipment Category
8	262.15111	Make-up Pump and Motor	Class/Equipment Sub-Category
9	262.151111	Make-up Pump	Class/Component

Note: The final account, in this case the 9th digit, is the line item where specific equipment and material technical and/or cost information is recorded. At levels above the 9th digit, cost information is collected from lower level accounts and recorded as the summation of the lower level accounts. Depending on the complexity of the system, or the level of detail available, the final account may appear at any digit level from the 5th digit to the 9th digit.

TABLE 2-4

ENERGY ECONOMIC DATA BASE

RELATIONSHIP OF "CONCEPT" TO "CONCICE"

"CONCEPT" PROGRAM EVOLUTION		DATA BASE INCORPORATED INTO "CONCEPT" PROGRAM
Year Of Publication	Name	
1971	CONCEPT I	WASH 1230
1973	CONCEPT II	(TECHNICAL CHANGE IN PROGRAM)
1974	CONCEPT III	WASH 1345
1976	CONCEPT IV	NUREG 0241 THROUGH 0248
1978	CONCEPT V	EEDB-I (1978)

Note: The numbers used in CONCEPT I are those developed in WASH 1230, and similarly for each succeeding CONCEPT.

TABLE 2-5

ENERGY ECONOMIC DATA BASE (EEDB)
UNITED ENGINEERS & CONSTRUCTORS INC.
EXAMPLE OF TWO-DIGIT LEVEL COST ESTIMATE
1190 MWe Boiling Water Reactor

Effective Date - 1/1/80

SUMMARY PAGE - 1

PLANT CODE 201 COST BASIS 01/80

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
**********	**************************	*************	************	*************	*************	**************
20 .	LAND AND LAND RIGHTS				2,614,000	2,614,000
21 .	STRUCTURES & IMPROVEMENTS	5,948,078	8622946 MH	119,192,472	62,838,649	187,979,199
22 .	REACTOR PLANT EQUIPMENT	142,955,969	2947200 MH	45,524,161	12,239,234	200,719,364
23 .	TURBINE PLANT EQUIPMENT	129,929,083	2651597 MH	40,221,462	7,964,066	178,114,611
24 .	ELECTRIC PLANT EQUIPMENT	22,966,220	2128879 MH	29,751,797	9,356,756	62,074,773
25 .	MISCELLANEOUS PLANT EQUIPT	9,556,111	483240 MH	7,405,770	1,563,436	18,525,317
26 .	MAIN COND HEAT REJECT SYS	20,775,764	487365 MH	7,039,313	1,769,782	29,584,859
	TOTAL DIRECT COSTS	332,131,225	17321227 MH	249,134,975	98,345,923	679,612,123
91 .	CONSTRUCTION SERVICES	49,907,710	2851800 MH	41,025,600	35,453,000	126,386,310
92 .	HOME OFFICE ENGRG.&SERVICE	156,465,100				156,465,100
93 .	FIELD OFFICE ENGRG&SERVICE	70,613,400			2,744,500	73,357,900
	TOTAL INDIRECT COSTS	276,986,210	2851800 MH	41,025,600	38,197,500	356,209,310
	TOTAL BASE COST	609,117,435	20173027 MH	290,160,575	136,543,423	1,035,821,433

Effective Date: January 1, 1980
(1) System : PWR-U5(LE)/U-T
Start Up : January 1, 1987

TABLE 2-6

ENERGY ECONOMIC DATA BASE
INPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

Account No.	Account Description	Units	SUMMARY OF INPUT QUANTITIES BY CALENDAR YEAR (FIVE YEAR PERIODS)						
			1987	1992	1997	2002	2007	2012	2017
.10	Initital Fuel Loaded	$/KgH							
.11	Uranium Supply	$/KgU							
.111	U_3O_8 Supply	$/lb U_3O_8	43	43	44.1	53.0	64.4	78.4	88.2
.112	UF_6 Conversion Services	$/KgU as UF_6	5.7	5.7	5.7	5.7	5.7	5.7	5.7
.113	Enrichment Services	$/SWU	99	105.6	116.6	123.2	124.3	123.2	122.1
.114	Depleted U Supply	$/KgU							
.12	Plutonium Supply	Parity value							
.13	U-233 Supply	Parity value							
.14	Thorium Supply	$/KgH							
.20	Fabrication	$/KgH	132	134.2	134.2	134.2	133.1	132	135.3
.21	Core Fabrication	$/KgH							
.22	Axial Blanket Fabrication	$/KgH							
.23	Radial Blanket Fabrication	$/KgH							
.30	Shipping to Temporary Storage	$/KgH							
.40	Temporary Storage	$/KgH							
.50	Shipping to Repository	$/KgH	26.4	24.2	22	22	19.8	19.8	17.6
.60	Disposal of Spent Fuel	$/KgH	140.8	140.8	140.8	140.8	140.8	140.8	140.8

---

(1) See Table 6-13 for System Designation

Effective Date: January 1, 1980
(1) System : PWR-U5 (LE)/U-T
Start Up : January 1, 1987

TABLE 2-7

ENERGY ECONOMIC DATA BASE
OUTPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

		OUTPUT QUANTITIES, 30 - YEAR LEVELIZED $/MBtu		
Account No.	Account Description	Direct Cost	Indirect Cost	Total Cost
.00	Total	.66	0.04	0.70
.10	Initial Fuel Loaded			
.11	Uranium Supply			
.111	U_3O_8 Supply	0.33	0.03	0.36
.112	UF_6 Conversion Services	0.01	0.00	0.01
.113	Enrichment Services	0.21		0.23
.114	Depleted U Supply			
.12	Plutonium Supply			
.13	U-233 Supply			
.14	Thorium Supply			
.20	Fabrication	0.06	0.00	0.06
.21	Core Fabrication			
.22	Axial Blanket Fabrication			
.23	Radial Blanket Fabrication			
.30	Shipping to Temporary Storage			
.40	Temporary Storage			
.50	Shipping to Repository	0.01	(0.00)	0.01
.60	Disposal of Spent Fuel	0.04	(0.01)	0.03

---

(1) See Table 6-13 for System Designation.

TABLE 2-8

ENERGY ECONOMIC DATA BASE   Effective Date - 1/1/80

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS FOR (PWR) NUCLEAR PLANT

```
SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
   FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1980.0

     PLANT TYPE IS PWR
     WITH EVAPORATIVE COOLING TOWERS
     NUMBER OF UNITS PER STATION 1
     THERMAL INPUT PER UNIT IS 3412. MWT
     PLANT NET HEAT RATE  10221.
     PLANT NET EFFICIENCY, PERCENT   33.38
     EACH UNIT IS 1139. MWE NET RATING
     ANNUAL NET GENERATION, MILLION KWH  6989.
     WITH A PLANT FACTOR OF 0.70

     STAFF, $1000/YR                     9377. (331 PERSONS AT $28328.)

     MAINTENANCE MATERIAL, $1000/YR      3201.
               FIXED                          3201.
               VARIABLE                          0.

     SUPPLIES AND EXPENSES, $1000/YR     5589.
               FIXED                          5082.
               VARIABLE                        507.

     INSURANCE AND FEES, $1000/YR         494.
               COMM. LIAB. INS.                344.
               GOV. LIAB. INS.                  22.
               RETROSPECTIVE PREMIUM             7.
               INSPECTION FEES & EXPENSES      121.

     ADMIN. AND GENERAL, $1000/YR        2649.

     TOTAL FIXED COSTS, $1000/YR                   20802.
     TOTAL VARIABLE COSTS, $1000/YR                  507.
     TOTAL ANNUAL O & M COSTS, $1000/YR            21310.

     FIXED UNIT O & M COSTS, MILLS/KWH(E)           2.98
     VARIABLE UNIT O & M COSTS, MILLS/KWH(E)        0.07
     TOTAL UNIT O & M COSTS, MILLS/KWH(E)           3.05
```

TABLE 2-9

ENERGY ECONOMIC DATA BASE   Effective Date - 1/1/80

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS FOR (HS12) COAL PLANT

```
SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
   FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1980.0

     PLANT TYPE IS COAL
     WITH EVAPORATIVE COOLING TOWERS
     NUMBER OF UNITS PER STATION 1
     WITH FGD SYSTEMS
     THERMAL INPUT PER UNIT IS 3298. MWT
     PLANT NET HEAT RATE   9134.
     PLANT NET EFFICIENCY, PERCENT   37.36
     EACH UNIT IS 1232. MWE NET RATING
     ANNUAL NET GENERATION, MILLION KWH  7560.
     WITH A PLANT FACTOR OF 0.70

     STAFF, $1000/YR                      7018. (259 PERSONS AT $27096.)

     MAINTENANCE MATERIAL, $1000/YR       2964.
               FIXED                           2295.
               VARIABLE                         669.

     SUPPLIES AND EXPENSES, $1000/YR     15579.
               FIXED                           1694.
               VAR.  - PLANT                    457.
                     - ASH & FGD SLUDGE       13428.

     ADMIN. AND GENERAL, $1000/YR         1101.

     TOTAL FIXED COSTS, $1000/YR                       12107.
     TOTAL VARIABLE COSTS, $1000/YR                    14555.
     TOTAL ANNUAL O & M COSTS, $1000/YR                26662.

     FIXED UNIT O & M COSTS, MILLS/KWH(E)               1.60
     VARIABLE UNIT O & M COSTS, MILLS/KWH(E)            1.93
     TOTAL UNIT O & M COSTS, MILLS/KWH(E)               3.53




     HEATING VALUE OF COAL, BTU/LB         11026.
     COAL BURNED, TONS/YEAR              3131333.
     PERCENT ASH                           11.60
     COST OF ASH DISPOSAL, $/TON            4.84
     PERCENT SULFUR                         3.50
     SULFUR (ORIGINAL),TONS/YR            109597.
     TONS LIMESTONE PER TON SULFUR          4.00
     TONS/YEAR LIMESTONE                  438387.
     COST OF LIMESTONE, $/TON              12.10
     COST OF SLUDGE DISPOSAL, $/DRY TON    14.52
```

TABLE 2-10

ENERGY ECONOMIC DATA BASE

COST BASES FOR POWER PLANT CAPITAL COST ESTIMATES

Include:

- Site Characteristics - Middletown, USA
- Code of Accounts - NUS-531 (Expanded)
- Detailed Statement of Bases:
  - Cost Date
  - Applicable Regulations
  - Applicable Codes & Standards
  - Plant Design Description

Exclude:

- Owner's Cost (Consultants, Site Selection, etc.)
- Fees and Permits (Federal, State, Local)
- State and Local Taxes
- Allowance for Funds Used During Construction
- Escalation
- Contingency
- Owner's Discretionary Items
  - Switchyard and Transmission Costs
  - Generator Step-up Transformer
  - Waste Disposal Costs
  - Spare Parts
  - Initial Fuel Supply
  - Nuclear Liability and Other Insurance

SECTION 3

3.0 ASSUMPTIONS AND GROUND-RULES FOR THE THIRD COST UPDATE

3.1 EFFECTIVE DATE OF THE EEDB THIRD UPDATE

The effective (cost and regulatory basis) date of this report is January 1, 1980.

3.2 COST PARAMETER GROUND-RULES

3.2.1 Base Costs

Base costs are developed in constant January 1, 1980 dollars, and are presented in the following forms:

a. Capital Costs

- $$\text{Present Costs (\$)} = \text{Direct plus Indirect Costs} \qquad (1)$$
- $$\text{Capacity Costs (\$/kWe)} = \frac{\text{Present Costs(\$)}}{\text{(CAP)}} \qquad (2)$$
- $$\text{Electric Energy Costs(m/kWh)} = \frac{\text{(Present Costs(\$))(1000 mills/\$)}}{\text{(CAP)(CF)(365 d/y)(24 h/d)}} \cdot \text{FCR} \qquad (3)$$

b. Fuel Costs

- Thermal Energy Costs (TEC) (¢/MBtu)
- $$\text{Electric Energy Costs (m/kWh)} = \text{(TEC)(HR)(10 mills/¢)}/(10^6) \qquad (4)$$

c. Operating and Maintenance Costs

- Present Annual Costs (PAC) ($/y)
- $$\text{Electric Energy Costs (m/kWh)} = \frac{\text{(PAC)(1000 mills/\$)}}{\text{(CAP)(CF)(365 d/y)(24 h/d)}} \cdot \text{LF} \qquad (5)$$

where:

CAP = Net Electrical Capacity in kWe*
(Net Power to Generator Step-Up Transformer)

CF = Capacity Factor in %+

FCR = Fixed Charge Rate in %/y+

HR = Net Station Heat Rate in Btu/kWh*

LF = Levelization Factor+

* These values are summarized for each model in Tables 4-1 and 4-2.
+ These values are given in Section 3.2.2.

3.2.2 Cost Parameters(1)

Cost parameters used are as follows:

Capacity Factor	70.0% (assumed)
Fixed Charge Rate	8.7%/y(2)
Inflation Rate	i = 0%/y
Escalation Rate	e = 0%/y(3)
Return on Investment	ROI = 3.5%/y(2)
Discount Rate	d = 3.5%/y(2)
Levelization Period (Fuel Cycle and O&M)	30 years (assumed)
Levelization Factor (O&M)	1(4)

Notes:

1. Costs reported in this update are derived on an inflation-free basis (i = 0%/y, e = 0%/y, d = 3.5%/y).
2. A discussion of the development of these eocnomic parameters are found in Appendix B.
3. The escalation rate is equal to or greater than zero for fuels, as discussed in Section 2.4.2.
4. A discussion of the development of this economic parameter may be found in Section 7.

3.2.3 Commercial Operation Dates

A commercial operation date is selected for each plant model to provide a basis for selecting fuel costs for the fuel cycle cost models. This is necessary because fuel costs may escalate due to scarcity, as discussed in Section 2.4.2.

Commercial operation dates are assumed to be January 1 of the year indicated below. Case I represents a sequential scenario with start-up of plants occurring in the year when the technology is assumed to be ready. Case II is a scenario for the earliest year when all of the technologies are assumed to be ready.

EEDB Model Number	Model Type	Commercial Operation Dates Case I	Case II
A1	BWR	1980/1987	2001
A2	HTGR-SC	1995	2001
A3	PWR	1980/1987	2001
A4	PHWR	1995	2001
B1	HTGR-PS	2001	2001
A5	LMFBR	2001	2001
C1	HS12	1980/1987	2001
C2	HS8	1980/1987	2001
C3	LS12	1980/1987	2001
C4	LS8	1980/1987	2001
D1	CGCC	1987	2001

The BWRs and PWRs are the only full scale nuclear plants currently operating on a commercial basis in the United States. For this reason, the costs of the Light Water Reactors are included for the earliest study date, January 1, 1980. Four of the coal-fired generating stations are currently operational and the costs for these are also given for January 1, 1980. It is assumed that the technology supporting the other nuclear plant types will mature at later dates. Data are also provided for the Light Water Reactors and the coal-fired plants in 1987, because it is assumed that the CGCC coal plant option will be operational by that date. Costs projected to 2001 are given for all of the nuclear and coal comparison plants.

Comparisons of alternatives having significantly different capital and fuel costs need to be considered in terms of common startup dates. This is especially important if low fuel costs of a given alternative tend to offset high capital costs, because capital cost escalation is zero on a constant dollar basis while fuel cost escalation is driven by scarcity.

3.3 TECHNICAL MODEL GROUND-RULES

3.3.1 General Ground-Rules

General assumptions and ground-rules for the Technical Models in the Base Data Studies and Reports listed in Table 1-3 and in the EEDB Initial and Second Updates are given below. Except for the cost and regulation effective date of January 1, 1980, the same assumptions and gound-rules apply to the Third Update of the EEDB, including each of the replacement Technical Models.

a. Cost data is based on prices effective as of January 1, 1980.

b. A full complement of licensing and design criteria, circa January 1, 1980, are utilized. Safety classifications, seismic categories and design codes for major structures and equipment are given in the Base Data Studies and Reports listed in Table 1-3.

c. The detailed technical models are developed for a single unit with sufficient land area to accommodate an identical second unit.

d. The design of the main heat rejection systems are based upon the use of mechanical draft wet cooling towers, and natural draft cooling towers (CGCC only). The nuclear plant ultimate heat sinks are based on mechancial draft wet cooling towers and mechanical draft dry cooling towers (HTGR only).

e. Each conceptual design utilizes two independent offsite sources of power; one at 500 kV and the other at 230 kV.

f. The design life for nuclear power generating stations (NPGS) is 40 years and for fossil power generating stations (FPGS) is 30 years; however, useful operating life is considered as 30 years for each.

g. Generating stations are base-loaded during the first part of their design life.

3.3.2 Specific Ground-Rules

Specific assumptions and ground-rules for each of the technical models of the Base Data Studies and Reports listed in Table 1-3 and for the EEDB Initial and Second Updates are given below. The same assumptions and ground-rules apply to those technical models remaining in the EEDB for the Third Update, with some modifications. Details of these modifications are given in Section 5.4. Additonally, assumptions and ground-rules are given for each of the replacement and new Technical Models in the Third Update.

3.3.2.1 Boiling Water Reactor (BWR) NPGS - Base Data Study

a. Plant design is based on the General Electric Technical Reference Plant Design, the General Electric Standard Safety Analysis Report (GESSAR), the General Electric 238 Inch Reactor Pressure Vessel (RPV) Nuclear Island Study Arrangements, and United Engineers' experience.

b. The reactor plant design is based upon the General Electric documents listed in paragraph a. above.

3.3.2.2 High Temperature Gas Cooled Reactor - Steam Cycle (HTGR-SC) NPGS - Base Data Study (a replacement Technical Model)

a. Plant design is based on "The HTGR for Electric Power

Generation - Design and Cost Evaluation" study, September, 1980, performed by United Engineers for Gas Cooled Reactor Associates.

b. Reactor plant design is based on a 2240 MWt, 858 MWe, 1000°F, 2400 psig HTGR Nuclear Steam Supply System, developed by General Atomic Company for the study listed in paragraph a. above.

c. Helium inventory is not included.

d. This HTGR NPGS is located on a site in Eastern Pennsylvania. The EEDB Third Update incorporates the necessary modifications to meet the ground rules that the HTGR NPGS is located on the "Middletown" site.

3.3.2.3 Pressurized Water Reactor (PWR) NPGS - Base Data Study

a. Plant design is based upon principal technical features corresponding to the Public Service Company of New Hampshire Seabrook Station, circa, July, 1976.

b. The reactor plant design is based upon the Westinghouse Reference Safety Analysis Report (RESAR-3S).

3.3.2.4 Pressurized Heavy Water Reactor (PHWR) NPGS - Base Data Study (a replacement Technical Model)

a. Plant design is based upon the "Conceptual Design of a Large Heavy Water Reactor for U.S. Siting", report number CEND-379, September, 1979.

b. The reactor concept is a two-loop, pressure tube design, heavy-water cooled and moderated type developed by Combustion Engineering and United Engineers for the study listed in paragraph a. above.

c. Where insufficient information is available, application design data from the Base Data Study (See Table 1-3) for the Pressurized Water Reactor NPGS is utilized.

d. The inventory of heavy-water for moderator and coolant is not included.

3.3.2.5 High Temperature Gas Cooled Reactor-Process Steam (HTGR-PS) NPGS - Base Data Study (a new Technical Model)

a. Plant design is based upon the "1170 MWt HTGR Steamer Cogeneration Plant - Design and Cost Study", report number UE&C/DOE 800716, August, 1980, performed by United Engineers and General Atomic Company for USDOE.

b. Reactor plant design is based upon a 1170 MWt, 150 MWe, 750°F, 650 psia HTGR Nuclear Steam Supply System, developed by General Atomic Company for the study listed in paragraph a. above.

c. Helium inventory is not included.

d. This HTGR NPGS is located on a site in Eastern Pennsylvania. The EEDB Third Update incorporates the necessary modifications to meet the ground-rule that the HTGR NPGS is located on the "Middletown" site.

3.3.2.6 Liquid Metal Fast Breeder Reactor (LMFBR) NPGS - Base Data Study

a. Plant design is based upon the target economic design described by Combustion-Engineering, Inc. in the Base Data Study (See Table 1-3) for a 1457 MWe LMFBR.

b. The reactor plant design is based upon the Combustion-Engineering, Inc., concept listed in paragraph a. above.

c. The inventory of sodium and NAK for primary and intermediate heat transport system coolant is not included.

3.3.2.7 High and Low Sulfur Coal-Fired (HS12, HS8, LS12 and LS8) FPGS - Base Data Studies

a. Plant designs incorporate a once-through, supercritical pressure, single reheat type, steam generator to supply steam to cross-compound, eight-flow turbines for the 1200 MWe units (HS12 and LS12) and to tandem-compound, four flow turbines for the 800 MWe units (HS8 and LS8.)

b. The steam generators for both the high sulfur coal-fired plants (HS12 and HS8) and the low sulfur coal-fired plants (LS12 and LS8) are designed for either a high sulfur Eastern coal or a low sulfur Western coal.

c. Each plant coal handling system is designed to unload a 100-car, unit train in five hours. The design provides indoor coal storage silos with a capacity sufficient for eight hours consumption at maximum rated capacity and an outdoor storage area with a capacity sufficient for 60 days consumption at maximum rated capacity.

d. Plant design for each high sulfur coal-fired plant (HS12 and HS8) includes a wet lime scrubber system for removal of sulfur-dioxide (SO_2) and an electrostatic precipitator for removal of particulates from the flue gas.

e. Plant design for each low sulfur coal-fired plant (LS12 and LS8) includes a dry lime scrubber and bag-house for removal of sulfur-dioxide (SO_2) and particulates from the flue gas.

3.3.2.8 Coal Gasification Combined Cycle (CGCC) FPGS - Base Data Study

a. Plant design is based on the reference process given in Table 1-3.

3.4 FUEL CYCLE COSTS GROUND-RULES

3.4.1 Nuclear Power Generating Stations

a. Operating life of nuclear plants are taken to be 30 years. Costs of individual expense items are given in the year of their occurrence and are levelized over the plant life.

b. Mass flow and related data are based upon NASAP (Non-Proliferation Alternative Systems Assessment Program) information.

c. Costs of current interest are those for "throwaway" cycles for the thermal reactors and plutonium recycle for the breeder reactors.

d. It is assumed that reprocessing of spent fuel is introduced when breeders are phased into use. Prior to that time, spent fuel elements from "throwaway" cycles are assumed to be shipped to a Federal repository.

e. Costs of onsite storage facilities for spent fuel are included in the plant capital costs in the Capital Cost Models, as described in Table 4-1.

f. It is assumed that plutonium bred from U-238 in breeder cycles has no economic value.

g. It is assumed that tails assay for enrichment is 0.2 percent by weight of U-235.

h. No credit is given for advanced isotope separation processes.

3.4.2 Fossil Power Generating Stations

a. Coal costs for plants starting up on January 1, 1980 reflect the results of the 1978 first quarter compensation settlement of the United Mine Workers contract. These additional cost effects are included in coal costs for plant startups in 1987 and 2001.

b. Coal cost data are derived from the sources listed below:

1. Messing, R. F. and Harris, H. E.: "Comparative Energy Values to 1990," Report No. R770602, Impact Securities Corp., (Subsidiary), Arthur D. Little, Inc., Cambridge, MA 02140, June, 1977.

2. Browne, Thomas E., et al. (Seven Authors): "Supply 77-EPRI Annual Energy Supply Forecasts," Report No. EA-634-SR, Electric Power Research Institute, Palo Alto, CA 94304, May, 1978.

3. Private Communication - "Estimates of Baseline Delivered Coal Costs" (PWC Job No. 3592) - Paul Weir Co., 20 North Wacker Drive, Chicago, IL 60606, October 13, 1978.

4. Monthly Energy Review, U.S. Department of Energy, Energy Information Administration, Washington, D.C. 20461 (Monthly Through January 1981).

SECTION 4

4.0 SUMMARY OF THIRD COST UPDATE

4.1 TECHNICAL SUMMARY

The current status of the Technical Models Base Parameters for the Third Update is summarized in Table 4-1 for Nuclear Power Generating Stations and Table 4-2 for Comparison Plants. These summaries present a listing of important or key parameters that establish the technical envelope of each plant.

4.2 FUEL CYCLE SUMMARY

Mass flows selected for each of the nuclear plants are presented in Table 4-3. Much of this data was derived from Non-Proliferation Alternative Systems Assessment Program (NASAP) information. NASAP calculations are based on a capacity factor of 75 percent, while the capacity factor selected for the EEDB is 70 percent. However, review of sensitivity of Fuel Cycle Costs to such a change in capacity factor reveals that the impact on alternative comparisons is negligible.

4.3 COST SUMMARY

Capital, Fuel, and Operating and Maintenance Costs are summarized for all plants, for their respective capacities, in Table 4-4. Tables 4-5 and 4-6 summarize the same data, except that the capital and O&M costs are normalized to the same net electrical and thermal capacities respectively. Table 4-7 lists footnotes for Tables 4-4, 4-5, and 4-6. The direct cost for each plant account at the two-digit level is normalized by using the following relationship and the appropriate scaling factor:

$$\frac{C_1}{C_2} = \left(\frac{P_1}{P_2}\right)^n$$

where: C_1 = Plant 1 Account Cost

C_2 = Plant 2 Account Cost

P_1 = Plant 1 Capacity

P_2 = Plant 2 Capacity

n = Scaling Factor

For the Third Update, values of "n" are estimated based on past experience. Values derived are 0.41 for BWR, PWR, and PHWR; 0.47 for HTGR and LMFBR; and 0.85 for HS12, HS8, LS12, and LS8. Since the indirect costs are directly proportional to the direct costs, the indirect costs are normalized by applying the following relationship:

$$\frac{C_{I1}}{C_{I2}} = \frac{C_{D1}}{C_{D2}}$$

where: C_{I1} = Plant 1 Total Indirect Cost

C_{I2} = Plant 2 Total Indirect Cost

C_{D1} = Plant 1 Total Direct Cost

C_{D2} = Plant 2 Total Direct Cost

Operating and Maintenance costs are normalized by recalculating the O&M costs from OMCOST with adjusted staffing and material inputs.

Care must be exercised in using the values developed in Table 4-6. At 3800 MWt, current tandem-compound or cross-compound turbine technology is exceeded by the net electric capacity for the HTGR-SC plant, and is questionable for the HS12, and LS12 plants. Domestic design of such plants in 1980 would require twin-turbines with associated increased capital costs for the turbines, turbine pedestals, turbine building, auxiliary systems and equipment and additional steam header piping and valves. Therefore, for 1980, the capital costs in Table 4-6 for these two plants should be increased by 10-20 percent of their respective base direct costs. However, it is anticipated that at some point in the future, required turbine technology will be available for all of the base plants and the costs in Table 4-6 will apply, providing they are adjusted to then current dollars in the year the technology is available.

4.4 COMMODITY AND MANHOUR SUMMARIES

Commodity summaries for nuclear and fossil power generating stations are given in Tables 4-8 and 4-9 respectively. Site labor summaries by craft are given for nuclear and fossil power generating stations in Tables 4-10 and 4-11 respectively. This information is derived from the data included in the Capital Cost Models for the base plants, which are presented in Section 5.

4.5 SUMMARY OF SIGNIFICANT COST PERTURBATIONS

The Third Update of the EEDB has evolved from the studies referenced in Tables 1-3 through 1-5 and the EEDB Initial and Second Updates, as discussed in Sections 1 and 2. Significant cost perturbations have occured between the preparation of the Second Update and the cost and regulation date of this Third Update. These perturbations are addressed separately below for capital, fuel, and operating and maintenance costs.

4.5.1 Capital Costs

The direct costs of all of the base plants are escalated to January 1, 1980 in accordance with the EEDB Capital Cost Update Procedure described in the Initial Update Report. Three plant models are replaced and individual accounts are modified and improved in definition as discussed in Section 5.4. Additionally, labor costs are increased, as discussed in Section 5.5.1, to allow for the industry experience that labor costs during the last several years continue to be understated.

The 1330 MWe, six loop, HTGR plant model is replaced with an improved 858 MWe, four loop, HTGR plant model. The replacement is based on extensive concept improvements made by Gas Cooled Reactor Associates (GCRA), a utility sponsored group dedicated to develop a commercially competitive HTGR Nuclear Power Generating Station. The 858 MWe HTGR represents a GCRA/General Atomic Company consensus that the improved four loop plant is currently the most likely concept to be deployed.

The 1162 MWe, three loop, CANDU type PHWR plant model is replaced with a 1260 MWe, two loop, U.S. design. The replacement is based upon a study for the conceptual design of a large heavy water reactor for U.S. siting, as described in Section 1.0.

The 917 MWe GCFR plant model is deleted, because the EEDB base model is sufficiently out-of-date to be of little value in comparing nuclear alternatives. Insufficient data and resources are currently available to prepare a replacement for the GCFR plant model. It is anticipated that when data and resources are available, the GCFR will be returned to the data base.

In place of the GCFR plant model, an 1170 MWt, 150 MWe HTGR-Process Steam Cogeneration plant model is included to provide information on high temperature nuclear derived process steam cogeneration applications.

The LMFBR Plant model is based on a "Target Economics" approach, as described in the EEDB Initial Update. In the Second Update of the EEDB, significant improvement is made in definition and detail in the Balance-of-Plant. These improvements and refinements allow the LMFBR model to be fully expanded and reported at the nine-digit code-of-accounts level of detail for cost, equipment and commodity tabulations. Additional improvement is made in this Third Update of the EEDB. Resultant target costs reflect a commercial reactor deployed in the year 2001, utilizing unit costs and quantities that represent a lower bound of possible LMFBR capital costs.

Revisions to the New Source Performance Standards require additional scrubbing for the high sulfur coal units and the addition of scrubbers to the low sulfur coal units. Since these new requirements were implemented by the cost and regulation date of January 1, 1980, adjustments are made to both the high and low sulfur coal plant Technical and Capital Cost Models in this Third Update of the EEDB.

4.5.2 Fuel Costs

The cost of raw U_30_8 in the nuclear fuel cycle (except for breeders) accounts for roughly 50% of the total cycle cost. The behavior of the market in U_30_8 over the past eight years is extremely erratic. Following the oil embargo of 1973, the forward price of U_30_8 rose steadily, reaching a point about six times above its price in 1973. However, new discoveries in Australia and Canada and the virtual elimination of new nuclear utility plant orders are currently causing the market to drop precipitiously.

In the Initial Update, concern is expressed that the price for U_30_8 may understate the fuel cycle costs, especially in projections to later years. For the

Second and Third Updates, it is thought that the initial values may be reasonably correct, and that the most recent long range projections may overstate the U_3O_8 cost. Predictions of U_3O_8 costs, especially those that extend into the next century, should be treated as educated guesses. For the Third Update, this view is tempered by the fact that U_3O_8 costs advanced very little from 1979 to 1980, relative to the general advance in inflation.

The remaining portions of the nuclear fuel cycle are more stable; however, those portions of the cycle involving fuel reprocessing and recovery are based on predictive analyses from government weapons operations, rather than on commercial experience.

Coal costs used for plants that start-up on January 1, 1980, include the impact of the 1978 coal strike settlement. The coal costs projected for future years also take account of the results of the contract settlement.

4.5.3 Operating and Maintenance Costs

O&M costs reported from OMCOST are refined on a continuous basis by ORNL to reflect the latest factors arising from regulatory and economic considerations. As a result of this continuous refinement, O&M cost projections have risen from previous estimates, and compare more favorably with actual reported experience. It is expected that this trend will continue in future EEDB updates.

4.6 IMPACT OF TMI (Three-Mile Island NPGS Incident)

At the present time, only a first approximation is available for the cost impact of TMI. In general, \$7 x 10^6 may be added to the Base Capital Cost and \$5 x 10^6 per year may be added to the Operating and Maintenance Costs for each NPGS to account for the cost impact of the lessons learned at TMI. Additional discussion is given in Sections 5.5 (Capital Costs) and 7.6 (O&M Costs).

Effective Date - 1/1/80

Sheet 1 of 4

TABLE 4-1

ENERGY ECONOMIC DATA BASE

NUCLEAR PLANT TECHNICAL MODELS BASE PARAMETER SUMMARY

Model Key Elements	BWR	HTGR-SC	PWR	PHWR	HTGR-PS	LMFBR
General Site	Middletown* Appendix A-1					
Operation	Base Load					
Cost Estimate Ref. Data	January 1, 1980					
Plant Life, Years	30 Years					
Number of Units	Single	Single	Single	Single	Single	Single
Net Power to GSU+	1190 MWe	858 MWe	1139 MWe	1260 MWe	150 MWe	1457 MWe
Net Plant Heat Rate, Btu/kWh	10,261	8,440	10,224	10,338	21,572	8,994
Net Plant Efficiency, %	33.26	38.3	33.38	33.16	12.82	38.34
Fuel (Initial Core)	UO_2	UO_2 + Th	UO_2	UO_2	UO_2 + Th	UO_2 + PuO_2
	3% Enriched	20% Enriched	3% Enriched	Slightly Enriched	20% Enriched	0.88% Enriched
Nuclear Fuel Storage	5/4 Core	1.3 Core	4/3 Core	4/3 Core	1.3 Core	4/3 Core
LICENSING						
Codes and Standards Reference Year	January 1, 1980					
CIVIL/STRUCTURAL						
Flooding Provision	No Special Provisions					
Turbine Building	Enclosed					
Seismic	SSE 0.25g OBE 0.125g					
Foundations	Rock a) Cat I-Mat b) Non-Cat I-Spread Ftgs.					

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*Modified to reflect January 1980 criteria

+Generator Step-up Transformer

TABLE 4-1

Effective Date - 1/1/80

ENERGY ECONOMIC DATA BASE

Sheet 2 of 4

NUCLEAR PLANT TECHNICAL MODELS BASE PARAMETER SUMMARY

<table>
<tr><th>Model
Key Elements</th><th>BWR</th><th>HTGR-SC</th><th>PWR</th><th>PHWR</th><th>HTGR-PS</th><th>LMFBR</th></tr>
<tr><td>Containment</td><td>Steel Containment w/Reinf. Concrete</td><td>Reinforced Concrete w/ Steel Liner</td><td>Reinforced Concrete w/ Steel Liner</td><td>Reinforced Concrete w/ Steel Liner</td><td>Reinforced Concrete w/ Steel Liner</td><td>Reinforced Concrete w/ Steel Liner</td></tr>
<tr><td>Turbine Pedestal</td><td colspan="6">High Tuned</td></tr>
<tr><td>Grade Elevation</td><td colspan="6">+ 18' 0"</td></tr>
<tr><td>Water Table</td><td colspan="6">+ 10' 0"</td></tr>
<tr><td>100 Year Maximum</td><td colspan="6">+ 8' 0"
100 Yrs. flood</td></tr>
<tr><td>External Missiles</td><td colspan="6">Tornadoes Only</td></tr>
<tr><td>MECHANICAL</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Steam Generator Type</td><td>None</td><td>Helical Coil Economizer/ Evaporator/ Superheater</td><td>Shell & Tube Heat Exchanger</td><td>Shell & Tube Heat Exchanger</td><td>Helical Coil Economizer/ Evaporator/ Superheater</td><td>Single Wall, Straight Tube Once Through Combined Evaporator/ Superheater</td></tr>
<tr><td>Primary Coolant Pumps</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Number</td><td>2</td><td>4</td><td>4</td><td>4</td><td>2</td><td>4/4**</td></tr>
<tr><td>Drive</td><td>Motor</td><td>Electric</td><td>Motor</td><td>Motor</td><td>Electric</td><td>Motor/Motor**</td></tr>
<tr><td>Flow</td><td>42,000 gpm</td><td>9.3x10^{6}lb/h</td><td>94,400 gpm</td><td>70,300 gpm</td><td>4.9x10^{6}lb/h</td><td>86,200 gpm/76,700 gpm**</td></tr>
<tr><td>Turbine Generator</td><td>Tandem Compound
6 flow, 1800 r/min
43" LSB</td><td>Tandem Compound
6 flow, 3600 r/min
31" LSB</td><td>Tandem Compound
6 flow, 1800 r/min
43" LSB</td><td>Tandem Compound
6 flow, 1800 r/min
43" LSB</td><td>Cross Compound
2 flow, 3600 r/min
6" LSB
LP Turbine - 29% flow</td><td>Tandem Compound
6 flow, 1800 r/min
43" LSB</td></tr>
<tr><td>Main Steam Conditions at HP Turbine Inlet</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Pressure, psia</td><td>960</td><td>2415</td><td>975</td><td>1085</td><td>2415</td><td>2200</td></tr>
<tr><td>Temperature, F</td><td>544</td><td>1000</td><td>544</td><td>554</td><td>1000</td><td>850</td></tr>
<tr><td>Flow, 10^{6}lb/h</td><td>13.9</td><td>7.3</td><td>13.7</td><td>16.3</td><td>3.8</td><td>14.39</td></tr>
<tr><td>Turbine Generator Rating</td><td>1235.4 MWe @
2.5 in-HgA</td><td>935 MWe
2.5 in-HgA</td><td>1192.4 MWe @
2.5 in-HgA</td><td>1343.6 MWe @
2.5 in-HgA</td><td>187 MWe @
2.5 in-HgA</td><td>1547 MWe @
2.5 in-HgA</td></tr>
<tr><td>Condensers</td><td>3 Single Shell
Transverse arrg.
Two pass
Split water box
Single Pressure</td><td>3 Single Shell
Longitudinal
Two pass
Split water box
Single Pressure</td><td>3 Single Shell
Transverse arrg.
Two pass
Split water box
Single Pressure</td><td>3 Single Shell
Transverse arrg.
Two pass
Split water box
Single Pressure</td><td>1 Single Shell
Longitudinal
One pass
Split water box
Single Pressure</td><td>3 Single Shell
Transverse arrg.
Two pass
Split water box
Single Pressure</td></tr>
</table>

** Primary loop/Secondary loop

Effective Date - 1/1/80

Sheet 3 of 4

TABLE 4-1

ENERGY ECONOMIC DATA BASE

NUCLEAR PLANT TECHNICAL MODELS BASE PARAMETER SUMMARY

Model Key Elements	BWR	HTGR-SC	PWR	PHWR	HTGR-PS	LMFBR
MECHANICAL (Cont'd)						
Cooling Tower Design Conditions	Mechanical Wet Evaporation Cooler					
Approach	18F					
Range	26F					
Wet Bulb	74F					
Ultimate Heat Sink (Cooling Tower Type)	Mechanical Wet Evaporative Cooling Tower	Mechanical Wet Evaporative Cooling Tower and Air Blast Heat Exchanger	Mechanical Wet Evaporative Cooling Tower	Mechanical Wet Evaporative Cooling Tower	Mechanical Wet Evaporative Cooling Tower and Air Blast Heat Exchanger	Air Blast Heat Exchangers
Boiler Feed Pumps						
Main: Number-Drive	2-Turbine	3 -Turbine	2-Turbine	2-Turbine	2-Motor	2-Turbine
Other: Number-Service-Drive	1-Start-up-Motor	3 -Booster Turbine	2-Emergency 1-Motor 1-Turbine 1-Start-up-Motor	2-Emergency-Motor	2-Booster-Turbine 3-Booster-Motor	2-Booster Motor
Boiler Feed Water Heater						
No. of Open Stages	None	1 @ 1 train	None	None	1 @ 1 train	1 @ 1 train
No. of HP Closed Stages	1 @ 2 trains	1 @ 2 trains and	1 @ 2 trains	2 @ 2 trains	1 @ 2 train	1 @ 3 trains*
No. of LP Closed Stages	4 @ 3 trains and 1 @ 2 trains	4 @ 2 trains	4 @ 3 trains and 1 @ 2 trains	4 @ 3 trains	2 @ 2 train	4 @ 2 trains
Stages of Reheat	One-Steam Reheat	None	One-Steam Reheat	One-Steam Reheat	None	Two Steam Reheat
ELECTRICAL						
Connection to Offsite Power	1 @ 500 kV 1 @ 230 kV					
Generator						
Power Factor	0.9	0.9	0.9	0.9	0.9	0.9
Short Circuit Ratio	0.58	0.50	0.58	0.58	0.50	0.58
Rating	1,400 MVA	1,040 MVA	1,350 MVA	1,400 MVA	155 MVA 52 MVA	1718 MVA
Generator Disconnect	Load Break Switch					

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* IP Closed Stage

Effective Date - 1/1/80

Sheet 4 of 4

TABLE 4-1

ENERGY ECONOMIC DATA BASE

NUCLEAR PLANT TECHNICAL MODELS BASE PARAMETER SUMMARY

Model Key Elements	BWR	HTGR-SC	PWR	PHWR	HTGR-PS	LMFBR
ELECTRICAL (Cont'd)						
Auxiliary Power System Voltage	13.8 kV, 4.16 kV and 480 Volts	13.8 kV and 480 Volts	13.8 kV, 4.16 kV and 480 Volts	13.8 kV, 4.16 kV and 480 Volts	13.8 kV and 480 Volts	13.8 kV, 4.16 kV and 480 Volts
Unit Auxiliary Transformer Nameplate Rating***	80 MVA	103 MVA	90 MVA	130 MVA	103 MVA	131 MVA
Reserve Auxiliary Transformer Nameplate Rating***	80 MVA	103 MVA	90 MVA	55 MVA	103 MVA	73 MVA
Control Room Wiring	← Wired Directly to Panels in Control Room →					
Multiplexing of BOP Cables	← None →					
Instrumentation	← Independent Sensors for Computer Input →					

*** Total of all transformers at top class of cooling rating.

Effective Date - 1/1/80

Sheet 1 of 4

TABLE 4-2

ENERGY ECONOMIC DATA BASE

COMPARISON PLANT TECHNICAL MODELS BASE PARAMETER SUMMARY

Model Key Elements	HS12	HS8	LS12	LS8	CGCC
General Site	Middletown* Appendix A-2				
Operation	Base Load				
Cost Estimate Ref. Date	January 1, 1980				
Plant Life, Years	30 Years				
Number of Units	Single				
Net Power To GSU+	1232 MWe	795 MWe	1236 MWe	795 MWe	630 MWe
Coal Firing Rate, Tons/Day	12,264	8,208	17,328	11,592	4,680
Net Plt Ht Rate, Btu/kWh	9,147	9,488	9,515	9,901	8,250
Net Plant Efficiency, %	37.31	35.97	35.87	34.46	41.37
Fuel	Eastern Coal Moisture (% by wt) 11.31 ----- Ultimate Analysis (% by wt dry) Carbon 69.33 Hydrogen 4.90 Nitrogen .86 Chlorine .04 Sulfur 3.61 Oxygen 9.64 ----- Calorific Value (Btu/lb) As Received 11,026 Dry 12,432	Same as HS12	Western Coal Moisture (% by wt) 31.8 ---- Ultimate Analysis (% by wt dry) Carbon 69.3 Hydrogen 5.2 Nitrogen 0.9 Chlorine - Sulfur 0.5 Oxygen 16.8 ----- Calorific Value (Btu/lb) As Received 8,164 Dry 11,970	Same as LS12	Pittsburgh Steam Coal Moisture (% by wt) 2.4 --- Ultimate Analysis (% by wt dry) Carbon 75.6 Hydrogen 5.2 Nitrogen 1.3 Chlorine - Sulfur 2.6 Oxygen 8.0 ----- Calorific Value (Btu/lb) As Received 13,156 Dry 13,480
Coal Delivery	100 Car Unit Train @ 5 hr. Max. Turn-around	100 Car Unit Train @ 5 hr. Max Turn-around	100 Car Unit Train @ 5 hr. Max Turn-around	100 Car Unit Train @ 5 hr. Max. Turn-around	Train Unloading 8 hrs/day
Coal Storage	60 Days @ Full Load 8 hrs. in Silos				90 Days @ Full Load 16 hrs. in Silos

---

*Modified to reflect coal plant siting and January, 1980 criteria.

+Generator Step-up Transformer

TABLE 4-2

Effective Date - 1/1/80

ENERGY ECONOMIC DATA BASE

Sheet 2 of 4

COMPARISON PLANT TECHNICAL MODELS BASE PARAMETER SUMMARY

Model Key Elements	HS12	HS8	LS12	LS8	CGCC
CIVIL/STRUCTURAL					
Flooding Provision	No Special Provisions				
Turbine Building	Enclosed				
Boiler House	Enclosed				
Seismic	Uniform Bldg. Code Zone 1				
Foundations	Spread Footings on Rock				
Turbine Pedestal	High Tuned				
Grade Elevation	18'0"				
Water Table	+10'0"				
100 Year Maximum Water Level	+8'0" 100 yrs. Flood				
MECHANICAL					
Steam Generator Type	Pulverized Coal Pressurized Furnace	Pulverized Coal Balanced Draft	Pulverized Coal Pressurized Furnace	Pulverized Coal Balanced Draft	Waste Heat Boiler and Coal Gasifier (Pulverized Coal)
Forced Draft Fan					
Number	3	2	3	2	2
Drive	Motor	Motor	Motor	Motor	Motor
Flow, scfm	680,000	680,000	701,000	700,000	167,000
Induced Draft Fan					
Number	None	2	None	2	None
Drive		Motor		Motor	
Flow, scfm		900,000		1,100,000	
Number of Pulverizers	7	7	8	8	4
Stack Height	750 ft.				270 ft. - Main Stack 250 ft. - Vent + Flare Stacks

Effective Date -1/1/80

Sheet 3 of 4

TABLE 4-2

ENERGY ECONOMIC DATA BASE

COMPARISON PLANT TECHNICAL MODELS BASE PARAMETER SUMMARY

Model Key Element	HS12	HS8	LS12	LS8	CGCC
MECHANICAL (Cont'd)					
SO_2 Scrubber	Lime (Wet)#	Lime (Wet)#	Lime (Dry)##	Lime (Dry)##	H_2S Scrubber - Stretford
Sludge Fixation	On-Site	On-Site	Not Required	Not Required	Not Required
Spent Product Disposal	Trucked Off-Site	Trucked Off-Site	Trucked Off-Site	Trucked Off-Site	Not Required
Turbine Generator	Cross Compound 8 Flow 3600/3600 r/min. 30" LSB	Tandem Compound 4 Flow 3600 r/min. 33.5" LSB	Cross Compound 8 Flow 3600/3600 r/min. 30" LSB	Tandem Compound 4 Flow 3600 r/min. 33.5" LSB	Tandem Compound 2 Flow 3600 r/min. 33.5" LSB
Main Steam Conditions at HP Turbine Inlet	Supercritical	Supercritical	Supercritical	Supercritical	Superheated
Pressure, psia	3515/600	3512/637	3515/600	3512/637	2535/455
Temperature, F	1000/1000	1000/1000	1000/1000	1000/1000	1000/1000
Flow, 10^6 lb/h	9.1	5.8	9.1	5.8	2.0
Gross Turbine Generator Output	1309 MWe @ 2.5/1.7 in-HgA	854 MWe @ 2.5/1.7 in-HgA	1309 MWe @ 2.5/1.7 in-HgA	854 MWe @ 2.5/1.7 in-HgA	655 MWe** 2.0 in-HgA
Condensers	2 Single Shell Longitudinal Arrgt. One Pass Split Water Box Dual Pressure	1 Single Shell Longitudinal Arrgt. One Pass Split Water Box Dual Pressure	2 Single Shell Longitudinal Arrgt. One Pass Split Water Box Dual Pressure	1 Single Shell Longitudinal Arrgt. One Pass Split Water Box Dual Pressure	1 Single Shell Longitudinal Arrgt. Two Pass Split Water Milti-Pressure
Main Heat Sink	← Mechanical Wet Evaporative Cooling Tower →				Natural Draft Wet Hyberbolic Cooling Tower
Cooling Tower Design Conditions	← Approach 18°F/Range 26°F/Wet Bulb Temperature 74°F →				Approach 16°F/Range 24°F Wet Bulb Temperature – 74°F
Boiler Feed Pumps					
Main: Number - Drive	← 2 - Turbine →				
Other: Number - Service Drive	← 2 - Booster - Motor →				2 - Startup - Motor

---

** Steam Turbine - 1 @ 372 MWe @ 2.0 in-HgA and
Gas Turbine - 4 @ 79.8 MWe

With Electrostatic Precipitator

With Baghouse

TABLE 4-2

ENERGY ECONOMIC DATA BASE

COMPARISON PLANT TECHNICAL MODELS BASE PARAMETER SUMMARY

Effective Date - 1/1/80

Sheet 4 of 4

Model Key Elements	HS12	HS8	LS12	LS8	CGCC
MECHANICAL (Cont'd.)					
Boiler Feedwater Heaters					
No. of Open Stages	1 @ 1 Train	1 @ 1 Train	1 @ 1 Train	1 @ 1 Train	1 @ 1 Train
No. HP Closed Stages	3 @ 3 Trains	2 @ 2 Trains	3 @ 3 Trains	2 @ 2 Trains	None
No. LP Closed Stages	4 @ 2 Trains	4 @ 2 Trains	4 @ 2 Trains	4 @ 2 Trains	2 @ 1 Train
Stages of Reheat	← One Boiler Reheat →				
ELECTRICAL					
Connection to Off-Site Power	← 1 @ 500 kV 1 @ 230 kV →				1 @ 345 kV 1 @ 138 kV
Generator					
Power Factor	0.9	0.9	0.9	0.9	0.9
Short Circuit Ratio	0.58	0.58	0.50	0.50	-
Rating	2 @ 722 MVA	1050 MVA	2 @ 722 MVA	1050 MVA	1 @ 412.2 MVA 4 @ 72.9 MVA
Generator Disconnect	← None →				
Auxiliary Power System Voltage	← 13.8 kV, 4.16 kV and 480 Volts →				4.16 kV and 480 Volts
Unit Auxiliary Transformer Nameplate Rating ***	120 MVA	95 MVA	121 MVA	95.7 MVA	52 MVA
Reserve Auxiliary Transformer Nameplate Rating ***	60 MVA	47.5 MVA	61 MVA	47.85 MVA	52 MVA
Control Room Wiring	← Wired Directly to Panels in Control Room →				
Multiplexing of BOP Cables	← None →				
Instrumentation	← Independent Sensors for Computer Input →				

*** Total of all transformers at top class of cooling rating.

Effective Date - 1/1/80

TABLE 4-3

ENERGY ECONOMIC DATA BASE

MASS FLOWS SELECTED FOR NUCLEAR PLANT FUEL CYCLES

Model No.	Nuclear Plant	NASAP(1) Reactor Fuel Type Identification	Raw Data Source
A1	BWR	Same as PWR(2)	
A2	HTGR-SC	HTGR-U5/T/Th-20%-T (Throw-away)	GAC
A3	PWR	PWR-U5(LE)/U-T (Throw-away)	CE
A4	PHWR	PHWR-U5(SE)/U-T(CANDU) (Throw-away)	CE
B1	HTGR-PS	Same as HTGR-SC	
A5	LMFBR	LMFBR-Pu/U/U/U-HT	HEDL

LEGEND

CE - Combustion Engineering, Inc.
GAC - General Atomic Company
HEDL - Hanford Engineering Development Laboratory

NOTES:

(1) Non-Proliferation Alternative Systems Assessment Program
(2) BWR data is not available; therefore, PWR date is used for BWR (Model A1) fuel cycle costs

TABLE 4-4

Effective Date - 1/1/80
Sheet 1 of 2

ENERGY ECONOMIC DATA BASE

COST UPDATE SUMMARY ($1980)(1)

(See Table 4-7 for Footnotes)

			Capital Cost(4)			Fuel Cycle Costs						O&M Costs	
						1980 Startup(5)		Variable Startup		2001 Startup(6)			
Model	MWt	MWe	$\$10^6$	$/kWe	m/kWh	¢/MBtu	m/kWh	¢/MBtu	m/kWh	¢/MBtu	m/kWh	$\$10^6/y$	m/kWh
BWR	3578	1190	1036	871	12.4	65(d)	6.7(d)	70(e)	7.2(e)	86	8.8	21.3	2.9
HTGR-SC(a)	2240	858	905	1055	15.0	*	*	79(f)	6.7(f)	85	7.2	20.4	3.9
PWR	3412	1139	1016	892	12.7	65	6.6	70(e)	7.2(e)	86	8.8	21.3	3.0
PHWR	3800	1260	1199	952	13.5	*	*	37(f)	3.8(f)	41	4.2	25.2	3.3
HTGR-PS(a)	1170	150	711	#	#	*	*	*	*	85	#	10.1	#
LMFBR	3800	1457	1586	1089	15.5	*	*	*	*	40	3.6	27.7	3.1
HS12	3302	1232	771	626	8.9	168	15.4	202(e)	18.5(e)	262	24.0	26.7	3.5
HS8	2210	795	531	668	9.5	168	15.9	202(e)	19.2(e)	262	24.9	22.1	4.5
LS12	3446	1236	724	586	8.3	241	22.9	288(e)	27.4(e)	344	32.7	27.3	3.6
LS8	2307	795	500	629	8.9	241	23.9	288(e)	28.5(e)	344	34.1	22.5	4.6
CGCC	1523	630(c)	444	705	10.0	*	*	198(e)	16.3(e)	259	21.4	10.5	2.7

---

* Not Applicable
\# Not Applicable for Cogeneration Facility

Effective Date - 1/1/80
Sheet 2 of 2

TABLE 4-4

ENERGY ECONOMIC DATA BASE

COST UPDATE SUMMARY ($1980)(1)

(See Table 4-7 for Footnotes)

			Total Energy Costs by Year of Start-up (m/kWh)			
Model	MWt	MWe	1980	1987	1995	2001
BWR	3578	1190	22.0	22.5	*	24.1
HTGR-SC(a)	2240	858	*	*	25.6	26.1
PWR	3412	1139	22.3	22.9	*	24.5
PHWR	3800	1260	*	*	20.6	21.0
HTGR-PS(a)	1170	150	#	#	#	#
LMFBR	3800	1457	*	*	*	22.2
HS12	3302	1232	27.8	30.9	*	36.4
HS8	2210	795	29.9	33.2	*	38.9
LS12	3446	1236	34.8	39.3	*	44.6
LS8	2307	795	37.4	42.0	*	47.6
CGCC	1523	630(c)	*	29.0	*	34.1

---

* Not Applicable
\# Not Applicable for Cogeneration Facility

TABLE 4-5

Effective Date - 1/1/80
Sheet 1 of 2

ENERGY ECONOMIC DATA BASE

NORMALIZED(2) COST UPDATE SUMMARY ($1980)(1)

(See Table 4-7 for Footnotes)

			Capital Cost(4)			Fuel Cycle Costs						O&M Costs	
						1980 Startup(5)		Variable Startup		2001 Startup(6)			
Model	MWt	MWe	$\$10^6$	$/kWe	m/kWh	¢/MBtu	m/kWh	¢/MBtu	m/kWh	¢/MBtu	m/kWh	$\$10^6/y$	m/kWh
BWR	3425	↑	1018	894	12.7	65(d)	6.7(d)	70(e)	7.2 (e)	86	8.8	21.3	3.0
HTGR-SC(a)	2974		1034	908	12.9	*	*	79(f)	6.7 (f)	85	7.2	20.4	2.9
PWR	3412		1016	892	12.7	65	6.6	70(e)	7.2 (e)	86	8.8	21.3	3.0
PHWR	3435	1139	1151	1011	14.3	*	*	37(f)	3.8 (f)	41	4.2	25.2	3.6
LMFBR	2971		1413	1241	17.6	*	*	*	*	40	3.6	27.6	4.0
HS12	3053		721	633	9.0	168	15.4	202(e)	18.5(e)	262	24.0	25.6	3.7
LS12	3166	↓	675	593	8.4	241	22.9	288(e)	27.4(e)	344	32.7	26.1	3.7

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* Not Applicable

TABLE 4-5

Effective Date - 1/1/80
Sheet 2 of 2

ENERGY ECONOMIC DATA BASE

NORMALIZED(2) COST UPDATE SUMMARY ($1980)(1)

(See Table 4-7 for Footnotes)

			Total Energy Costs by Year of Start-up (m/kWh)			
Model	MWt	MWe	1980	1987	1995	2001
BWR	3425	1139	22.4	22.9	*	24.5
HTGR-SC(a)	2974		*	*	22.5	23.0
PWR	3412		22.3	22.9	*	24.5
PHWR	3435		*	*	21.7	22.1
LMFBR	2971		*	*	*	25.2
HS12	3053		28.1	31.2	*	36.7
LS12	3166		35.0	39.5	*	44.8

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* Not Applicable

TABLE 4-6

Effective Date - 1/1/80
Sheet 1 of 2

ENERGY ECONOMIC DATA BASE

NORMALIZED(3) COST UPDATE SUMMARY ($1980)(1)

(See Table 4-7 for Footnotes)

			Capital Cost(4)			Fuel Cycle Costs						O&M Costs	
						1980 Startup(5)		Variable Startup		2001 Startup(6)			
Model	MWt(3)	MWe	$\$10^6$	$/kWe	m/kWh	¢/MBtu	m/kWh	¢/MBtu	m/kWh	¢/MBtu	m/kWh	$\$10^6/y$	m/kWh
BWR	3800	1264	1062	840	11.9	65(d)	6.7(d)	70(e)	7.2(e)	86	8.8	21.4	2.8
HTGR-SC(a)		1456(b)	1161	797	11.3	*	*	79(f)	6.7(f)	85	7.2	20.5	2.3
PWR		1269	1062	837	11.9	65	6.6	70(e)	7.2(e)	86	8.8	21.4	2.8
PHWR		1260	1199	952	13.5	*	*	37(f)	3.8(f)	41	4.2	25.2	3.3
LMFBR		1457	1586	1089	15.5	*	*	*	*	40	3.6	27.7	3.1
HS12		1418(b)	869	613	8.7	168	15.4	202(e)	18.5(e)	262	24.0	28.8	3.3
LS12		1363	787	577	8.2	241	22.9	288(e)	27.4(e)	344	32.7	28.8	3.4

---

* Not Applicable

TABLE 4-6

Effective Date - 1/1/80
Sheet 2 of 2

ENERGY ECONOMIC DATA BASE

NORMALIZED(3) COST UPDATE SUMMARY ($1980)(1)

(See Table 4-7 for Footnotes)

			Total Energy Costs by Year of Start-up (m/kWh)			
Model	MWt	MWe	1980	1987	1995	2001
BWR	3800	1264	21.4	21.9	*	23.5
HTGR-SC(a)		1456(b)	*	*	20.3	20.8
PWR		1269	21.3	21.9	*	23.5
PHWR		1260	*	*	20.6	21.0
LMFBR		1457	*	*	*	22.2
HS12		1418(b)	27.4	30.5	*	36.0
LS12		1363	34.5	39.0	*	44.3

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* Not Applicable

TABLE 4-7

ENERGY ECONOMIC DATA BASE

COST UPDATE SUMMARY ($1980)(1)
FOOTNOTES FOR TABLES 4-4, 4-5 AND 4-6

1. Data in Constant 1980 Dollars (Inflation-Free)
2. Normalized to a Plant Size Providing 1139 MWe (Net); Not Applicable to HTGR-PS, HS8, LS8 and CGCC
3. Normalized to a Plant Size Providing 3800 MWt (Net); Not Applicable to HTGR-PS, HS8, LS8 and CGCC
4. Total Base Cost = Direct Cost + Indirect Cost
5. Based on Plant Commercial Operation Date of January 1, 1980
6. Based on Plant Commercial Operation Date of January 1, 2001

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a. SC = Steam Cycle; PS = Process Steam Cogeneration

b. Tandem-Compound or Cross-Compound Turbines are not available in this capacity in 1980; therefore, if Twin-Turbines are utilized, higher capital costs accrue for structures and Turbine Plant Equipment accounts.

c. Four Gas-Turbine-Generators and One Steam-Turbine-Generator

d. BWR Fuel Cycle Data not available; PWR data are used for BWR Fuel Cycle Costs

e. Based on Plant Commercial Operation Date of January 1, 1987

f. Based on Plant Commercial Operation Date of January 1, 1995

TABLE 4-8

ENERGY ECONOMIC DATA BASE

COMMODITY SUMMARY OF NUCLEAR POWER GENERATING STATIONS#

Model/Rating (MWe)		BWR/1190		HTGR-SC/858		PWR/1139		PHWR/1260		LMFBR/1457	
Commodity	Unit	Qty.x10^3	$/Unit@	Qty.x10^3	$/Unit@	Qty.x10^3	$/Unit@	Qty.x10^3	$/Unit@	Qty.x10^3	$/Unit@
Excavation	CY	536	12.87	423	6.32	529	12.98	523	12.97	771	15.32
Reinforcing Steel and Structural Steel	TN	31	1,503.00	31	1,498.00	33	1,527.00	32	1,556.00	56	1,520.00
Concrete	CY	205	88.91	191(a)	86.81	174	88.95	164	89.73	261	91.19
BOP Pumps (1000 HP and UP)	HP	57	82.92	84	64.16	49	90.15	80	66.95	139	50.60
Piping+	LB	6,864	12.32	2,908	11.03	7,011	13.26	6,746	11.06	6,840	13.31
Wire and Cable	LF	4,550	4.63	4,062	5.07	4,608	4.60	5,170	4.10	6,473	4.42
Turbine-Generator	LT	-	75.24*	-	58.42*	-	76.07*	-	77.18*	-	67.55*
Nuclear Steam Supply System	LT	-	92.44*	-	185.31*	-	102.72*	-	122.15*	-	248.94*

HTGR-PS: Data not available from three-digit level Capital Cost Model

* Cost per Unit is in Dollars per Kilowatt ($/kW)

+ Includes Carbon Steel and Stainless Steel Piping

@ 1980 Constant Dollars

(a) Does not include pre-stressed concrete reactor vessel (PCRV)

TABLE 4-9 Effective Date - 1/1/80

ENERGY ECONOMIC DATA BASE

COMMODITY SUMMARY OF FOSSIL POWER GENERATING STATIONS#

Model/Rating (MWe)		HS12/1232		HS8/795		LS12/1236		LS8/795	
Commodity	Unit	Qty. x 10^3	$/Unit[@]	Qty. x 10^3	$/Unit[@]	Qty. x 10^3	$/Unit[@]	Qty. x 10^3	$/Unit[@]
Excavation	CY	220	6.64	180	6.91	254	6.11	198	6.29
Reinforcing Steel and Structural Steel	TN	31	1,201.00	24	1,155.00	33	1,200.00	25	1,174.00
Concrete	CY	108	77.44	89	77.51	117	75.35	93	76.24
BOP Pumps (1000 HP and UP)	HP	104	39.37	66	46.33	104	39.37	66	46.33
Piping	LB	7,892	5.69	4,250	5.27	7,997	5.50	4,226	5.27
Wire and Cable	LF	3,985	3.29	3,390	3.33	3,988	3.29	3,422	3.31
Turbine-Generator	LT	---	62.23*	---	50.68*	---	63.23*	---	50.68*
Fossil Steam Supply System	LT	---	80.25*	---	84.57*	---	81.98*	---	85.53*

\# CGCC: Data not available from three-digit level Capital Cost Model

* Cost per Unit is in Dollars per Kilowatt ($/kW)

@ 1980 Constant Dollars

TABLE 4-10

ENERGY ECONOMIC DATA BASE

SITE LABOR SUMMARY FOR NUCLEAR POWER GENERATING STATIONS#

Model/MWe	BWR/1190		HTGR-SC/858		PWR/1139		PHWR/1260		LMFBR/1457	
Craft	MHx10^3	$\$x10^3$*	MHx10^3	$\$x10^3$*	MHx10^3	$\$x10^3$*	MHx10^3	$\$x10^3$*	MHx10^3	$\$x10^3$*
Boiler Makers	610	10,255	663	11,192	903	15,195	968	16,288	1,378	23,184
Carpenters	2,216	30,156	1,865	25,379	2,074	28,225	1,905	25,932	2,404	32,718
Electricians	2,565	36,093	2,245	31,582	2,529	35,588	2,834	39,878	3,874	54,504
Ironworkers	2,431	37,093	2,015	30,756	2,020	30,819	2,119	32,334	4,025	61,421
Laborers	2,090	22,157	1,578	16,737	1,978	20,959	1,883	19,962	2,675	28,351
Operating Engineers	1,470	22,154	874	13,192	1,228	18,517	1,211	18,249	1,904	28,694
Pipe Fitters	4,315	69,742	1,856	29,929	4,255	68,500	3,897	62,738	5,545	89,278
Others	1,624	21,755	1,740	24,291	1,329	17,773	1,414	17,288	2,177	29,310
TOTAL	17,321	249,135	12,836	183,058	16,317	235,576	16,231		23,982	347,460
MH/kW	14.6		15.0		14.3		13.0		16.5	

HTGR-PS: Data not available from three-digit Capital Cost Model

@ These numbers do not include the labor hours for erection of the Pre-stressed Concrete Reactor Vessel.

* 1980 Constant Dollars

TABLE 4-11 Effective Date - 1/1/80

ENERGY ECONOMIC DATA BASE

SITE LABOR SUMMARY FOR FOSSIL POWER GENERATING STATIONS#

	HS12/1232		HS8/795		LS12/1236		LS8/795	
Model/MWe Craft	MH x 10^3	\$ x 10^{3*}	MH x 10^3	\$ x 10^{3*}	MH x 10^3	\$ x 10^{3*}	MH x 10^3	\$ x 10^{3*}
Boiler Makers	290	4,883	209	3,522	158	2,662	116	1,954
Carpenter	390	5,304	320	4,359	389	5,301	308	4,190
Electricians	1,830	25,742	1,515	21,317	1,679	23,620	1,415	19,910
Ironworkers	942	14,378	718	10,939	918	14,005	720	10,993
Laborers	618	6,558	498	5,284	756	8,017	590	6,253
Operating Engineers	643	9,688	463	6,981	598	9,017	442	6,657
Pipe Fitters	3,783	60,900	2,488	40,052	3,839	61,803	2,555	41,142
Others	2,378	33,673	1,665	23,510	2,469	35,299	1,729	23,617
TOTAL	10,874	161,126	7,876	115,964	10,806	159,724	7,875	114,716
MH/kW	8.8		9.9		8.7		9.9	

CGCC: Data not available from three-digit level Capital Cost Model

* 1980 Constant Dollars

SECTION 5

5.0 CAPITAL COST THIRD UPDATE

The Third Update of the Capital Costs in the Energy Economic Data Base is accomplished in two distinct steps. The first step is the evaluation and adjustment of the technical models to assure that they reflect current changes in state-of-the-art designs, regulations, codes and standards. The second step is the adjustment of the capital cost models to reflect escalation, and to accommodate the technical model revisions. This section of the report presents the detailed results of the capital cost update, followed by a description of the changes to the technical and capital cost models which support it.

5.1 CAPITAL COST UPDATE PROCEDURE

A specific capital cost update procedure is developed for the EEDB, and is described in the Initial Update Report.* This update procedure is utilized for the selected technical models given in Tables 1-1 and 1-2 to develop the Third Update of the Capital Cost.

5.2 CAPITAL COST SUMMARY

Capital costs are prepared for the EEDB as Base Construction Costs, which are the sum of the Direct and Indirect Capital Costs. Base costs include those cost elements listed in Table 2-10, as discussed in Section 2. Direct, Indirect and Base Capital Costs are summarized for all plants in Table 5-1.

Tables 5-2 and 5-3 also summarize the same data for all plants, except that the capital costs are normalized to the same net electrical and thermal capacities, respectively. The normalization process is discussed in Section 4.3. The net electrical capacity chosen for this process is that of the

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* Refer to Section 8.1 for additonal details

Pressurized Water Reactor Nuclear Power Generating Station (NPGS) Technical Model, so that capital costs of the other technical models can be compared to this most frequently chosen industry cost base. The net thermal capacity chosen for the normalization process is the maximum licensable NPGS thermal rating of 3800 MWt, so that costs can be compared on the basis of maximum economy-of-scale.

5.3 DETAILED CAPITAL COSTS, COMMODITIES AND MANHOURS

Results of the Capital Cost Third Update are presented for each technical plant model at the two-digit and three-digit cost-code-of-accounts level in Tables 5-4 through 5-14 as follows:

Nuclear Plant Models	Table Number	Fossil Plant Models	Table Number
BWR	5-4	HS12	5-10
HTGR-SC	5-5	HS8	5-11
PWR	5-6	LS12	5-12
PHWR	5-7	LS8	5-13
HTGR-PS	5-8	CGCC	5-14
LMFBR	5-9		

The first sheet of each table is a two-digit level cost tabulation and the following four sheets are the three-digit level cost tabulation for each plant model.

Additional detail, down to the nine-digit cost-code-of-accounts level, is available in the Backup Data File, as discussed in Section 2.3.5. A total on the order of 10,000 computer sheets of cost and commodity detail is available from this file.

Commodities, including materials, equipment and craft labor manhours are tabulated for each technical plant model in Tables 5-15 through 5-23 as follows:

Nuclear Plant Models	Table Number	Fossil Plant Models	Table Number
BWR	5-15	HS12	5-20
HTGR-SC	5-16	HS8	5-21
PWR	5-17	LS12	5-22
PHWR	5-18	LS8	5-23
LMFBR	5-19		

Tabulations for the HTGR-PS Nuclear Plant Model and for the CGCC Fossil Plant Model are not included, because they have not yet been sufficiently detailed to produce this information. When necessary information becomes available to expand the technical models for HTGR-PS and CGCC to the required degree of detail, they will be included in the data base.

5.4 TECHNICAL MODEL UPDATE

The Base Data Studies and Reports listed in Table 1-3 are reviewed and modified in accordance with the EEDB update procedure. Section 3.3 gives the assumptions and ground-rules for each of the technical models of the Base Data Studies and Reports. Appendix C1 contains Section 5.4 of the Initial Update (1978) and Appendix C2 contains portions of Section 5.4 of the Second Update (1979) which discuss the detailed modifications made to the Technical Models in the Base Data Studies and Reports for the Initial and Second Updates of the EEDB.

This section discuses additional modifications to the Technical Models required for the Third Update of the EEDB to the cost and regulation date of January 1, 1980. The applicable Base Data Study or Report, together with the appropriate modifications listed in Appendices C1 and C2 and this section, comprise the Technical Models for the Third Update of the Energy Economic Data Base.

5.4.1 General Modifications

A general review is done for each Technical Model in the Data Base, as modified for the Initial and Second Updates, to improve internal consistency among models and to assure that technical features and cost drivers are current. This review is accomplished in two phases. During the first phase, checks are made to assure that system, equipment, commodities and manhours track from model to model according to the Code-of-Accounts. Additionally, spot checks are made on cost significant items to assure that data has not been lost, misplaced or incorrectly entered in the update.

During the second phase of the general review, each model is modified, as required, to improve licensability, system performance, operability and constructability. As a first step in this phase, a detailed review is made of the US Nuclear Regulatory Commission Regulatory Guides. New guides and revisions that have been issued since the Second Update cost and regulation date (1/1/79), but prior to the Third Update cost and regulation date (1/1/80) are identified. Each is evaluated for requirements necessitating addition or revision to existing design features. Modifications to Technical and Cost Models are then made based on this evaluation. Appendix D contains a tabulation of the results of the Regulatory Guide Review. Following incorporation of these modifications, a general review is made of the current state-of-the-art for nuclear and fossil-fired power generating stations. Where required, modifications are made to those Technical Models that are not in accord with current practice.

5.4.2 Specific Modifications

The following pages discuss the specific Technical Model replacements, deletions, additions and concept modifications made during the Third Update. For convenience, the discussion of each plant model is started at the top of a new page.

DoE/ET/33020-
T1

5.4.2.1 EEDB Model Number A1, Model Type BWR, EEDB Third (1980) Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - Boiling Water Reactor Plant (NUREG-0242, COO-2477-6)

ACCOUNT 220A Nuclear Steam Supply System (NSSS)

The nuclear steam supply package is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 231 Turbine-Generator

The turbine-generator is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 233 Condensing Systems

The main condenser tube material is changed from 90-10 copper-nickel to stainless steel to reflect the current trend in BWR plant design.

ACCOUNT 241 Switchgear
ACCOUNT 242 Station Service Equipment
ACCOUNT 245 Electric Structures and Wiring Containers
ACCOUNT 246 Power and Control Wiring

The electrical distribution system is modified to support the changes to the main cooling towers (refer to Account 262).

ACCOUNT 262 Main Condenser Heat Rejection System/Mechanical Equipment

The design of the main cooling towers is changed to reflect current vendor capabilities and practice. The quantity and diameter of the towers are changed from three and 260 feet to two and 285 feet, respectively. The number of fans per tower is changed from 12 to 16.

5.4.2.2 EEDB Model Number A2, Model Type HTGR-SC, EEDB Third (1980) Update

The six loop, 3360 MWt, 1330 MWe HTGR NPGS is replaced in the Third Update with a four loop, 2240 MWt, 858 MW HTGR-SC (Steam Cycle) NPGS.

Considerable work has been performed during the last several years to improve the commercial viability of the HTGR concept. This work has been done by Gas Cooled Reactor Associates (GCRA), an electric utility consortium, in conjunction with General Atomic Company (GAC), and with the assistance of USDOE funding.

The decision to replace the six loop plant with the four loop plant in the EEDB is based on two facts. First, the ongoing GCRA work has rendered the EEDB six-loop model obsolete. Second, GCRA and GAC are currently concentrating their efforts on the smaller plant as the preferred concept. The basis for the EEDB four loop plant is the following study.

Base Data Study: The HTGR for Electric Power Generation - Design and Cost Evaluation (GCRA/AE/78-1)

The conceptual design and cost estimates described in this base data study are directly compatible with the EEDB Program. Therefore, the study results are directly incorporated into the EEDB with the following modifications to meet the EEDB groundrules and the revisions incorporated in the Third Update:

1. Minor modifications are made to transfer the conceptual design from an Eastern Pennsylvania site to the "Middletown" site.

2. Minor modifications are made to obtain conformance to the EEDB Code-of-Accounts.

3. Modifications are made to increase the construction site labor manhours to approximately 17 manhours per kilowatt (Refer to Section 5.5.1).

4. The design of the main cooling towers is modified to reflect current vendor capabilities and practice.

3. Modifications are made to increase the construction site labor manhours to approximately 17 manhours per kilowatt (Refer to Section 5.5.1).

4. The design of the main cooling towers is modified to reflect current vendor capabilities and practice.

Additional impetus is provided to make this change in the Third Update. During 1980, the EEDB Program was selected to support the capital cost estimating effort for the candidate reactors in the USDOE Replacement Production Reactor Feasibility Study. The preferred GAC candidate reactor in this study is the four loop, 2240 MWt type, as modified to produce special materials.

5.4.2.3 EEDB Model Number A3, Model Type PWR, EEDB Third (1980) Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - Pressurized Water Reactor Plant (NUREG-0241, COO-2477-5)

ACCOUNT 220A Nuclear Steam Supply System (NSSS)

The nuclear steam supply package is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 231 Turbine-Generator

The turbine-generator is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 241 Switchgear
ACCOUNT 242 Station Service Equipment
ACCOUNT 245 Electric Structures and Wiring Containers
ACCOUNT 246 Power and Control Wiring

The electrical distribution system is modified to support the changes to the main cooling towers (refer to Account 262).

ACCOUNT 262 Main Condenser Heat Rejection System/Mechanical Equipment

The design of the main cooling towers is changed to reflect current vendor capabilities and practice. The quantity and diameter of the towers are changed from three and 250 feet to two and 285 feet, respectively. The number of fans per tower is changed from 12 to 16.

5.4.2.4 EEDB Model Number A4, Model Type PHWR, EEDB Third (1980) Update

The three loop, 3800 MWt, 1162 MWe CANDU type PHWR NPGS is replaced in the Third Update with a two loop 3800 MWt, 1260 MWe PHWR NPGS, specifically designed for U.S. siting.

This replacement is made to accommodate the desire of USDOE to meet the EEDB objective with alternatives based on U.S. designs sited in the contiguous United States. The study selected as the basis for this change is the following joint Combustion Engineering/United Engineers study, funded by USDOE.

Base Data Study: Conceptual Design of a Large HWR for U.S. Siting (Combustion Engineering, Inc. CEND-379)

The conceptual design and cost estimates described in this base data study are directly compatible with the EEDB Program. Therefore, the study results are directly incorporated into the EEDB with the following modifications to meet the EEDB groundrules and the revisions incorporated in the Third Update:

1. Modifications are made to replace refrigeration systems, used for primary, moderator and reactor plant service cooling, with conventional water systems.
2. Modifications are made in the Structural, Electric Plant and Miscellaneous Plant accounts to support the replacement of the refrigeration systems used for primary, moderator and reactor plant service cooling.
3. Modifications are made to increase the construction site labor manhours to approximately 17 manhours per kilowatt (Refer to Section 5.5.1)
4. The design of the main cooling towers is modified to reflect current vendor capabilities and practice.

5.4.2.5A EEDB Model Number B1, Model Type GCFR, EEDB Third (1980) Update - Deleted

Base Data Study: Capital Cost - Gas Cooled Fast Reactor Plant (COO-2477-16)

The Gas Cooled Fast Breeder Reactor NPGS is deleted from the data base in the Third Update.

The decision to make this deletion is based on two facts. First, the ongoing GCRA/GAC work on the HTGR, described in Section 5.4.2.2, has been incorporated into the GAC GCFR NPGS development, rendering the EEDB conceptual design obsolete. Second, the extensive revisions required to update the GCFR NPGS cannot be currently accommodated by the priorities set and the resources available for the EEDB Program.

5.4.2.5B EEDB Model Number B1, Model Type HTGR-PS, EEDB Third (1980) Update

An 1170 MWt, 150 MWe HTGR-PS (Process Steam Cogeneration) NPGS is added to the data base in the Third Update.

The decision to add the HTGR-PS NPGS is based upon the need to expand the data base into the area of nuclear cogeneration in general and process steam from HTGRs in particular. The basis for this additon is the following USDOE sponsored study.

Base Data Study: 1170 MWt HTGR Steamer Cogeneration Plant - Design and Cost Study (UE&C/DOE-800716)

The conceptual design and cost estimates described in this base data study are directly compatible with the EEDB Program. Therefore, the study results are directly incorporated into the EEDB with the following modifications to meet the EEDB groundrules and the revisions incorporated in the Third Update:

1. Minor modifications are made to transfer the conceptual design from an Eastern Pennsylvania site to the "Middletown" site.

2. Minor modifications are made to obtain conformance to the EEDB Code-of-Accounts.

3. Modifications are made to increase the construction site labor manhours to approximately 17 manhours per kilowatt (Refer to Section 5.5.1).

4. The design of the main cooling towers is changed to reflect current vendor capabilities and practice.

5.4.2.6 EEDB Model Number A5, Model Type LMFBR, EEDB Third (1980) Update

Base Data Study: NSSS Capital Costs for a Mature LMFBR Industry and Addendum (Combustion Engineering Inc. - CE-FBR-78-532 & CE-ADD-80-310)

ACCOUNT 211 Yardwork

The excavation for the nuclear island buildings is increased. The increase is the result of revisions to the nuclear island building plan and location of the base mat, 24 feet deeper in the ground (refer to Account 212).

ACCOUNT 212 Reactor Containment Building

The containment building is increased in overall height by 24 feet to provide additional space for miscellaneous equipment and the containment cell gas cooling systems (refer to Account 220A). In addition, the internal structure is revised to accommodate a larger reactor vessel, a reactor guard vessel, revised fuel handling, and the removal of the ex-vessel fuel storage tank (refer to Account 220A). The cylindrical portion of the containment has an inside diameter of 187 feet. It measures 227 feet from the top of the foundation mat to the springline of the dome. The inside height from the top of the mat to the dome is 274.5 feet. The gross volume of the containment is 7,100,000 cubic feet.

ACCOUNT 215 Reactor Service Building

The reactor service building is revised to accommodate an increased fuel handling requirement which includes the housing of a larger (1-1/3 core capacity) ex-vessel storage tank (refer to Account 220A). This building is increased in height to maintain compatibility with the containment building and to provide additional equipment space.

The major portion of the reactor service building is 146 feet high, abuts the containment and has one straight side of 131 feet, and the other side is 145 feet. The overall volume is 2,280 x 10^3 cubic feet.

ACCOUNT 218E Steam Generator Buildings

The steam generator buildings are revised to adjust the structures to account for an additional 24 feet of below-grade design. Overall height of the buildings remains unchanged (refer to Account 212).

ACCOUNT 218W Auxiliary Heat Transport System Bays

The bay adjacent to the reactor service building is revised to be compatible with the floor plans of the new reactor service building (refer to Account 215).

ACCOUNT 220A Nuclear Steam Supply System (NSSS)

This account is revised based on Combustion Engineering Report CE-ADD-80-310, "NSSS Capital Costs for a Mature LMFBR Industry - Addendum." A copy of this report is included in Appendix E. This revision includes a larger reactor vessel with internal downcomers and a reactor vessel guard-vessel. Also incorporated in this addendum is a revised fuel handling system with a 1-1/3 core fuel storage capability. The larger fuel storage vessel and guard-vessel are located in the reactor service building and replace the 1/3 core fuel storage vessel located in the reactor containment building in EEDB Phases I & II Conceptual design.

The primary sodium loop isolation valves are eliminated in the Third Update.

ACCOUNT 222 Main Heat Transfer Transport System

This account is revised to reflect the decrease in primary sodium loop piping which results from the increase in reactor vessel diameter (refer to Account 220A).

ACCOUNT 225 Fuel Handling

The fuel handling system installation is revised to reflect the changes in NSSS fuel handling equipment (refer to Account 220A). The ex-vessel storage tank (EVST) cooling system capacity is increased to accommodate the need to remove 1-1/3 core spent fuel decay heat.

ACCOUNT 226 Other Reactor Plant Equipment

The cell cooling systems are revised to conform to the latest NSSS configuration (refer to Account 220A). Two systems, the reactor head, and the machinery dome cooling systems are deleted. A system to cool the cell that contains the EVST sodium cooling system is added.

ACCOUNT 241 Switchgear
ACCOUNT 242 Station Service Equipment
ACCOUNT 245 Electric Structures and Wiring Containers
ACCOUNT 246 Power and Control Wiring

The electrical distribution system is modified to support the changes to the Nuclear Steam Supply System and the main cooling towers (refer to Accounts 220A and 262).

ACCOUNT 252 Air, Water And Steam Service System

The passive sodium fire protection systems are revised to reflect current technology.

ACCOUNT 262 Mechanical Equipment

The design of the main cooling towers is changed to reflect current vendor capabilities and practice. The number of cooling towers is changed from 3 to 2. The new towers are 285 feet in diameter and 35 feet to the fan deck. Each tower uses 16 - 33 foot diameter fans per tower.

5.4.2.7 EEDB Model Number C1, Model Type HS12, EEDB Third (1980) Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - High and Low Sulfur Coal Plants - 1200 MWe (Nominal) (NUREG-0243, COO-2477-7)

ACCOUNT 220A Fossil Steam Supply Steam

The fossil steam supply system package is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 222 Draft System

The electrostatic precipitators (which are part of the draft system account) are upgraded to meet the 1979 New Source Performance Standards (NSPS) particulate limit of 0.03 pounds per million Btu heat input.

ACCOUNT 225 Flue Gas Desulfurization Structures

The flue gas desulfurization structures are modified to accommodate the upgraded flue gas desulfurization system (refer to Account 226).

ACCOUNT 226 Desulfurization Equipment

The flue gas desulfurization system is upgraded to meet the 1979 New Source Performance Standards sulfur dioxide (SO_2) limit of 0.06 pounds per million Btu heat input with SO_2 removal between 70% and 90%.

ACCOUNT 231 Turbine-Generator

The turbine-generator is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 241 Switchgear
ACCOUNT 242 Station Service Equipment
ACCOUNT 245 Electric Structures and Wiring Containers
ACCOUNT 246 Power and Control Wiring

The electrical distribution system is modified to support the changes to the precipitator, flue gas desulfurization system, and main cooling towers (refer to Accounts 222, 226 and 262).

ACCOUNT 262 Main Condenser Heat Rejection System/Mechanical Equipment

The design of the main cooling towers is modified to reflect current vendor capabilities and practice.

5.4.2.8 EEDB Model Number C2, Model Type HS8, EEDB Third (1980) Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - Low and High Sulfur Coal Plants - 800 MWe (Nominal) (NUREG-0244, COO-2477-8)

ACCOUNT 220A Fossil Steam Supply System

The fossil steam supply system package is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 222 Draft System

The electrostatic precipitators (which are part of the draft system account) are upgraded to meet the 1979 New Source Performance Standards (NSPS) particulate limit of 0.03 pounds per million Btu heat input.

ACCOUNT 225 Flue Gas Desulfurization Structures

The flue gas desulfurization structures are modified to accommodate the upgraded flue gas desulfurization system (refer to Account 226).

ACCOUNT 226 Desulfurization Equipment

The flue gas desulfurization system is upgraded to meet the 1979 New Source Performance Standards (NSPS) sulfur dioxide (SO_2) limit of 0.06 pounds per million Btu heat input with SO_2 removal between 70% and 90%.

ACCOUNT 231 Turbine-Generator

The turbine-generator is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 241 Switchgear
ACCOUNT 242 Station Service Equipment
ACCOUNT 245 Electric Structures and Wiring Containers
ACCOUNT 246 Power and Control Wiring

The electrical distribution system is modified to support the changes to the precipitator, flue gas desulfurization system, and main cooling towers (refer to Accounts 222, 226 and 262).

ACCOUNT 262 Main Condenser Heat Rejection System/Mechanical Equipment

The design of the main cooling towers is modified to reflect current vendor capabilities and practice.

5.4.2.9 EEDB Model Number C3, Model Type LS12, EEDB Third (1980) Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - High and Low Sulfur Coal Plants - 1200 MWe (Nominal) (NUREG-0243, COO-2477-7)

ACCOUNT 220A Fossil Steam Supply System

The fossil steam supply system package is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 222 Draft System

The flue gas ductwork arrangement is modified and the induced draft (I.D.) fan is upgraded to accommodate the addition of the baghouse and dry flue gas desulfurization system (refer to Account 226).

ACCOUNT 223 Ash and Dust Handling System

The fly ash system is modified to accommodate the increased number of pick-up points and dust loading associated with the dry flue gas desulfurization system (refer to Account 226).

ACCOUNT 225 Flue Gas Desulfurization Structures

The following structures associated with the baghouse and dry flue gas desulfurization system are added (refer to Account 226):

- Lime unloading building
- Lime preparation building
- Spray dryer supports and enclosures
- Baghouse supports and enclosures
- Waste product disposal and recycling structures.

ACCOUNT 226 Flue Gas Desulfurization System

A flue gas desulfurization system is added to comply with the 1979 New Source Performance Standards (NSPS) sulfur dioxide (SO_2) limit of 0.06 pounds per million Btu heat input with SO_2 removal between 70% and 90%.

The system is designed on the dry absorption principle, where lime slurry is injected into spray dryer absorbers. The SO_2 in the flue gas is absorbed by the lime slurry forming a powdery waste material which falls into the bottom of the spray dryer.

Fly ash and other particulates carried over are collected in a baghouse which provides particulate removal in compliance with the 1979 New Source Performance Standards (NSPS) limit of 0.03 pounds per million Btu heat input. (The baghouse replaces the electrostatic precipitator previously used.) Part of the SO_2 removal process also takes place in the baghouse.

The flue gas desulfurization system consists of the following major subsystems:

- Dry Lime Handling

  Pebble lime is received from bottom-dump rail cars into receiving hoppers. From the hoppers, it is conveyed to the storage silos and eventually to the lime preparation building. All transfer areas are equipped with fabric filters to collect fugitive dust.

- Lime Slaking

  Pebble lime is slaked in the lime preparation buildings in closed loop ball mill spiral classifier circuits. Lime is fed by weigh belt feeders into the ball mills which are supplied with the required amount of water for slaking. The slurry is latter transferred to the slurry feed tanks that supply the spray dryer absorbers.

- Spray Dryer Absorbing

  The flue gas is introduced into each spray dryer absorber through a roof and a central gas disperser. A rotary atomizer placed in the center of the roof gas dispenser atomizes the lime slurry into fine droplets, providing an extremely large surface area for reaction with the incoming flue gas.

- Particle Collection

  A portion of the fly ash and the reacted and unreacted reagent is collected in the bottom of the spray dryer absorbers. The main particulate control, however, is provided by the fabric filter baghouse. The fabric filter is properly sectionalized in order to assure suitable isolation capability.

- Ash Handling

  Fly ash from the baghouse hoppers is collected by a pneumatic conveying system and transferred into the ash disposal silos. A portion of the fly ash is transferred into the surge bin at the slaking/slurry preparation area for recycling.

- Waste Disposal

  The waste product from the ash disposal silo is conveyed to the waste surge silo, which is located in a designated on-site area. The material is metered from the waste surge silo into a mixer. Water is then added to the mixer in proportion to the solids to achieve a damp, dustless blend. The mixer then discharges to a truck for the haul to the disposal area.

ACCOUNT 241 Switchgear
ACCOUNT 242 Station Service Equipment
ACCOUNT 245 Electric Structures and Wiring Containers
ACCOUNT 246 Power and Control Wiring

The electrical distribution system is modified to support the addition of the baghouse and the dry flue gas desulfurization system, the elimination of the precipitator, and the changes to the main cooling towers (refer to Accounts 222, 226 and 262).

ACCOUNT 262 Main Condenser Heat Rejection System/Mechanical Equipment

The design of the main cooling towers is modified to reflect current vendor capabilities and practice.

5.4.2.10 EEDB Model Number C4, Model Type LS8, EEDB Third (1980) Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost -
Low and High Sulfur Coal Plants - 800 MWe (Nominal)
(NUREG-0244, COO-2477-8)

ACCOUNT 220A Fossil Steam Supply System

The fossil steam supply system package is reviewed for conformance with current manufacturers' quotations. No significant technical changes are required.

ACCOUNT 222 Draft System

The flue gas ductwork arrangement is modified and the induced draft (I.D.) fan is upgraded to accommodate the addition of the baghouse and dry flue gas desulfurization system (refer to Account 226).

ACCOUNT 223 Ash and Dust Handling System

The fly ash system is modified to accommodate the increased number of pick-up points and dust loading associated with the dry flue gas desulfurization system (refer to Account 226).

ACCOUNT 225 Flue Gas Desulfurization Structures

The following structures associated with the baghouse and dry flue gas desulfurization system are added (refer to Account 226):

- Lime unloading building
- Lime preparation building
- Spray dryer supports and enclosures
- Baghouse supports and enclosures
- Waste product disposal and recycling structures.

ACCOUNT 226 Flue Gas Desulfurization System

A flue gas desulfurization system is added to comply with the 1979 New Source Performance Standards (NSPS) sulfur dioxide (SO_2) limit of 0.06 pounds per million Btu heat input with SO_2 removal between 70% and 90%.

The system is designed on the dry absorption principle, where lime slurry is injected into spray dryer absorbers. The SO_2 in the flue gas is absorbed by the lime slurry forming a powdery waste material which falls into the bottom of the spray dryer.

Fly ash and other particulates carried over are collected in a baghouse which provides particulate removal in compliance with the 1979 New Source Performance Standards (NSPS) limit of 0.03 pounds per million Btu heat input. (The baghouse replaces the electrostatic precipitator previously used.) Part of the SO_2 removal process also takes place in the baghouse.

The flue gas desulfurization system consists of the following major subsystems:

- Dry Lime Handling

  Pebble lime is received from bottom-dump rail cars into receiving hoppers. From the hoppers, it is conveyed to the storage silos and eventually to the lime preparation building. All transfer areas are equipped with fabric filters to collect fugitive dust.

- Lime Slaking

  Pebble lime is slaked in the lime preparation buildings in closed loop ball mill spiral classifier circuits. Lime is fed by weigh belt feeders into the ball mills which are supplied with the required amount of water for slaking. The slurry is later transferred to the slurry feed tanks that supply the spray dryer absorbers.

- Spray Dryer Abosrbing

  The flue gas is introduced into each spray dryer absorber through a roof and a central gas disperser. A rotary atomizer placed in the center of the roof gas dispenser atomizes the lime slurry into fine droplets, providing an extremely large surface area for reaction with the incoming flue gas.

- Particle Collection

  A portion of the fly ash and the reacted and unreacted reagent is collected in the bottom of the spray dryer abosrbers. The main particulate control, however, is provided by the fabric filter baghouse. The fabric filter is properly sectionalized in order to assure suitable isolation capability.

- Ash Handling

  Fly ash from the baghouse hoppers is collected by a pneumatic conveying system and transferred into the ash disposal silos. A portion of the fly ash is transferred into the ash disposal silos. A portion of the fly ash is transferred into the surge bin at the slaking/slurry preparation area for recycling.

- Waste Disposal

  The waste product from the ash disposal silo is conveyed to the waste surge silo, which is located in a designated on-site area. The material is metered from the waste surge silo into a mixer. Water is then added to the mixer in proportion to the solids to achieve a damp, dustless blend. The mixer then discharges to a truck for the haul to the disposal area.

ACCOUNT 241 Switchgear
ACCOUNT 242 Station Service Equipment
ACCOUNT 245 Electric Structures and Wiring Container
ACCOUNT 246 Power and Control Wiring

The electrical distribution system is modified to support the addition of the baghouse and the dry flue gas desulfurization system, the elimination of the precipitator, and the changes to the main cooling towers (refer to Accounts 222, 226 and 262).

ACCOUNT 262 Main Condenser Heat Rejection System/Mechanical Equipment

The design of the main cooling towers is modified to reflect current vendor capabilities and practice.

5.4.2.11 EEDB Model Number D1, Model Type CGCC, EEDB Third (1980) Update

Base Data Study: Study of Electric Plant Applications For Low Btu Gasification of Coal For Electric Power Generation (FE-1545-59)

Minor modifications are made in the Third Update to bring the CGCC in closer conformance to the EEDB Groundrules.

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Text pages 5-11 through 5-29 renumbered

5.4.3 Ongoing Modifications

During the course of preparing the Third Update of the EEDB, it became apparent that general piping systems modifications were required for some of the Technical Models that would take more effort than could be allotted to the resources available for a single update. Consequently, these efforts are spread over the Third, Fourth and Fifth Updates but, although they are initiated in the Third Update, the results will not be reported until the Fifth Update is completed.

5.5 COST MODEL UPDATE

5.5.1 Direct Costs

Modifications to equipment, material and craft labor man-hours and associated costs are made, as required, to reflect the Technical Model modifications described in Section 5.4 above. Additionally, adjustments are made to reflect January 1, 1980 construction labor man-hours to arrive at new labor costs based on both the modified and unmodified labor hours. Total direct costs are revised accordingly.

The adjustment to reflect 1980 construction labor manhours in the Third Update increases the labor content for the nuclear power generating stations from approximately 11.5 manhours per kilowatt to approximately 17 manhours per kilowatt. This represents a major change to the total direct costs for each nuclear power generating station model. For example, the change increases the total direct costs of the PWR NPGS by approximately 15%.

The EEDB Technical and Capital Cost Models are based on the Base Data Studies tabulated in Table 1-3 and Section 8.1. These studies were made during a 1976/1978 time frame. Labor content for installing systems, equipment and commodities was well established at that time and was incorporated into the Base Data Studies and eventually into the EEDB. Since that period there has been a growing awareness in the utility industry that the labor content for major utility construction projects is grossly understated.

This perception has grown as more and more entities experience puzzling cost overruns of large magnitude. Generally, the overruns are attributed to equipment and commodity cost increases, driven by escalating codes and standards and rapidly rising inflation. As investigations of the cost increases become more numerous, it becomes apparent that other factors are contributing to the magnitude of the increases. One major factor is currently preceived to be rising labor content. It is thought that the labor content is being driven upwards by increases in quantities of equipment and commodities to be installed; "on-again/off-again" construction activities, caused by regulatory or intervenor actions; schedule stretchouts, causing inefficient utilization of labor; and a general decline in construction labor productivity.

As the perception grows that cost estimates are using increasingly understated labor content, greater efforts are made to identify the magnitude of the understatement. By the end of 1980, data and experience indicates that labor content for a large nuclear power generating station ranges from 16 to 22 manhours per kilowatt. The uncertainty caused by such a wide range has prevented making compensating adjustments in the EEDB, prior to the Third Update.

The decision to make an adjustment in the Third Update was made in late December, 1980, after reviewing two recent studies on the subject and relevant industry experience. The studies are listed as references 27 and 28 in Section 8.1. One of the studies (reference 27) is based on an extensive survey of the recent experience of nuclear utilities with construction labor content. The concensus of these studies and recent industry experience is that a valid manhour per kilowatt number would be one near the low end of the range cited above. Values at the high end of the range are thought to be representative of special situations. Consequently, a value of 17 manhours per kilowatt is chosen for the Third Update. Additional impetus is provided to make this decision, because the EEDB Program is selected to support the capital cost estimating effort for the USDOE Replacement Production Reactor Feasibility Study during 1980.

5.5.2 Indirect Costs

Construction Services (Account 91), Home Office Engineering and Services (Account 92) and Field Office Engineering and Services (Account 93) are reviewed to assumed that they continue to reflect direct Factory Equipment Costs, direct craft labor hour costs, direct craft labor hour costs and current field practice. Modifications are made in Construction Services to account for the increases in construction labor content, discussed in Section 5.5.1.

The decision to make an adjustment in the Third Update was made in late December, 1980, after reviewing two recent studies on the subject and relevant industry experience. The studies are listed as references 27 and 28 in Section 8.1. One of the studies (reference 27) is based on an extensive survey of the recent experience of nuclear utilities with construction labor content. The concensus of these studies and recent industry experience is that a valid manhour per kilowatt number would be one near the low end of the range cited above. Values at the high end of the range are thought to be representative of special situations. Consequently, a value of 17 manhours per kilowatt is chosen for the Third Update. Additional impetus is provided to make this decision, because the EEDB Program is selected to support the capital cost estimating effort for the USDOE Replacement Production Reactor Feasibility Study during 1980.

5.5.2 Indirect Costs

Construction Services (Account 91), Home Office Engineering and Services (Account 92) and Field Office Engineering and Services (Account 93) are reviewed to assumed that they continue to reflect direct Factory Equipment Costs, direct craft labor hour costs, direct craft labor hour costs and current field practice. Modifications are made in Construction Services to account for the increases in construction labor content, discussed in Section 5.5.1.

5.6 TMI - RELATED CAPITAL COSTS

As of January 1, 1980, the full effect of the accident at the Three-Mile Island (TMI) Nuclear Power Generating Station in early 1979 is not completely identified. Analyses and evaluations are continuing to determine the effects on capital costs for nuclear power plants.

As a first approximation, seven million dollars ($\$7 \times 10^6$) may be added to the 1980 total Base Cost of each of the Nuclear Power Generating Stations in the EEDB. This covers the additional of Emergency Response Facilities, additional emergency power supplies, additional instrumentation and supporting and auxiliary equipment, required to respond to the lessons learned at TMI.

A more detailed analysis of the TMI related costs is planned to be included in the Fourth Update (1981) of the EEDB.

Effective Date - 1/1/80

TABLE 5-1

ENERGY ECONOMIC DATA BASE

CAPITAL COST UPDATE SUMMARY
($1980 x 10^6) (a)

	Nuclear Plant Models						Comparison Plant Models				
Model	BWR	HTGR-SC	PWR	PHWR	HTGR-PS	LMFBR	HS12	HS8	LS12	LS8	CGCC
MWt	3578	2240	3412	3800	1170	3800	3302	2210	3446	2307	1523
MWe	1190	858	1139	1260	150	1457	1232	795	1236	795	630
Direct Cost	680	577	665	820	426	1093	638	440	606	417	357
Indirect Cost	356	328	351	379	285	493	133	91	118	83	87
Base Cost	1036	905	1016	1199	711	1586	771	531	724	500	444
$/kWe	871	1055	892	952	(b)	1089	626	668	586	629	705

(a) Data in Constant $1980 (Inflation-Free)
(b) Not Applicable for Process Steam/Cogeneration Plant

TABLE 5-2

ENERGY ECONOMIC DATA BASE

NORMALIZED[(a)] CAPITAL COST UPDATE SUMMARY
($1980 x 10^6) (b)

	Nuclear Plant Models(c)					Comparison Plant Models(d)	
Model	BWR	HTGR-SC	PWR	PHWR	LMFBR	HS12	LS12
MWt	3425	2974	3412	3435	2971	3053	3166
MWe	1139					1139	
Direct Cost	668	659	665	787	974	597	565
Indirect Cost	350	375	351	364	439	124	110
Base Cost	1018	1034	1016	1151	1413	721	675
$/kWe	894	908	892	1011	1241	633	593
PWR Cost Ratio $/kWe	1.00	1.02	1.00	1.13	1.39	0.71	0.66

(a) Normalized to a plant size providing 1139 MWe (Net)
(b) Data in Constant $1980 (Inflation-Free)
(c) Normalization not Applicable to HTGR-PS
(d) Normalization not Applicable to HS8, LS8, and CGCC

Effective Date - 1/1/80

TABLE 5-3

ENERGY ECONOMIC DATA BASE

NORMALIZED(a) CAPITAL COST UPDATE SUMMARY
($1980 x 10^6)(b)

	Nuclear Plant Models(c)					Comparison Plant Models(d)	
Model	BWR	HTGR-SC	PWR	PHWR	LMFBR	HS12	LS12
MWt	← 3800 →					← 3800 →	
MWe	1264	1456(e)	1269	1260	1457	1418(e)	1363
Direct Cost	697	740	695	820	1093	719	659
Indirect Cost	365	421	367	379	493	150	128
Base Cost	1062	1161	1062	1199	1586	869	787
$/kWe	840	797	837	952	1089	613	577
PWR Cost Ratio $/kWe	1.00	0.95	1.00	1.14	1.30	0.73	0.69

(a) Normalized to a plant size of 3800 MWt or its equivalent

(b) Data in Constant $1980 (Inflation-Free)

(c) Normalization Not Applicable to HTGR-PS

(d) Normalization Not Applicable to HS8, LS8, and CGCC

(e) Tandem-Compound or Cross-Compound Turbines are not available for this application in 1980; therefore, if Twin Turbines are utilized, higher capital costs accrue for Structures and Turbine Plant Equipment accounts

TABLE 5-4

ENERGY ECONOMIC DATA BASE

1190 MWe BOILING WATER REACTOR NPGS

CAPITAL COST ESTIMATE

PLANT CODE 201
COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1190 MWE BOILING WATER REACTOR

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,614,000	2,614,000
21 .	STRUCTURES & IMPROVEMENTS	5,948,078	8622946 MH	119,192,472	62,838,649	187,979,199
22 .	REACTOR PLANT EQUIPMENT	142,955,969	2947200 MH	45,524,161	12,239,234	200,719,364
23 .	TURBINE PLANT EQUIPMENT	129,929,083	2651597 MH	40,221,462	7,964,066	178,114,611
24	ELECTRIC PLANT EQUIPMENT	22,966,220	2128879 MH	29,751,797	9,356,756	62,074,773
25 .	MISCELLANEOUS PLANT EQUIPT	9,556,111	483240 MH	7,405,770	1,563,436	18,525,317
26 .	MAIN COND HEAT REJECT SYS	20,775,764	487365 MH	7,039,313	1,769,782	29,584,859
	TOTAL DIRECT COSTS	332,131,225	17321227 MH	249,134,975	98,345,923	679,612,123
91	CONSTRUCTION SERVICES	49,907,710	2851800 MH	41,025,600	35,453,000	126,386,310
92 .	HOME OFFICE ENGRG.&SERVICE	156,465,100				156,465,100
93 .	FIELD OFFICE ENGRG&SERVICE	70,613,400			2,744,500	73,357,900
	TOTAL INDIRECT COSTS	276,986,210	2851800 MH	41,025,600	38,197,500	356,209,310
	TOTAL BASE COST	609,117,435	20173027 MH	290,160,575	136,543,423	1,035,821,433

PLANT CODE 201 COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1190 MWE BOILING WATER REACTOR

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,614,000	2,614,000
211.	YARDWORK	222,797	661854 MH	8,298,123	6,160,918	14,681,838
212.	REACTOR CONTAINMENT BLDG	1,295,317	2822341 MH	40,841,567	22,788,552	64,925,436
213.	TURBINE ROOM + HEATER BAY	1,510,214	1744503 MH	23,896,408	14,914,941	40,321,563
214.	SECURITY BUILDING	42,147	48799 MH	679,367	338,937	1,060,451
215.	AUXILIARY BLDG + TUNNELS	361,015	554931 MH	7,445,175	2,690,096	10,496,286
216.	WASTE PROCESS BUILDING	178,246	454023 MH	6,129,360	2,585,099	8,892,705
217.	FUEL STORAGE BLDG	129,633	532874 MH	7,529,066	3,497,057	11,155,756
218A.	CONTROL RM/D-G BUILDING	1,440,281	1067178 MH	14,337,010	5,218,801	20,996,092
218B.	ADMINISTRATION+SERVICE BLG	708,784	280425 MH	4,008,245	2,458,059	7,175,088
218D.	FIRE PUMP HOUSE,INC FNDTNS	27,008	16120 MH	223,942	106,873	357,823
218K.	PIPE TUNNELS		32015 MH	424,697	140,907	565,604
218S.	HOLDING POND		11920 MH	156,364	50,463	206,827
218T.	ULTIMATE HEAT SINK STRUCT	32,636	380471 MH	5,033,581	1,830,450	6,896,667
218V.	CONTR RM EMG AIR INTK STR		15492 MH	189,567	57,496	247,063
21 .	STRUCTURES & IMPROVEMENTS	5,948,078	8622946 MH	119,192,472	62,838,649	187,979,199

PLANT CODE 201 COST BASIS 01/80

ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1190 MWE BOILING WATER REACTOR

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
**********	*************************	*************	************	*************	*************	**************
220A.	NUCLEAR STEAM SUPPLY(NSSS)	110,000,000				110,000,000
220B.	NSSS OPTIONS					
221.	REACTOR EQUIPMENT	713,019	760728 MH	11,868,618	4,479,678	17,061,315
222.	MAIN HEAT XFER XPORT SYS.	406,820	251076 MH	3,903,904	390,245	4,700,969
223.	SAFEGUARDS SYSTEM	6,862,544	620048 MH	9,621,990	979,784	17,464,318
224.	RADWASTE PROCESSING	9,933,242	411111 MH	6,383,006	1,540,620	17,856,868
225.	FUEL HANDLING + STORAGE	993,992	90520 MH	1,394,460	163,863	2,552,315
226.	OTHER REACTOR EQUIP.	5,345,723	480032 MH	7,442,025	2,397,940	15,185,688
227.	INSTRUMENTATION + CONTROL	8,700,629	112324 MH	1,565,721	132,123	10,398,473
228.	REACTOR PLANT MISC ITEMS		221361 MH	3,344,437	2,154,981	5,499,418
22 .	REACTOR PLANT EQUIPMENT	142,955,969	2947200 MH	45,524,161	12,239,234	200,719,364
231.	TURBINE GENERATOR	86,670,926	625455 MH	9,089,419	1,641,463	97,401,808
233.	CONDENSING SYSTEMS	16,037,540	411988 MH	6,411,831	1,208,629	23,658,000
234.	FEED HEATING SYSTEM	12,150,979	548572 MH	8,514,754	851,946	21,517,679
235.	OTHER TURBINE PLANT EQUIP.	13,695,576	821196 MH	12,665,602	1,498,704	27,859,882
236.	INSTRUMENTATION + CONTROL	1,374,062	73471 MH	1,023,779	91,111	2,488,952
237.	TURBINE PLANT MISC ITEMS		170915 MH	2,516,077	2,672,213	5,188,290
23 .	TURBINE PLANT EQUIPMENT	129,929,083	2651597 MH	40,221,462	7,964,066	178,114,611

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	6,715,990	92245 MH	1,306,213	133,239	8,155,442
242.	STATION SERVICE EQUIPMENT	14,345,915	151659 MH	2,151,932	342,042	16,839,889
243.	SWITCHBOARDS	643,535	15245 MH	215,494	89,152	948,181
244.	PROTECTIVE EQUIPMENT		111802 MH	1,562,436	699,600	2,262,036
245.	ELECT.STRUC +WIRING CONTNR		828090 MH	11,521,237	2,480,258	14,001,495
246.	POWER & CONTROL WIRING	1,260,780	929838 MH	12,994,485	5,612,465	19,867,730
24 .	ELECTRIC PLANT EQUIPMENT	22,966,220	2128879 MH	29,751,797	9,356,756	62,074,773
251.	TRANSPORTATION & LIFT EQPT	1,917,304	32487 MH	499,714	148,502	2,565,520
252.	AIR,WATER+STEAM SERVICE SY	4,425,354	405014 MH	6,270,175	1,157,890	11,853,419
253.	COMMUNICATIONS EQUIPMENT	2,099,646	34498 MH	482,110	230,946	2,812,702
254.	FURNISHINGS + FIXTURES	1,113,807	11241 MH	153,771	26,098	1,293,676
25 .	MISCELLANEOUS PLANT EQUIPT	9,556,111	483240 MH	7,405,770	1,563,436	18,525,317
261.	STRUCTURES	124,720	159341 MH	2,149,644	1,039,812	3,314,176
262.	MECHANICAL EQUIPMENT	20,651,044	328024 MH	4,889,669	729,970	26,270,683
26 .	MAIN COND HEAT REJECT SYS	20,775,764	487365 MH	7,039,313	1,769,782	29,584,859
	TOTAL DIRECT COSTS	332,131,225	17321227 MH	249,134,975	98,345,923	679,612,123

PLANT CODE 201 COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1190 MWE BOILING WATER REACTOR

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
911.	TEMPORARY CONSTRUCTION FAC		2469600 MH	35,527,800	10,912,000	46,439,800
912.	CONSTRUCTION TOOLS & EQUIP		382200 MH	5,497,800	23,732,500	29,230,300
913.	PAYROLL INSURANCE & TAXES	49,907,710				49,907,710
914.	PERMITS,INS. & LOCAL TAXES				808,500	808,500
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	49,907,710	2851800 MH	41,025,600	35,453,000	126,386,310
921.	HOME OFFICE SERVICES	147,877,400				147,877,400
922.	HOME OFFICE Q/A	6,312,900				6,312,900
923.	HOME OFFICE CONSTRCTN MGMT	2,274,800				2,274,800
92 .	HOME OFFICE ENGRG.&SERVICE	156,465,100				156,465,100
931.	FIELD OFFICE EXPENSES				2,744,500	2,744,500
932.	FIELD JOB SUPERVISION	61,810,100				61,810,100
933.	FIELD QA/QC	5,216,200				5,216,200
934.	PLANT STARTUP & TEST	3,587,100				3,587,100
93 .	FIELD OFFICE ENGRG&SERVICE	70,613,400			2,744,500	73,357,900
	TOTAL INDIRECT COSTS	276,986,210	2851800 MH	41,025,600	38,197,500	356,209,310
	TOTAL BASE COST	609,117,435	20173027 MH	290,160,575	136,543,423	1,035,821,433

TABLE 5-5

ENERGY ECONOMIC DATA BASE

858 MWe HIGH TEMPERATURE GAS COOLED REACTOR-STEAM CYCLE NPGS

CAPITAL COST ESTIMATE

PLANT CODE 338 COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
858 MWE HIGH TEMPERATURE GAS COOLED REACTOR-SC

SUMMARY PAGE 1
06/22/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND + LAND RIGHTS				2,614,000	2,614,000
21 .	STRUCTURES & IMPROVEMENTS	4,146,254	6462035 MH	89,537,474	48,262,503	141,946,231
22 .	REACTOR PLANT EQUIPMENT	191,790,006	2115551 MH	31,852,026	19,230,694	242,872,726
23 .	TURBINE PLANT EQUIPMENT	70,868,963	1546599 MH	23,200,960	4,466,804	98,536,727
24 .	ELECTRIC PLANT EQUIP	16,457,181	1952776 MH	27,232,257	10,524,331	54,213,769
25 .	MISC. PLANT EQUIP	7,115,681	363594 MH	5,546,413	1,214,291	13,876,385
26 .	MAIN COND HEAT REJECT SYS	15,391,077	395879 MH	5,688,083	2,208,592	23,287,752
	TOTAL DIRECT COSTS	305,769,162	12836434 MH	183,057,213	88,521,215	577,347,590
91 .	CONSTRUCTION SERVICES	37,090,545	2484300 MH	32,585,490	30,039,000	99,715,035
92 .	HOME OFFICE ENGRG.&SERVICE	158,074,900				158,074,900
93 .	FIELD OFFICE ENGRG&SERVICE	64,873,050			5,488,100	70,361,150
	TOTAL INDIRECT COSTS	260,038,495	2484300 MH	32,585,490	35,527,100	328,151,085
	TOTAL BASE COST	565,807,657	15320734 MH	215,642,703	124,048,315	905,498,675

PLANT CODE 338 COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
858 MWE HIGH TEMPERATURE GAS COOLED REACTOR-SC

06/22/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
*********	*************************	************	***********	*************	************	*************
20 .	LAND + LAND RIGHTS				2,614,000	2,614,000
211.	YARDWORK	217,440	461749 MH	5,943,271	4,345,804	10,506,515
212.	REACTOR CONTAINMENT BLDG	758,489	1975241 MH	28,801,682	18,975,803	48,535,974
213.	TURBINE BUILDING	530,413	310245 MH	4,456,143	4,163,950	9,150,506
214.	SECURITY BUILDING	37,600	19509 MH	281,027	171,787	490,414
215.	AUX REACTOR SERVICE BLDG	696,200	536801 MH	7,327,019	3,534,005	11,557,224
216.	MAIN CIRC CONTROL BLDG		12277 MH	170,753	414,891	585,644
217.	LONG TERM FUEL STORAGE BLD	57,893	451643 MH	6,162,204	2,544,362	8,764,459
218A.	CONTROL, AUXIL & D.G.BLDG	1,386,232	1035746 MH	14,042,980	4,794,533	20,223,745
218B.	ADMIN + SERV BLDG	332,419	220501 MH	3,165,748	2,159,459	5,657,626
218D.	FIRE PUMP HOUSE	28,902	9009 MH	128,491	60,582	217,975
218E.	L.P. HELIUM STORAGE AREA		42495 MH	583,106	565,072	1,148,178
218F.	NON-VITAL SWITCHGEAR BLDG		6136 MH	85,892	69,100	154,992
218H.	DIES CLG + FL OIL STG BLDG	11,130	185987 MH	2,473,000	868,618	3,352,748
218I.	WAREHOUSE		8166 MH	114,409	98,411	212,820
218J.	CONTAINMENT ANNULUS BLDG		229185 MH	3,099,001	1,387,067	4,486,068
218K.	CONTAIN PENETRATION BLDG	27,526	413290 MH	5,499,052	2,021,452	7,548,030
218S.	HOLDING PUMP + CONTRL HSE		18906 MH	252,034	104,124	356,158
218T.	ULTIM HEAT SINK STR+TUNNLS	39,647	518182 MH	6,859,420	1,960,385	8,859,452
218V.	CTL RM EMG AIR IN STR	22,363	6967 MH	92,242	23,098	137,703
21 .	STRUCTURES & IMPROVEMENTS	4,146,254	6462035 MH	89,537,474	48,262,503	141,946,231

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
858 MWE HIGH TEMPERATURE GAS COOLED REACTOR-SC

PLANT CODE 338
COST BASIS 01/80

06/22/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
220A.	NUCLEAR STEAM SUPPLY(NSSS)	159,000,000				159,000,000
220B.	NSSS OPTIONS					
221.	REACTOR EQUIPMENT	516,623	983239 MH	14,480,788	17,316,771	32,314,182
222.	MAIN HEAT TRANS SYS.	1,662,072	169152 MH	2,749,017	290,163	4,701,252
223.	SAFEGUARDS COOL. SYS.	5,095,958	196586 MH	3,045,074	391,608	8,532,640
224.	RAD WASTE PROCESSING	2,592,141	82516 MH	1,278,431	174,512	4,045,084
225.	NUCLEAR FUEL HANDLING + ST	5,379,445	101818 MH	1,555,271	144,668	7,079,384
226.	OTHER REACTOR PLANT EQUIP	14,488,556	331182 MH	5,120,922	569,883	20,179,361
227.	INSTRUMENTATION + CONTROL	2,655,211	103940 MH	1,448,348	25,683	4,129,242
228.	REACTOR PLANT MISC ITEMS	400,000	147118 MH	2,174,175	317,406	2,891,581
22 .	REACTOR PLANT EQUIPMENT	191,790,006	2115551 MH	31,852,026	19,230,694	242,872,726
231.	TURBINE GENERATOR	45,719,575	543442 MH	7,797,634	1,917,656	55,434,865
233.	CONDENSING SYS.	8,155,985	199021 MH	3,205,116	621,511	11,982,612
234.	FEED HEAT. SYS.	8,586,455	265596 MH	4,132,182	461,334	13,179,971
235.	OTHER TURB PLANT EQUIP	7,559,848	377626 MH	5,835,317	830,030	14,225,195
236.	INSTRUMENTATION + CONTROL	847,100	70414 MH	981,170	10,344	1,838,614
237.	TURBINE PLANT MISC ITEMS		90500 MH	1,249,541	625,929	1,875,470
23 .	TURBINE PLANT EQUIPMENT	70,868,963	1546599 MH	23,200,960	4,466,804	98,536,727

PLANT CODE 338 COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
858 MWE HIGH TEMPERATURE GAS COOLED REACTOR-SC

06/22/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	5,709,424	88908 MH	1,258,965	129,258	7,097,647
242.	STATION SERVICE EQUIP	9,370,686	135234 MH	1,891,587	319,623	11,581,896
243.	SWITCHBOARDS	586,865	16192 MH	228,156	20,530	835,551
244.	PROTECTIVE EQUIP		121692 MH	1,700,653	618,759	2,319,412
245.	ELEC STRUC + WIRING CNTNRS		751069 MH	10,418,342	2,332,716	12,751,058
246.	POWER & CONTROL WIRING	790,206	839681 MH	11,734,554	7,103,445	19,628,205
24 .	ELECTRIC PLANT EQUIP	16,457,181	1952776 MH	27,232,257	10,524,331	54,213,769
251.	TRANSPORTATION+LIFT EQUIP	2,146,162	27242 MH	419,034	41,904	2,607,100
252.	AIR WTR+STEAM SERV SYS	2,643,083	290087 MH	4,486,815	1,090,629	8,220,527
253.	COMMUNICATIONS EQUIP	1,224,922	34399 MH	480,272	40,448	1,745,642
254.	FURNISHINGS + FIXTURES	1,101,514	11866 MH	160,292	41,310	1,303,116
25 .	MISC. PLANT EQUIP	7,115,681	363594 MH	5,546,413	1,214,291	13,876,385
261.	STRUCTURES	101,497	120151 MH	1,653,755	919,315	2,674,567
262.	MECHANICAL EQUIPMENT	15,289,580	275728 MH	4,034,328	1,289,277	20,613,185
26 .	MAIN COND HEAT REJECT SYS	15,391,077	395879 MH	5,688,083	2,208,592	23,287,752
	TOTAL DIRECT COSTS	305,769,162	12836434 MH	183,057,213	88,521,215	577,347,590

PLANT CODE 338 COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
858 MWE HIGH TEMPERATURE GAS COOLED REACTOR-SC

06/22/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
911.	TEMPORARY CONSTRUCTION FAC		2153550 MH	27,458,130	9,334,000	36,792,130
912.	CONSTRUCTION TOOLS & EQUIP		330750 MH	5,127,360	19,669,000	24,796,360
913.	PAYROLL INSURANCE & TAXES	37,090,545				37,090,545
914.	PERMITS,INS. & LOCAL TAXES				1,036,000	1,036,000
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	37,090,545	2484300 MH	32,585,490	30,039,000	99,715,035
921.	HOME OFFICE SERVICES	149,311,000				149,311,000
922.	HOME OFFICE Q/A	6,479,400				6,479,400
923.	HOME OFFICE CONSTRCTN MGMT	2,284,500				2,284,500
92 .	HOME OFFICE ENGRG &SERVICE	158,074,900				158,074,900
931.	FIELD OFFICE EXPENSES				5,488,100	5,488,100
932.	FIELD JOB SUPERVISION	56,131,700				56,131,700
933.	FIELD QA/QC	5,126,350				5,126,350
934.	PLANT STARTUP & TEST	3,615,000				3,615,000
93 .	FIELD OFFICE ENGRG&SERVICE	64,873,050			5,488,100	70,361,150
	TOTAL INDIRECT COSTS	260,038,495	2484300 MH	32,585,490	35,527,100	328,151,085
	TOTAL BASE COST	565,807,657	15320734 MH	215,642,703	124,048,315	905,498,675

TABLE 5-6

ENERGY ECONOMIC DATA BASE

1139 MWe PRESSURIZED WATER REACTOR NPGS

CAPITAL COST ESTIMATE

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1139 MWE PRESSURIZED WATER REACTOR

PLANT CODE 148
COST BASIS 01/80

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,614,000	2,614,000
21 .	STRUCTURES + IMPROVEMENTS	8,823,398	7614673 MH	105,308,745	54,348,827	168,480,970
22 .	REACTOR PLANT EQUIPMENT	158,748,701	3007057 MH	46,612,094	13,241,478	218,602,273
23 .	TURBINE PLANT EQUIPMENT	120,390,157	2585417 MH	39,291,540	7,740,705	167,422,402
24 .	ELECTRIC PLANT EQUIPMENT	20,814,621	2106496 MH	29,430,551	9,208,369	59,453,541
25 .	MISCELLANEOUS PLANT EQUIPT	10,106,911	519466 MH	7,966,630	1,628,119	19,701,660
26 .	MAIN COND HEAT REJECT SYS	20,218,911	482595 MH	6,965,958	1,762,428	28,947,297
	TOTAL DIRECT COSTS	339,102,699	16315704 MH	235,575,518	90,543,926	665,222,143
91 .	CONSTRUCTION SERVICES	47,334,400	2748900 MH	39,624,200	33,968,000	120,926,600
92 .	HOME OFFICE ENGRG.&SERVICE	156,465,100				156,465,100
93 .	FIELD OFFICE ENGRG&SERVICE	70,613,400			2,744,500	73,357,900
	TOTAL INDIRECT COSTS	274,412,900	2748900 MH	39,624,200	36,712,500	350,749,600
	TOTAL BASE COST	613,515,599	19064604 MH	275,199,718	127,256,426	1,015,971,743

PLANT CODE 148 COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1139 MWE PRESSURIZED WATER REACTOR

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,614,000	2,614,000
211.	YARDWORK	222,797	658973 MH	8,259,154	6,106,856	14,588,807
212.	REACTOR CONTAINMENT BLDG	4,085,441	2401316 MH	34,705,674	18,027,789	56,818,904
213.	TURBINE ROOM + HEATER BAY	567,452	587299 MH	8,392,679	8,924,430	17,884,561
214.	SECURITY BUILDING	42,147	48799 MH	679,367	338,937	1,060,451
215.	PRIM AUX BLDG + TUNNELS	753,740	727138 MH	9,866,647	3,664,680	14,285,067
216.	WASTE PROCESS BUILDING	223,400	703585 MH	9,416,677	3,657,077	13,297,154
217.	FUEL STORAGE BLDG	771,118	337468 MH	4,841,007	2,072,742	7,684,867
218A.	CONTROL RM/D-G BUILDING	1,327,325	926176 MH	12,621,865	4,494,658	18,443,848
218B.	ADMINISTRATION+SERVICE BLG	707,191	280396 MH	4,007,756	2,457,895	7,172,842
218D.	FIRE PUMP HOUSE,INC FNDTNS	27,008	16191 MH	225,047	107,493	359,548
218E.	EMERGENCY FEED PUMP BLDG	28,185	205072 MH	2,716,943	710,482	3,455,610
218F.	MANWAY TUNNELS (RCA TUNLS)	2,043	49437 MH	655,953	194,508	852,504
218G.	ELEC. TUNNELS	3,699	557 MH	8,655	3,613	15,967
218H.	NON-ESSEN. SWGR BLDG	16,676	21709 MH	293,955	163,210	473,841
218J.	MN STEAM + FW PIPE ENC	9,247	206965 MH	2,772,357	1,350,210	4,131,814
218K.	PIPE TUNNELS		25588 MH	339,715	112,432	452,147
218M.	HYDROGEN RECOMBINER STRUCT	3,293	9044 MH	122,746	57,106	183,145
218P.	CONTAIN EQ HATCH MSLE SHLD		14149 MH	186,290	40,740	227,030
218S.	HOLDING POND		11920 MH	156,364	50,463	206,827
218T.	ULTIMATE HEAT SINK STRUCT	32,636	367399 MH	4,850,327	1,756,010	6,638,973
218V.	CONTR RM EMG AIR INTK STR		15492 MH	189,567	57,496	247,063
21 .	STRUCTURES + IMPROVEMENTS	8,823,398	7614673 MH	105,308,745	54,348,827	168,480,970

PLANT CODE 148 COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1139 MWE PRESSURIZED WATER REACTOR

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
220A.	NUCLEAR STEAM SUPPLY(NSSS)	117,000,000				117,000,000
220B.	NSSS OPTIONS					
221.	REACTOR EQUIPMENT	656,080	128499 MH	2,024,645	2,738,418	5,419,143
222.	MAIN HEAT XFER XPORT SYS.	5,389,978	550359 MH	8,665,815	880,037	14,935,830
223.	SAFEGUARDS SYSTEM	5,247,033	678527 MH	10,534,410	1,448,780	17,230,223
224.	RADWASTE PROCESSING	7,577,759	366113 MH	5,692,795	988,046	14,258,600
225.	FUEL HANDLING + STORAGE	3,532,051	87992 MH	1,351,196	162,326	5,045,573
226.	OTHER REACTOR PLANT EQUIP	9,032,188	899296 MH	13,960,274	4,366,728	27,359,190
227.	RX INSTRUMENTATION+CONTROL	8,403,099	79205 MH	1,104,221	93,974	9,601,294
228.	REACTOR PLANT MISC ITEMS	1,910,513	217066 MH	3,278,738	2,563,169	7,752,420
22 .	REACTOR PLANT EQUIPMENT	158,748,701	3007057 MH	46,612,094	13,241,478	218,602,273
231.	TURBINE GENERATOR	83,967,599	613342 MH	8,909,156	1,627,607	94,504,362
233.	CONDENSING SYSTEMS	13,189,651	397590 MH	6,185,168	1,185,150	20,559,969
234.	FEED HEATING SYSTEM	12,416,731	559622 MH	8,686,896	869,117	21,972,744
235.	OTHER TURBINE PLANT EQUIP.	9,412,037	790928 MH	12,261,939	1,458,100	23,132,076
236.	INSTRUMENTATION + CONTROL	1,404,139	56605 MH	788,768	67,377	2,260,284
237.	TURBINE PLANT MISC ITEMS		167330 MH	2,459,613	2,533,354	4,992,967
23 .	TURBINE PLANT EQUIPMENT	120,390,157	2585417 MH	39,291,540	7,740,705	167,422,402

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	6,851,200	90961 MH	1,288,023	131,420	8,270,643
242.	STATION SERVICE EQUIPMENT	11,996,346	141150 MH	1,995,743	313,224	14,305,313
243.	SWITCHBOARDS	643,535	15245 MH	215,494	89,152	948,181
244.	PROTECTIVE EQUIPMENT		111802 MH	1,562,436	699,600	2,262,036
245.	ELECT.STRUC +WIRING CONTNR		809006 MH	11,255,679	2,422,921	13,678,600
246.	POWER & CONTROL WIRING	1,323,540	938332 MH	13,113,176	5,552,052	19,988,768
24 .	ELECTRIC PLANT EQUIPMENT	20,814,621	2106496 MH	29,430,551	9,208,369	59,453,541
251.	TRANSPORTATION & LIFT EQPT	2,418,453	41675 MH	641,029	162,634	3,222,116
252.	AIR,WATER+STEAM SERVICE SY	4,475,005	432052 MH	6,689,720	1,208,441	12,373,166
253.	COMMUNICATIONS EQUIPMENT	2,099,646	34498 MH	482,110	230,946	2,812,702
254.	FURNISHINGS + FIXTURES	1,113,807	11241 MH	153,771	26,098	1,293,676
25 .	MISCELLANEOUS PLANT EQUIPT	10,106,911	519466 MH	7,966,630	1,628,119	19,701,660
261.	STRUCTURES	124,720	159353 MH	2,149,826	1,039,812	3,314,358
262.	MECHANICAL EQUIPMENT	20,094,191	323242 MH	4,816,132	722,616	25,632,939
26	MAIN COND HEAT REJECT SYS	20,218,911	482595 MH	6,965,958	1,762,428	28,947,297
	TOTAL DIRECT COSTS	339,102,699	16315704 MH	235,575,518	90,543,926	665,222,143

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1139 MWE PRESSURIZED WATER REACTOR

PLANT CODE 148
COST BASIS 01/80

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
911.	TEMPORARY CONSTRUCTION FAC		2381400 MH	34,326,600	10,510,500	44,837,100
912.	CONSTRUCTION TOOLS & EQUIP		367500 MH	5,297,600	22,665,500	27,963,100
913.	PAYROLL INSURANCE & TAXES	47,334,400				47,334,400
914.	PERMITS,INS. & LOCAL TAXES				792,000	792,000
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	47,334,400	2748900 MH	39,624,200	33,968,000	120,926,600
921.	HOME OFFICE SERVICES	147,877,400				147,877,400
922.	HOME OFFICE Q/A	6,312,900				6,312,900
923.	HOME OFFICE CONSTRCTN MGMT	2,274,800				2,274,800
92 .	HOME OFFICE ENGRG.&SERVICE	156,465,100				156,465,100
931.	FIELD OFFICE EXPENSES				2,744,500	2,744,500
932.	FIELD JOB SUPERVISION	61,810,100				61,810,100
933.	FIELD QA/QC	5,216,200				5,216,200
934.	PLANT STARTUP & TEST	3,587,100				3,587,100
93 .	FIELD OFFICE ENGRG&SERVICE	70,613,400			2,744,500	73,357,900
	TOTAL INDIRECT COSTS	274,412,900	2748900 MH	39,624,200	36,712,500	350,749,600
	TOTAL BASE COST	613,515,599	19064604 MH	275,199,718	127,256,426	1,015,971,743

TABLE 5-7

ENERGY ECONOMIC DATA BASE

1260 MWe PRESSURIZED HEAVY WATER REACTOR NPGS

CAPITAL COST ESTIMATE

PLANT CODE 165
COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1260 MWE PRESSURIZED HEAVY WATER REACTOR

06/19/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND + LAND RIGHTS				2,614,000	2,614,000
21 .	STRUCTURES + IMPROVEMENTS	9,584,141	8351048 MH	115,597,610	73,141,465	198,323,216
22 .	REACTOR PLANT EQUIPMENT	220,265,780	2956878 MH	45,779,163	13,908,334	279,953,277
23 .	TURBINE PLANT EQUIPMENT	146,316,375	3165474 MH	48,127,318	9,269,238	203,712,931
24 .	ELECTRIC PLANT EQUIPMENT	19,809,281	2625952 MH	36,656,993	11,601,466	68,067,740
25 .	MISCELLANEOUS PLANT EQUIPT	12,859,202	687143 MH	10,320,446	1,424,840	24,604,488
26 .	MAIN COND HEAT REJECT SYS	31,197,499	621279 MH	9,020,979	2,094,448	42,312,926
	TOTAL DIRECT COSTS	440,032,278	18407774 MH	265,502,509	114,053,791	819,588,578
91 .	CONSTRUCTION SERVICES	53,142,500	3009800 MH	43,465,450	36,987,500	133,595,450
92 .	HOME OFFICE ENGRG.&SERVICE	166,861,200				166,861,200
93 .	FIELD OFFICE ENGRG&SERVICE	75,836,200			3,206,500	79,042,700
	TOTAL INDIRECT COSTS	295,839,900	3009800 MH	43,465,450	40,194,000	379,499,350
	TOTAL BASE COST	735,872,178	21417574 MH	308,967,959	154,247,791	1,199,087,928

PLANT CODE 165

COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1260 MWE PRESSURIZED HEAVY WATER REACTOR

06/19/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND + LAND RIGHTS				2,614,000	2,614,000
211.	YARDWORK	222,139	650098 MH	8,121,428	5,614,306	13,957,873
212.	REACTOR CONTAINMENT BLDG	3,969,214	2952546 MH	42,454,186	21,824,614	68,248,014
213.	TURBINE ROOM + HEATER BAY	661,117	602297 MH	8,624,887	9,478,700	18,764,704
214.	SECURITY BUILDING	42,147	48314 MH	673,608	334,097	1,049,852
215.	RX SERV.& F.H. BUILDING	987,827	1147855 MH	14,159,657	5,003,697	20,151,181
216.	D2O UPGRADING TOWER STRUCT	118,539	126928 MH	1,604,709	1,166,358	2,889,606
218A.	CONTROL RM/D-G BUILDING	1,508,899	1019090 MH	13,697,439	4,081,213	19,287,551
218B.	ADMINISTRATION+WAREHOUSE	674,087	279484 MH	3,993,440	2,452,616	7,120,143
218D.	FIRE PUMP HOUSE,INC FNDTNS	22,223	16015 MH	222,333	107,166	351,722
218J.	PENETRATIONS BUILDING	95,313	208134 MH	2,790,845	9,251,558	12,137,716
218K.	PIPE TUNNELS		25588 MH	339,715	112,432	452,147
218S.	HOLDING POND		10303 MH	133,745	42,383	176,128
218T.	ULTIMATE HEAT SINK STRUCT	32,636	309904 MH	4,092,051	4,367,664	8,492,351
218V.	CONTR RM EMG AIR INTK STR		15492 MH	189,567	54,661	244,228
219.	AFI	1,250,000	939000 MH	14,500,000	9,250,000	25,000,000
21 .	STRUCTURES + IMPROVEMENTS	9,584,141	8351048 MH	115,597,610	73,141,465	198,323,216

PLANT CODE 165 COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1260 MWE PRESSURIZED HEAVY WATER REACTOR

06/19/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
*********	*************************	************	***********	************	************	*************
220A.	NUCLEAR STEAM SUPPLY(NSSS)	153,909,962				153,909,962
220B.	NSSS OPTIONS					
221.	REACTOR EQUIPMENT	1,161,570	313327 MH	4,936,611	3,781,168	9,879,349
222A.	MAIN HEAT XFER XPORT SYS.	2,880,422	572511 MH	9,001,302	1,207,452	13,089,176
222B.	MODERATOR CIRCUIT	19,791	43988 MH	685,120	78,481	783,392
223.	SAFEGUARDS SYSTEM	2,700,333	299230 MH	4,643,839	540,167	7,884,339
224.	RADWASTE PROCESSING	5,744,080	170348 MH	2,652,115	738,335	9,134,530
225.	FUEL HANDLING + STORAGE	2,775,943	140656 MH	2,179,694	245,185	5,200,822
226.	OTHER REACTOR PLANT EQUIP	13,327,549	727537 MH	11,285,678	2,875,686	27,488,913
227.	RX INSTRUMENTATION+CONTROL	8,185,617	108215 MH	1,516,066	128,691	9,830,374
228.	REACTOR PLANT MISC ITEMS	1,910,513	217066 MH	3,278,738	2,563,169	7,752,420
229.	AFI	27,650,000	364000 MH	5,600,000	1,750,000	35,000,000
22 .	REACTOR PLANT EQUIPMENT	220,265,780	2956878 MH	45,779,163	13,908,334	279,953,277
231.	TURBINE GENERATOR	94,913,858	658607 MH	9,635,550	1,719,875	106,269,283
233.	CONDENSING SYSTEMS	14,079,740	459474 MH	7,145,815	1,134,360	22,359,915
234.	FEED WATER HEATING SYSTEM	9,885,408	621831 MH	9,666,732	1,036,483	20,588,623
235.	OTHER TURBINE PLANT EQUIP.	9,387,936	790848 MH	12,262,832	1,458,299	23,109,067
236.	INSTRUMENTATION + CONTROL	1,249,433	56138 MH	782,265	66,727	2,098,425
237.	TURBINE PLANT MISC ITEMS		178576 MH	2,634,124	2,653,494	5,287,618
239.	AFI	16,800,000	400000 MH	6,000,000	1,200,000	24,000,000
23 .	TURBINE PLANT EQUIPMENT	146,316,375	3165474 MH	48,127,318	9,269,238	203,712,931

PLANT CODE 165 | COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1260 MWE PRESSURIZED HEAVY WATER REACTOR

06/19/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	5,937,910	97643 MH	1,382,645	135,664	7,456,219
242.	STATION SERVICE EQUIPMENT	9,871,176	150897 MH	2,132,720	325,996	12,329,892
243.	SWITCHBOARDS	542,300	15246 MH	215,497	78,062	835,859
244.	PROTECTIVE EQUIPMENT		111921 MH	1,564,103	529,100	2,093,203
245.	ELECT.STRUC +WIRING CONTNR		899013 MH	12,504,787	2,552,706	15,057,493
246.	POWER & CONTROL WIRING	1,137,895	1040232 MH	14,537,241	6,619,938	22,295,074
249.	AFI	2,320,000	311000 MH	4,320,000	1,360,000	8,000,000
24 .	ELECTRIC PLANT EQUIPMENT	19,809,281	2625952 MH	36,656,993	11,601,466	68,067,740
251.	TRANSPORTATION & LIFT EQPT	2,418,453	41675 MH	641,029	162,634	3,222,116
252.	AIR,WATER+STEAM SERVICE SY	5,518,268	363032 MH	5,621,272	599,936	11,739,476
253.	COMMUNICATIONS EQUIPMENT	2,016,673	174195 MH	2,434,374	426,172	4,877,219
254.	FURNISHINGS + FIXTURES	1,085,808	11241 MH	153,771	26,098	1,265,677
259.	AFI	1,820,000	97000 MH	1,470,000	210,000	3,500,000
25 .	MISCELLANEOUS PLANT EQUIPT	12,859,202	687143 MH	10,320,446	1,424,840	24,604,488
261.	STRUCTURES	124,720	162157 MH	2,185,965	1,039,812	3,350,497
262.	MECHANICAL EQUIPMENT	27,742,779	393122 MH	5,890,014	829,636	34,462,429
269.	AFI	3,330,000	66000 MH	945,000	225,000	4,500,000
26 .	MAIN COND HEAT REJECT SYS	31,197,499	621279 MH	9,020,979	2,094,448	42,312,926
	TOTAL DIRECT COSTS	440,032,278	18407774 MH	265,502,509	114,053,791	819,588,578

PLANT CODE 165 COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1260 MWE PRESSURIZED HEAVY WATER REACTOR

06/19/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
911.	TEMPORARY CONSTRUCTION FAC		2607500 MH	37,656,450	11,352,000	49,008,450
912.	CONSTRUCTION TOOLS & EQUIP		402300 MH	5,809,000	24,728,000	30,537,000
913.	PAYROLL INSURANCE & TAXES	53,142,500				53,142,500
914.	PERMITS,INS. & LOCAL TAXES				907,500	907,500
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	53,142,500	3009800 MH	43,465,450	36,987,500	133,595,450
921.	HOME OFFICE SERVICES	157,813,700				157,813,700
922.	HOME OFFICE Q/A	6,776,000				6,776,000
923.	HOME OFFICE CONSTRCTN MGMT	2,271,500				2,271,500
92 .	HOME OFFICE ENGRG.&SERVICE	166,861,200				166,861,200
931.	FIELD OFFICE EXPENSES				3,206,500	3,206,500
932.	FIELD JOB SUPERVISION	66,537,900				66,537,900
933.	FIELD QA/QC	5,640,800				5,640,800
934.	PLANT STARTUP & TEST	3,657,500				3,657,500
93 .	FIELD OFFICE ENGRG&SERVICE	75,836,200			3,206,500	79,042,700
	TOTAL INDIRECT COSTS	295,839,900	3009800 MH	43,465,450	40,194,000	379,499,350
	TOTAL BASE COST	735,872,178	21417574 MH	308,967,959	154,247,791	1,199,087,928

TABLE 5-8

ENERGY ECONOMIC DATA BASE

150 MWe HIGH TEMPERATURE GAS COOLED REACTOR-PROCESS STEAM NPGS

CAPITAL COST ESTIMATE

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
150 MWE HIGH TEMPERATURE GAS COOLED REACTOR-PS

PLANT CODE 325

COST BASIS 01/80

06/23/81

ACCT NO **********	ACCOUNT DESCRIPTION **************************	FACTORY EQUIP. COSTS *************	SITE LABOR HOURS ************	SITE LABOR COST *************	SITE MATERIAL COST *************	TOTAL COSTS **************
20 .	LAND + LAND RIGHTS				2,614,000	2,614,000
21 .	STRUCTURES & IMPROVEMENTS	4,085,903	5521394 MH	76,316,112	38,479,114	118,881,129
22 .	REACTOR PLANT EQUIPMENT	140,007,358	1541097 MH	23,200,753	13,756,920	176,965,031
23 .	TURBINE PLANT EQUIPMENT	40,669,963	910662 MH	13,620,320	3,288,421	57,578,704
24 .	ELECTRIC PLANT EQUIP	13,313,659	1818031 MH	25,357,990	11,845,055	50,516,704
25 .	MISC. PLANT EQUIP	6,380,756	346691 MH	5,284,539	1,188,133	12,853,428
26 .	MAIN COND HEAT REJECT SYS	3,595,472	128072 MH	1,876,286	832,712	6,304,470
	TOTAL DIRECT COSTS	208,053,111	10265947 MH	145,656,000	72,004,355	425,713,466
91 .	CONSTRUCTION SERVICES	29,828,985	2152080 MH	27,768,300	23,238,000	80,835,285
92 .	HOME OFFICE ENGRG.&SERVICE	143,988,220				143,988,220
93 .	FIELD OFFICE ENGRG&SERVICE	55,899,770			4,714,660	60,614,430
	TOTAL INDIRECT COSTS	229,716,975	2152080 MH	27,768,300	27,952,660	285,437,935
	TOTAL BASE COST	437,770,086	12418027 MH	173,424,300	99,957,015	711,151,401

PLANT CODE 325 COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
150 MWE HIGH TEMPERATURE GAS COOLED REACTOR-PS

06/23/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND + LAND RIGHTS				2,614,000	2,614,000
211.	YARDWORK	217,511	321662 MH	4,133,112	2,991,015	7,341,638
212.	REACTOR CONTAINMENT BLDG	758,016	1562907 MH	22,755,532	14,773,042	38,286,590
213.	TURBINE BUILDING	551,370	205482 MH	2,918,138	1,974,904	5,444,412
214.	SECURITY BUILDING	37,600	19509 MH	281,027	171,787	490,414
215.	AUX. REACTOR SERVICE BLDG	520,786	520645 MH	7,100,095	3,345,559	10,966,440
216.	MAIN CIRC CONTROL BLDG		7115 MH	100,870	358,091	458,961
217.	FUEL STORAGE BLDG	57,969	317460 MH	4,336,545	1,772,705	6,167,219
218A.	CONTROL, AUXIL & D G.BLDG	1,386,232	947382 MH	12,860,516	4,364,052	18,610,800
218B.	ADMIN + SERV BLDG	332,419	220501 MH	3,165,748	2,159,459	5,657,626
218D.	FIRE PUMP HOUSE	28,902	9009 MH	128,491	60,582	217,975
218E.	HELIUM STORAGE AREA		47881 MH	635,631	291,071	926,702
218F.	MAKE-UP WATER TREAT BLDG	94,505	303772 MH	4,031,358	863,620	4,989,483
218H.	DIES CLG + FL OIL STG BLDG	11,130	132949 MH	1,760,160	577,045	2,348,335
218I.	WAREHOUSE		8166 MH	114,409	98,411	212,820
218J.	CONTAINMENT ANNULUS BLDG		201120 MH	2,715,949	1,191,675	3,907,624
218K.	CONTAIN PENETRATION BLDG	27,526	413290 MH	5,499,052	2,021,452	7,548,030
218S.	HOLDING POND		12077 MH	158,343	51,263	209,606
218T.	ULTIMATE HEAT SINK STRUCT	39,574	263500 MH	3,528,894	1,390,283	4,958,751
218V.	CTL RM EMG AIR IN STR	22,363	6967 MH	92,242	23,098	137,703
21 .	STRUCTURES & IMPROVEMENTS	4,085,903	5521394 MH	76,316,112	38,479,114	118,881,129

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
220A.	NUCLEAR STEAM SUPPLY(NSSS)	114,100,000				114,100,000
220B.	NSSS OPTIONS					
221.	REACTOR EQUIPMENT	416,623	647874 MH	9,799,273	12,282,097	22,497,993
222.	MAIN HEAT TRANS SYS.	1,284,415	86745 MH	1,408,172	150,515	2,843,102
223.	SAFEGUARDS COOL. SYS.	3,227,025	167597 MH	2,595,278	310,550	6,132,853
224.	RAD WASTE PROCESSING	2,075,314	71933 MH	1,114,210	147,442	3,336,966
225.	NUCLEAR FUEL HANDLING + ST	4,062,589	74934 MH	936,317	87,229	5,086,135
226.	OTHER REACTOR PLANT EQUIP	12,113,795	244166 MH	3,769,499	417,111	16,300,405
227.	INSTRUMENTATION + CONTROL	2,327,597	102200 MH	1,424,100	32,070	3,783,767
228.	REACTOR PLANT MISC ITEMS	400,000	145648 MH	2,153,904	329,906	2,883,810
22 .	REACTOR PLANT EQUIPMENT	140,007,358	1541097 MH	23,200,753	13,756,920	176,965,031
231.	TURBINE GENERATOR	17,708,115	281829 MH	4,040,982	1,016,075	22,765,172
233.	CONDENSING SYS.	1,518,252	113879 MH	1,795,080	300,810	3,614,142
234.	FEED HEAT. SYS.	5,709,543	144022 MH	2,242,065	253,565	8,205,173
235.	OTHER TURB PLANT EQUIP	14,991,488	241035 MH	3,709,522	658,883	19,359,893
236.	INSTRUMENTATION + CONTROL	742,565	70046 MH	976,050	510,088	2,228,703
237.	TURBINE PLANT MISC ITEMS		59851 MH	856,621	549,000	1,405,621
23 .	TURBINE PLANT EQUIPMENT	40,669,963	910662 MH	13,620,320	3,288,421	57,578,704

PLANT CODE 325 COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
150 MWE HIGH TEMPERATURE GAS COOLED REACTOR-PS

06/23/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	5,538,071	91822 MH	1,300,222	139,365	6,977,658
242.	STATION SERVICE EQUIP	6,699,868	126316 MH	1,771,212	285,923	8,757,003
243.	SWITCHBOARDS	751,233	16192 MH	228,156	20,530	999,919
244.	PROTECTIVE EQUIP		121692 MH	1,700,653	672,728	2,373,381
245.	ELEC STRUC + WIRING CNTNRS		712659 MH	9,885,575	2,376,068	12,261,643
246.	POWER & CONTROL WIRING	324,487	749350 MH	10,472,172	8,350,441	19,147,100
24 .	ELECTRIC PLANT EQUIP	13,313,659	1818031 MH	25,357,990	11,845,055	50,516,704
251.	TRANSPORTATION+LIFT EQUIP	2,031,157	27242 MH	419,034	41,904	2,492,095
252.	AIR WTR+STEAM SERV SYS	2,268,893	273469 MH	4,228,917	1,062,205	7,560,015
253.	COMMUNICATIONS EQUIP	1,085,625	34399 MH	480,272	40,448	1,606,345
254.	FURNISHINGS + FIXTURES	995,081	11581 MH	156,316	43,576	1,194,973
25 .	MISC. PLANT EQUIP	6,380,756	346691 MH	5,284,539	1,188,133	12,853,428
261.	STRUCTURES	60,311	57026 MH	864,825	331,687	1,256,823
262.	MECHANICAL EQUIPMENT	3,535,161	71046 MH	1,011,461	501,025	5,047,647
26 .	MAIN COND HEAT REJECT SYS	3,595,472	128072 MH	1,876,286	832,712	6,304,470
	TOTAL DIRECT COSTS	208,053,111	10265947 MH	145,656,000	72,004,355	425,713,466

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
150 MWE HIGH TEMPERATURE GAS COOLED REACTOR-PS

06/23/81

PLANT CODE 325

COST BASIS 01/80

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
911.	TEMPORARY CONSTRUCTION FAC		1831620 MH	22,801,170	7,064,000	29,865,170
912.	CONSTRUCTION TOOLS & EQUIP		320460 MH	4,967,130	15,524,000	20,491,130
913.	PAYROLL INSURANCE & TAXES	29,828,985				29,828,985
914.	PERMITS,INS. & LOCAL TAXES				650,000	650,000
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	29,828,985	2152080 MH	27,768,300	23,238,000	80,835,285
921.	HOME OFFICE SERVICES	136,449,300				136,449,300
922.	HOME OFFICE Q/A	5,574,200				5,574,200
923.	HOME OFFICE CONSTRCTN MGMT	1,964,720				1,964,720
92 .	HOME OFFICE ENGRG.&SERVICE	143,988,220				143,988,220
931.	FIELD OFFICE EXPENSES				4,714,660	4,714,660
932.	FIELD JOB SUPERVISION	47,510,070				47,510,070
933.	FIELD QA/QC	4,916,100				4,916,100
934	PLANT STARTUP & TEST	3,473,600				3,473,600
93 .	FIELD OFFICE ENGRG&SERVICE	55,899,770			4,714,660	60,614,430
	TOTAL INDIRECT COSTS	229,716,975	2152080 MH	27,768,300	27,952,660	285,437,935
	TOTAL BASE COST	437,770,086	12418027 MH	173,424,300	99,957,015	711,151,401

TABLE 5-9

ENERGY ECONOMIC DATA BASE

1457 MWe LIQUID METAL FAST BREEDER REACTOR NPGS

CAPITAL COST ESTIMATE

UNITED ENGINEERS & CONSTRUCTORS INC. SUMMARY PAGE 1

PLANT CODE 401 COST BASIS 01/80

ENERGY ECONOMIC DATA BASE (EEDB) PHASE III

1457 MWE LIQUID METAL FAST BREEDER REACTOR 06/19/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
**********	*************************	************	***********	************	************	*************
20 .	LAND AND LAND RIGHTS				2,614,000	2,614,000
21 .	STRUCTURES + IMPROVEMENTS	13,144,091	11593817 MH	162,140,251	89,505,854	264,790,196
22 .	REACTOR PLANT EQUIPMENT	397,995,222	5131436 MH	79,007,753	21,011,674	498,014,649
23 .	TURBINE PLANT EQUIPMENT	135,734,402	2829395 MH	42,950,473	7,852,609	186,537,484
24 .	ELECTRIC PLANT EQUIPMENT	22,563,784	2924053 MH	40,785,737	12,799,048	76,148,569
25 .	MISCELLANEOUS PLANT EQUIPT	17,350,805	1011578 MH	15,465,570	2,317,525	35,133,900
26 .	MAIN COND HEAT REJECT SYS	21,355,477	491865 MH	7,109,977	1,776,687	30,242,141
	TOTAL DIRECT COSTS	608,143,781	23982144 MH	347,459,761	137,877,397	1,093,480,939
91 .	CONSTRUCTION SERVICES	69,763,200	4001400 MH	58,140,000	41,272,000	169,175,200
92 .	HOME OFFICE ENGRG.&SERVICE	233,581,700				233,581,700
93 .	FIELD OFFICE ENGRG&SERVICE	86,623,900			3,454,000	90,077,900
	TOTAL INDIRECT COSTS	389,968,800	4001400 MH	58,140,000	44,726,000	492,834,800
	TOTAL BASE COST	998,112,581	27983544 MH	405,599,761	182,603,397	1,586,315,739

UNITED ENGINEERS & CONSTRUCTORS INC.

PLANT CODE 401   COST BASIS 01/80

ENERGY ECONOMIC DATA BASE (EEDB) PHASE III

1457 MWE LIQUID METAL FAST BREEDER REACTOR

06/19/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,614,000	2,614,000
211.	YARDWORK	222,797	954343 MH	11,908,706	7,315,809	19,447,312
212.	REACTOR CONTAINMENT BLDG	6,118,987	4979685 MH	72,209,055	39,232,966	117,561,008
213.	TURBINE ROOM + HEATER BAY	564,010	655430 MH	9,370,608	9,764,020	19,698,638
214.	SECURITY BUILDING	42,147	48799 MH	679,934	338,937	1,061,018
215.	REACTOR SERVICE BUILDING	1,358,129	1066010 MH	14,654,402	6,413,698	22,426,229
216.	WASTE PROCESS BUILDING					
217.	FUEL STORAGE BLDG					
218A.	CONTROL RM/D-G BUILDING	2,173,208	1093373 MH	15,055,609	6,415,237	23,644,054
218B.	ADMINISTRATION BUILDING	189,877	91028 MH	1,288,404	842,774	2,321,055
218C.	D/G COOLING TOWER		89729 MH	1,200,216	464,617	1,664,833
218D.	FIRE PUMP HOUSE,INC FNDTNS	27,008	16191 MH	225,047	107,493	359,548
218E.	STEAM GENERATOR BUILDING	865,286	815997 MH	11,254,106	6,998,208	19,117,600
218H.	NON-ESSEN. SWGR BLDG.	18,687	32560 MH	440,332	239,950	698,969
218I.	AUXILIARY BUILDINGS	577,134	847412 MH	11,484,793	5,267,045	17,328,972
218K.	PIPE TUNNELS		34120 MH	455,958	167,342	623,300
218N.	MAINTENANCE BUILDING	544,625	198626 MH	2,839,289	1,722,706	5,106,620
218R.	AUXILIARY BOILER BUILDING	133,656	55783 MH	797,105	576,403	1,507,164
218S.	HOLDING POND		11920 MH	156,364	50,463	206,827
218T.	ULTIMATE HEAT SINK STRUCT	91,325	185619 MH	2,456,544	747,336	3,295,205
218V.	CONTR RM EMG AIR INTK STR		15492 MH	189,567	57,496	247,063
218W.	AUX HEAT TRANS SYS BAYS	217,215	401700 MH	5,474,212	2,783,354	8,474,781
21 .	STRUCTURES + IMPROVEMENTS	13,144,091	11593817 MH	162,140,251	89,505,854	264,790,196

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1457 MWE LIQUID METAL FAST BREEDER REACTOR

PLANT CODE 401
COST BASIS 01/80

06/19/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
220A.	NUCLEAR STEAM SUPPLY(NSSS)	362,700,000				362,700,000
220B.	NSSS OPTIONS					
221.	REACTOR EQUIPMENT	3,508,000	400970 MH	6,320,427	4,897,698	14,726,125
222.	MAIN HEAT XFER XPORT SYS.	16,092,826	2801929 MH	43,628,977	4,222,572	63,944,375
223.	SAFEGUARDS SYSTEM	19,357	137915 MH	2,142,693	214,270	2,376,320
224.	RADWASTE PROCESSING	3,003,737	213072 MH	3,299,102	375,544	6,678,383
225.	FUEL HANDLING	2,531,613	339042 MH	5,282,612	498,659	8,312,884
226.	OTHER REACTOR PLANT EQUIP	6,294,220	767307 MH	11,314,328	1,500,144	19,108,692
227.	RX INSTRUMENTATION+CONTROL	1,361,802	133035 MH	1,875,549	160,926	3,398,277
228.	REACTOR PLANT MISC ITEMS	2,483,667	338166 MH	5,144,065	9,141,861	16,769,593
22 .	REACTOR PLANT EQUIPMENT	397,995,222	5131436 MH	79,007,753	21,011,674	498,014,649
231.	TURBINE GENERATOR	93,982,234	739280 MH	10,722,290	2,096,325	106,800,849
233.	CONDENSING SYSTEMS	16,891,076	599496 MH	9,380,112	1,005,800	27,276,988
234.	FEED HEATING SYSTEM	14,537,571	434424 MH	6,730,214	671,374	21,939,159
235.	OTHER TURBINE PLANT EQUIP.	8,928,077	813547 MH	12,614,371	1,296,307	22,838,755
236.	INSTRUMENTATION + CONTROL	1,395,444	56605 MH	788,768	75,599	2,259,811
237.	TURBINE PLANT MISC ITEMS		186043 MH	2,714,718	2,707,204	5,421,922
23 .	TURBINE PLANT EQUIPMENT	135,734,402	2829395 MH	42,950,473	7,852,609	186,537,484

PLANT CODE 401
COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1457 MWE LIQUID METAL FAST BREEDER REACTOR

06/19/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	8,027,030	120355 MH	1,704,252	173,107	9,904,389
242.	STATION SERVICE EQUIPMENT	12,446,679	151644 MH	2,144,307	332,813	14,923,799
243.	SWITCHBOARDS	643,535	15246 MH	215,497	89,152	948,184
244.	PROTECTIVE EQUIPMENT		112013 MH	1,565,395	715,050	2,280,445
245.	ELECT.STRUC +WIRING CONTNR		1221875 MH	16,947,986	3,731,089	20,679,075
246.	POWER & CONTROL WIRING	1,446,540	1302920 MH	18,208,300	7,757,837	27,412,677
24 .	ELECTRIC PLANT EQUIPMENT	22,563,784	2924053 MH	40,785,737	12,799,048	76,148,569
251.	TRANSPORTATION & LIFT EQPT	3,252,895	50568 MH	777,830	71,000	4,101,725
252.	AIR,WATER+STEAM SERVICE SY	10,563,113	910701 MH	13,988,284	1,983,985	26,535,382
253.	COMMUNICATIONS EQUIPMENT	2,309,611	37948 MH	530,318	232,582	3,072,511
254.	FURNISHINGS + FIXTURES	1,225,186	12361 MH	169,138	29,958	1,424,282
25 .	MISCELLANEOUS PLANT EQUIPT	17,350,805	1011578 MH	15,465,570	2,317,525	35,133,900
261.	STRUCTURES	124,720	159353 MH	2,151,256	1,039,812	3,315,788
262.	MECHANICAL EQUIPMENT	21,230,757	332512 MH	4,958,721	736,875	26,926,353
26 .	MAIN COND HEAT REJECT SYS	21,355,477	491865 MH	7,109,977	1,776,687	30,242,141
	TOTAL DIRECT COSTS	608,143,781	23982144 MH	347,459,761	137,877,397	1,093,480,939

PLANT CODE 401

COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1457 MWE LIQUID METAL FAST BREEDER REACTOR

06/19/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
**********	**************************	*************	***********	*************	*************	*************
911.	TEMPORARY CONSTRUCTION FAC		3466800 MH	50,371,000	10,714,000	61,085,000
912.	CONSTRUCTION TOOLS & EQUIP		534600 MH	7,769,000	29,320,500	37,089,500
913.	PAYROLL INSURANCE & TAXES	69,763,200				69,763,200
914.	PERMITS,INS. & LOCAL TAXES				1,237,500	1,237,500
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	69,763,200	4001400 MH	58,140,000	41,272,000	169,175,200
921.	HOME OFFICE SERVICES	221,828,200				221,828,200
922.	HOME OFFICE Q/A	9,482,000				9,482,000
923.	HOME OFFICE CONSTRCTN MGMT	2,271,500				2,271,500
92 .	HOME OFFICE ENGRG.&SERVICE	233,581,700				233,581,700
931.	FIELD OFFICE EXPENSES				3,454,000	3,454,000
932.	FIELD JOB SUPERVISION	73,648,300				73,648,300
933.	FIELD QA/QC	7,771,500				7,771,500
934.	PLANT STARTUP & TEST	5,204,100				5,204,100
93 .	FIELD OFFICE ENGRG&SERVICE	86,623,900			3,454,000	90,077,900
	TOTAL INDIRECT COSTS	389,968,800	4001400 MH	58,140,000	44,726,000	492,834,800
	TOTAL BASE COST	998,112,581	27983544 MH	405,599,761	182,603,397	1,586,315,739

TABLE 5-10

ENERGY ECONOMIC DATA BASE
1232 MWe HIGH SULFUR COAL FPGS
CAPITAL COST ESTIMATE

PLANT CODE 610   COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1232 MWE HIGH SULFUR COAL

SUMMARY PAGE 1
06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,614,000	2,614,000
21 .	STRUCTURES + IMPROVEMENTS	1,778,010	1640432 MH	22,521,448	36,431,343	60,730,801
22 .	BOILER PLANT EQUIPMENT	236,827,494	5606671 MH	85,055,219	22,636,179	344,518,892
23 .	TURBINE PLANT EQUIPMENT	119,368,739	1838159 MH	28,072,098	6,541,125	153,981,962
24 .	ELECTRIC PLANT EQUIPMENT	13,250,720	1245315 MH	17,394,291	10,099,040	40,744,051
25 .	MISCELLANEOUS PLANT EQUIPT	7,433,847	258934 MH	3,949,047	1,077,863	12,460,757
26 .	MAIN COND HEAT REJECT SYS	17,001,538	284143 MH	4,132,088	1,386,679	22,520,305
	TOTAL DIRECT COSTS	395,660,348	10873654 MH	161,124,191	80,786,229	637,570,768
91 .	CONSTRUCTION SERVICES	31,655,013	1549400 MH	22,919,000	25,239,000	79,813,013
92 .	HOME OFFICE ENGRG.&SERVICE	25,630,000				25,630,000
93 .	FIELD OFFICE ENGRG&SERVICE	26,413,200			1,507,000	27,920,200
	TOTAL INDIRECT COSTS	83,698,213	1549400 MH	22,919,000	26,746,000	133,363,213
	TOTAL BASE COST	479,358,561	12423054 MH	184,043,191	107,532,229	770,933,981

UNITED ENGINEERS & CONSTRUCTORS INC.

PLANT CODE 610 COST BASIS 01/80

ENERGY ECONOMIC DATA BASE (EEDB) PHASE III

1232 MWE HIGH SULFUR COAL

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,614,000	2,614,000
211	YARDWORK	151,907	269124 MH	3,221,670	4,310,438	7,684,015
212.	STEAM GENERATOR BUILDING	593,970	548021 MH	7,817,285	15,835,858	24,247,113
213.	TURBINE,HEATER,CONTROL BLD	334,966	290253 MH	4,136,222	7,613,110	12,084,298
218B.	ADMINISTRATION+SERVICE BLD	237,923	67996 MH	970,497	1,159,274	2,367,694
218D.	FIRE PUMPHOUSE					
218I.	ELECTRICAL SWITCHGR BLDGS	28,880	7210 MH	102,982	59,173	191,035
218M.	COAL CAR THAW SHED		2319 MH	31,147	16,741	47,888
218N.	ROTARY CAR DUMP BLDG+TUNNL	4,590	39606 MH	521,683	478,987	1,005,260
218O.	COAL BREAKER HOUSE	73,064	20647 MH	300,034	479,822	852,920
218P.	COAL CRUSHER HOUSE	103,742	15900 MH	231,900	278,808	614,450
218Q.	BOILER HOUSE TRANSFR TOWER	3,530	5987 MH	89,122	189,239	281,891
218R.	ROTARY PLOW MAINTNCE SHED	7,955	97642 MH	1,287,271	1,011,269	2,306,495
218T.	LOCOMOTIVE REPAIR GARAGE	15,239	4912 MH	70,333	88,771	174,343
218U.	MATERIAL HANDL+SERVICE BLD	18,090	10550 MH	151,347	187,306	356,743
218V.	WASTE WATER TREATMENT BLDG	3,904	11624 MH	152,818	127,305	284,027
218W.	MISC COAL HANDLING STRUCT	200,250	75183 MH	991,806	1,464,551	2,656,607
219.	STACK STRUCTURE		173458 MH	2,445,331	3,130,691	5,576,022
21 .	STRUCTURES + IMPROVEMENTS	1,778,010	1640432 MH	22,521,448	36,431,343	60,730,801

PLANT CODE 610
COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1232 MWE HIGH SULFUR COAL

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
220A.	FOSSIL STEAM SUPPLY SYSTEM	81,058,200	1100000 MH	16,190,900	1,619,090	98,868,190
221.	STEAM GENERATING SYSTEM	1,623,570	37651 MH	585,136	72,082	2,280,788
222.	DRAFT SYSTEM	18,143,379	412685 MH	6,425,143	2,141,808	26,710,330
223.	ASH + DUST HANDLING SYSTEM	7,100,795	115826 MH	1,779,537	268,460	9,148,792
224.	FUEL HANDLING SYSTEMS	9,046,246	144286 MH	2,259,490	759,806	12,065,542
225.	FLUE GAS DESULFUR STRUCT	48,304	72440 MH	1,026,764	1,318,177	2,393,245
226.	DESULFURIZATION EQUIPMENT	116,450,839	3523965 MH	53,920,483	14,413,432	184,784,754
227.	INSTRUMENTATION + CONTROL	3,139,651	53628 MH	747,281	39,588	3,926,520
228.	BOILER PLANT MISC ITEMS	216,510	146190 MH	2,120,485	2,003,736	4,340,731
22	BOILER PLANT EQUIPMENT	236,827,494	5606671 MH	85,055,219	22,636,179	344,518,892
231.	TURBINE GENERATOR	73,903,613	347571 MH	4,994,344	1,940,593	80,838,550
233.	CONDENSING SYSTEMS	10,089,320	164659 MH	2,600,613	400,134	13,090,067
234.	FEED HEATING SYSTEM	19,836,892	312966 MH	4,859,204	487,316	25,183,412
235.	OTHER TURBINE PLANT EQUIP.	15,407,143	920340 MH	14,280,234	1,456,208	31,143,585
236.	INSTRUMENTATION + CONTROL	131,771	823 MH	11,468	573	143,812
237.	TURBINE PLANT MISC ITEMS		91800 MH	1,326,235	2,256,301	3,582,536
23 .	TURBINE PLANT EQUIPMENT	119,368,739	1838159 MH	28,072,098	6,541,125	153,981,962

PLANT CODE 610 COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1232 MWE HIGH SULFUR COAL

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	7,112,600	67230 MH	951,990	102,577	8,167,167
242.	STATION SERVICE EQUIPMENT	4,580,895	60010 MH	842,192	171,239	5,594,326
243.	SWITCHBOARDS	724,365	10530 MH	148,868	83,569	956,802
244.	PROTECTIVE EQUIPMENT		85400 MH	1,201,337	960,311	2,161,648
245.	ELECT.STRUC +WIRING CONTNR		572875 MH	7,971,356	2,845,863	10,817,219
246.	POWER & CONTROL WIRING	832,860	449270 MH	6,278,548	5,935,481	13,046,889
24 .	ELECTRIC PLANT EQUIPMENT	13,250,720	1245315 MH	17,394,291	10,099,040	40,744,051
251.	TRANSPORTATION & LIFT EQPT	1,624,931	8125 MH	124,177	113,118	1,862,226
252.	AIR,WATER+STEAM SERVICE SY	4,080,596	182401 MH	2,824,874	363,458	7,268,928
253.	COMMUNICATIONS EQUIPMENT	150,080	25000 MH	349,375	227,853	727,308
254.	FURNISHINGS + FIXTURES	819,465	6717 MH	91,639	20,092	931,196
255.	WASTE WATER TREATMENT EQPT	758,775	36691 MH	558,982	353,342	1,671,099
25 .	MISCELLANEOUS PLANT EQUIPT	7,433,847	258934 MH	3,949,047	1,077,863	12,460,757
261.	STRUCTURES	117,758	80451 MH	1,087,717	889,306	2,094,781
262.	MECHANICAL EQUIPMENT	16,883,780	203692 MH	3,044,371	497,373	20,425,524
26 .	MAIN COND HEAT REJECT SYS	17,001,538	284143 MH	4,132,088	1,386,679	22,520,305
	TOTAL DIRECT COSTS	395,660,348	10873654 MH	161,124,191	80,786,229	637,570,768

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1232 MWE HIGH SULFUR COAL

PLANT CODE 610
COST BASIS 01/80

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
911.	TEMPORARY CONSTRUCTION FAC		1329800 MH	19,669,000	6,985,000	26,654,000
912.	CONSTRUCTION TOOLS & EQUIP		219600 MH	3,250,000	17,632,500	20,882,500
913.	PAYROLL INSURANCE & TAXES	31,655,013				31,655,013
914.	PERMITS,INS. & LOCAL TAXES				621,500	621,500
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	31,655,013	1549400 MH	22,919,000	25,239,000	79,813,013
921.	HOME OFFICE SERVICES	24,272,600				24,272,600
922.	HOME OFFICE Q/A					
923.	HOME OFFICE CONSTRCTN MGMT	1,357,400				1,357,400
92 .	HOME OFFICE ENGRG.&SERVICE	25,630,000				25,630,000
931.	FIELD OFFICE EXPENSES				1,507,000	1,507,000
932.	FIELD JOB SUPERVISION	25,290,100				25,290,100
933.	FIELD QA/QC	447,700				447,700
934.	PLANT STARTUP & TEST	675,400				675,400
93 .	FIELD OFFICE ENGRG&SERVICE	26,413,200			1,507,000	27,920,200
	TOTAL INDIRECT COSTS	83,698,213	1549400 MH	22,919,000	26,746,000	133,363,213
	TOTAL BASE COST	479,358,561	12423054 MH	184,043,191	107,532,229	770,933,981

TABLE 5-11

ENERGY ECONOMIC DATA BASE
795 MWe HIGH SULFUR COAL FPGS
CAPITAL COST ESTIMATE

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
795 MWE HIGH SULFUR COAL

PLANT CODE 640
COST BASIS 01/80

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,614,000	2,614,000
21 .	STRUCTURES + IMPROVEMENTS	1,521,807	1358185 MH	18,609,427	28,906,852	49,038,086
22 .	BOILER PLANT EQUIPMENT	165,361,106	4002409 MH	60,614,179	16,061,242	242,036,527
23 .	TURBINE PLANT EQUIPMENT	63,970,119	993451 MH	15,090,315	3,915,380	82,975,814
24 .	ELECTRIC PLANT EQUIPMENT	12,066,757	1082365 MH	15,119,376	8,902,791	36,088,924
25 .	MISCELLANEOUS PLANT EQUIPT	6,747,478	221728 MH	3,373,062	936,608	11,057,148
26 .	MAIN COND HEAT REJECT SYS	11,729,615	217920 MH	3,155,837	1,127,276	16,012,728
	TOTAL DIRECT COSTS	261,396,882	7876058 MH	115,962,196	62,464,149	439,823,227
91 .	CONSTRUCTION SERVICES	22,902,058	1167650 MH	17,189,250	17,677,000	57,768,308
92	HOME OFFICE ENGRG &SERVICE	18,749,500				18,749,500
93 .	FIELD OFFICE ENGRG&SERVICE	13,242,900			1,083,500	14,326,400
	TOTAL INDIRECT COSTS	54,894,458	1167650 MH	17,189,250	18,760,500	90,844,208
	TOTAL BASE COST	316,291,340	9043708 MH	133,151,446	81,224,649	530,667,435

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
**********	*************************	*************	***********	*************	*************	**************
20 .	LAND AND LAND RIGHTS				2,614,000	2,614,000
211.	YARDWORK	151,907	226642 MH	2,721,124	3,684,649	6,557,680
212.	STEAM GENERATOR BUILDING	485,267	401733 MH	5,711,851	11,056,439	17,253,557
213.	TURBINE,HEATER,CONTROL BLD	271,625	248081 MH	3,533,062	6,393,582	10,198,269
218B.	ADMINISTRATION+SERVICE BLD	217,168	61441 MH	876,975	1,017,199	2,111,342
218I.	ELECTRICAL SWITCHGR BLDGS	26,737	6649 MH	94,976	53,328	175,041
218M.	COAL CAR THAW SHED		2319 MH	31,147	16,741	47,888
218N.	ROTARY CAR DUMP BLDG+TUNNL	4,590	39606 MH	521,683	478,987	1,005,260
218O.	COAL BREAKER HOUSE	73,064	20647 MH	300,034	479,822	852,920
218P.	COAL CRUSHER HOUSE	103,742	14825 MH	216,554	252,346	572,642
218Q.	BOILER HOUSE TRANSFR TOWER	2,344	3040 MH	44,887	96,608	143,839
218R.	ROTARY PLOW MAINTNCE SHED	7,955	97642 MH	1,287,271	1,011,269	2,306,495
218T.	LOCOMOTIVE REPAIR GARAGE	15,239	4912 MH	70,333	88,771	174,343
218U.	MATERIAL HANDL+SERVICE BLD	18,090	10550 MH	151,347	187,306	356,743
218V.	WASTE WATER TREATMENT BLDG	3,904	8841 MH	117,366	102,626	223,896
218W.	MISC COAL HANDLING STRUCT	140,175	64740 MH	866,274	1,340,204	2,346,653
219.	STACK STRUCTURE		146517 MH	2,064,543	2,646,975	4,711,518
21 .	STRUCTURES + IMPROVEMENTS	1,521,807	1358185 MH	18,609,427	28,906,852	49,038,086

PLANT CODE 640
COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
795 MWE HIGH SULFUR COAL

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
*********	*************************	************	***********	************	************	*************
220A.	FOSSIL STEAM SUPPLY SYSTEM	55,310,000	736304 MH	10,837,659	1,083,766	67,231,425
221.	STEAM GENERATING SYSTEM	1,269,836	28830 MH	448,116	58,378	1,776,330
222.	DRAFT SYSTEM	10,563,498	268889 MH	4,183,959	1,371,606	16,119,063
223.	ASH + DUST HANDLING SYSTEM	5,168,228	102228 MH	1,566,700	220,279	6,955,207
224.	FUEL HANDLING SYSTEMS	8,570,118	125981 MH	1,960,102	516,326	11,046,546
225.	FLUE GAS DESULFUR STRUCT	34,339	57091 MH	808,486	1,059,636	1,902,461
226.	DESULFURIZATION EQUIPMENT	81,177,411	2469783 MH	37,776,380	10,269,290	129,223,081
227.	INSTRUMENTATION + CONTROL	3,051,166	81040 MH	1,129,253	78,159	4,258,578
228.	BOILER PLANT MISC ITEMS	216,510	132263 MH	1,903,524	1,403,802	3,523,836
22 .	BOILER PLANT EQUIPMENT	165,361,106	4002409 MH	60,614,179	16,061,242	242,036,527
231.	TURBINE GENERATOR	38,343,108	237233 MH	3,420,001	1,137,446	42,900,555
233.	CONDENSING SYSTEMS	7,972,923	127632 MH	2,018,604	272,864	10,264,391
234.	FEED HEATING SYSTEM	10,676,665	176888 MH	2,746,598	281,818	13,705,081
235.	OTHER TURBINE PLANT EQUIP.	6,845,652	372965 MH	5,786,177	612,296	13,244,125
236.	INSTRUMENTATION + CONTROL	131,771	823 MH	11,468	573	143,812
237.	TURBINE PLANT MISC ITEMS		77910 MH	1,107,467	1,610,383	2,717,850
23 .	TURBINE PLANT EQUIPMENT	63,970,119	993451 MH	15,090,315	3,915,380	82,975,814

PLANT CODE 640

COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
795 MWE HIGH SULFUR COAL

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
*********	************************	************	***********	************	************	************
241.	SWITCHGEAR	6,180,180	57640 MH	816,194	85,298	7,081,672
242.	STATION SERVICE EQUIPMENT	4,629,012	50615 MH	711,220	137,805	5,478,037
243.	SWITCHBOARDS	597,485	9030 MH	127,628	81,345	806,458
244.	PROTECTIVE EQUIPMENT		76400 MH	1,075,563	876,461	1,952,024
245.	ELECT.STRUC +WIRING CONTNR		502760 MH	6,995,539	2,497,925	9,493,464
246.	POWER & CONTROL WIRING	660,080	385920 MH	5,393,232	5,223,957	11,277,269
24 .	ELECTRIC PLANT EQUIPMENT	12,066,757	1082365 MH	15,119,376	8,902,791	36,088,924
251.	TRANSPORTATION & LIFT EQPT	1,538,775	7200 MH	109,945	111,695	1,760.415
252.	AIR,WATER+STEAM SERVICE SY	3,508,478	154351 MH	2,390,192	313,973	6,212,643
253.	COMMUNICATIONS EQUIPMENT	150,080	25000 MH	349,375	227,853	727,308
254.	FURNISHINGS + FIXTURES	819,465	6717 MH	91,639	20,092	931,196
255.	WASTE WATER TREATMENT EQPT	730,680	28460 MH	431,911	262,995	1,425,586
25 .	MISCELLANEOUS PLANT EQUIPT	6,747,478	221728 MH	3,373,062	936,608	11,057,148
261.	STRUCTURES	102,267	64352 MH	870,463	732,083	1,704,813
262.	MECHANICAL EQUIPMENT	11,627,348	153568 MH	2,285,374	395,193	14,307,915
26 .	MAIN COND HEAT REJECT SYS	11,729,615	217920 MH	3,155,837	1,127,276	16,012,728
	TOTAL DIRECT COSTS	261,396,882	7876058 MH	115,962,196	62,464,149	439,823,227

PLANT CODE 640
COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
795 MWE HIGH SULFUR COAL

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
911.	TEMPORARY CONSTRUCTION FAC		1016400 MH	14,964,000	5,368,000	20,332,000
912.	CONSTRUCTION TOOLS & EQUIP		151250 MH	2,225,250	11,869,000	14,094,250
913.	PAYROLL INSURANCE & TAXES	22,902,058				22,902,058
914.	PERMITS,INS. & LOCAL TAXES				440,000	440,000
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	22,902,058	1167650 MH	17,189,250	17,677,000	57,768,308
921.	HOME OFFICE SERVICES	17,578,000				17,578,000
922.	HOME OFFICE Q/A					
923.	HOME OFFICE CONSTRCTN MGMT	1,171,500				1,171,500
92 .	HOME OFFICE ENGRG &SERVICE	18,749,500				18,749,500
931.	FIELD OFFICE EXPENSES				1,083,500	1,083,500
932.	FIELD JOB SUPERVISION	12,364,000				12,364,000
933.	FIELD QA/QC	316,800				316,800
934.	PLANT STARTUP & TEST	562,100				562,100
93 .	FIELD OFFICE ENGRG&SERVICE	13,242,900			1,083,500	14,326,400
	TOTAL INDIRECT COSTS	54,894,458	1167650 MH	17,189,250	18,760,500	90,844,208
	TOTAL BASE COST	316,291,340	9043708 MH	133,151,446	81,224,649	530,667,435

TABLE 5-12

ENERGY ECONOMIC DATA BASE

1236 MWe LOW SULFUR COAL FPGS

CAPITAL COST ESTIMATE

PLANT CODE 630

COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1236 MWE LOW SULFUR COAL

SUMMARY PAGE 1

07/10/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,614,000	2,614,000
21 .	STRUCTURES + IMPROVEMENTS	2,578,037	1738430 MH	23,510,306	36,403,107	62,491,450
22 .	BOILER PLANT EQUIPMENT	207,846,245	5156796 MH	78,234,671	26,282,727	312,363,643
23 .	TURBINE PLANT EQUIPMENT	118,794,054	1838159 MH	28,072,098	6,541,124	153,407,276
24 .	ELECTRIC PLANT EQUIPMENT	13,093,620	1228120 MH	17,154,239	10,038,155	40,286,014
25 .	MISCELLANEOUS PLANT EQUIPT	7,433,847	258934 MH	3,949,047	1,077,863	12,460,757
26 .	MAIN COND HEAT REJECT SYS	17,001,538	284143 MH	4,132,088	1,387,396	22,521,022
	TOTAL DIRECT COSTS	366,747,341	10504582 MH	155,052,449	84,344,372	606,144,162
91 .	CONSTRUCTION SERVICES	30,563,000	1533600 MH	22,640,400	20,828,500	74,031,900
92 .	HOME OFFICE ENGRG.&SERVICE	22,227,700				22,227,700
93 .	FIELD OFFICE ENGRG&SERVICE	20,095,900			1,259,500	21,355,400
	TOTAL INDIRECT COSTS	72,886,600	1533600 MH	22,640,400	22,088,000	117,615,000
	TOTAL BASE COST	439,633,941	12038182 MH	177,692,849	106,432,372	723,759,162

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1236 MWE LOW SULFUR COAL

07/10/81

PLANT CODE 630
COST BASIS 01/80

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
**********	**************************	*************	************	*************	*************	**************
20 .	LAND AND LAND RIGHTS				2,614,000	2,614,000
211.	YARDWORK	151,907	281920 MH	3,367,780	4,488,838	8,008,525
212.	STEAM GENERATOR BUILDING	593,970	546521 MH	7,794,595	15,737,838	24,126,403
213.	TURBINE,HEATER,CONTROL BLD	334,966	290253 MH	4,136,222	7,619,090	12,090,278
218B.	ADMINISTRATION+SERVICE BLG	237,923	67996 MH	970,497	1,159,274	2,367,694
218D.	FIRE PUMPHOUSE					
218I.	ELECTRICAL SWITCHGR BLDGS	28,880	7210 MH	102,982	59,173	191,035
218L.	STACK/RECLAIM TRANSFR TOWR	7,112	9792 MH	132,955	110,740	250,807
218M.	COAL CAR THAW SHED		2319 MH	31,147	16,741	47,888
218N.	ROTARY CAR DUMP BLDG+TUNNL	4,590	39606 MH	521,683	478,987	1,005,260
218O.	DEAD STORAGE RECLM HOPPERS		20995 MH	281,924	243,720	525,644
218P.	COAL CRUSHER HOUSE	109,926	17126 MH	249,765	304,560	664,251
218Q.	BOILER HOUSE TRANSFR TOWER	3,530	5987 MH	89,122	189,239	281,891
218R.	DEAD STORAGE TRANSFER TUNL		53295 MH	705,850	521,921	1,227,771
218T.	LOCOMOTIVE REPAIR GARAGE	15,239	4912 MH	70,333	88,771	174,343
218U.	MATERIAL HANDL+SERVICE BLD	18,090	10550 MH	151,347	187,306	356,743
218V.	WASTE WATER TREATMENT BLDG	3,904	11624 MH	152,818	127,305	284,027
218W.	MISC COAL HANDLING STRUCT	1,068,000	194866 MH	2,305,955	1,938,913	5,312,868
219.	STACK STRUCTURE		173458 MH	2,445,331	3,130,691	5,576,022
21 .	STRUCTURES + IMPROVEMENTS	2,578,037	1738430 MH	23,510,306	36,403,107	62,491,450

PLANT CODE 630
COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1236 MWE LOW SULFUR COAL

07/10/81

ACCT NO **********	ACCOUNT DESCRIPTION *************************	FACTORY EQUIP. COSTS *************	SITE LABOR HOURS ************	SITE LABOR COST *************	SITE MATERIAL COST *************	TOTAL COSTS **************
220A.	FOSSIL STEAM SUPPLY SYSTEM	83,058,000	1128000 MH	16,603,032	1,660,303	101,321,335
221.	STEAM GENERATING SYSTEM	1,623,570	37651 MH	585,136	72,082	2,280,788
222.	DRAFT SYSTEM	3,540,729	166623 MH	2,586,789	1,111,540	7,239,058
223.	ASH + DUST HANDLING SYSTEM	3,339,580	84774 MH	1,302,298	183,809	4,825,687
224.	FUEL HANDLING SYSTEMS	12,852,242	220446 MH	3,452,140	1,247,535	17,551,917
225.	FLUE GAS DESULFUR STRUCT	85,533	236127 MH	3,359,571	6,065,859	9,510,963
226.	FLUE GAS CLEANING EQUIP	99,921,376	3091195 MH	47,585,948	13,964,893	161,472,217
227.	INSTRUMENTATION + CONTROL	3,208,705	53620 MH	747,169	39,588	3,995,462
228.	BOILER PLANT MISC ITEMS	216,510	138360 MH	2,012,588	1,937,118	4,166,216
22 .	BOILER PLANT EQUIPMENT	207,846,245	5156796 MH	78,234,671	26,282,727	312,363,643
231.	TURBINE GENERATOR	75,391,174	347571 MH	4,994,344	1,940,592	82,326,110
233.	CONDENSING SYSTEMS	10,344,902	164659 MH	2,600,613	400,134	13,345,649
234.	FEED HEATING SYSTEM	18,482,740	312966 MH	4,859,204	487,316	23,829,260
235.	OTHER TURBINE PLANT EQUIP.	14,443,373	920340 MH	14,280,234	1,456,208	30,179,815
236.	INSTRUMENTATION + CONTROL	131,865	823 MH	11,468	573	143,906
237.	TURBINE PLANT MISC ITEMS		91800 MH	1,326,235	2,256,301	3,582,536
23 .	TURBINE PLANT EQUIPMENT	118,794,054	1838159 MH	28,072,098	6,541,124	153,407,276

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	7,150,080	66705 MH	944,557	101,814	8,196,451
242.	STATION SERVICE EQUIPMENT	4,386,315	54260 MH	762,179	149,844	5,298,338
243.	SWITCHBOARDS	724,365	10530 MH	148,868	83,569	956,802
244.	PROTECTIVE EQUIPMENT		73400 MH	1,033,638	964,076	1,997,714
245.	ELECT.STRUC +WIRING CONTNR		572875 MH	7,971,356	2,786,663	10,758,019
246.	POWER & CONTROL WIRING	832,860	450350 MH	6,293,641	5,952,189	13,078,690
24 .	ELECTRIC PLANT EQUIPMENT	13,093,620	1228120 MH	17,154,239	10,038,155	40,286,014
251.	TRANSPORTATION & LIFT EQPT	1,624,931	8125 MH	124,177	113,118	1,862,226
252.	AIR,WATER+STEAM SERVICE SY	4,080,596	182401 MH	2,824,874	363,458	7,268,928
253.	COMMUNICATIONS EQUIPMENT	150,080	25000 MH	349,375	227,853	727,308
254.	FURNISHINGS + FIXTURES	819,465	6717 MH	91,639	20,092	931,196
255.	WASTE WATER TREATMENT EQPT	758,775	36691 MH	558,982	353,342	1,671,099
25 .	MISCELLANEOUS PLANT EQUIPT	7,433,847	258934 MH	3,949,047	1,077,863	12,460,757
261.	STRUCTURES	117,758	80451 MH	1,087,717	890,023	2,095,498
262.	MECHANICAL EQUIPMENT	16,883,780	203692 MH	3,044,371	497,373	20,425,524
26 .	MAIN COND HEAT REJECT SYS	17,001,538	284143 MH	4,132,088	1,387,396	22,521,022
	TOTAL DIRECT COSTS	366,747,341	10504582 MH	155,052,449	84,344,372	606,144,162

PLANT CODE 630 COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
1236 MWE LOW SULFUR COAL

07/10/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
**********	**************************	*************	************	*************	*************	**************
911.	TEMPORARY CONSTRUCTION FAC		1306400 MH	19,288,800	5,648,500	24,937,300
912.	CONSTRUCTION TOOLS & EQUIP		227200 MH	3,351,600	14,641,000	17,992,600
913.	PAYROLL INSURANCE & TAXES	30,563,000				30,563,000
914.	PERMITS,INS. & LOCAL TAXES				539,000	539,000
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	30,563,000	1533600 MH	22,640,400	20,828,500	74,031,900
921.	HOME OFFICE SERVICES	20,870,300				20,870,300
922.	HOME OFFICE Q/A					
923.	HOME OFFICE CONSTRCTN MGMT	1,357,400				1,357,400
92 .	HOME OFFICE ENGRG.&SERVICE	22,227,700				22,227,700
931.	FIELD OFFICE EXPENSES				1,259,500	1,259,500
932.	FIELD JOB SUPERVISION	19,250,000				19,250,000
933.	FIELD QA/QC	341,000				341,000
934.	PLANT STARTUP & TEST	504,900				504,900
93 .	FIELD OFFICE ENGRG&SERVICE	20,095,900			1,259,500	21,355,400
	TOTAL INDIRECT COSTS	72,886,600	1533600 MH	22,640,400	22,088,000	117,615,000
	TOTAL BASE COST	439,633,941	12038182 MH	177,692,849	106,432,372	723,759,162

TABLE 5-13

ENERGY ECONOMIC DATA BASE

795 MWe LOW SULFUR COAL FPGS

CAPITAL COST ESTIMATE

PLANT CODE 620
COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
795 MWE LOW SULFUR COAL

SUMMARY PAGE 1
07/10/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,614,000	2,614,000
21 .	STRUCTURES + IMPROVEMENTS	2,053,182	1395990 MH	18,883,598	28,462,461	49,399,241
22 .	BOILER PLANT EQUIPMENT	146,317,211	3674307 MH	54,597,430	18,871,361	219,786,002
23 .	TURBINE PLANT EQUIPMENT	64,277,834	996877 MH	15,143,499	3,937,912	83,359,245
24 .	ELECTRIC PLANT EQUIPMENT	10,656,760	1074593 MH	15,010,599	8,917,336	34,584,695
25 .	MISCELLANEOUS PLANT EQUIPT	6,748,611	221819 MH	3,374,469	936,760	11,059,840
26 .	MAIN COND HEAT REJECT SYS	11,729,615	218058 MH	3,157,763	1,127,276	16,014,654
	TOTAL DIRECT COSTS	241,783,213	7581644 MH	110,167,358	64,867,106	416,817,677
91 .	CONSTRUCTION SERVICES	21,833,115	1156200 MH	16,769,950	15,422,000	54,025,065
92 .	HOME OFFICE ENGRG.&SERVICE	16,283,300				16,283,300
93 .	FIELD OFFICE ENGRG&SERVICE	11,808,500			869,000	12,677,500
	TOTAL INDIRECT COSTS	49,924,915	1156200 MH	16,769,950	16,291,000	82,985,865
	TOTAL BASE COST	291,708,128	8737844 MH	126,937,308	81,158,106	499,803,542

PLANT CODE 620
COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
795 MWE LOW SULFUR COAL

07/10/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				2,614,000	2,614,000
211.	YARDWORK	151,907	236870 MH	2,837,889	3,827,024	6,816,820
212.	STEAM GENERATOR BUILDING	485,267	401733 MH	5,711,851	11,056,439	17,253,557
213.	TURBINE,HEATER,CONTROL BLD	271,625	248081 MH	3,533,062	6,393,582	10,198,269
218B.	ADMINISTRATION+SERVICE BLD	217,168	61441 MH	876,975	1,017,199	2,111,342
218I.	ELECTRICAL SWITCHGR BLDGS	26,737	6649 MH	94,976	53,328	175,041
218L.	STACK/RECLAIM TRANSFR TOWR	5,519	7039 MH	95,791	79,489	180,799
218M.	COAL CAR THAW SHED		2319 MH	31,147	16,741	47,888
218N.	ROTARY CAR DUMP BLDG+TUNNL	4,590	39606 MH	521,683	478,987	1,005,260
218O.	DEAD STG RECLAIM HOPPER		20995 MH	281,924	243,720	525,644
218P.	COAL CRUSHER HOUSE	103,742	15900 MH	231,900	278,808	614,450
218Q.	BOILER HOUSE TRANSFR TOWER	2,344	3040 MH	44,887	96,608	143,839
218R.	DEAD STRG TRANSFER TUNNEL	12,800	39185 MH	518,989	367,585	899,374
218T.	LOCOMOTIVE REPAIR GARAGE	15,239	4912 MH	70,333	88,771	174,343
218U.	MATERIAL HANDL+SERVICE BLD	18,090	10550 MH	151,347	187,306	356,743
218V.	WASTE WATER TREATMENT BLDG	3,904	8841 MH	117,366	102,626	223,896
218W.	MISC COAL HANDLING STRUCT	734,250	142312 MH	1,698,935	1,527,273	3,960,458
219.	STACK STRUCTURE		146517 MH	2,064,543	2,646,975	4,711,518
21 .	STRUCTURES + IMPROVEMENTS	2,053,182	1395990 MH	18,883,598	28,462,461	49,399,241

PLANT CODE 620
COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
795 MWE LOW SULFUR COAL

07/10/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
**********	**************************	*************	************	*************	*************	**************
220A.	FOSSIL STEAM SUPPLY SYSTEM	56,910,000	753315 MH	10,080,108	1,008,011	67,998,119
221.	STEAM GENERATING SYSTEM	1,271,725	28980 MH	450,443	58,611	1,780,779
222.	DRAFT SYSTEM	2,218,066	99145 MH	1,535,171	668,520	4,421,757
223.	ASH + DUST HANDLING SYSTEM	2,649,663	66690 MH	1,023,286	147,284	3,820,233
224.	FUEL HANDLING SYSTEMS	11,916,978	187008 MH	2,909,923	774,562	15,601,463
225.	FLUE GAS DESULFUR STRUCT	58,599	205556 MH	2,951,464	5,072,253	8,082,316
226.	FLUE GAS CLEANING EQUIP	68,044,902	2126893 MH	32,704,904	9,716,114	110,465,920
227.	INSTRUMENTATION + CONTROL	3,030,768	81040 MH	1,129,253	78,159	4,238,180
228.	BOILER PLANT MISC ITEMS	216,510	125680 MH	1,812,878	1,347,847	3,377,235
22 .	BOILER PLANT EQUIPMENT	146,317,211	3674307 MH	54,597,430	18,871,361	219,786,002
231.	TURBINE GENERATOR	38,317,872	237233 MH	3,420,001	1,162,526	42,900,399
233.	CONDENSING SYSTEMS	7,972,923	127632 MH	2,018,604	272,864	10,264,391
234.	FEED HEATING SYSTEM	11,010,057	180306 MH	2,799,657	279,258	14,088,972
235.	OTHER TURBINE PLANT EQUIP.	6,845,117	372973 MH	5,786,302	612,308	13,243,727
236.	INSTRUMENTATION + CONTROL	131,865	823 MH	11,468	573	143,906
237.	TURBINE PLANT MISC ITEMS		77910 MH	1,107,467	1,610,383	2,717,850
23 .	TURBINE PLANT EQUIPMENT	64,277,834	996877 MH	15,143,499	3,937,912	83,359,245

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
795 MWE LOW SULFUR COAL

PLANT CODE 620
COST BASIS 01/80

07/10/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
241.	SWITCHGEAR	5,635,690	58140 MH	823,274	86,006	6,544,970
242.	STATION SERVICE EQUIPMENT	3,763,390	45823 MH	643,996	124,502	4,531,888
243.	SWITCHBOARDS	597,600	9030 MH	127,628	81,345	806,573
244.	PROTECTIVE EQUIPMENT		72400 MH	1,019,663	880,176	1,899,839
245.	ELECT.STRUC +WIRING CONTNR		502760 MH	6,995,539	2,497,925	9,493,464
246.	POWER & CONTROL WIRING	660,080	386440 MH	5,400,499	5,247,382	11,307,961
24 .	ELECTRIC PLANT EQUIPMENT	10,656,760	1074593 MH	15,010,599	8,917,336	34,584,695
251.	TRANSPORTATION & LIFT EQPT	1,538,775	7200 MH	109,945	111,695	1,760,415
252.	AIR,WATER+STEAM SERVICE SY	3,509,611	154442 MH	2,391,599	314,125	6,215,335
253.	COMMUNICATIONS EQUIPMENT	150,080	25000 MH	349,375	227,853	727,308
254.	FURNISHINGS + FIXTURES	819,465	6717 MH	91,639	20,092	931,196
255.	WASTE WATER TREATMENT EQPT	730,680	28460 MH	431,911	262,995	1,425,586
25 .	MISCELLANFOUS PLANT EQUIPT	6,748,611	221819 MH	3,374,469	936,760	11,059,840
261.	STRUCTURES	102,267	64490 MH	872,389	732,083	1,706,739
262.	MECHANICAL EQUIPMENT	11,627,348	153568 MH	2,285,374	395,193	14,307,915
26 .	MAIN COND HEAT REJECT SYS	11,729,615	218058 MH	3,157,763	1,127,276	16,014,654
	TOTAL DIRECT COSTS	241,783,213	7581644 MH	110,167,358	64,867,106	416,817,677

PLANT CODE 620 COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
795 MWE LOW SULFUR COAL

07/10/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
**********	*************************	*************	************	*************	*************	**************
911.	TEMPORARY CONSTRUCTION FAC		1001100 MH	14,520,050	4,532,000	19,052,050
912.	CONSTRUCTION TOOLS & EQUIP		155100 MH	2,249,900	10,510,500	12,760,400
913.	PAYROLL INSURANCE & TAXES	21,833,115				21,833,115
914.	PERMITS,INS & LOCAL TAXES				379,500	379,500
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	21,833,115	1156200 MH	16,769,950	15,422,000	54,025,065
921.	HOME OFFICE SERVICES	15,111,800				15,111,800
922.	HOME OFFICE Q/A					
923.	HOME OFFICE CONSTRCTN MGMT	1,171,500				1,171,500
92 .	HOME OFFICE ENGRG &SERVICE	16,283,300				16,283,300
931	FIELD OFFICE EXPENSES				869,000	869,000
932.	FIELD JOB SUPERVISION	11,183,700				11,183,700
933.	FIELD QA/QC	198,000				198,000
934.	PLANT STARTUP & TEST	426,800				426,800
93 .	FIELD OFFICE ENGRG&SERVICE	11,808,500			869,000	12,677,500
	TOTAL INDIRECT COSTS	49,924,915	1156200 MH	16,769,950	16,291,000	82,985,865
	TOTAL BASE COST	291,708,128	8737844 MH	126,937,308	81,158,106	499,803,542

TABLE 5-14

ENERGY ECONOMIC DATA BASE

630 MWe COAL GASIFICATION COMBINED CYCLE FPGS

CAPITAL COST ESTIMATE

PLANT CODE 660

COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
630 MWE COAL GASIFICATION COMBINED CYCLE

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
20 .	LAND AND LAND RIGHTS				653,500	653,500
21 .	STRUCTURES + IMPROVEMENTS	2,230,488	741232 MH	10,235,849	15,014,656	27,480,993
22 .	GASIFIER/BOILER PLT EQUIP.	110,805,285	2811474 MH	43,009,667	2,572,810	156,387,762
23 .	TURBINE PLANT EQUIPMENT	97,840,862	1840197 MH	28,237,026	2,015,603	128,093,491
24 .	ELECTRIC PLANT EQUIPMENT	6,793,470	1034496 MH	14,474,295	8,620,412	29,888,177
25 .	MISCELLANEOUS PLANT EQUIPT	1,877,327	176640 MH	2,676,630	499,875	5,053,832
26 .	MAIN COND HEAT REJECT SYS	6,622,563	117790 MH	1,712,882	423,130	8,758,575
	TOTAL DIRECT COSTS	226,169,995	6721829 MH	100,346,349	29,799,986	356,316,330
91 .	CONSTRUCTION SERVICES	19,573,630	990000 MH	14,792,825	19,778,000	54,144,455
92 .	HOME OFFICE ENGRG.&SERVICE	18,750,600				18,750,600
93 .	FIELD OFFICE ENGRG&SERVICE	13,237,400			1,122,000	14,359,400
	TOTAL INDIRECT COSTS	51,561,630	990000 MH	14,792,825	20,900,000	87,254,455
	TOTAL BASE COST	277,731,625	7711829 MH	115,139,174	50,699,986	443,570,785

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
630 MWE COAL GASIFICATION COMBINED CYCLE

PLANT CODE 660
COST BASIS 01/80

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
**********	**************************	*************	************	*************	*************	**************
20 .	LAND AND LAND RIGHTS				653,500	653,500
211.	YARDWORK	92,065	155070 MH	1,951,105	2,461,604	4,504,774
213.	TURBINE GENERATOR BLDG	258,110	188157 MH	2,724,510	6,254,948	9,237,568
214.	CONTROL BUILDING	73,099	45818 MH	656,303	716,188	1,445,590
218B.	ADMINISTRATION+SERVICE BLD		82200 MH	1,202,538	1,590,255	2,792,793
218C.	FUEL OIL STORAGE TANKS		7700 MH	113,762	92,599	206,361
218D.	FUEL OIL FORWARDING HOUSE	3,179	2986 MH	40,836	30,344	74,359
218I.	DIESEL GEN & SWITCHGR BLDG		16320 MH	231,711	287,012	518,723
218M.	COAL CAR THAW SHED		2205 MH	28,607	13,710	42,317
218N.	COAL UNLOADING FACILITY		3125 MH	40,978	26,945	67,923
218P.	COAL CRUSHER HOUSE		660 MH	9,221	7,775	16,996
218R.	ROTARY PLOW MAINTNCE SHED					
218T.	LOCOMOTIVE REPAIR GARAGE					
218U.	COAL HANDLING CNTRL HOUSE		930 MH	12,516	11,850	24,366
218V.	WATER TREATMENT BLDG.	13,463	17140 MH	231,108	210,788	455,359
218W.	MISC COAL HANDLING STRUCT	140,175	43400 MH	527,970	269,688	937,833
218Z.	MISC SMALL BUILDINGS				134,659	134,659
219A.	FLUE GAS STACK		146561 MH	2,065,065	2,648,691	4,713,756
219B.	VENT + FLARE STACK	1,650,397	28960 MH	399,619	257,600	2,307,616
21 .	STRUCTURES + IMPROVEMENTS	2,230,488	741232 MH	10,235,849	15,014,656	27,480,993

PLANT CODE 660 COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
630 MWE COAL GASIFICATION COMBINED CYCLE

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
221.	GASIFIER SYSTEM	49,795,704	1207555 MH	18,453,488	590,825	68,840,017
222.	DRAFT SYSTEM	2,123,527	63812 MH	989,445		3,112,972
223.	ASH HANDLING SYSTEM	1,400,913	56951 MH	872,323	89,806	2,363,042
224.	FUEL HANDLING SYSTEMS	4,916,018	129353 MH	1,991,730	1,150,164	8,057,912
225.	PARTICULATE REMOVAL SYSTEM	12,624,241	298568 MH	4,592,483		17,216,724
226.	DESULFURIZATION SYSTEM	14,616,441	345670 MH	5,316,992		19,933,433
227.	STEAM GENERATING SYSTEM	19,530,361	493689 MH	7,698,309	411,158	27,639,828
228.	INSTRUMENTATION + CONTROL	2,763,563	92400 MH	1,287,547	67,304	4,118,414
229.	BOILER PLANT MISC. ITEMS	3,034,517	123476 MH	1,807,350	263,553	5,105,420
22 .	GASIFIER/BOILER PLT EQUIP.	110,805,285	2811474 MH	43,009,667	2,572,810	156,387,762
231.	STEAM TURBINE GENERATOR	25,961,672	106100 MH	1,540,416	519,142	28,021,230
232.	GAS TURBINE GENERATORS	63,361,015	1428966 MH	21,960,354	169,300	85,490,669
233.	CONDENSING SYSTEMS	3,384,198	65239 MH	1,026,697	112,200	4,523,095
234.	FEED HEATING SYSTEM	3,225,795	67260 MH	1,045,425	90,918	4,362,138
235.	OTHER TURBINE PLANT EQUIP.	1,908,182	106182 MH	1,648,618	166,824	3,723,624
236.	INSTRUMENTATION + CONTROL					
237.	TURBINE PLANT MISC ITEMS		66450 MH	1,015,516	957,219	1,972,735
23 .	TURBINE PLANT EQUIPMENT	97,840,862	1840197 MH	28,237,026	2,015,603	128,093,491

PLANT CODE 660   COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
630 MWE COAL GASIFICATION COMBINED CYCLE

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
**********	**************************	*************	************	*************	*************	*************
241.	SWITCHGEAR	2,918,470	31052 MH	439,705	47,618	3,405,793
242.	STATION SERVICE EQUIPMENT	2,622,250	27009 MH	380,420	56,851	3,059,521
243.	SWITCHBOARDS	243,400	3370 MH	47,720	4,772	295,892
244.	PROTECTIVE EQUIPMENT		88600 MH	1,246,056	915,079	2,161,135
245.	ELECT.STRUC +WIRING CONTNR		448430 MH	6,266,811	2,201,869	8,468,680
246.	POWER & CONTROL WIRING	1,009,350	436035 MH	6,093,583	5,394,223	12,497,156
24 .	ELECTRIC PLANT EQUIPMENT	6,793,470	1034496 MH	14,474,295	8,620,412	29,888,177
251.	TRANSPORTATION & LIFT EQPT	270,092	2740 MH	42,146	65,875	378,113
252.	AIR,WATER+STEAM SERVICE SY	1,267,523	134980 MH	2,088,746	381,426	3,737,695
253.	COMMUNICATIONS EQUIPMENT	175,401	37620 MH	525,740	52,574	753,715
254.	FURNISHINGS + FIXTURES	164,311	1300 MH	19,998		184,309
25 .	MISCELLANEOUS PLANT EQUIPT	1,877,327	176640 MH	2,676,630	499,875	5,053,832
261.	STRUCTURES	5,269	24487 MH	326,847	237,854	569,970
262.	MECHANICAL EQUIPMENT	6,617,294	93303 MH	1,386,035	185,276	8,188,605
26 .	MAIN COND HEAT REJECT SYS	6,622,563	117790 MH	1,712,882	423,130	8,758,575
	TOTAL DIRECT COSTS	226,169,995	6721829 MH	100,346,349	29,799,986	356,316,330

PLANT CODE 660 COST BASIS 01/80

UNITED ENGINEERS & CONSTRUCTORS INC.
ENERGY ECONOMIC DATA BASE (EEDB) PHASE III
630 MWE COAL GASIFICATION COMBINED CYCLE

06/16/81

ACCT NO	ACCOUNT DESCRIPTION	FACTORY EQUIP. COSTS	SITE LABOR HOURS	SITE LABOR COST	SITE MATERIAL COST	TOTAL COSTS
911.	TEMPORARY CONSTRUCTION FAC		850000 MH	12,690,825	5,835,500	18,526,325
912.	CONSTRUCTION TOOLS & EQUIP		140000 MH	2,102,000	13,497,000	15,599,000
913.	PAYROLL INSURANCE & TAXES	19,573,630				19,573,630
914.	PERMITS,INS. & LOCAL TAXES				445,500	445,500
915.	TRANSPORTATION					
91 .	CONSTRUCTION SERVICES	19,573,630	990000 MH	14,792,825	19,778,000	54,144,455
921.	HOME OFFICE SERVICES	17,579,100				17,579,100
922.	HOME OFFICE Q/A					
923.	HOME OFFICE CONSTRCTN MGMT	1,171,500				1,171,500
92 .	HOME OFFICE ENGRG.&SERVICE	18,750,600				18,750,600
931.	FIELD OFFICE EXPENSES				1,122,000	1,122,000
932.	FIELD JOB SUPERVISION	12,361,800				12,361,800
933.	FIELD QA/QC	313,500				313,500
934.	PLANT STARTUP & TEST	562,100				562,100
93 .	FIELD OFFICE ENGRG&SERVICE	13,237,400			1,122,000	14,359,400
	TOTAL INDIRECT COSTS	51,561,630	990000 MH	14,792,825	20,900,000	87,254,455
	TOTAL BASE COST	277,731,625	7711829 MH	115,139,174	50,699,986	443,570,785

Effective Date - 1/1/80

TABLE 5-15

ENERGY ECONOMIC DATA BASE

COMMODITY AND CRAFT MANHOUR SUMMARY

1190 MWe BOILING WATER REACTOR NUCLEAR POWER GENERATING STATION

NUCLEAR PLANT QUANTITIES

Commodity	Unit	Quantity	Cost/Unit (a)
Excavation	CY	536,000	12.87
Fill	CY	396,000	2.96
Formwork	SF	2,405,620	16.23
Reinforcing Steel	TN	20,348	1,503.00
Concrete	CY	205,234	88.91
Embedded Steel	TN	697	7,683.00
Structural Steel	TN	10,800	1,484.70
Special Steel Liners	LT	--	33.87*
Carbon Steel Piping (NS)	LB	1,857,481	15.14
Stainless Steel Piping (NS)	LB	196,000	65.98
Carbon Steel Piping (NNS)	LB	4,477,000	7.98
Stainless Steel Piping (NNS)	LB	334,000	23.34
Commodity (cont'd)			
Valves	LT	--	15.55*
Fire Protection	LT	--	0.70*
BOP Pump (1000 HP & above)	HP	57,400+	82.92
Heat Exchangers	LT	--	30.54*
Turbine Generator	LT	--	75.24*
Instrumentation and Control	LT	--	14.08*
Lighting	LT	--	3.48*
Duct Runs and Containers	LF	496,114	26.44
Wire and Cable	LF	4,550,000	4.63
Electrical Balance of Plant	LT	--	24.28*
Nuclear Steam Supply System	LT	--	92.44*
All Others	LT	--	377.23*

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* Cost per unit is in dollars per kilowatt (NS) = Nuclear Safety Grade (NNS) = Non-Nuclear Safety Grade

\+ Includes Boiler Feed Pumps

(a) Data in Constant $1980 (Inflation-Free)

NUCLEAR PLANT MANHOURS

Craft	Manhours	Cost x 10^3 (a)
Boiler Makers	609,692	10,255
Carpenters	2,215,698	30,156
Electricians	2,565,263	36,093
Ironworkers	2,430,714	37,093
Laborers	2,090,362	22,157
Craft (cont'd)		
Millwrights	306,910	4,502
Operating Engineers	1,470,105	22,154
Pipe Fitters	4,314,922	69,472
Sheet Metal Workers	304,424	4,180
All Others	1,013,137	13,073
TOTAL CRAFT LABOR	17,321,243	249,135

TABLE 5-16

Effective Date - 1/1/80

ENERGY ECONOMIC DATA BASE

COMMODITY AND CRAFT MANHOUR SUMMARY

858 MWe HIGH TEMPERATURE GAS-COOLED REACTOR - STEAM CYCLE NUCLEAR POWER GENERATING STATION

NUCLEAR PLANT QUANTITIES

Commodity	Unit	Quantity	Cost/Unit(a)	Commodity (cont'd)	Unit	Quantity	Cost/Unit(a)
Excavation	CY	423,115	6.32	Valves	LT	--	11.73*
Fill	CY	338,408	4.38	Fire Protection	LT	--	1.32*
Formwork	SF	1,617,699	16.68	BOP Pump (1000 HP & above)	HP	84,100+	64.16
Reinforcing Steel	TN	22,564	1,505.00	Heat Exchangers	LT	--	31.61*
Concrete	CY	190,862#	86.81#	Turbine Generator	LT	--	58.42*
Embedded Steel	TN	817	7,510.00	Instrumentation and Control	LT	--	15.02*
Structural Steel	TN	8,342	1,496.00	Lighting	LT	--	3.44*
Special Steel Liners	LT	--	25.52*	Duct Runs and Containers	LF	476,000	23.98
Carbon Steel Piping (NS)	LB	613,540	13.35	Wire and Cable	LF	4,061,584	5.07
Stainless Steel Piping (NS)	LB	133,028	32.54	Electrical Balance of Plant	LT	--	24.78*
Carbon Steel Piping (NNS)	LB	1,839,835	7.25	Nuclear Steam Supply System	LT	--	185.31*
Stainless Steel Piping (NNS)	LB	321,803	19.40	All Others	LT	--	500.30*

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* Cost per unit is in dollars per kilowatt

\+ Includes Boiler Feed Pumps

(a) Data in Constant $1980 (Inflation-Free)

(NS) = Nuclear Safety Grade

(NNS) = Non-Nuclear Safety Grade

\# = Does Not Include Pre-stressed Concrete Vessel

NUCLEAR PLANT MANHOURS

Craft	Manhours	Cost x 10^3(a)	Craft (cont'd)	Manhours	Cost x 10^3(a)
Boiler Makers	662,760	11,192	Millwrights	226,623	3,335
Carpenters	1,864,739	25,379	Operating Engineers	873,661	13,192
Electricians	2,244,607	31,582	Pipe Fitters	1,855,711	29,929
Ironworkers	2,014,820	30,756	Sheet Metal Workers	105,141	1,444
Laborers	1,578,957	16,737	All Others	1,409,469	19,512
			TOTAL CRAFT LABOR	12,836,488	183,058

TABLE 5-17

Effective Date - 1/1/80

ENERGY ECONOMIC DATA BASE

COMMODITY AND CRAFT MANHOUR SUMMARY

1139 MWe PRESSURIZED WATER REACTOR NUCLEAR POWER GENERATING STATION

NUCLEAR PLANT QUANTITIES

Commodity	Unit	Quantity	Cost/Unit(a)
Excavation	CY	529,000	12.98
Fill	CY	396,000	2.96
Formwork	SF	2,035,000	17.09
Reinforcing Steel	TN	21,600	1,556.00
Concrete	CY	174,000	88.95
Embedded Steel	TN	546	7,671.00
Structural Steel	TN	11,300	1,486.00
Special Steel Liners	LT	--	17.44*
Carbon Steel Piping (NS)	LB	1,500,300	14.53
Stainless Steel Piping (NS)	LB	440,170	55.52
Carbon Steel Piping (NNS)	LB	4,661,000	7.98
Stainless Steel Piping (NNS)	LB	410,000	23.26
Commodity (cont'd)			
Valves	LT	--	12.21*
Fire Protection	LT	--	0.74*
BOP Pump (1000 HP & above)	HP	48,900	90.15
Heat Exchangers	LT	--	30.90*
Turbine Generator	LT	--	76.07*
Instrumentation and Control	LT	--	13.65*
Lighting	LT	--	3.78*
Duct Runs and Containers	LF	485,000	26.43
Wire and Cable	LF	4,608,000	4.60
Electrical Balance of Plant	LT	--	23.40*
Nuclear Steam Supply System	LT	--	102.72*
All Others	LT	--	396.69*

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* Cost per unit is in dollars per kilowatt

(NS) = Nuclear Safety Grade

(NNS) = Non-Nuclear Safety Grade

\+ Including Boiler Feed Pumps

(a) Data in Constant $1980 (Inflation-Free)

NUCLEAR PLANT MANHOURS

Craft	Manhours	Cost x 10^3(a)
Boiler Makers	903,379	15,195
Carpenters	2,073,867	28,225
Electricians	2,529,384	35,588
Ironworkers	2,019,573	30,819
Laborers	1,977,251	20,959
Craft (cont'd)		
Millwrights	239,949	3,520
Operating Engineers	1,228,739	18,517
Pipe Fitters	4,254,653	68,500
Sheet Metal Workers	178,000	2,445
All Others	910,918	11,808
TOTAL CRAFT LABOR	16,315,713	235,576

TABLE 5-18 Effective Date - 1/1/80

ENERGY ECONOMIC DATA BASE

COMMODITY AND CRAFT MANHOUR STUDY

1260 MWe PRESSURIZED HEAVY WATER REACTOR NUCLEAR POWER GENERATING STATION

NUCLEAR PLANT QUANTITIES

Commodity	Unit	Quantity	Cost/Unit(a)
Excavation	CY	523,000	12.97
Fill	CY	397,000	3.08
Formwork	SF	1,707,000	18.03
Reinforcing Steel	TN	22,369	1,575.00
Concrete	CY	164,139	89.73
Embedded Steel	TN	606	7,671.70
Structural Steel	TN	9,800	1,486.00
Special Steel Liners	LT	--	16.15*
Carbon Steel Piping (NS)	LB	1,845,000	15.80
Stainless Steel Piping (NS)	LB	86,500	62.10
Carbon Steel Piping (NNS)	LB	4,717,000	7.96
Stainless Steel Piping (NNS)	LB	99,000	25.51
Valves	LT	--	9.90*
Fire Protection	LT	--	0.74*
BOP Pump (1000 HP & above)	BHP	79,500+	66.95
Heat Exchangers	LT	--	36.47*
Turbine Generator	LT	--	77.18*
Instrumentation and Control	LT	--	11.65*
Lighting	LT	--	2.59*
Duct Runs and Containers	LF	540,500	25.99
Wire and Cable	LF	5,170,000	4.10
Electrical Balance of Plant	LT	--	21.74*
Nuclear Steam Supply System	LT	--	122.15*
All Others	LT	--	475.71*

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* Cost per unit is in dollars per kilowatt (NS) = Nuclear Safety Grade (NNS) = Non-Nuclear Safety Grade

\+ Includes Boiler Feed Pumps

(a) Data in Constant $1980 (Inflation-Free)

NUCLEAR PLANT MANHOURS

Craft	Manhours	Cost x 10^3 (a)
Boiler Makers	968,341	16,288
Carpenters	1,905,374	25,932
Electricians	2,834,262	39,878
Ironworkers	2,118,860	32,334
Laborers	1,883,214	19,962
Millwrights	278,706	4,089
Operating Engineers	1,210,978	18,249
Pipe Fitters	3,896,734	62,738
Sheet Metal Workers	92,880	1,275
All Others	1,041,471	11,924
TOTAL CRAFT LABOR	16,230,820	232,669

TABLE 5-19

Effective Date - 1/1/80

ENERGY ECONOMIC DATA BASE

COMMODITY AND CRAFT MANHOUR SUMMARY

1457 MWe LIQUID METAL FAST-BREEDER REACTOR NUCLEAR POWER GENERATING STATION

NUCLEAR PLANT QUANTITIES

Commodity	Unit	Quantity	Cost/Unit [(a)]
Excavation	CY	771,353	15.32
Fill	CY	265,465	4.06
Formwork	SF	2,227,992	15.36
Reinforcing Steel	TN	39,756	1,560.00
Concrete	CY	261,428	91.19
Embedded Steel	TN	1,536	7,648.00
Structural Steel	TN	15,554	1,485.00
Special Steel Liners	LT	--	33.01*
Carbon Steel Piping (NS)	LB	555,097	8.35
Stainless Steel Piping (NS)	LB	763,822	45.78
Carbon Steel Piping (NNS)	LB	4,703.421	7.97
Stainless Steel Piping (NNS)	LB	817,991	17.05
Commodity (cont'd)	**Unit**	**Quantity**	**Cost/Unit [(a)]**
Valves	LT	--	7.27*
Fire Protection	LT	--	11.16*
BOP Pump (1000 HP & above)	HP	139,250+	50.60
Heat Exchangers	LT	--	27.16*
Turbine Generator	LT	--	67.55*
Instrumentation and Control	LT	--	6.42*
Lighting	LT	--	5.07*
Duct Runs and Containers	LF	780,165	23.70
Wire and Cable	LF	6,473,035	4.42
Electrical Balance of Plant	LT	--	20.04*
Nuclear Steam Supply System	LT	--	248.94*
All Others	LT	--	447.30*

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* Cost per unit is in dollars per kilowatt

(NS) = Nuclear Safety Grade

(NNS) = Non-Nuclear Safety Grade

\+ Includes Main Boiler Feed Pumps

(a) Data in Constant $1980 (Inflation-Free)

NUCLEAR PLANT MANHOURS

Craft	Manhours	Cost x 10^3 [(a)]
Boiler Makers	1,378,350	23,184
Carpenters	2,403.981	32,718
Electricians	3,873,807	54,504
Ironworkers	4,024,980	61.421
Laborers	2,674,638	28.351
Craft (cont'd)	**Manhours**	**Cost x 10^3 [(a)]**
Millwrights	405,549	5,949
Operating Engineers	1,904,025	28,694
Pipe Fitters	5,545,204	89,278
Sheet Metal Workers	405,292	5,565
All Others	1,366,337	17,796
TOTAL CRAFT LABOR	23,982,163	347,460

TABLE 5-20 Effective Date 1/1/80

ENERGY ECONOMIC DATA BASE

COMMODITY AND CRAFT MANHOUR SUMMARY

1232 MWe HIGH SULFUR COAL-FIRED FOSSIL POWER GENERATING STATION

COMPARISON COAL PLANT QUANTITIES

Commodity	Unit	Quantity	Cost/Unit (a)
Excavation	CY	220,000	6.64
Fill	CY	99,000	7.06
Formwork	SF	1,067,000	6.84
Reinforcing Steel	TN	7,000	949.00
Concrete	CY	108,000	77.44
Embedded Steel	TN	369	4,955.00
Structural Steel	TN	24,400	1,254.00
Carbon Steel Piping	LB	4,672,573	4.49
Stainless Steel Piping	LB	600	18.71
Chrome-Moly Piping	LB	3,219,000	7.43
Valves	LT	--	3.12*
Fire Protection	LT	--	.49*
Pumps (1000 HP & up)	HP	103,750+	39.37
Commodity (cont'd)	**Unit**	**Quantity**	**Cost/Unit (a)**
Heat Exchanger	LT	--	24.82*
Turbine Generator	LT	--	62.23*
Coal Handling#	LT	--	9.75*
Dust Col. & Elec. Precipitator	LT	--	15.00*
SO_2 Removal System & Structures	LT	--	151.93*
Heat., Ventilating, & Air Cond.	LT	--	5.24*
Ash Handling	LT	--	6.05*
Instrumentation and Control	LT	--	5.03*
Lighting	LT	--	1.66*
Duct Runs & Wire Containers	LF	646,000	15.33
Wire and Cable	LF	3,985,000	3.29
Electrical Balance of Plant	LT	--	13.95*
Fossil Steam Supply System	LT	--	80.25*
All Others	LT	--	149.31*

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* Cost per unit is in dollars per kilowatt

(a) Data in Constant $1980 (Inflation-Free)

\+ Includes Boiler Feed Pumps

\# Does Not Include Ignition Oil System

COMPARISON COAL PLANT MANHOURS

Craft	Manhours	Cost x 10^3 (a)
Boiler Makers	290,298	4,883
Carpenters	389,693	5,304
Electricians	1,829,575	25,742
Ironworkers	942,189	14,378
Laborers	618,637	6,558
Craft (cont'd)	**Manhours**	**Cost x 10^3 (a)**
Millwrights	315,118	4,623
Operating Engineers	642,870	9,688
Pipe Fitters	3,782,634	60,900
Sheet Metal Workers	@	@
All Others	2,062,743	29,050
TOTAL CRAFT LABOR	10,873,757	161,126

@ Not Applicable

TABLE 5-21

Effective Date - 1/1/80

ENERGY ECONOMIC DATA BASE

COMMODITY AND CRAFT MANHOUR SUMMARY

795 MWe HIGH SULFUR COAL-FIRED FOSSIL POWER GENERATING STATION

COMPARISON COAL PLANT QUANTITIES

Commodity	Unit	Quantity	Cost/Unit (a)
Excavation	CY	180,000	6.91
Fill	CY	84,000	6.90
Formwork	SF	896,000	6.68
Reinforcing Steel	TN	5,500	951.00
Concrete	CY	88,500	77.51
Embedded Steel	TN	314	4,955.00
Structural Steel	TN	18,000	1,249.00
Carbon Steel Piping	LB	3,037,000	4.51
Stainless Steel Piping	LB	600	18.71
Chrome-Moly Piping	LB	1,212,000	7.17
Valves	LT	--	3.75*
Fire Protection	LT	--	.73*
Pumps (1000 HP & up)	HP	66,320+	46.33

Commodity (cont'd)	Unit	Quantity	Cost/Unit (a)
Heat Exchanger	LT	--	24.59*
Turbine Generator	LT	--	50.68*
Coal Handling (Fac. Equip.)	LT	--	13.84*
Dust Col. & Elec. Precipitator	LT	--	14.11*
SO$_2$ Removal System & Structures	LT	--	164.94*
Heat., Ventilating, & Air Cond.	LT	--	5.27*
Ash Handling	LT	--	6.85*
Instrumentation and Control	LT	--	7.94*
Lighting	LT	--	2.10*
Duct Runs & Wire Containers	LF	568,000	15.30
Wire and Cable	LF	3,390,000	3.33
Electrical Balance of Plant	LT	--	19.77*
Fossil Steam Supply System	LT	--	84.57*
All Others	LT	--	155.95*

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* Cost per unit is in dollars per kilowatt

(a) Data in Constant $1980 (Inflation-Free)

\+ Includes Boiler Feed Pumps

* Does Not Include Ignition Oil System

COMPARISON COAL PLANT MANHOURS

Craft	Manhours	Cost x 10^3 (a)
Boiler Makers	209,399	3,522
Carpenters	320,280	4,359
Electricians	1,515,072	21,317
Ironworkers	716,823	10,939
Laborers	498,446	5,284

Craft (cont'd)	Manhours	Cost x 10^3 (a)
Millwrights	231,953	3,403
Operating Engineers	463,210	6,981
Pipe Fitters	2,487,750	40,052
Sheet Metal Workers	@	
All Others	1,433,218	20,107
TOTAL CRAFT LABOR	7,876,151	115,964

@ Not Applicable

TABLE 5-22

Effective Date - 1/1/80

ENERGY ECONOMIC DATA BASE

COMMODITY AND CRAFT MANHOUR SUMMARY

1236 MWe LOW SULFUR COAL-FIRED FOSSIL POWER GENERATING STATION

COMPARISON COAL PLANT QUANTITIES

Commodity	Unit	Quantity	Cost/Unit (a)
Excavation	CY	253,603	6.11
Fill	CY	123,993	7.06
Formwork	SF	1,062,866	6.84
Reinforcing Steel	TN	6,900	950.31
Concrete	CY	116,678	75.35
Embedded Steel	TN	389	4,955.00
Structural Steel	TN	26,330	1,256.00
Carbon Steel Piping	LB	4,672,570	4.49
Stainless Steel Piping	LB	600	18.71
Chrome-Moly Piping	LB	3,323,900	6.91
Valves	LT	--	3.31*
Fire Protection	LT	--	0.51*
Pumps (1000 HP & up)	HP	103,750[+]	39.37
Commodity (cont'd)	**Unit**	**Quantity**	**Cost/Unit (a)**
Heat Exchanger	LT	--	23.97*
Turbine Generator	LT	--	63.23*
Coal Handling[#]	LT	--	14.16*
Dust Col. & Elec. Precipitator	LT	--	--
SO_2 Removal System & Structure	LT	--	142.16*
Heat., Ventilating, & Air Cond.	LT	--	10.33*
Ash Handling	LT	--	5.98*
Instrumentation and Control	LT	--	4.42*
Lighting	LT	--	1.67*
Duct Runs & Wire Containers	LF	646,250	15.23
Wire and Cable	LF	3,987,720	3.29
Electrical Balance of Plant	LT	--	13.59*
Fossil Steam Supply System	LT	--	81.98*
All Others	LT	--	119.39*

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* Cost per unit is in dollars per kilowatt

(a) Data in Constant $1980 (Inflation-Free)

\+ Includes Boiler Feed Pumps

COMPARISON COAL PLANT MANHOURS

Craft	Manhours	Cost x 10^3 (a)
Boiler Makers	158,276	2,662
Carpenters	389,465	5,301
Electricians	1,678,776	23,620
Ironworkers	917,731	14,005
Laborers	756,365	8,017
Craft (cont'd)	**Manhours**	**Cost x 10^3 (a)**
Millwrights	340,056	4,989
Operating Engineers	598,349	9,017
Pipe Fitters	3,838,679	61,803
Sheet Metal Workers	@	@
All Others	2,127,899	30,310
TOTAL CRAFT LABOR	10,805,596	159,724

@ Not Applicable

Effective Date - 1/1/80

TABLE 5-23

ENERGY ECONOMIC DATA BASE

COMMODITY AND CRAFT MANHOUR SUMMARY

795 MWe LOW SULFUR COAL-FIRED FOSSIL POWER GENERATING STATION

COMPARISON COAL PLANT QUANTITIES

Commodity	Unit	Quantity	Cost/Unit$^{(a)}$
Excavation	CY	198,266	6.29
Fill	CY	101,228	7.01
Formwork	SF	856,460	6.68
Reinforcing Steel	TN	5,311	948.00
Concrete	CY	92,675	76.24
Embedded Steel	TN	325	4,955.00
Structural Steel	TN	19,375	1,255.00
Carbon Steel Piping	LB	3,013,380	4.50
Stainless Steel Piping	LB	600	18.71
Chrome-Moly Piping	LB	1,212,000	7.17
Valves	LT	--	3.93*
Fire Protection	LT	--	0.77*
Pumps (1000 HP & up)	HP	66,320+	46.33
Heat Exchanger	LT	--	24.94*
Turbine Generator	LT	--	50.68*
Coal Handling#	LT	--	19.57*
Dust Col. & Elec. Precipitator	LT	--	--
SO_2 Removal System & Structures	LT	--	160.05*
Heat., Ventilating, & Air Cond.	LT	--	10.85*
Ash Handling	LT	--	7.03*
Instrumentation and Control	LT	--	7.11*
Lighting	LT	--	2.11*
Duct Runs & Wire Containers	LF	567,500	15.31
Wire and Cable	LF	3,421,500	3.31
Electrical Balance of Plant	LT	--	17.61*
Fossil Steam Supply System	LT	--	85.53*
All Others	LT	--	130.38*

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* Cost per unit is in dollars per kilowatt

\+ Includes Boiler Feed Pumps # Does Not Include Ignition Oil Systen

(a) Data in Constant $1980 (Inflation-Free)

COMPARISON COAL PLANT MANHOURS

Craft	Manhours	Cost x $10^{3(a)}$
Boiler Makers	116,154	1.954
Carpenters	307,829	4.190
Electricians	1,415,067	19.910
Ironworkers	720,350	10.993
Laborers	589,893	6.253
Millwrights	243,969	3,579
Operating Engineers	441,733	6,657
Pipe Fitters	2.555,458	41,142
Sheet Metal Workers	@	@
All Others	1,484,274	20,038
TOTAL CRAFT LABOR	7,874,727	114,716

@ Not Applicable

6.0 FUEL COST THIRD UPDATE

The Third Update of the fuel costs in the Energy Economic Data Base covers both fissile (uranium, thorium and plutonium) and fossil fuels (coal). It provides fuel costs for all of the technical models in the Data Base, in accordance with a consistent set of ground-rules. Broad ground-rules and assumptions governing fuel costs are discussed in Section 3. This section presents the detailed bases for both the nuclear and fossil fuel costs.

6.1 FUEL COST SUMMARY

Fuel costs are prepared for the EEDB as total thermal costs (¢/MBtu). Nuclear fuel cycle costs for the Third Update consist of Fuel, (including ore conversion and enrichment) Fabrication, Transportation, Reprocessing (Breeder options only) and Disposal costs. Costs for short term on-site spent fuel storage are included in the Capital Costs; long term storage is assumed to be off-site at a Federal depository. Coal fuel costs for the Third Update consist of Fuel and Transportation costs only. Costs for Flue-Gas-Desulfurization are not included in the coal fuel costs. These costs are included in the Capital and the Operating and Maintenance costs.

Fuel costs are summarized in Table 6-1 for all plants for startups in the year 2001. Table 6-2 summarizes fuel costs for the commercialized technologies for plant startup in the year 1980. Table 6-3 gives data for the advanced technologies for variable plant startups in the year when the technologies are expected to be deployed commercially. Table 6-3 includes the LWR plants for comparison.

6.2 NUCLEAR FUEL CYCLE COST UPDATE PROCEDURE

The Initial Update of the nuclear fuel cycle costs is a first-of-a-kind effort, performed by United Engineers & Constructors, Inc. and their subcontractor, the NUS Corporation, to produce a fuel cycle cost data base for the EEDB. In the Second Update, a specific nuclear fuel cycle cost update procedure was developed for the EEDB and is described in Appendix F. This procedure is utilized to develop the nuclear fuel cycle costs for this Third Update, for the selected technical models given in Table 1-1.

6.3 DETAILED FUEL COSTS

Results of the Fuel Cost Third Update are presented for each technical plant model in the Tables listed below. Specific BWR mass flow data is not available for this study; therefore, PWR data is used for the BWR (Model A1).

Nuclear Plant Model	Year of Startup	Fuel Cycle Cost Table Number	Fossil Plant Model	Year of Startup	Fuel Cost Table Number
PWR	1980	6-4a/4b	HS12	1980	6-14a
PWR	1987	6-5a/5b	HS12	1987	6-14b
PWR	2001	6-6a/6b	HS12	2001	6-14c
HTGR-SC	1995	6-7a/7b	HS8	1980	6-14a
HTGR-SC	2001	6-8a/8b	HS8	1987	6-14b
PHWR	1995	6-9a/9b	HS8	2001	6-14c
PHWR	2001	6-10a/10b	LS12	1980	6-14a
HTGR-PS	2001	6-11a/11b	LS12	1987	6-14b
LMFBR	2001	6-12a/12b	LS12	2001	6-14c
Explanation of Fuel Cycle System Designation		6-13	LS8	1980	6-14a
			LS8	1987	6-14b
			LS8	2001	6-14c
			CGCC	1987	6-14b
			CGCC	2001	6-14c

For the nuclear fuel cycle costs, "a" tables tabulate Input Cost Components and "b" tables tabulate Output Cost Components. In the "a" series of nuclear fuel cycle cost tables, the costs of the fuel cycle components are assumed to remain unchanged in terms of constant $1980. In the "b" series of nuclear fuel cycle cost tables, the costs are given for Direct, Indirect and Total Costs levelized over the nominal 30-year plant lifetime from the year of plant startup. The values in the "a" tables are given in terms of unit market prices and in the "b" tables are given in $/MBtu.

The costs are based on the mass flow characteristics of the specific reactor type for which the costs are computed, at equilibrium conditions. These characteristics are applied as derived coefficients to the unit costs for the materials/services given in the "a" tables.

6.4 PROJECTION OF ECONOMIC PARAMETERS FOR FUEL

The projection of several national economic parameters is a key element in the calculation of nuclear and coal fuel cost estimates. Principal among these are the long term inflation rate, interest rate, and discount rate. They are particularly relevant in calculating the levelized fuel cost for either a nuclear or coal-fired power generating station.

The levelized fuel cost is the uniform annual cost of the fuel over the lifetime of the plant, in which the fuel is utilized, whose stream of payments has the same present value as the stream of the annual predicted fuel cost over that period.

Levelized values for each component of the nuclear fuel cycle are provided in constant 1980 dollars.

The coal fuel costs for the EEDB Third Update are stated in terms of first year costs in constant 1980 dollars. The assumption is made that no escalation will occur for coal, even though it is expected that coal will rise over time to the levels of more expensive, competing fuels. This is a conservative assumption in terms of the objective, assumptions and groundrules of the EEDB Program. This assumption is subject to examination in future updates. When valid information becomes available, projections of future coal costs will be incorporated. For the case where escalation of coal costs is incorporated into a total generation cost calculation, a levelization factor must be computed and applied to the first year costs before the fuel costs are added to capital and operating and maintenance costs. Consistent rates of interest and escalation must be used in the computation for compatibility and consistency with the capital and O&M costs. An approximation of the levelization factor may be computed with the following equation:

$$LF = \left[\frac{i\ (1 + e)}{i - e}\right] \bullet \left[\frac{(1 + i)^n - (1 + e)^n}{(1 + i)^n - 1}\right]$$

Where: LF = levelization factor
i = discount rate per annum
e = escalation rate per annum
n = levelization period in years

6.5 NUCLEAR FUEL CYCLE COSTS

The Nuclear Power Generating Stations (NPGS) currently deployed in the United States consist of Light Water Reactors (LWR's) and a single High Temperature Gas cooled Reactor (HTGR). The HTGR NPGS is a 300 MWe demonstration unit representing a one-of-a-kind situation, because commercialization of this design is indefinitely postponed. The Light Water Reactor NPGS utilize both Pressurized Water Reactors (PWRs) and Boiling Water Reactors (BWRs). The PWRs are manufactured by Westinghouse, Babcock and Wilcox and Combustion Engineering Companies. The General Electric Company is the sole manufacturer of the BWR.

In the Third Update of the EEDB, nuclear fuel cycle costs are developed for five different reactor plant types; the Pressurized Water Reactor (PWR), the Boiling Water Reactor (BWR), the High Temperature Gas Cooled Reactor (HTGR), the Pressurized Heavy Water Reactor (PHWR) and the Liquid Metal Fast Breeder Reactor (LMFBR) Nuclear Power Generating Stations. The last two of these reactors have no commercial prototypes in existence in the United States today. Reactor and cost input data for the commercialized LWR fuel cycle are based on a significant amount of real operational experience. The extrapolation of this data is reasonable in predicting future costs. It is important to emphasize that the data in the fuel cycle costs for the remaining four reactor types are based entirely upon analytical and predictive models and not on commercial experience.

The similarities of the BWR and the PWR are such that the fuel utilization characteristics differ only slightly. Consequently, their fuel costs, levelized over the nominal plant lifetime, do not vary more than ± 10 percent. The fuel cycle for the LWRs are exemplified in the Third Update by the PWR data. The values given in the NASAP (Nonproliferation Alternative Systems Assessment Program) are used to attain a normalized value for the LWRs as a class. Since there are minor but real variations among the LWR reactors currently operating and those under construction, the use of NASAP data provides a neutral basis for the computation of costs. Therefore, the explicit fuel cycle costs calculated for the PWR are utilized to represent both PWRs and BWRs.

Because of the lack of experimental information regarding the three as yet uncommercialized reactors (HTGR, PHWR, and LMFBR), data on mass flow for these reactor types have also been taken from the NASAP study (Volume 9), which represents a neutral and agreed upon body of data for the reactor types in question.

6.5.1 Nuclear Fuel Cycle Description

Nuclear fuel cycle cost analysis for the Third Update of the EEDB is based on the steps in a typical uranium/plutonium fuel cycle, illustrated in Figure 6.1. This Figure shows a complete reactor fuel cycle from mining of uranium ore through reprocessing of irradiated fuel, recovery of uranium and plutonium from spent fuel and shipment of high level waste to permanent storage. Under this scheme, the uranium and plutonium are recycled through the reactor fuel cycle. It should be noted that the reprocessing portions of the fuel cycle shown in Figure 6.1 are included for completeness and to provide economic data for this option. Currently, reactor fuel for the commercial Light Water Reactors is not being reprocessed. The alternate back-end of the fuel cycle, without the reprocessing option shown in Figure 6.1, includes temporary storage and eventual disposal of the spent fuel without reprocessing.

A standardized cost code-of-accounts format for presentation of the fuel cycle costs is developed. which correlates to the steps in the typical uranium/plutonium fuel cycle. The cost code-of-accounts numbering system is an extension of the format developed by USAEC Report NUS-531, "Guide for Economic Evaluation of Nuclear Reactor Plant Designs."

6.5.2 Components of the Nuclear Fuel Cycle Cost Analysis

The total nuclear fuel cycle cost is composed of direct and indirect cost components. The direct cost component is the cost of the fuel consumed as reflected in the cost of the materials and services for each step of the nuclear fuel cycle. It is independent of calendar time and plant capacity factor. The indirect cost component is the carrying charge associated with the value of the reactor fuel during a given calendar period. It includes interest on borrowed money, return on equity, federal and state income taxes, and other costs associated with the time value of money. Since the indirect cost component is dependent of time, it is related to the plant's performance in terms of the plant's capacity factor. Both the direct and indirect cost estimates are developed on an inflation-free basis and reported in constant 1980 dollars.

The nuclear fuel cycle costs developed here are levelized over the life of the reactors, which is assumed to be 30 years. This permits comparison of the various reactor fuel cycle systems on the same economic basis.

In addition, the total nuclear fuel cycle costs include the economic impact of the initial core on the thirty year levelized fuel cycle cost. This effect is considered, because the initial core is larger and more expensive than the reloads, which represent only part of the core. The total impact of the initial core cost on the total levelized fuel cost is dependent on the reactor, fuel cycle and generating history.

6.5.2.1 Direct Costs

Direct costs are the costs of materials and/or services associated with each step in the fuel cycle shown in Figure 6.1. These are as follows:

a. The cost of U_3O_8 in dollars per pound - \$/lb U_3O_8.

b. The cost per kilogram for conversion of the U_3O_8 to UF_6 - \$/Kg U.

c. The cost for enrichment of the UF_6 to the level required by the particular reactor fuel cycle under consideration. The cost is given in dollars per separative work unit - \$/SWU.

d. The cost for fabrication, carrying the enriched UF_6 to pelletized UO_2 and encapsulating in a cladding material, followed by assembly of single fuel rods into a fuel element - \$/Kg U (or HM).

e. The costs for shipping fuel to the reactor site - the point of use - \$/Kg U (or HM); in this report, these costs are included in fabrication cost.

f. The cost of shipping spent fuel after on-site storage, to (a) reprocessing or (b) a Federal repository for spent fuel storage - \$/Kg HM.

g. The cost of spent fuel disposal - \$/Kg HM or the cost for reprocessing of spent fuel - \$/Kg HM.

h. The cost for disposal of waste from the reprocessing operation - \$/Kg HM.

i. The cost/refund value of the recovered U or Pu as shipped for fuel fabrication of mixed oxide fuel - MOX - \$/Kg HM.

The assignment of a specific dollar value to the individual steps of the direct costs in the nuclear fuel cycle remains open to discussion. In the Third Update of the EEDB, the costs for these steps have been derived from the best

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U_3O_8 = uranium ore concentrate
UO_2 = uranium oxide
HM = heavy metal
UF_6 = uranium hexafluoride
U = elemental uranium

information available and represent either a consensus of current estimates or actual costs. The values given in Tables 6-4a through 6-12a ("a" tables only) summarize the fuel cycle unit prices used in this evaluation.

It must be noted that the costs for natural uranium are taken over the period from 1980 to 2030, with values for these and the intervening years shown in Table 6-15.

Fuel fabrication costs depend on various fuel cycle options in the reactor types involved. These costs are summarized, by reactor type, in the "a" tables.

The shipping of fuel to a site usually constitutes a minor cost which is absorbed under fabrication costs. However, the handling of the plutonium-rich material from the LMFBR requires greater care and incurs greater shipping costs.

When spent fuel elements are removed from the reactor, they are generally stored in a safe and shielded area on-site to permit the short-lived fission products to decay. Storage times may vary from 120 days to 10 years. Under the assumptions of the EEDB Program, the investment cost of this spent fuel storage is included in the capital cost of the plant. Consequently, there is no explicit charge given for on-site spent fuel storage facilities, even though the time value of money for the fuel storage period is included in the fuel cycle costs.

The shipping of spent fuel from the reactor site to a reprocessing plant or a temporary or permanent Federal repository for spent fuel elements, does require significant expenditures. These expenditures differ for the types of fuel shipped, and are shown in the "a" tables. The Third Update considers throwaway cycles for the non-breeders and plutonium recycle for the breeders.

The projected reprocessing costs for the breeder reactor is also given in the "a" tables. In terms of constant dollars, it has been assumed that there will be some productivity increase with the passing of time and that this productivity increase will be accompanied by a reduction in the cost of operation.

It is generally accepted that the value of the plutonium and of the uranium recovered in reprocessing, will be economically attractive only when that portion of the fuel cycle, with its attendant waste disposal, is shown to be less expensive than the use of fresh uranium and the subsequent steps of enrichment and fuel fabrication. For the fast breeder reactor, therefore, the assumption is implicit that the plutonium will be bred from depleted U-238, which is considered to have no value. This may be noted in the "a" tables.

6.5.2.2 Indirect Costs

In addition to the direct costs, there are related cost factors, which affect the overall fuel cycle cost. These indirect costs usually include:

- Interest on borrowed money,
- Return on equity,
- Federal and State income taxes,
- Other taxes
- Other costs related to the time-value of money.

The calculation of indirect fuel cycle costs requires that all the factors affecting them be projected over the time period for which they are being calculated. Indirect costs are related to the time when payments for materials and services are made, and the amount of time that the fuel spends in the reactor. Therefore, indirect costs are impacted by the lead and lag times associated with payments for materials and services and by the performance of the plant as measured by its capacity factor.

It is often not possible to establish a linear relationship between indirect costs and the direct costs for the associated fuel cycle steps. Generally, a discounted cash flow analysis is used to precisely determine the indirect costs, when the information available can support this level of accuracy. However, adequate estimates of indirect cost can be derived by an interest rate approach.

6.5.2.3 Other Factors

The power plant lifetime for all reactors is assumed to be 30 years. The startup dates considered are discussed in Section 3.0.

The lead and lag times involved in the procurement of fuel, the reprocessing step (where reprocessing is involved), and the eventual crediting of the recovered materials, affect costs, because they represent a charge similar to an interest rate. The lead time is the length of time from the payment for materials and services at the beginning of the fuel cycle, to the time this fuel is placed in the reactor core. This lead time simulates the progress payment schedule. The lag time is the length of time from discharge of fuel from the reactor to the point when payments are made for materials and/or services at the back-end of the cycle, or to receipt of credit, if any, for recovered fuel. A summary of the lead and lag times used in the Fuel Cycle Cost Third Update are tabulated in Table 6-16.

In the various steps of the fuel cycles, where the fuel itself undergoes processing, some losses are inevitable. However, on the basis of experience, they are considered to be too small to significantly affect the overall costs in any step of the fuel cycle. For all of the reactor types and fuel cycle options presented, it is assumed that the tails assay for enrichment is approximately 0.2 weight percent U-235. Minor changes in the percentage of the tails assay are not expected to affect the costs of the fuel cycle significantly. Advanced isotope separation technology is not considered in this report.

6.5.3 General Approach to Nuclear Fuel Cycle Cost Analysis

The general approach to Nuclear Fuel Cycle Cost Analysis consists of the following activites:

1. Projection of general economic parameters over the period of interest, including long term escalation, interest and discount rates.
2. Selection of the nuclear fuel cycle calculation method that is appropriate for the level of accuracy required and the availability of the input data.
3. Selection of the desired combinations of reactor type and fuel cycle alternatives.
4. Acquisition of mass flow data for the selected combinations of reactor type and fuel cycle alternative.
5. Acquisition of input unit cost data projections for each step of each nuclear fuel cycle under consideration over the time period of interest

6. Calculation of the direct and indirect cost components for each step in the reactor-cycle combination being analyzed for the period of interest.

7. Calculation of the levelized total nuclear fuel cycle cost for each cycle case being analyzed over the period of interest.

The calculation of the direct costs is dependent on the reactor core design and the energy and mass balance associated with the cycle selected. The calculation of the indirect costs is dependent on time and reactor performance. Consequently, although the direct costs are the largest component of the fuel cycle, the indirect costs are the more difficult to calculate, because of the complexities associated with the time related accounting.

Since precise calculation of the nuclear fuel cycle costs requires an accurate calculation of the indirects, a detailed cash flow analysis, which is usually computerized, is utilized where great accuracy is required. Very complex and sophisticated programs have been developed. Their complexity is limited only by the level of accuracy desired for a specific application. Fuel management of operating reactors is an example of a situation which requires precise results. Bid evaluation of alternative U_3O_8 or fabricated fuel bids is another example where precision is important. In cases where such high precision is unneeded or unjustified, adequate estimates of indirect costs can be derived from an interest rate approach.

6.5.3.1 Selection of An Approximate Method

Review of the USDOE objectives for the EEDB Program results in a decision to adopt an "Approximate Method" of nuclear fuel cycle calculations, rather than to utilize a computerized, detailed cash flow technique. The reasons for this decision are as follows:

- The objective of the EEDB Program is to provide normalized comparisons between generic alternatives, rather than the detailed comparisons of specific alternatives found in actual industry cases.
- Use of the EEDB, following the Initial Update, has provided the experience that evaluation of alternatives on a quick response basis is often required. This experience indicates that a simpler and more flexible method for developing fuel cycle costs is required.
- The projections of input unit costs for each fuel cycle component have great uncertainity because they reflect a "national generic average value". The average value may differ substantially from the costs associated with specific bids in actual cases. The range of long term bid prices associated with different economic conditions at different times in different parts of the county results in this disparity. This is particularly true of the U_3O_8 price. (A review of the tables and charts on U_3O_8 contract prices in the USDOE, Grand Junction Office reports will demonstrate this fact.)
- The projection of input unit costs for each fuel cycle component over a period of fifty years is also subject to the uncertainties associated with political policy decisions, technological innovations and the general discontinuities of supply/demand interrelationships.
- Only the LWR reactor core with "once-through" fuel cycle has actual experience to support "precise" economic analyses. The HTGR, PHWR and LMFBR are based on conceptual designs and specifications.

Therefore, there is little justification to utilize highly accurate, but complex, calculation techniques for the purpose of comparing alternatives. The development of the approximate method is based upon the detailed data base developed for the Initial Update of the EEDB by United Engineers and its subcontractor, NUS Corporation of Rockville, MD.

6.5.3.2 Calculation Approach for the Third Update

The approximate method of nuclear fuel cycle calculation utilized in this update is based on NUS-3190, "Fuel Cycle Cost Estimates for LWR, HTGR, CANDU

Type HWR, LMFBR and GCFR"; NUREG-0480, "Coal and Nuclear: A Comparison of the Cost of Generating Baseload Electricity by Region"; and other reports (Refer to Section 8.1, References 5, 6, 7, 8 and 9).

A set of direct cost proportionality constants or approximation factors are developed for the direct cost associated with each step of each reactor-cycle combination addressed. In order to maintain continuity and consistency with the EEDB Initial Update, mathematical relationships are established between the input cost per unit given in NUS-3190 and the direct cost value in terms of thermal costs given as output. The input unit costs are given in the "a" series of Tables 6-4 through 6-12. The direct cost answers are given in the "b" series of Tables 6-4 through 6-12. The direct cost approximation factors are verified by using the existing data to demonstrate their validity.

The approximate method utilizes an expression* to calculate the indirect cost as a function of the lead and lag times associated with the direct cost expenditure, the residence time of the fuel in the reactor and the cost of money used as a basis for calculating the carrying charges.

The impact of the initial core relative to the equilibrium core, on the total 30 year nuclear fuel cycle cost, varies with each reactor-cycle combination. To account for this impact, the "Approximate Method" distinguishes between the initial core and the equilibrium core in calculation of directs and indirects and combines them on a weighted average basis during calculation.

The Nuclear Fuel Cycle Update Procedure (Approximation Factors Method) is described in detail in Appendix F.

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* The expression used is adapted from that given in NUREG-0480 at the bottom of page C-15. The general discussion of the nature of carrying charges which forms the basis for the approach is given on pages C-14, C-15, and C-16 of that source.

6.5.4 Input Unit Cost Projections

The total nuclear fuel cycle cost is a function of the market prices of the materials, processes and services associated with each step of the cycle. These market prices are referred to as the input unit costs in this discussion. As previously noted, the principal fuel cycle cost experience is derived from operations with the LWRs. However, only a partial segment of the full fuel cycle is completely defined. Government policy decisions have not yet been made on the reprocessing of spent fuel and the disposal of high level radioactive wastes. Therefore, cost experience is lacking in these areas, as well as the associated area of the value of the recovery of spent fuel. It is important to recognize the absence of experiential cost data for the reprocessing portion of the fuel cycle in the case of the LMFBR, because the recycling of fuel is an integral part of these fuel cycles.

All values for unit input costs associated with the nuclear fuel cycle steps are given in constant 1980 dollars. In some cases, the costs of the fuel cycle steps remain constant or decline with respect to time. This effect is caused by such factors as the presumed savings resulting from familiarity with the processes, or from the quantity of the system throughput.

In other cases, particularly that of the uranium ore, the costs may increase with time. In the inflation-free context of the EEDB Program, this increase is due to a change in the amount of effort required to extract ore from sources less rich in uranium, thereby requiring additional processing steps or longer application of the same processing steps. In other words, the increase in cost arises from a real change in the amount of energy, labor and materials expended in producing the same product and quantity and is referred to as escalation caused by scarcity. This is an attempt to distinguish it from escalation caused by inflation, which represents a change in the value of money, rather than a change in the cost of the process. To illustrate the effect of input unit cost changes on fuel cycle costs, sensitivity studies were reported in NUS-3190. These are included in the Initial Update of the EEDB. This work shows the impact of a change in a particular fuel cycle step on the total fuel cost.

6.5.4.1 Data Sources for Input Unit Costs

Although there are a number of references for projections of nuclear fuel cycle unit input costs, the one selected for the Third Update of the EEDB is NUREG CR-1041, "Fuel Cycle Cost Projections," Battelle Pacific Northwest Laboratories; December, 1979. This report addresses input cost projections for six LWR cases. The projections represent three nuclear electric growth rates for a "once-through" fuel cycle environment and three nuclear electric growth rates for a "recycle" environment.

The ground-rules for the Third Update of the EEDB specify a "once-through" cycle for the LWRs, HTGR and PHWR cases and the initiation of reprocessing for the LMFBR case to the extent necessary to support their operation. Therefore, the input unit costs for U_3O_8, conversion, fabrication and spent fuel shipping are taken from the case for a "once-through" fuel cycle with medium nuclear growth for all reactors. The reprocessing and high level waste disposal input unit costs for the LMFBR are adapted from the estimates of these costs for LWR fuel, as given in the case for "recycle" with medium nuclear growth. All unit cost projections in

NUREG CR-1041 are based on zero inflation rate.

6.5.4.2 Adaptation of Input Unit Cost Data

The input costs given in NUREG CR-1041 are given in constant 1979 dollars. The Third Update of the EEDB adjusts all of the nuclear fuel cycle input costs components (except for U_3O_8) from 1979 to 1980 dollars by applying an escalation factor of 10 percent. Although NUREG CR-1041 uses a 4 percent discount rate, for its fuel cycle calculations, the Third Update Groundrule for the discount rate cites a value of 3.5 percent. Therefore, the present worth calculation performed on the adjusted unit input cost projections, as part of the levelized price calculation, utilizes a discount rate of 3.5 percent. The input unit values given in the "a" tables (the "a" series of Tables 6-4 through 6-12) in this section are given in constant 1980 dollars. The output costs given in the "b" tables (the "b" series of Tables 6-4 through 6-12) in this section are the levelized fuel cycle costs.

Since the NUREG CR-1041 input data applies only to the LWR, it is necessary to adapt these inputs to create input unit costs for the HTGR, PHWR and LMFBR reactors. This is accomplished by using the NUS-3190 data to develop ratio's between non-LWR reactors and LWR reactors for various fuel cycle steps. These ratio's are then applied to the appropriate LWR input unit costs to develop non-LWR input unit costs.

6.5.4.3 Discussion of U_3O_8 Costs

For non-breeder reactors, the cost of U_3O_8 is the largest contributor to the total nuclear fuel cost. This is particularly true when the reactors are coupled with a "once-through" fuel cycle. Changes in the cost of U_3O_8 have the largest impact on these reactor cycle combinations.

More U_3O_8 is consumed nationally during the thirty year life of a power generating station under a "once-through" scenario than is consumed under a "recycle" scenario. This results in a faster depletion of known uranium reserves for the "once-through" cycle. Therefore, the price of uranium during the life of a power plant should experience a larger escalation rate during a "once-through" case than during the "recycle" case, because of an incremental escalation associated with faster depletion of the reserves. In addition, if the deployment of nuclear power generating stations is very rapid, the demand for uranium increases the consumption of the lower cost reserves faster than if a medium or low deployment rate occurs.

NUREG CR-1041 recognizes these relationships by giving projections for six scenarios; three involving a "once-through" cycle and three involving a "recycle" scenario. The uranium cost projection based on a "once-through" cycle for all LWRs and a medium expansion rate in nuclear power plants is selected for the Third Update. It is, over the period examined, considerably higher than the recycle environment for LWRs with a medium expansion rate in nuclear power plants. Consequently, it is considered a conservative selection for use in comparing the "once-through" fuel cycle costs with coal alternatives.

The U_3O_8 cost projection is adjusted in the Third Update to account for the lowering in U_3O_8 demand that is beginning to be noticed in 1980. It is believed that this is caused in part by a lack of new nuclear plant orders and the continued postponement and cancellation of plants on order. The adjustment consists of moving the U_3O_8 cost projection curve from NUREG CR-1041 forward in time by one year to account for the aforementioned factors. Thus, in the Third Update, the NUREG CR-1041 price in 1979 dollars predicted to occur in 2000 A.D. is delayed to 2001 A.D. In addition the 1979 prices given in NUREG CR-1041 for U_3O_8 are not escalated as are the input unit cost projections for the remainder of the fuel cycle steps.

The U_3O_8 cost adopted from NUREG CR-1041 for the Third Update are considerably higher than that developed for the Initial Update of the EEDB. This is due, in part, to the development of a single average cost curve for U_3O_8 in the Initial Update, for use with both "once-through" and "recycle" operation modes. The NUREG CR-1041 study develops separate "once-through" and "recycle" scenario curves. Because of the current lack of policy on reprocessing, the NUREG CR-1041 "once-through" curve is the only realistic choice for the non-breeder reactors in the Third Update.

A general perception has been in vogue that the cost of uranium concentrate (U_3O_8 or "yellowcake") will increase over the next half century. This assumption arises from the very large increase in the forward price of U_3O_8, which occurred after the 1973 oil embargo and which was aggravated by the difficulties encountered by one of the major nuclear fuel suppliers in meeting its commitments. The price of U_3O_8 rose by a factor of six in the space of three years. In addition, projections of installed nuclear capacity in the early 2000 timeframe were higher during the mid-seventies than they are now.

Subsequently, a number of external factors are tending to lower the price of U_3O_8. Among these are the discovery of very large and rich new uranium deposits in Australia and Canada, the settlement of the suits brought against the major fuel supplier who could not meet commitments and the reduction in the projections of installed nuclear capacity in the early 2000 time period. Although the 1980 price of uranium in current dollars remains about the same as the 1978 price, it has, in fact, dropped in terms of constant dollars.

It can be seen that the forecasting of future fluctuations in the cost of "yellowcake" is complicated by the political, economic and demand uncertainties associated with nuclear energy. Projections for the Third Update are based on conservative and reasonable assumptions, that account for the factors discussed above. Projected U_3O_8 prices are given in Table 6-15.

6.5.5 Description of Reactor Types and Their Fuel Cycles

A description of the reactor types and their associated fuel cycles prepared for the Initial Update of the EEDB is included in Appendix G of the "Phase II Final Report and Second Update." This description includes the reactor-fuel cycle combinations being updated in the Third Update of the EEDB. It is also includes descriptions of some cycles, which are not updated in the Third Update.

As noted earlier, the differences between the two LWR types, the Boiling Water Reactor and the Pressurized Water Reactor, have a relatively insignificant effect on the overall fuel cycle costs. Consequently, it is assumed during this analysis that the data developed for the PWR case also apply to the BWR case.

The descriptions of the reactor-fuel cycle combinations in Appendix G of the Second Update report, which form the basis for the fuel cycle costs, are based on preliminary NASAP data. Final data is published in Volume IX of the NASAP study, DOE/NE-0001/9 and are incorporated in the Third Update.

The rated powers of the nuclear systems listed in Table 1-1 differ in some cases from the nominal thermal powers listed for the preliminary NASAP systems. However, the mass flow relationships remain unchanged for a determinate reactor type over a relatively large range of output power. Thus, although the total mass of fuel used (200 MTU vs 150 MTU) is different for two PWRs of different thermal power, the level of initial enrichment (3%), the average burnup (30,000 MWd/T) and the heat rate (10,200 Btu/kWh) are approximately the same. Therefore, the total cost of fuel is different, but the specific costs in $/MBtu or mills/kWh are the same for the same portions of the nuclear fuel cycle. Consequently, the differences between the EEDB nuclear system's rated power and the prliminary NASAP nominal rated power do not affect the calculated costs of the nuclear fuel cycle for the reactor types studied.

6.5.6 Nuclear Fuel Cycle Cost Results

Nuclear fuel cycle costs are prepared for the reactor-cycle cases of interest in the Third Update of the EEDB for a cost and regulation date of January 1, 1980. These calculations use unit input data adapted from NUREG CR-1041 and an "Approximate Method" of nuclear fuel cycle calculation.

6.5.6.1 Detailed Results

The details of the input unit costs used for each case and the fuel cycle component costs are given in Tables 6-4a/4b through 6-12a/12b.

6.5.6.2 Summary Results

A summary of the 30-year levelized fuel cycle costs are given in Table 6-17 for the reactor types listed in Table 1-1. Both direct and indirect costs are given separately, as well as the total levelized cost, extending over the 30-years of plant operating life beginning with the year of startup noted. Table 6-18 gives the breakdown of the levelized costs by individual cost component for various options in the fueling mode of the different reactor types. Note that for both tables, the breeder reactor cases involve a zero bred fuel value. The total 30-year levelized fuel cycle cost in $/MBtu and m/kWh for the base reactors and their fueling modes is given in Table 6-19.

Table 6-20 shows the percentage of the total costs attributable to each cost component. For the thermal neutron spectrum reactor (LWRs, HTGRs, and PHWRs) the uranium supply is the largest single cost. This category includes the U_3O_8, conversion to UF_6 and enrichment to the desired concentration of U-235 (or U-233). For the fast neutron spectrum reactors, such as the LMFBR, the uranium supply cost is shown as zero, because the intended fissile fuel is Pu and no value has been assigned to the enrichment processing tails or the depleted uranium recovered in reprocessing, either or both of which constitute the fertile portions of the cores and blankets.

6.5.6.3 Considerations Surrounding the Nuclear Fuel Cycle Cost Third Update

The principal fuel cycle cost experience is derived from operations with the LWRs. With the exception of the costs for uranium oxide fuel and enrichment prior to reactor operation, there is very little experience accessible for the remaining reactor fuel cycles. The government's current policy, not to permit reprocessing of LWR fuel, leaves the back-end of the LWR fuel cycle and its costs open to uncertainty, since there is no experience to support the projections, except reprocessing of naval reactor cores and weapons material. The fuel cycle costs presented in this section are, therefore, based as far as possible upon the past history of the light water reactors and the prevailing disposition of the uranium-oxide market. All of the values presented here represent points taken in a band of varying costs whose limits are not well defined and whose actual range is uncertain at this time. Despite these shortcomings, which are inherent in the current conditions of nuclear energy in the United States, the costs presented in this study permit an evaluation of:

- Comparison of different reactor types with each other.
- Comparison of different reactor types with alternatives

It must be emphasized that the data on costs permit comparison rather than the establishment of absolute values in the market place. Unless it is explicitly stated otherwise, all costs presented assume zero inflation and are given in terms of constant 1980 dollars.

6.6 COAL COSTS

6.6.1 Introduction

Coal costs are needed to assess the economics of coal-fired steam supply systems for central electric generating stations. Unlike the nuclear fuels, which are treated as quasi-capital investments with depreciation and potential salvage factors, coal is a consumable cost item. Although coal is often treated as an operational cost, the costs of coal are presented in this study as separate items of expense, to facilitate the economic comparison of nuclear and coal energy sources for production of electricity. Nuclear fuels are designed and fabricated to match reactor operating characteristics. Coal-fired boilers and associated systems, however, are designed to operate on existing coals with generically similar characteristics. For economic reasons, the selection and procurement of long-term coal supplies are frequently made concurrently with, and largely determine, the design of the coal-fired steam supply for the generating station.

The costs of coal are determined principally by:

a. the costs of extraction from the ground; and,

b. the costs of transportation to the site of use.

Coal in the United States varies widely in its characteristics, its accessibility, and its geographic distribution. This variability directly affects the costs to the user. The average calorific value of the coal, its sulfur content, the extraction method dictated by its underground location, and its distance from the user, all affect costs. It is not reasonable to expect, therefore, a single, clearly defined coal price.

6.6.2 Coal Cost Estimate

The coal costs for plants having startup in 1980 are shown in Table 6-14a. These values include the results of the United Mine Workers (UMW) strike settlement, concluded in the first quarter of 1978. Values are also given for plant startups in 1987 and 2001 in Tables 6-14b and 6-14c. Table 6-21 shows the increase in the average delivered contract coal prices for the year 1980. The average costs for 1978 include both pre- and post-UMW strike settlement effects. This step increase is used as the starting point for estimating the coal costs for 1987 and 2001. The intent of the coal estimate is to provide costs for the years 1980, 1987 and 2001, in terms of constant 1980 dollars.

6.6.3 Data Sources Used for Coal Costs

Data for the coal costs were derived from studies by Electric Power Research Institute, by A. D. Little, by Paul Weir Company, and by United Engineers & Constructors Inc., based on Federal Energy Regulatory Commission information, as referenced in Section 3.4.2b.

6.6.4 Productivity, Escalation and Inflation

The estimates provided include allowances for increases in costs resulting from known conditions such as productivity decreases at the mines and increased difficulties in mining methods, which reflect larger expenditures of energy and manhours. This approach is somewhat pessimistic since it ignores possible increases in productivity; however, recent industry experience shows a marked decline in productivity beginning in 1970. This fact is documented in EPRI Report No. EA-634-SR, entitled, "Supply 77-EPRI Annual Energy Supply Forecasts", published in 1978.

Inflation, which is understood as the change in the value of money, is explicitly excluded. The value of escalation for scarcity is also excluded, even though it is understood that the cost of coal may rise to the level of competitive fuels. This is a conservative assumption for the Third Update of the EEDB.

6.6.5 Coal Transportation Costs

Transportation mileage costs for coal in selected cases represent a major contributor to the total coal costs to the utility. These costs are influenced by whether the coal cars and locomotives are owned by the carrier or by the user/shipper and whether eastern or western railroads are used. Costs for transportation are often equal to the mine-mouth costs, especially when coal is transported over 1,000 rail-miles. In the Third Update of the EEDB, the following assumptions are made:

a. The coal - fired plants are located at sites assumed to be 500 miles and 2,000 miles from the coal mine. The location of the hypothetical "Middletown" site is 2,000 miles from a western low sulfur coal mine and 500 miles from an eastern high sulfur coal mine.

b. All transportation equipment used belongs to the carrier.

c. Unit trains of 100 cars, at 70 to 100 tons per car, or 7,000 to 10,000 tons per unit train, are used in each shipment.

d. Mileage costs are computed from rail rates provided by the Interstate Commerce Commission for eastern and western railroad routes.

6.6.6 Characterization and Analysis of Coals

The two significiant characteristics and analyses of coal for establishing costs are:

a. calorific/heating value in Btu/lb, and

b. impurity content; sulfur content in percentage points.

These two characteristics determine the price paid for coal by the utility. The analyses for the eastern and western mined coals discussed in this update are shown in Tables 6-22, 6-23, and 6-24.

The concern over the reactions from SO_2 and NO_x with water in the atmosphere to form both sulfur and nitrogen oxides is increasing, because they potentially have a deleterious effect on plant life and aquatic species. The effluents from burning coals used in the Third Update require scrubbing in various degrees. Effluent treatment for NO_x is not included.

The selection of a hypothetical plant site in the northeastern U.S. for low- or high sulfur FPGS has placed a burden on western coals, since the largest costs are for rail delivery of these coals. Since the Middletown site is 2,000 miles from the low-sulfur coal mine, but only 500 miles from the high-sulfur coal mine, eastern coals are favored over western coals in terms of total energy costs.

6.6.7 Composite Coal Costs

Composite coal costs are plotted in Figure 6.2. Costs are given in constant (inflation-free) 1980 dollars. The curves represent composite costs for all coals in the United States in the indicated categories. For the later dates, the data are increasingly speculative, but represent the best current estimates. The curves are based on composite costs, calorific values and transportation distances.

The curves generally indicate that unit fuel costs for eastern high-sulfur coals are slightly higher than for western low-sulfur coals, while unit energy costs are significantly higher for western low-sulfur coals than for eastern low sulfur coals. Additionally, it is expected that costs will rise in the future with fuel unit costs rising more rapidly than energy unit costs. It may also be expected that the impact of the 1980 coal strike settlement will cause eastern coal prices to rise more rapidly than those of western coals.

TABLE 6-1

Effective Date - 1/1/80

ENERGY ECONOMIC DATA BASE

FUEL COST UPDATE SUMMARY - 2001 STARTUP

(¢/MBtu)(a)

	Nuclear Plant Models						Comparison Plant Models				
Model	BWR	HTGR-SC	PWR	PHWR	HTGR-PS	LMFBR	HS12	HS8	LS12	LS8	CGCC
MWt	3578	2240	3412	3800	1170	3800	3302	2210	3446	2307	1523
MWe	1190	858	1139	1260	150	1457	1232	795	1236	795	630
Fuel Cost	76(c)	78(b)	76(b)	33(b)	78	*	201	201	87	87	208
Fabrication Cost	6(c)	4	6	5	4	13	*	*	*	*	*
Transportation Cost	1(c)	1	1	1	1	4	61	61	257	257	51
Reprocessing	*	*	*	*	*	22	*	*	*	*	*
Disposal Cost	3(c)	2	3	2	2	1	+	+	+	+	+
TOTAL	86(c)	85	86	41	85	40	262	262	344	344	259

---

* Not Applicable

\+ Disposal Costs for Coal-Fired Plants are Included in O&M Costs, Section 7

(a) Data in Constant $1980 (Inflation-Free)

(b) Cost of U_3O_8

(c) Complete BWR data are not Available; therefore, PWR Data are used for BWR (Model A1) Fuel Cycle Costs

TABLE 6-2

ENERGY ECONOMIC DATA BASE

FUEL COST UPDATE SUMMARY - 1980 STARTUP

(¢/MBtu)(a)

	Nuclear Plant Models		Comparison Plant Models			
Model	BWR	PWR	HS12	HS8	LS12	LS8
MWt	3578	3412	3302	2210	3446	2307
MWe	1190	1139	1232	795	1236	795
Fuel Cost	55(b)	55	123	123	57	57
Fabrication Cost	6(b)	6	*	*	*	*
Transportation Cost	1(b)	1	45	45	184	184
Disposal Cost	3(b)	3	+	+	+	+
TOTAL	65(b)	65	168	168	241	241

---

* Not Applicable

\+ Disposal Costs for Coal-Fired Plants are Included in O&M Costs, Section 7

(a) Data in Constant $1980 (Inflation-Free)

(b) Complete BWR Data are not Available; therefore, PWR Data are used for BWR (Model A1) Fuel Cycle Costs

TABLE 6-3 Effective Date - 1/1/80

ENERGY ECONOMIC DATA BASE

FUEL COST UPDATE SUMMARY - VARIABLE STARTUP

(¢/MBtu)(a)

	Nuclear Plant Models				Coal Plant Models				
Model	BWR(b)	HTGR-SC(c)	PWR(b)	PHWR(c)	HS12(b)	HS8(b)	LS12(b)	LS8(b)	CGCC(b)
MWt	3578	2240	3412	3800	3302	2210	3446	2307	1523
MWe	1190	858	1139	1162	1232	795	1236	795	630
Fuel Cost	60(d)	71	60	29	150	150	68	68	154
Fabrication Cost	6(d)	4	6	5	*	*	*	*	*
Transportation Cost	1(d)	2	1	1	52	52	220	220	44
Disposal Cost	3(d)	2	3	2	+	+	+	+	+
TOTAL	70(d)	79	70	37	202	202	288	288	198

---

* Not Applicable

\+ Disposal Costs for Coal-Fired Plants are Included in O&M Costs, Section 7

(a) Data in Constant $1980 (Inflation-Free)

(b) 1987 Startup

(c) 1995 Startup

(d) Complete BWR Data are not Available; therefore, PWR Data are used for BWR (Model A1) Fuel Cycle Costs

Effective Date: January 1, 1980
(1) System : PWR-U5(LE)/U-T
Start Up : January 1, 1980

TABLE 6-4a

ENERGY ECONOMIC DATA BASE
INPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

			SUMMARY OF INPUT QUANTITIES BY CALENDAR YEAR (FIVE YEAR PERIODS)						
Account No.	Account Description	Units	1980	1985	1990	1995	2000	2005	2010
.10	Initital Fuel Loaded	$/KgH							
.11	Uranium Supply	$/KgU							
.111	U_3O_8 Supply	$/lb U_3O_8	43	43	43	43	49.6	59.6	72.5
.112	UF_6 Conversion Services	$/KgU as UF_6	5.7	5.7	5.7	5.72	5.7	5.7	5.7
.113	Enrichment Services	$/SWU	97.9	99	99	105.6	122.1	124.3	124.3
.114	Depleted U Supply	$/KgU							
.12	Plutonium Supply	Parity value							
.13	U-233 Supply	Parity value							
.14	Thorium Supply	$/KgH							
.20	Fabrication	$/KgH	132.0	132.0	134.2	134.2	134.2	133.1	132.0
.21	Core Fabrication	$/KgH							
.22	Axial Blanket Fabrication	$/KgH							
.23	Radial Blanket Fabrication	$/KgH							
.30	Shipping to Temporary Storage	$/KgH							
.40	Temporary Storage	$/KgH							
.50	Shipping to Repository	$/KgH	26.4	26.4	24.2	24.2	22	22	19.8
.60	Disposal of Spent Fuel	$/KgH	140.8	140.8	140.8	140.8	140.8	140.8	140.8

---

(1) See Table 6-13 for System Designation

Effective Date: January 1, 1980
(1) System : PWR-U5(LE)/U-T
Start Up : January 1, 1980

TABLE 6-4b

ENERGY ECONOMIC DATA BASE
OUTPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

		OUTPUT QUANTITIES, 30 - YEAR LEVELIZED $/MBtu		
Account No.	Account Description	Direct Cost	Indirect Cost	Total Cost
.00	Total	0.62	0.03	0.65
.10	Initial Fuel Loaded			
.11	Uranium Supply			
.111	U_3O_8 Supply	0.29	0.03	0.32
.112	UF_6 Conversion Services	0.02	0.00	0.02
.113	Enrichment Services	0.20	0.01	0.21
.114	Depleted U Supply			
.12	Plutonium Supply			
.13	U-233 Supply			
.14	Thorium Supply			
.20	Fabrication	0.06	0.00	0.06
.21	Core Fabrication			
.22	Axial Blanket Fabrication			
.23	Radial Blanket Fabrication			
.30	Shipping to Temporary Storage			
.40	Temporary Storage			
.50	Shipping to Repository	0.01	(0.00)	0.01
.60	Disposal of Spent Fuel	0.04	(0.01)	0.03

---

(1) See Table 6-13 for System Designation.

Effective Date: January 1, 1980
(1) System : PWR-U5(LE)/U-T
Start Up : January 1, 1987

TABLE 6-5a

ENERGY ECONOMIC DATA BASE
INPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

Account No.	Account Description	Units	SUMMARY OF INPUT QUANTITIES BY CALENDAR YEAR (FIVE YEAR PERIODS)						
			1987	1992	1997	2002	2007	2012	2017
.10	Initital Fuel Loaded	$/KgH							
.11	Uranium Supply	$/KgU							
.111	U_3O_8 Supply	$/lb U_3O_8	43	43	44.1	53.0	64.4	78.4	88.2
.112	UF_6 Conversion Services	$/KgU as UF_6	5.7	5.7	5.7	5.7	5.7	5.7	5.7
.113	Enrichment Services	$/SWU	99	105.6	116.6	123.2	124.3	123.2	122.1
.114	Depleted U Supply	$/KgU							
.12	Plutonium Supply	Parity value							
.13	U-233 Supply	Parity value							
.14	Thorium Supply	$/KgH							
.20	Fabrication	$/KgH	132	134.2	134.2	134.2	133.1	132	135.3
.21	Core Fabrication	$/KgH							
.22	Axial Blanket Fabrication	$/KgH							
.23	Radial Blanket Fabrication	$/KgH							
.30	Shipping to Temporary Storage	$/KgH							
.40	Temporary Storage	$/KgH							
.50	Shipping to Repository	$/KgH	26.4	24.2	22	22	19.8	19.8	17.6
.60	Disposal of Spent Fuel	$/KgH	140.8	140.8	140.8	140.8	140.8	140.8	140.8

---

(1) See Table 6-13 for System Designation

Effective Date: January 1, 1980
(1) System : PWR-U5(LE)/U-T
Start Up : January 1, 1987

TABLE 6-5b

ENERGY ECONOMIC DATA BASE
OUTPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

Account No.	Account Description	OUTPUT QUANTITIES, 30 - YEAR LEVELIZED $/MBtu		
		Direct Cost	Indirect Cost	Total Cost
.00	Total	0.66	0.04	0.70
.10	Initial Fuel Loaded			
.11	Uranium Supply			
.111	U_3O_8 Supply	0.33	0.03	0.36
.112	UF_6 Conversion Services	0.01	0.00	0.01
.113	Enrichment Services	0.21		0.23
.114	Depleted U Supply			
.12	Plutonium Supply			
.13	U-233 Supply			
.14	Thorium Supply			
.20	Fabrication	0.06	0.00	0.06
.21	Core Fabrication			
.22	Axial Blanket Fabrication			
.23	Radial Blanket Fabrication			
.30	Shipping to Temporary Storage			
.40	Temporary Storage			
.50	Shipping to Repository	0.01	(0.00)	0.01
.60	Disposal of Spent Fuel	0.04	(0.01)	0.03

---

(1) See Table 6-13 for System Designation.

Effective Date: January 1, 1980
(1) System : PWR-U5(LE)/U-T
Start Up : January 1, 2001

TABLE 6-6a

ENERGY ECONOMIC DATA BASE
INPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

			SUMMARY OF INPUT QUANTITIES BY CALENDAR YEAR (FIVE YEAR PERIODS)						
Account No.	Account Description	Units	2000	2005	2010	2015	2020	2025	2030
.10	Initital Fuel Loaded	\$/KgH							
.11	Uranium Supply	\$/KgU							
.111	U_3O_8 Supply	\$/1b U_3O_8	49.6	59.6	72.5	88.2	91.4	91.4	91.4
.112	UF_6 Conversion Services	\$/KgU as UF_6	5.7	5.7	5.7	5.7	5.7	5.7	5.7
.113	Enrichment Services	\$/SWU	122.1	124.3	124.3	123.2	121	121	119.9
.114	Depleted U Supply	\$/KgU							
.12	Plutonium Supply	Parity value							
.13	U-233 Supply	Parity value							
.14	Thorium Supply	\$/KgH							
.20	Fabrication	\$/KgH	134.2	133.1	132	132	135.3	133.1	133.1
.21	Core Fabrication	\$/KgH							
.22	Axial Blanket Fabrication	\$/KgH							
.23	Radial Blanket Fabrication	\$/KgH							
.30	Shipping to Temporary Storage	\$/KgH							
.40	Temporary Storage	\$/KgH							
.50	Shipping to Repository	\$/KgH	22	19.8	19.8	17.6	17.6	15.4	15.4
.60	Disposal of Spent Fuel	\$/KgH	140.8	140.8	140.8	140.8	140.8	140.8	140.8

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(1) See Table 6-13 for System Designation

Effective Date: January 1, 1980
(1) System : PWR-U5(LE)/U-T
Start Up : January 1, 2001

TABLE 6-6b

ENERGY ECONOMIC DATA BASE
OUTPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

		OUTPUT QUANTITIES, 30 - YEAR LEVELIZED $/MBtu		
Account No.	Account Description	Direct Cost	Indirect Cost	Total Cost
.00	Total	0.81	0.05	0.86
.10	Initial Fuel Loaded			
.11	Uranium Supply			
.111	U_3O_8 Supply	0.46	0.04	0.50
.112	UF_6 Conversion Services	0.01	0.00	0.01
.113	Enrichment Services	0.23	0.02	0.25
.114	Depleted U Supply			
.12	Plutonium Supply			
.13	U-233 Supply			
.14	Thorium Supply			
.20	Fabrication	0.06	0.00	0.06
.21	Core Fabrication			
.22	Axial Blanket Fabrication			
.23	Radial Blanket Fabrication			
.30	Shipping to Temporary Storage			
.40	Temporary Storage			
.50	Shipping to Repository	0.01	(0.00)	0.01
.60	Disposal of Spent Fuel	0.04	(0.01)	0.03

---

(1) See Table 6-13 for System Designation.

Effective Date: January 1, 1980
(1) System : HTGR-SC-U5/U/Th-20%-T
Start Up : January 1, 1995

TABLE 6-7a

ENERGY ECONOMIC DATA BASE
INPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

Account No.	Account Description	Units	SUMMARY OF INPUT QUANTITIES BY CALENDAR YEAR (FIVE YEAR PERIODS)						
			1995	2000	2005	2010	2015	2020	2025
.10	Initital Fuel Loaded	$/KgH							
.11	Uranium Supply	$/KgU							
.111	U_3O_8 Supply	$/lb U_3O_8	43.0	49.6	59.6	72.5	88.2	91.4	91.4
.112	UF_6 Conversion Services	$/KgU as UF_6	5.7	5.7	5.7	5.7	5.7	5.7	5.7
.113	Enrichment Services	$/SWU	105.6	122.1	124.3	124.3	123.2	121	121
.114	Depleted U Supply	$/KgU							
.12	Plutonium Supply	Parity value							
.13	U-233 Supply	Parity value							
.14	Thorium Supply	$/KgH							
.20	Fabrication	$/KgH	358.5	355.6	352.7	349.8	349.8	358.5	352.7
.21	Core Fabrication	$/KgH							
.22	Axial Blanket Fabrication	$/KgH							
.23	Radial Blanket Fabrication	$/KgH							
.30	Shipping to Temporary Storage	$/KgH							
.40	Temporary Storage	$/KgH							
.50	Shipping to Repository	$/KgH	378.1	343.8	309.4	309.4	275	275	240.6
.60	Disposal of Spent Fuel	$/KgH	388.7	388.7	388.7	388.7	388.7	388.7	388.7

---

(1) See Table 6-13 for System Designation

Effective Date: January 1, 1980
(1) System : HTGR-SC-U5/U/Th-20%-T
Start Up : January 1, 1995

TABLE 6-7b

ENERGY ECONOMIC DATA BASE
OUTPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

		OUTPUT QUANTITIES, 30 - YEAR LEVELIZED $/MBtu		
Account No.	Account Description	Direct Cost	Indirect Cost	Total Cost
.00	Total	0.74	0.05	0.79
.10	Initial Fuel Loaded			
.11	Uranium Supply			
.111	U_3O_8 Supply	0.35	0.03	0.38
.112	UF_6 Conversion Services	0.01	0.00	0.01
.113	Enrichment Services	0.30	0.02	0.32
.114	Depleted U Supply			
.12	Plutonium Supply			
.13	U-233 Supply			
.14	Thorium Supply			
.20	Fabrication	0.04	0.00	0.04
.21	Core Fabrication			
.22	Axial Blanket Fabrication			
.23	Radial Blanket Fabrication			
.30	Shipping to Temporary Storage			
.40	Temporary Storage			
.50	Shipping to Repository	0.02	(0.00)	0.02
.60	Disposal of Spent Fuel	0.02	(0.00)	0.02

---

(1) See Table 6-13 for System Designation.

Effective Date: January 1, 1980
(1) **System** : HTGR-SC-U5/U/Th-20%-T
Start Up : January 1, 2001

TABLE 6-8a

ENERGY ECONOMIC DATA BASE
INPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

			SUMMARY OF INPUT QUANTITIES BY CALENDAR YEAR (FIVE YEAR PERIODS)						
Account No.	Account Description	Units	2000	2005	2010	2015	2020	2025	2030
.10	Initital Fuel Loaded	$/KgH							
.11	Uranium Supply	$/KgU							
.111	U_3O_8 Supply	$/lb U_3O_8	49.6	59.6	72.5	88.2	91.4	91.4	91.4
.112	UF_6 Conversion Services	$/KgU as UF_6	5.7	5.7	5.7	5.7	5.7	5.7	5.7
.113	Enrichment Services	$/SWU	121.1	124.3	124.3	123.2	121	121	119.9
.114	Depleted U Supply	$/KgU							
.12	Plutonium Supply	Parity value							
.13	U-233 Supply	Parity value							
.14	Thorium Supply	$/KgH							
.20	Fabrication(2)	$/KgH	355.6	352.7	349.8	349.8	358.5	352.7	352.7
.21	Core Fabrication	$/KgH							
.22	Axial Blanket Fabrication	$/KgH							
.23	Radial Blanket Fabrication	$/KgH							
.30	Shipping to Temporary Storage	$/KgH							
.40	Temporary Storage	$/KgH							
.50	Shipping to Repository(2)	$/KgH	343.8	309.4	309.4	275	275	240.6	240.6
.60	Disposal of Spent Fuel	$/KgH	388.7	388.7	388.7	388.7	388.7	388.7	388.7

---

(1) See Table 6-13 for System Designation
(2) Initial Core Fuel/Reload Fuel

Effective Date: January 1, 1980
(1) System : HTGR-SC-U5/U/Th-20%-T
Start Up : January 1, 2001

TABLE 6-8b

ENERGY ECONOMIC DATA BASE
OUTPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

		OUTPUT QUANTITIES, 30 - YEAR LEVELIZED $/MBtu		
Account No.	Account Description	Direct Cost	Indirect Cost	Total Cost
.00	Total	0.80	0.05	0.85
.10	Initial Fuel Loaded			
.11	Uranium Supply			
.111	U_3O_8 Supply	0.41	0.03	0.44
.112	UF_6 Conversion Services	0.01	0.00	0.01
.113	Enrichment Services	0.31	0.02	0.33
.114	Depleted U Supply			
.12	Plutonium Supply			
.13	U-233 Supply			
.14	Thorium Supply			
.20	Fabrication	0.04	0.00	0.04
.21	Core Fabrication			
.22	Axial Blanket Fabrication			
.23	Radial Blanket Fabrication			
.30	Shipping to Temporary Storage			
.40	Temporary Storage			
.50	Shipping to Repository	0.01	(0.00)	0.01
.60	Disposal of Spent Fuel	0.02	(0.00)	0.02

---

(1) See Table 6-13 for System Designation.

Effective Date: January 1, 1980
(1) **System** : PHWR-U5(SE)/U-T
Start Up : January 1, 1995

TABLE 6-9a

ENERGY ECONOMIC DATA BASE
INPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

Account No.	Account Description	Units	SUMMARY OF INPUT QUANTITIES BY CALENDAR YEAR (FIVE YEAR PERIODS)						
			1995	2000	2005	2010	2015	2020	2025
.10	Initital Fuel Loaded	$/KgH							
.11	Uranium Supply	$/KgU							
.111	U_3O_8 Supply	$/lb U_3O_8	43.0	49.6	59.6	72.5	88.2	91.9	91.4
.112	UF_6 Conversion Services	$/KgU as UF_6	5.7	5.7	5.7	5.7	5.7	5.7	5.7
.113	Enrichment Services	$/SWU	105.6	122.1	124.3	124.3	123.2	121	121
.114	Depleted U Supply	$/KgU							
.12	Plutonium Supply	Parity value							
.13	U-233 Supply	Parity value							
.14	Thorium Supply	$/KgH							
.20	Fabrication	$/KgH	79.5	78.9	78.2	77.6	77.6	79.5	78.2
.21	Core Fabrication	$/KgH							
.22	Axial Blanket Fabrication	$/KgH							
.23	Radial Blanket Fabrication	$/KgH							
.30	Shipping to Temporary Storage	$/KgH							
.40	Temporary Storage	$/KgH							
.50	Shipping to Repository	$/KgH	18.2	16.5	14.9	14.9	13.2	13.2	11.6
.60	Disposal of Spent Fuel	$/KgH	87.2	87.2	87.2	87.2	87.2	87.2	87.2

---

(1) See Table [illegible]-13 for System Designation

Effective Date: January 1, 1980
(1) System : PHWR-U5(SE)/U-T
Start Up : January 1, 1995

TABLE 6-9b

ENERGY ECONOMIC DATA BASE
OUTPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

		OUTPUT QUANTITIES, 30 - YEAR LEVELIZED $/MBtu		
Account No.	Account Description	Direct Cost	Indirect Cost	Total Cost
.00	Total	0.37	0.00	0.37
.10	Initial Fuel Loaded			
.11	Uranium Supply			
.111	U_3O_8 Supply	0.22	0.01	0.23
.112	UF_6 Conversion Services	0.01	0.00	0.01
.113	Enrichment Services	0.05	0.00	0.05
.114	Depleted U Supply			
.12	Plutonium Supply			
.13	U-233 Supply			
.14	Thorium Supply			
.20	Fabrication	0.05	0.00	0.05
.21	Core Fabrication			
.22	Axial Blanket Fabrication			
.23	Radial Blanket Fabrication			
.30	Shipping to Temporary Storage			
.40	Temporary Storage			
.50	Shipping to Repository	0.01	(0.00)	0.01
.60	Disposal of Spent Fuel	0.03	(0.01)	0.02

---

(1) See Table 6-13 for System Designation.

Effective Date: January 1, 1980
(1) System : PHWR U5(SE)/U-T
Start Up : January 1, 2001

TABLE 6-10a

ENERGY ECONOMIC DATA BASE
INPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

Account No.	Account Description	Units	SUMMARY OF INPUT QUANTITIES BY CALENDAR YEAR (FIVE YEAR PERIODS)						
			2000	2005	2010	2015	2020	2025	2030
.10	Initital Fuel Loaded	$/KgH							
.11	Uranium Supply	$/KgU							
.111	U_3O_8 Supply	$/lb U_3O_8	49.6	59.6	72.9	88.2	91.4	91.4	91.4
.112	UF_6 Conversion Services	$/KgU as UF_6	5.7	5.7	5.7	5.7	5.7	5.7	5.7
.113	Enrichment Services	$/SWU	122.1	124.3	124.3	123.2	121	121	119.9
.114	Depleted U Supply	$/KgU							
.12	Plutonium Supply	Parity value							
.13	U-233 Supply	Parity value							
.14	Thorium Supply	$/KgH							
.20	Fabrication	$/KgH	78.9	78.2	77.6	77.6	79.5	78.2	78.2
.21	Core Fabrication	$/KgH							
.22	Axial Blanket Fabrication	$/KgH							
.23	Radial Blanket Fabrication	$/KgH							
.30	Shipping to Temporary Storage	$/KgH							
.40	Temporary Storage	$/KgH							
.50	Shipping to Repository	$/KgH	16.5	14.9	14.9	13.2	13.2	11.6	11.6
.60	Disposal of Spent Fuel	$/KgH	87.2	87.2	87.2	87.2	87.2	87.2	87.2

---

(1) See Table 6-13 for System Designation

Effective Date: January 1, 1980
(1) System : PHWR-U5(SE)/U-T
Start Up : January 1, 2001

TABLE 6-10b

ENERGY ECONOMIC DATA BASE
OUTPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

Account No.	Account Description	OUTPUT QUANTITIES, 30 - YEAR LEVELIZED $/MBtu Direct Cost	Indirect Cost	Total Cost
.00	Total	0.41	0.00	0.41
.10	Initial Fuel Loaded			
.11	Uranium Supply			
.111	U_3O_8 Supply	0.26	0.01	0.27
.112	UF_6 Conversion Services	0.01	0.00	0.01
.113	Enrichment Services	0.05	0.00	0.05
.114	Depleted U Supply			
.12	Plutonium Supply			
.13	U-233 Supply			
.14	Thorium Supply			
.20	Fabrication	0.05	0.00	0.05
.21	Core Fabrication			
.22	Axial Blanket Fabrication			
.23	Radial Blanket Fabrication			
.30	Shipping to Temporary Storage			
.40	Temporary Storage			
.50	Shipping to Repository	0.01	(0.00)	0.01
.60	Disposal of Spent Fuel	0.03	(0.01)	0.02

---

(1) See Table 6-13 for System Designation.

Effective Date: January 1, 1980
(1) System : HTGR-PS-U5/U/Th-20%-T
Start Up : January 1, 2001

TABLE 6-11a

ENERGY ECONOMIC DATA BASE
INPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

Account No.	Account Description	Units	SUMMARY OF INPUT QUANTITIES BY CALENDAR YEAR (FIVE YEAR PERIODS)						
			2000	2005	2010	2015	2020	2025	2030
.10	Initital Fuel Loaded	$/KgH							
.11	Uranium Supply	$/KgU							
.111	U_3O_8 Supply	$/lb U_3O_8	49.6	59.6	72.5	88.2	91.4	91.4	91.4
.112	UF_6 Conversion Services	$/KgU as UF_6	5.7	5.7	5.7	5.7	5.7	5.7	5.7
.113	Enrichment Services	$/SWU	121.1	124.3	124.3	123.2	121	121	119.9
.114	Depleted U Supply	$/KgU							
.12	Plutonium Supply	Parity value							
.13	U-233 Supply	Parity value							
.14	Thorium Supply	$/KgH							
.20	Fabrication	$/KgH	355.6	352.7	349.8	349.8	358.5	352.7	352.7
.21	Core Fabrication	$/KgH							
.22	Axial Blanket Fabrication	$/KgH							
.23	Radial Blanket Fabrication	$/KgH							
.30	Shipping to Temporary Storage	$/KgH							
.40	Temporary Storage	$/KgH							
.50	Shipping to Repository(2)	$/KgH	343.8	309.4	309.4	275	275	240.6	240.6
.60	Disposal of Spent Fuel	$/KgH	388.7	288.7	388.7	388.7	388.7	388.7	388.7

---

(1) See Table 6-13 for System Designation
(2) Initial Core Fuel/Reload Fuel

Effective Date: January 1, 1980
(1) System : HTGR-PS-U5/U/Th-20%-T
Start Up : January 1, 2001

TABLE 6-11b

ENERGY ECONOMIC DATA BASE
OUTPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

Account No.	Account Description	OUTPUT QUANTITIES, 30 - YEAR LEVELIZED $/MBtu		
		Direct Cost	Indirect Cost	Total Cost
.00	Total	0.80	0.05	0.85
.10	Initial Fuel Loaded			
.11	Uranium Supply			
.111	U_3O_8 Supply	0.41	0.03	0.44
.112	UF_6 Conversion Services	0.01	0.00	0.01
.113	Enrichment Services	0.31	0.02	0.33
.114	Depleted U Supply			
.12	Plutonium Supply			
.13	U-233 Supply			
.14	Thorium Supply			
.20	Fabrication	0.04	0.00	0.04
.21	Core Fabrication			
.22	Axial Blanket Fabrication			
.23	Radial Blanket Fabrication			
.30	Shipping to Temporary Storage			
.40	Temporary Storage			
.50	Shipping to Repository	0.01	(0.00)	0.01
.60	Disposal of Spent Fuel	0.02	(0.00)	0.02

---

(1) See Table 6-13 for System Designation.

Effective Date: January 1, 1980
(1) System : LMFBR-Pu/U/U/U-HT
Start Up : January 1, 2001

TABLE 6-12a

ENERGY ECONOMIC DATA BASE
INPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

Account No.	Account Description	Units	SUMMARY OF INPUT QUANTITIES BY CALENDAR YEAR (FIVE YEAR PERIODS) 2000	2005	2010	2015	2020	2025	2030
.10	Initial Fuel Loaded	$/KgH							
.11	Uranium Supply	$/KgU							
.111	U_3O_8 Supply	$/lb U_3O_8	0	0	0	0	0	0	0
.112	UF_6 Conversion Services	$/KgU as UF_6							
.113	Enrichment Services	$/SWU							
.114	Depleted U Supply	$/KgU	0	0	0	0	0	0	0
.12	Plutonium Supply	Parity value	0	0	0	0	0	0	0
.13	U-233 Supply	Parity value							
.14	Thorium Supply	$/KgH							
.20	Fabrication	$/KgH							
.21	Core Fabrication	$/KgH	583	578	573	573	588	578	578
.22	Axial Blanket Fabrication	$/KgH	37.2	36.8	36.5	36.5	37.5	36.8	36.8
.23	Radial Blanket Fabrication	$/KgH	134.2	133.1	132	132	135.3	133.1	133.1
.30	Shipping to Temporary Storage	$/KgH							
.40	Temporary Storage	$/KgH							
.50	Shipping to Reprocessor	$/KgH	129.3	116.3	116.3	103.4	103.4	90.5	90.5
.60	Reprocessing	$/KgH	463	396	329	316	310	310	310
.70	Disposal of Reprocessing Wastes	$/KgH	331.8	331.8	331.8	331.8	331.8	331.8	331.8
.80	Final Fuel Recovered (Credits)	$/KgH							
.81	Uranium	$/KgH	0	0	0	0	0	0	0
.811	Equivalent U_3O_8 Supply	$/lb U_3O_8							
.812	Equivalent UF_6 Conversion Services	$/KgU							
.813	Equivalent Enrichment Services	$/SWU							
.82	Fissile Plutonium	Parity value	0	0	0	0	0	0	0
.83	Bred U-233	Parity value							
.90	Refabrication of Recovered Fuel	$/KgH							

---

(1) See Table 6-13 for System Designation

Effective Date: January 1, 1980
(1) System : LMFBR-Pu/U/U/U-HT
Start Up : January 1, 2001

TABLE 6-12b

ENERGY ECONOMIC DATA BASE
OUTPUT NUCLEAR FUEL COST COMPONENTS
No Escalation
Constant January 1, 1980 Dollars

		OUTPUT QUANTITIES, 30 - YEAR LEVELIZED \$/MBtu		
Account No.	Account Description	Direct Cost	Indirect Cost	Total Cost
.00	Total	0.40	0.00	0.40
.10	Initital Fuel Loaded			
.11	Uranium Supply(2)			
.111	U_3O_8 Supply	--	--	--
.112	UF_6 Conversion Services			
.113	Enrichment Services			
.114	Depleted U Supply			
.12	Plutonium Supply(3)	--	--	--
.13	U-233 Supply			
.14	Thorium Supply			
.20	Facbrication(4)			
.21	Core Fabrication	0.10	0.00	0.10
.22	Axial Blanket Fabrication	0.01	0.00	0.01
.23	Radial Blanket Fabrication	0.02	0.00	0.02
.30	Shipping to Temporary Storage			
.40	Temporary Storage			
.50	Shipping to Reprocessor	0.04	(0.00)	0.04
.60	Reprocessing }	0.22	(0.00)	0.22
.70	Disposal of Reprocessing Wastes }	0.01	(0.00)	0.01
.80	Final Fuel Recovered (Credits)			
.81	Uranium(2)			
.811	Equivalent U_3O_8 Supply			
.812	Equivalent UF_6 Conversion Services			
.813	Equivalent Enrichment Services			
.82	Fissile Plutonium(3)			
.83	Bred U-233			
.90	Refabrication of Recovered Fuel			

---

(1) See Table 6-13 for System Designation

(2) Final uranium value (account .81) is included in Uranium Supply (account .11) such that the value entered under account .11 represents the net uranium consumed.

(3) Final value of fissile plutonium (account .82 is included in Plutonium Supply (account .12) such that the value entered under account .12 represents the net fissile plutonium consumed.

(4) Includes fabrication of core, axial blanket and radial blanket (account .21, .22 and .23)

TABLE 6-13

ENERGY ECONOMIC DATA BASE

EXPLANATION OF FUEL CYCLE SYSTEM DESIGNATION
(Refer to Tables 6-4 through 6-12)

System Designation	Reactor Type	Fuel-Type	Fuel Cycle Alternative
PWR-U5(LE)/U-T	LWR(PWR)	Low-enriched uranium (UO_2)	Throwaway
HTGR-SC-U5/U/Th-20%-T	HTGR-SC	Medium-enriched uranium (20%) and thorium (UC_2-ThO_2)	Throwaway
PHWR-U5(SE)/U-T (CANDU)	PHWR	Slightly enriched (1.2%) uranium (UO_2)	Throwaway
HTGR-PS-U5/U/Th-20%-T	HTGR-PS	Medium-enriched uranium (20%) and thorium (UC_2-ThO_2)	Throwaway
LMFBR-Pu/U/U/U/HT	LMFBR	Pu/depleted uranium-core and depleted uranium blankets (PuO_2-UO_2/UO_2/UO_2)	Recycle of plutonium in breeders

Effective Date: January 1, 1980
System : Coal-Fired FPGS(5)
Startup : January 1, 1980

TABLE 6-14a
ENERGY ECONOMIC DATA BASE
COAL FUEL COST COMPONENTS
No Escalation
(Constant January 1, 1980 Dollars)

Plant Type		Coal	Coal Costs(1)		Transportation Costs(2)				Total
Model	MWe	Type(3)	$/tons	$/MBtu	$/t-mi(4)	Miles	$/ton	$/MBtu	$/MBtu
HS12	1232	EHS	27.15	1.23	0.020	500	10.00	0.45	1.68
HS8	795								
LS12	1236	WLS	9.38	0.57	0.015	2000	30.00	1.84	2.41
LS8	795								

---

(1) Coal Costs are FOB Mine-mouth
(2) Transportation Costs are "Delivered to User"
(3) EHS = Eastern (High Sulfur) Coal; WLS = Western (Low Sulfur) Coal. Refer to Tables 6-22 and 6-23 for Coal Constituents
(4) $/t-mi = $ per ton-mile
(5) FPGS = Fossil Power Generating Station

Effective Date: January 1, 1980
System : Coal-Fired FPGS(5)
Startup : January 1, 1987

TABLE 6-14b
ENERGY ECONOMIC DATA BASE
COAL FUEL COST COMPONENTS
No Escalation
(Constant January 1, 1980 Dollars)

Plant Type		Coal	Coal Costs(1)		Transportation Costs(2)				Total
Model	MWe	Type(3)	$/ton	$/MBtu	$/t-mi(4)	Miles	$/ton	$/MBtu	$/MBtu
HS12	1232	EHS	33.03	1.50	0.023	500	11.50	0.52	2.02
HS8	795								
LS12	1236	WLS	11.05	0.68	0.018	2000	36.00	2.20	2.88
LS8	795								
CGCC	630	PHS	40.40	1.54	0.023	500	11.50	0.44	1.98

---

(1) Coal Costs are FOB Mine-mouth
(2) Transportation Costs are "Delivered to User"
(3) EHS = Eastern (High Sulfur) Coal; WLS = Western (Low Sulfur) Coal; PHS = Pittsburgh Steam (High Sulfur) Coal. Refer to Tables 6-22, 6-23 and 6-24 for Coal Constituents
(4) $/t-mi = $ per ton-mile
(5) FPGS = Fossil Power Generating Station

Effective Date: January 1, 1980
System : Coal-Fired FPGS(5)
Startup : January 1, 2001

TABLE 6-14c
ENERGY ECONOMIC DATA BASE
COAL FUEL COST COMPONENTS
No Escalation
(Constant January 1, 1980 Dollars)

Plant Type		Coal	Coal Costs(1)		Transportation Costs(2)				Total
Model	MWe	Type(3)	$/ton	$/MBtu	$/t-mi(4)	Miles	$/ton	$/MBtu	$/MBtu
HS12	1232	EHS	44.43	2.01	0.027	500	13.50	0.61	2.62
HS8	795								
LS12	1236	WLS	14.19	0.87	0.021	2000	42.00	2.57	3.44
LS8	795								
CGCC	630	PHS	54.77	2.08	0.027	500	13.50	0.51	2.59

---

(1) Coal Costs are FOB Mine-mouth

(2) Transportation Costs are "Delivered to User"

(3) EHS = Eastern (High Sulfur) Coal; WLS = Western (Low Sulfur) Coal; PHS = Pittsburgh Steam (High Sulfur) Coal. Refer to Tables 6-22, 6-23 and 6-24 for Coal Constituents

(4) $/t-mi = $ per ton-mile

(5) FPGS = Fossil Power Generating Station

TABLE 6-15

ENERGY ECONOMIC DATA BASE
PROJECTED U_3O_8 COSTS
(January 1980 Dollars)

YEAR	\$/1b U_3O_8
1980 through 1996	43
1997	44
1998	46
1999	48
2000	50
2002	53
2004	57
2006	62
2008	67
2010	73
2015	88
2020	91
2025	91
2030	91

TABLE 6-16 Effective Date - 1/1/80

ENERGY ECONOMIC DATA BASE

SUMMARY OF FUEL CYCLE LEAD AND LAG TIMES
(In Quarter-Years)

Lead Time (to reactor startup date)	PWR	HTGR	PHWR (f)	FBR
1. Payment for U_3O_8 purchased				
Initial core	7	7	5/5	(g)
Reloads	4	4	2/4	(g)
2. Payment for Plutonium purchased				
Initial core	--	--	--	5
Reloads	(a)	--	--	(h)
3. Payment for Conversion Services				
Initial core	5.667	5.667	-/-	--
Reloads	2.667	2.667	-/2.667	--
4. Payment for Enrichment Services				
Initial core	5	5	-/-	--
Reloads	2	2	-/2	--
5. Payment for Fabrication				
Initial core	2	2(d)	2/2	2
Reloads	1	1(d)	1/1	1
Lag Time (from discharge date from reactor)				
6. Payment for Spent Fuel Shipping	2/20(b)	2/20(b)	40/40	2
7. Payment for Reprocessing Services	2	2	--	2
8. Payment for Waste Disposal	2	2	--	--
9. Payment for Spent Fuel Disposal	20	20	40/40	--
10. Receipt of Credit for Uranium Recovered	3(c)	2(e)	--	3
11. Receipt of Credit for Plutonium Recovered	3(a)	--	--	3(h)

ENERGY ECONOMIC DATA BASE

SUMMARY OF FUEL CYCLE LEAD AND LAG TIMES
(In Quarter-Years)

(a) For recycle alternative, recovered plutonium will be recycled to the subsequent cycles with a lag time of 2 cycle lengths (self-generated mode).

(b) Recycle alternative/throwaway alternative.

(c) For recycle alternative, recovered uranium will be recycled to the subsequent cycles with a lag time of 2 cycle lengths (self-generated mode).

(d) Fabrication costs include material cost for THO_2.

(e) For recycle alternative, recovered uranium will be recycled to the subsequent cycles with a lag time of 1 cycle length (self-generated mode), based on GAC mass flows.

(f) Natural uranium fuel cycle/slightly enriched uranium fuel cycle; (CANDU).

(g) It is assumed that makeup uranium is depleted uranium whose value is zero.

(h) Recovered plutonium will be recycled to the subsequent cycles with a lag time of 2 cycle lengths. Net plutonium gained or added will be sold at the lag time, or purchased at the lead time, respectively.

TABLE 6-17

ENERGY ECONOMIC DATA BASE

SUMMARY OF 30-YEAR LEVELIZED FUEL CYCLE COSTS

($MBtu, January 1980 Dollars)

Reactor/Fuel Cycle Designation	Direct Cost	Indirect Cost	Cycle Cost	Assumed Reactor Commercial Operation Date
PWR-U5(LE)/U-T	0.66	0.04	0.70	1987
HTGR-SC-U5/U/Th-20%-T	0.74	0.05	0.79	1995
PHWR-U5(SE)/U-T (CANDU)	0.37	0.00	0.37	1995
HTGR-PS-U5/U/Th-20%-T	0.80	0.05	0.85	2001
LMFBR-Pu/U/U/U-HT	0.40	0.00	0.40	2001

TABLE 6-18

Effective Date - 1/1/80

ENERGY ECONOMIC DATA BASE

SUMMARY BREAKDOWN OF 30 YEAR LEVELIZED FUEL CYCLE COSTS

($/MBtu, January 1980 Dollars)

Reactor/System Designation	Start-Up Year	Uranium Supply(1)	Plutonium Supply(2)	Fabrication(3)	Shipping(4)	Reprocessing or Disposal(5)	Total
PWR-U5(LE)/U-T	1987	0.60	0.00	0.06	0.01	0.03	0.70
HTGR-SC-U5/U/Th-20%-T	1995	0.71	0.00	0.04	0.02	0.02	0.79
PHWR-U5(SE)/U-T (CANDU)	1995	0.29	0.00	0.05	0.01	0.02	0.37
HTGR-PS-U5/U/Th-20%-T	2001	0.78	0.00	0.04	0.01	0.02	0.85
LMFBR-Pu/U/U/U-HT	2001	0.00	0.00	0.13	0.04	0.23	0.40

---

(1) Net uranium consumed including U-233 for those fuel cycles involving reprocessing. For throwaway fuel cycles, these figures represent the initial cost of uranium.

(2) Net plutonium consumed.

(3) Total fabrication of all types of fuel including recycle fuel or blanket fuel assemblies, where applicable.

(4) Shipping to reprocessor for those fuel cycles involving reprocessing, or shipping to permanent disposal facility for throwaway fuel cycles.

(5) Reprocessing and High Level Waste disposal, or permanent disposal of spent fuel assemblies.

TABLE 6-19

ENERGY ECONOMIC DATA BASE

BASE REACTORS AND THEIR FUELING MODES 30 YEAR LEVELIZED COSTS

(January 1980 Dollars)

REACTOR TYPE	FUELING MODEL	ASSUMED REACTOR COMMERCIAL OPERATION DATE	COSTS	
			\$/MBtu	m/kWh(2)
PWR and BWR(1)	Throwaway (U only)	1987	0.70	7.2
HTGR-SC	Throwaway (U only)	1995	0.79	6.6
PHWR	Throwaway	1995	0.37	3.8
HTGR-PS	Throwaway (U only)	2001	0.85	(3)
LMFBR	U Blanket Recycle Pu	2001	0.40	3.6

(1) BWR data not available for fuel costs; PWR data used for BWR (Model A1).

(2) Based on net plant heat rates given in Table 4-1.

(3) Not applicable for a Cogeneration Facility.

TABLE 6-20

ENERGY ECONOMIC DATA BASE

FUEL CYCLE COST COMPONENTS
PERCENTAGE VALUES

(January 1980 Dollars)

REACTOR TYPE	FUELING MODE	PERCENT OF TOTAL FUEL CYCLE COST		
		URANIUM SUPPLY	FUEL FABRICATION	SHIPPING AND REPROCESSING/ SPENT FUEL DISPOSAL
PWR BWR(1) 1987	Throwaway (U only)	85.7	8.6	5.7
HTGR-SC 1995	Throwaway (U only)	89.9	5.1	5.0
PHWR 1995	Throwaway	78.4	13.5	8.1
HTGR-PS 2001	Throwaway (U only)	91.8	4.7	3.5
LMFBR 2001	U Blanket Recycle Pu	-	32.5	67.5

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(1) BWR data not available for fuel costs; PWR data used for BWR (Model A1).

TABLE 6-21

ENERGY ECONOMIC DATA BASE

AVERAGE DELIVERED CONTRACT PRICES OF STEAM COAL(1)

(1980 $/short ton)

Date	Price
1976	18.39
1977	20.34
1978	23.75
1979	26.17
1980	
January	27.41
February	27.67
March	27.71
April	28.50
May	28.39
June	28.78
July	29.27
August	29.71
September	29.59
October	29.42
November	29.67
December	29.35
Average	28.80

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(1) From: May 1981 USDOE Monthly Energy Review; p. 89

Effective Date - 1/1/80

TABLE 6-22

ENERGY ECONOMIC DATA BASE

HIGH SULFUR COAL ANALYSIS

Coal Type : Eastern High Sulfur Bituminous Coal

Location :
- State Illinois
- County St. Clair
- Seam Illinois No. 6

Reserves (Est.): 3,000,000,000 Tons

DESIGN BASIS COAL ANALYSIS

Moisture (Percent by Weight):	11.3
Proximate Analysis (Percent by Weight, Dry):	
Volatile Matter	39.72
Fixed Carbon	48.68
Ash	11.60
Ultimate Analysis (Percent by Weight, Dry):	
Carbon	69.33
Hydrogen	4.90
Nitrogen	.86
Chlorine	.04
Sulfur	3.61
Oxygen	9.64
Ash Analysis (Percent by Weight, Dry):	
P_2O_5	.05
SiO_2	45.73
Fe_2O_3	18.38
Al_2O_3	19.40
TiO_2	1.30
CaO	5.50
MgO	.95
SO_3	6.63
K_2O	1.53
Na_2O	.51
Undetermined	.02
Calorific Value (Btu/lb)	
As Received	11,026
Dry	12,432
Ash Fusion Temperature (°F Red./°F Ox.)	
Initial	1950/2270
H = W	2140/2380
H = 1/2W	2140/2400
Fluid	2250/2500

TABLE 6-23

ENERGY ECONOMIC DATA BASE

LOW SULFUR COAL ANALYSIS

Coal Type : Western Low Sulfur Sub-Bituminous Coal

Location :
State Wyoming
County Campbell
Seam Roland Smith

Reserves (Est.): 1,000,000,000 Tons

DESIGN BASIS COAL ANALYSIS

Moisture (Percent by Weight)	31.8
<u>Proximate Analysis (Percent by Weight, Dry):</u>	
Volatile Matter	47.6
Fixed Carbon	45.1
Ash	7.3
<u>Ultimate Analysis (Percent by Weight, Dry):</u>	
Carbon	69.3
Hydrogen	5.2
Nitrogen	0.9
Sulfur	0.5
Oxygen	16.8
<u>Ash Analysis (Percent by Weight, Dry):</u>	
SiO_2	28.8
Fe_2O_3	9.0
Al_2O_3	13.0
TiO_2	0.7
CaO	25.0
MgO	6.5
SO_3	18.0
K_2O	0.4
Na_2O	1.2
<u>Calorific Value (Btu/lb)</u>	
As Received	8,164
Dry	11,970
<u>Ash Fusion Temperature (^{o}F Red./^{o}F Ox.)</u>	
Initial	2140/2160
H = W	2180/2190
H = 1/2W	2200/2210
Fluid	2280/2370

TABLE 6-24

ENERGY ECONOMIC DATA BASE

PITTSBURGH STEAM (HIGH SULFUR) COAL ANALYSIS

Coal Type :	Eastern High Sulfur Bituminous Coal
Location :	
State	Pennsylvania
County	Washington
Seam	Pittsburgh No. 8
Reserves (Est.):	6,600,000,000 Tons

DESIGN BASIS COAL ANALYSIS

Moisture (Percent by Weight)	2.4
Proximate Analysis (Percent by Weight, Dry):	
Volatile Matter	39.2
Fixed Carbon	51.2
Ash	7.3
Ultimate Analysis (Percent by Weight):	
Carbon	75.6
Hydrogen	5.2
Nitrogen	1.3
Sulfur	2.6
Oxygen	8.0
Ash Analysis (Percent by Weight, Dry):	
P_2O_5	.28
SiO_2	46.95
Fe_2O_3	18.4
Al_2O_3	25.64
TiO_2	1.01
CaO	2.0
MgO	.67
SO_3	1.97
K_2O	1.75
Na_2O	.45
Calorific Value (Btu/lb)	
As Received	13,156
Dry	13,480
Ash Fusion Temperature (^{o}F)	2,440

FIGURE 6-1
NUCLEAR FUEL CYCLE ACTIVITIES

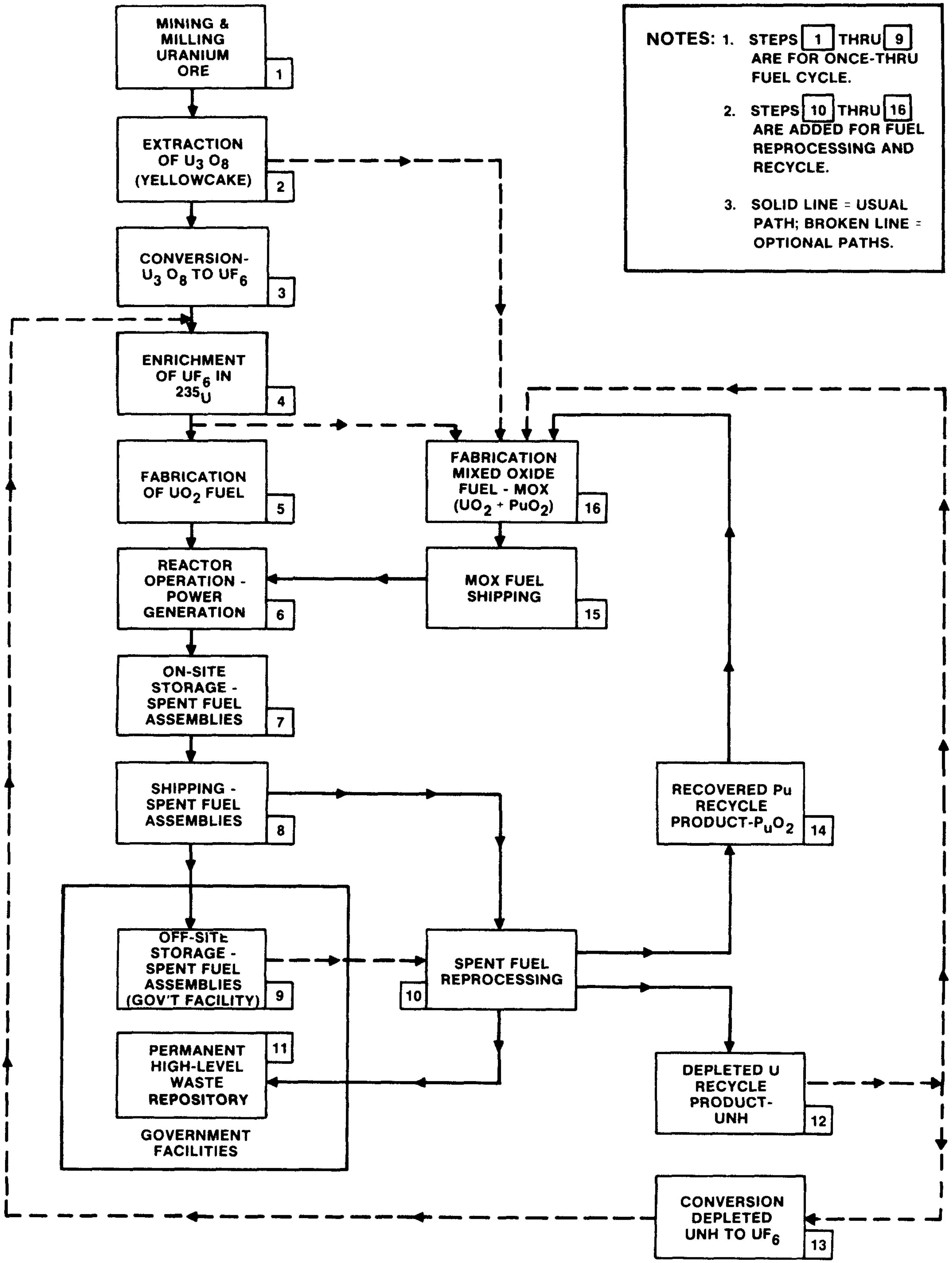
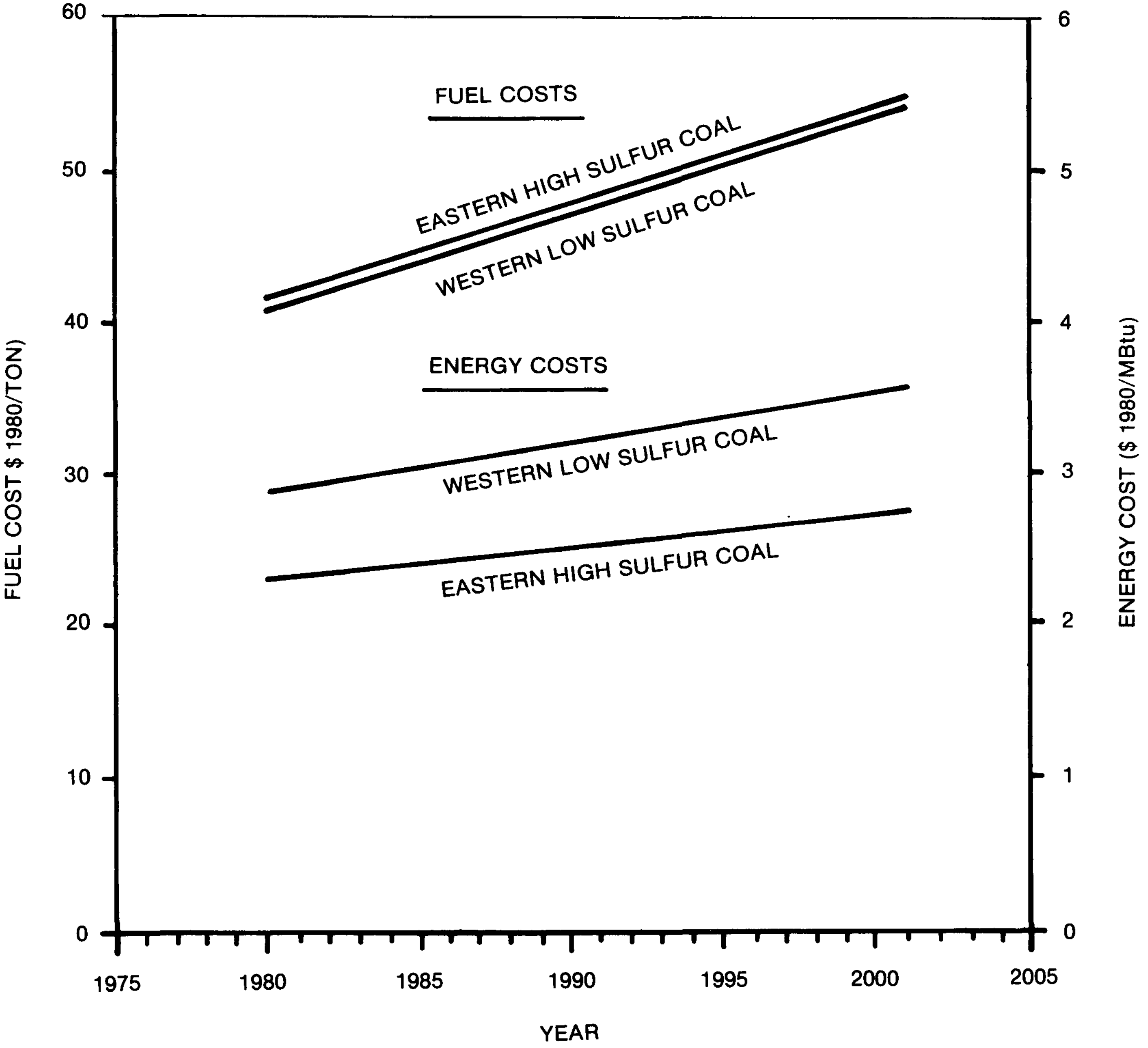


FIGURE 6-2
ENERGY ECONOMIC DATA BASE
PROJECTED AVERAGE DELIVERED COAL COSTS
(JANUARY 1980 DOLLARS)



SECTION 7

7.0 OPERATION AND MAINTENANCE COST THIRD UPDATE

The Third Update of the EEDB Operation and Maintenance (O&M) costs is composed of nuclear and fossil-fired power generating stations O&M costs. For this report, the accounting breakdown includes the major cost areas for each type of plant, but does not define separate expenses for the reactor or boiler plant and the turbine plant. The O&M cost estimates accomodate state-of-the-art designs, regulations, codes and standards current as of January 1, 1980. This section of the report presents the detailed results of the O&M cost update with a description of the major cost changes.

7.1 OPERATION AND MAINTENANCE COST UPDATE PROCEDURE

The procedure for estimating O&M costs is developed by the Oak Ridge National Laboratory (ORNL) and reported in ORNL/TM-6467 "A Procedure for Estimating Nonfuel Operation and Maintenance Costs for Large Steam-Electric Power Plants." The cost estimating update procedure involves the combination of empirical functions, that represent historical experience, with new factors arising from regulatory and economic considerations. Implementation of the procedure is through OMCOST, a digital computer program developed by ORNL. OMCOST is applied to the selected technical models tabulated in Tables 1-1 and 1-2 to produce the Operation and Maintenance Cost Third Update. Input to OMCOST is staffing and material requirements. ORNL prepares and updates these data on a continuing basis.

7.2 OPERATION AND MAINTENANCE COST SUMMARY

O&M costs are prepared for the EEDB Third Update as the sum of staff, maintenance material and supply costs and expenses, insurance and fees, and administrative and general expenses. Total O&M costs are summarized for all plants for the year 1980 in Table 7-1.

7.3 DETAILED OPERATING AND MAINTENANCE COSTS

Results of the Operating and Maintenance Cost Third Update are presented for each technical plant model in Tables 7-2 through 7-12 as follows:

Nuclear Plant Model	Table Number	Fossil Plant Model	Table Number
BWR	7-2	HS12	7-8
HTGR-SC	7-3	HS8	7-9
PWR	7-4	LS12	7-10
PHWR	7-5	LS8	7-11
HTGR-PS	7-6	CGCC	7-12
LMFBR	7-7		

These tables contain all of the O&M data available in the EEDB. There are no additional data in the Backup Data File.

7.4 OPERATION AND MAINTENANCE COST MODEL UPDATE

To quantify staff requirements, staff for both nuclear and fossil-fueled plants are organized according to function. Fossil-fueled plants, although their organization is similar to that of nuclear plants with regard to plant operation functions, differ in personnel allotment and job classifications. In addition, they do not require staffing for quality assurance or health physics. The total staffing used in this study for nuclear and fossil-fueled plants is tabulated in Tables 7-13 through 7-19 as follows:

Plant Model	Table Number
LWR Power Plants (BWR and PWR)	7-13
HTGR-SC Power Plants	7-14
PHWR Power Plants	7-15
HTGR-PS	7-16
LMFBR Power Plants	7-17
Coal-Fired Power Plants with FGD System	7-18

Although licensed reactor operators may receive a five to ten percent premium, nuclear and fossil-fueled plant personnel are assigned the same hourly rates. Nonlicensed jobs in nuclear and fossil work are not significantly different in function. However, considerably more preparation and training may be required to learn nuclear plant procedure for repairs and inspections.

The amount of the various major replacement items, expendable materials, and services used to maintain the power plant, is variable throughout the plant life. To date, historical data on new plant designs are not extensive enough to provide direct relationships for large plants. Therefore, the relationship of materials to maintenance labor as a percentage is estimated for a 70 percent plant capacity factor. Results were discussed with operating personnel as a check.

Operation and maintenance of coal-fired plants tend to be more labor intensive than that of nuclear plants because of the routine maintenance involved with burning coal and the effect of high operating temperatures on the equipment.

Maintenance costs are estimated for operation at base-load conditions near 100 percent capability.

Variable maintenance costs are judged on the basis that 25 percent of the total maintenance is subject to change with load when operating between 50 and 80 percent capacity factor. This judgment is based on factors known to influence incremental costs for coal pulverizers, fuel handling, heat transfer surfaces and certain nonfuel supplies sensitive to load.

The nonregenerative limestone-slurry scrubbing process is used to show a process with high sulfur removal and with economics intermediate among the various systems available for flue gas desulfurization (FGD). For both of the low sulfur coal-fired power plants, the operating cost of their dry scrubbing systems are estimated by using the cost of the wet scrubbing systems. Lower operating costs are expected for dry FGD systems; however, there is not sufficient operating experience with dry FGD systems to confirm this assumption. Estimate of O&M costs for dry FGD systems will be incorporated in future updates when sufficient data becomes available.

The maintenance material cost factors as a percentage of maintenance labor cost are as follows:

	Percentage of Maintenance Labor Cost		
	Fixed	Variable	Total
Nuclear	100	0	100
Coal with FGD	62	20	82

The O&M costs for cooling the main turbine condenser water and other plant heat exchangers are considered for evaporative cooling towers only. These costs range from $25,000 to $50,000 annually for both nuclear and coal plants.

Supplies and expenses include certain consumable materials and expenses that are unrecoverable after use in O&M activities. These include makeup fluids, chemical gases, lubricants, office and personnel supplies, monitoring and record services, and offsite contract services. Costs of limestone and offsite sludge disposal associated with the limestone slurry scrubbing process for flue gas desulfurization are also included.

Operators of nuclear power plants are required to maintain financial protection to a total limit of $580,000,000. This limit is divided as of January 1, 1980 as follows:

	$\$10^6$
Private Insurance	160
Retrospective Premium	340
Government Indemnity	80
	580

The estimated annual premiums for nuclear insurance are as follows:

Commercial Coverage ($160 million)	$284,000
Retrospective Premium	$ 6,000
Government Coverage ($ 80 million)	6 $/MWt to 3000 MWt

Safety, environmental, and health physics inspections are routinely performed at specified frequencies for purposes of reviewing a licensed program by the Nuclear Regulatory Commission. The annual estimate for these inspections is $100,000 for the first unit and $80,000 for each additional unit.

Administrative and general expenses include the owner's offsite salaries and expenses directly allocable to a specific power production facility. In this report, the magnitude of administrative and general expenses is related to fixed O&M costs, minus insurance and operating fees. Values of 10 and 15 percent of total fixed cost of staff, maintenance materials, and supplies and expenses have been used to estimate administrative and general costs for nuclear and fossil plants respectively.

7.5 LEVELIZATION FACTOR

The Operation and Maintenance costs for the EEDB Third Update are stated in terms of the first year cost (i.e., 1980 dollars). If one wishes to compute a unit electricity cost using the inflation-free operation and maintenance costs, then the first year cost, after conversion to an electric energy cost, may be added directly to the inflation-free capital and fuel cycle costs. For an inflated case, a levelization factor must be computed and applied to the first year cost before the O&M costs are added to the inflated capital and fuel costs. Consistent rates of interest and escalation must be used in the computation for compatibility and consistency with the capital and fuel costs. An approximation of the levelization factor may be computed with the following equation:

$$LF = \left[\frac{i\ (1 + e)}{i - e}\right] \bullet \left[\frac{(1 + i)^n - (1 + e)^n}{(1 + i)^n - 1}\right]$$

Where:
LF = levelization factor
i = discount rate per annum
e = escalation rate per annum
n = levelization period in years

7.6 TMI RELATED OPERATIONAL COSTS

As of January 1, 1980, the full effect of the accident at TMI is not completely identified. Analyses and evaluations are continuing to determine the effects on operation and maintenance cost for nuclear power plants.

As a first approximation, an additional five million dollars per year may be added to the 1980 estimates for operation and maintenance of the nuclear power plants. This, essentially, covers the increase in engineering, technical and operating staff resulting from lessons learned from TMI.

A more detailed analysis of the TMI-related costs is planned to be included in the Fourth Update (1981) of the EEDB.

TABLE 7-1

Effective Date - 1/1/80

ENERGY ECONOMIC DATA BASE

OPERATION AND MAINTENANCE COST UPDATE
(Constant $1980)

Model	MWe	$\$10^6$/yr.	Mills/kWh
BWR	1190	21.3	2.9
HTGR-SC	858	20.4	3.9
PWR	1139	21.3	3.0
PHWR	1260	25.2	3.3
HTGR-PS	150	10.8	*
LMFBR	1457	27.7	3.1
HS12	1232	26.7	3.5
HS8	795	22.1	4.5
LS12	1236	27.3	3.6
LS8	795	22.5	4.6
CGCC	630	10.5	2.7

* Not Applicable for Process Steam/Cogeneration Plant

TABLE 7-2
ENERGY ECONOMIC DATA BASE
(Constant $1980)

Effective Date - 1/1/80

```
SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
   FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1980.0

     PLANT TYPE IS BWR
     WITH EVAPORATIVE COOLING TOWERS
     NUMBER OF UNITS PER STATION 1
     THERMAL INPUT PER UNIT IS 3578. MWT
     PLANT NET HEAT RATE  10259.
     PLANT NET EFFICIENCY, PERCENT   33.26
     EACH UNIT IS 1190. MWE NET RATING
     ANNUAL NET GENERATION, MILLION KWH  7302.
     WITH A PLANT FACTOR OF 0.70

     STAFF, $1000/YR                     9377. (331 PERSONS AT $28328.)

     MAINTENANCE MATERIAL, $1000/YR      3201.
               FIXED                          3201.
               VARIABLE                          0.

     SUPPLIES AND EXPENSES, $1000/YR     5612.
               FIXED                          5082.
               VARIABLE                        530.

     INSURANCE AND FEES, $1000/YR         494.
               COMM. LIAB. INS.                344.
               GOV. LIAB. INS.                  22.
               RETROSPECTIVE PREMIUM             7.
               INSPECTION FEES & EXPENSES      121.

     ADMIN. AND GENERAL, $1000/YR        2649.

     TOTAL FIXED COSTS, $1000/YR                  20802.
     TOTAL VARIABLE COSTS, $1000/YR                 530.
     TOTAL ANNUAL O & M COSTS, $1000/YR           21332.

     FIXED UNIT O & M COSTS, MILLS/KWH(E)           2.85
     VARIABLE UNIT O & M COSTS, MILLS/KWH(E)        0.07
     TOTAL UNIT O & M COSTS, MILLS/KWH(E)           2.92
```

TABLE 7-3
ENERGY ECONOMIC DATA BASE
(Constant $1980)

Effective Date - 1/1/80

```
SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
   FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1980.0

     PLANT TYPE IS HTGR
     WITH EVAPORATIVE COOLING TOWERS
     NUMBER OF UNITS PER STATION 1
     THERMAL INPUT PER UNIT IS 2240. MWT
     PLANT NET HEAT RATE   8908.
     PLANT NET EFFICIENCY, PERCENT   38.30
     EACH UNIT IS  858. MWE NET RATING
     ANNUAL NET GENERATION, MILLION KWH  5265.
     WITH A PLANT FACTOR OF 0.70

     STAFF, $1000/YR                     9377. (331 PERSONS AT $28328.)

     MAINTENANCE MATERIAL, $1000/YR      3201.
               FIXED                          3201.
               VARIABLE                          0.

     SUPPLIES AND EXPENSES, $1000/YR     4732.
               FIXED                          4477.
               VARIABLE                        255.

     INSURANCE AND FEES, $1000/YR         488.
               COMM. LIAB. INS.                344.
               GOV. LIAB. INS.                  16.
               RETROSPECTIVE PREMIUM             7.
               INSPECTION FEES & EXPENSES      121.

     ADMIN. AND GENERAL, $1000/YR        2558.

     TOTAL FIXED COSTS, $1000/YR                   20101.
     TOTAL VARIABLE COSTS, $1000/YR                  255.
     TOTAL ANNUAL O & M COSTS, $1000/YR            20356.

     FIXED UNIT O & M COSTS, MILLS/KWH(E)           3.82
     VARIABLE UNIT O & M COSTS, MILLS/KWH(E)        0.05
     TOTAL UNIT O & M COSTS, MILLS/KWH(E)           3.87
```

TABLE 7-4
ENERGY ECONOMIC DATA BASE
(Constant $1980)

Effective Date - 1/1/80

```
SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
   FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1980.0

     PLANT TYPE IS PWR
     WITH EVAPORATIVE COOLING TOWERS
     NUMBER OF UNITS PER STATION 1
     THERMAL INPUT PER UNIT IS 3412. MWT
     PLANT NET HEAT RATE  10221.
     PLANT NET EFFICIENCY, PERCENT   33.38
     EACH UNIT IS 1139. MWE NET RATING
     ANNUAL NET GENERATION, MILLION KWH  6989.
     WITH A PLANT FACTOR OF 0.70

     STAFF, $1000/YR                     9377. (331 PERSONS AT $28328.)

     MAINTENANCE MATERIAL, $1000/YR      3201.
               FIXED                          3201.
               VARIABLE                          0.

     SUPPLIES AND EXPENSES, $1000/YR     5589.
               FIXED                          5082.
               VARIABLE                        507.

     INSURANCE AND FEES, $1000/YR         494.
               COMM. LIAB. INS.                344.
               GOV. LIAB. INS.                  22.
               RETROSPECTIVE PREMIUM             7.
               INSPECTION FEES & EXPENSES      121.

     ADMIN. AND GENERAL, $1000/YR        2649.

     TOTAL FIXED COSTS, $1000/YR                   20802.
     TOTAL VARIABLE COSTS, $1000/YR                  507.
     TOTAL ANNUAL O & M COSTS, $1000/YR            21310.

     FIXED UNIT O & M COSTS, MILLS/KWH(E)            2.98
     VARIABLE UNIT O & M COSTS, MILLS/KWH(E)         0.07
     TOTAL UNIT O & M COSTS, MILLS/KWH(E)            3.05
```

TABLE 7-5
ENERGY ECONOMIC DATA BASE
(Constant $1980) Effective Date - 1/1/80

```
SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
   FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1980.0

        PLANT TYPE IS PHWR
        WITH EVAPORATIVE COOLING TOWERS
        NUMBER OF UNITS PER STATION 1
        THERMAL INPUT PER UNIT IS 3800. MWT
        PLANT NET HEAT RATE  10291.
        PLANT NET EFFICIENCY, PERCENT   33.16
        EACH UNIT IS 1260. MWE NET RATING
        ANNUAL NET GENERATION, MILLION KWH  7732.
        WITH A PLANT FACTOR OF 0.70

        STAFF, $1000/YR                     8838. (312 PERSONS AT $28328.)

        MAINTENANCE MATERIAL, $1000/YR      2663.
                  FIXED                          2663.
                  VARIABLE                          0.

        SUPPLIES AND EXPENSES, $1000/YR    10079.
                  FIXED - PLANT                  5445.
                        - HEAVY WATER LOSSES
                          AND UPKEEP             4073.
                  VARIABLE                        561.

        INSURANCE AND FEES, $1000/YR         494.
                  COMM. LIAB. INS.                344.
                  GOV. LIAB. INS.                  22.
                  RETROSPECTIVE PREMIUM             7.
                  INSPECTION FEES & EXPENSES      121.

        ADMIN. AND GENERAL, $1000/YR        3153.

        TOTAL FIXED COSTS, $1000/YR                   24666.
        TOTAL VARIABLE COSTS, $1000/YR                  561.
        TOTAL ANNUAL O & M COSTS, $1000/YR            25227.

        FIXED UNIT O & M COSTS, MILLS/KWH(E)           3.19
        VARIABLE UNIT O & M COSTS, MILLS/KWH(E)        0.07
        TOTAL UNIT O & M COSTS, MILLS/KWH(E)           3.26
```

TABLE 7-6

ENERGY ECONOMIC DATA BASE
(Constant $1980)

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1980.0

PLANT TYPE IS HTGR-PS
WITH EVAPORATIVE COOLING TOWERS
NUMBER OF UNITS PER STATION 1
THERMAL INPUT PER UNIT IS 1170 MWt
PLANT NET HEAT RATE 21572
PLANT NET EFFICIENCY, PERCENT 12.82
EACH UNIT IS 150 MWe **NET RATING**
ANNUAL NET GENERATION, MILLION kWh 920.
WITH A PLANT FACTOR OF 0.70

STAFF, $1000/YR	5269.	(186 PERSONS AT $28328.)
MAINTENANCE MATERIAL, $1000/YR	1601.	
FIXED		1601.
VARIABLE		0.
SUPPLIES AND EXPENSES, $1000/YR	2367.	
FIXED		2239.
VARIABLE		128.
INSURANCE AND FEES, $1000/YR	244.	
COMM. LIAB. INS.		172.
GOV. LIAB. INS.		8.
RETROSPECTIVE PREMIUM		4.
INSPECTION FEES & EXPENSES		60.
ADMIN. AND GENERAL, $1000/YR	2558.	
TOTAL FIXED COSTS, $1000/YR		10051.
TOTAL VARIABLE COSTS, $1000/YR		128.
TOTAL ANNUAL O&M COSTS, $1000/YR		10179
FIXED UNIT O&M COSTS, MILLS/kWh (E)		NOT APPLICABLE
VARIABLE UNIT O&M COSTS, MILLS/kWh (E)		NOT APPLICABLE
TOTAL UNIT O&M COSTS, MILLS/kWh (E)		NOT APPLICABLE

TABLE 7-7
ENERGY ECONOMIC DATA BASE
(Constant $1980)

Effective Date - 1/1/80

```
SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
   FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1980.0

     PLANT TYPE IS LMFBR
     WITH EVAPORATIVE COOLING TOWERS
     NUMBER OF UNITS PER STATION 1
     THERMAL INPUT PER UNIT IS 3800. MWT
     PLANT NET HEAT RATE   8899.
     PLANT NET EFFICIENCY, PERCENT   38.34
     EACH UNIT IS 1457. MWE NET RATING
     ANNUAL NET GENERATION, MILLION KWH  8940.
     WITH A PLANT FACTOR OF 0.70

     STAFF, $1000/YR                    9660. (341 PERSONS AT $28328.)

     MAINTENANCE MATERIAL, $1000/YR     7469.
               FIXED                         7469.
               VARIABLE                         0.

     SUPPLIES AND EXPENSES, $1000/YR    6591.
               FIXED                         6050.
               VARIABLE                       541.

     INSURANCE AND FEES, $1000/YR        494.
               COMM. LIAB. INS.               344.
               GOV. LIAB. INS.                 22.
               RETROSPECTIVE PREMIUM            7.
               INSPECTION FEES & EXPENSES     121.

     ADMIN. AND GENERAL, $1000/YR       3477.

     TOTAL FIXED COSTS, $1000/YR                   27150.
     TOTAL VARIABLE COSTS, $1000/YR                  541.
     TOTAL ANNUAL O & M COSTS, $1000/YR            27691.

     FIXED UNIT O & M COSTS, MILLS/KWH(E)            3.04
     VARIABLE UNIT O & M COSTS, MILLS/KWH(E)         0.06
     TOTAL UNIT O & M COSTS, MILLS/KWH(E)            3.10
```

TABLE 7-8
ENERGY ECONOMIC DATA BASE
(Constant $1980)

Effective Date - 1/1/80

```
SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
   FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1980.0

     PLANT TYPE IS COAL
     WITH EVAPORATIVE COOLING TOWERS
     NUMBER OF UNITS PER STATION 1
     WITH FGD SYSTEMS
     THERMAL INPUT PER UNIT IS 3298. MWT
     PLANT NET HEAT RATE   9134.
     PLANT NET EFFICIENCY, PERCENT   37.36
     EACH UNIT IS 1232. MWE NET RATING
     ANNUAL NET GENERATION, MILLION KWH  7560.
     WITH A PLANT FACTOR OF 0.70

     STAFF, $1000/YR                      7018. (259 PERSONS AT $27096.)

     MAINTENANCE MATERIAL, $1000/YR       2964.
               FIXED                           2295.
               VARIABLE                         669.

     SUPPLIES AND EXPENSES, $1000/YR     15579.
               FIXED                           1694.
               VAR.   - PLANT                   457.
                      - ASH & FGD SLUDGE      13428.

     ADMIN. AND GENERAL, $1000/YR         1101.

     TOTAL FIXED COSTS, $1000/YR                    12107.
     TOTAL VARIABLE COSTS, $1000/YR                 14555.
     TOTAL ANNUAL O & M COSTS, $1000/YR             26662.

     FIXED UNIT O & M COSTS, MILLS/KWH(E)            1.60
     VARIABLE UNIT O & M COSTS, MILLS/KWH(E)         1.93
     TOTAL UNIT O & M COSTS, MILLS/KWH(E)            3.53




     HEATING VALUE OF COAL, BTU/LB        11026.
     COAL BURNED, TONS/YEAR             3131333.
     PERCENT ASH                          11.60
     COST OF ASH DISPOSAL, $/TON           4.84
     PERCENT SULFUR                        3.50
     SULFUR (ORIGINAL),TONS/YR          109597.
     TONS LIMESTONE PER TON SULFUR         4.00
     TONS/YEAR LIMESTONE                438387.
     COST OF LIMESTONE, $/TON             12.10
     COST OF SLUDGE DISPOSAL, $/DRY TON   14.52
```

TABLE 7-9
ENERGY ECONOMIC DATA BASE
(Constant $1980)

Effective Date - 1/1/80

```
SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
   FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1980.0

     PLANT TYPE IS COAL
     WITH EVAPORATIVE COOLING TOWERS
     NUMBER OF UNITS PER STATION 1
     WITH FGD SYSTEMS
     THERMAL INPUT PER UNIT IS 2208. MWT
     PLANT NET HEAT RATE   9477.
     PLANT NET EFFICIENCY, PERCENT   36.01
     EACH UNIT IS  795. MWE NET RATING
     ANNUAL NET GENERATION, MILLION KWH  4878.
     WITH A PLANT FACTOR OF 0.70

     STAFF, $1000/YR                    7018. (259 PERSONS AT $27096.)

     MAINTENANCE MATERIAL, $1000/YR     2964.
               FIXED                         2295.
               VARIABLE                       669.

     SUPPLIES AND EXPENSES, $1000/YR   10979.
               FIXED                         1694.
               VAR.  - PLANT                  295.
                     - ASH & FGD SLUDGE      8990.

     ADMIN. AND GENERAL, $1000/YR       1101.

     TOTAL FIXED COSTS, $1000/YR                  12107.
     TOTAL VARIABLE COSTS, $1000/YR                9954.
     TOTAL ANNUAL O & M COSTS, $1000/YR           22062.

     FIXED UNIT O & M COSTS, MILLS/KWH(E)          2.48
     VARIABLE UNIT O & M COSTS, MILLS/KWH(E)       2.04
     TOTAL UNIT O & M COSTS, MILLS/KWH(E)          4.52




     HEATING VALUE OF COAL, BTU/LB       11026.
     COAL BURNED, TONS/YEAR            2096417.
     PERCENT ASH                          11.60
     COST OF ASH DISPOSAL, $/TON           4.84
     PERCENT SULFUR                        3.50
     SULFUR (ORIGINAL),TONS/YR           73375.
     TONS LIMESTONE PER TON SULFUR         4.00
     TONS/YEAR LIMESTONE                293498.
     COST OF LIMESTONE, $/TON             12.10
     COST OF SLUDGE DISPOSAL, $/DRY TON   14.52
```

TABLE 7-10
ENERGY ECONOMIC DATA BASE
(Constant $1980) Effective Date - 1/1/80

```
SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
   FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1980.0

     PLANT TYPE IS COAL
     WITH EVAPORATIVE COOLING TOWERS
     NUMBER OF UNITS PER STATION 1
     WITH FGD SYSTEMS
     THERMAL INPUT PER UNIT IS 3444. MWT
     PLANT NET HEAT RATE   9508.
     PLANT NET EFFICIENCY, PERCENT   35.89
     EACH UNIT IS 1236. MWE NET RATING
     ANNUAL NET GENERATION, MILLION KWH  7584.
     WITH A PLANT FACTOR OF 0.70

     STAFF, $1000/YR                    7018. (259 PERSONS AT $27096.)

     MAINTENANCE MATERIAL, $1000/YR      2964.
               FIXED                          2295.
               VARIABLE                        669.

     SUPPLIES AND EXPENSES, $1000/YR    16175.
               FIXED                          1694.
               VAR.  - PLANT                   459.
                     - ASH & FGD SLUDGE      14022.

     ADMIN. AND GENERAL, $1000/YR        1101.

     TOTAL FIXED COSTS, $1000/YR                   12107.
     TOTAL VARIABLE COSTS, $1000/YR                15150.
     TOTAL ANNUAL O & M COSTS, $1000/YR            27258.

     FIXED UNIT O & M COSTS, MILLS/KWH(E)           1.60
     VARIABLE UNIT O & M COSTS, MILLS/KWH(E)        2.00
     TOTAL UNIT O & M COSTS, MILLS/KWH(E)           3.59




     HEATING VALUE OF COAL, BTU/LB       11026.
     COAL BURNED, TONS/YEAR            3269955.
     PERCENT ASH                          11.60
     COST OF ASH DISPOSAL, $/TON           4.84
     PERCENT SULFUR                        3.50
     SULFUR (ORIGINAL),TONS/YR          114448.
     TONS LIMESTONE PER TON SULFUR         4.00
     TONS/YEAR LIMESTONE                457794.
     COST OF LIMESTONE, $/TON             12.10
     COST OF SLUDGE DISPOSAL, $/DRY TON   14.52
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TABLE 7-11
ENERGY ECONOMIC DATA BASE
(Constant $1980)

Effective Date - 1/1/80

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SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS
   FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1980.0

     PLANT TYPE IS COAL
     WITH EVAPORATIVE COOLING TOWERS
     NUMBER OF UNITS PER STATION 1
     WITH FGD SYSTEMS
     THERMAL INPUT PER UNIT IS 2306. MWT
     PLANT NET HEAT RATE   9897.
     PLANT NET EFFICIENCY, PERCENT   34.48
     EACH UNIT IS  795. MWE NET RATING
     ANNUAL NET GENERATION, MILLION KWH  4878.
     WITH A PLANT FACTOR OF 0.70

     STAFF, $1000/YR                     7018. (259 PERSONS AT $27096.)

     MAINTENANCE MATERIAL, $1000/YR      2964.
               FIXED                         2295.
               VARIABLE                       669.

     SUPPLIES AND EXPENSES, $1000/YR    11378.
               FIXED                         1694.
               VAR.  - PLANT                  295.
                     - ASH & FGD SLUDGE      9389.

     ADMIN. AND GENERAL, $1000/YR        1101.

     TOTAL FIXED COSTS, $1000/YR                  12107.
     TOTAL VARIABLE COSTS, $1000/YR               10353.
     TOTAL ANNUAL O & M COSTS, $1000/YR           22461.

     FIXED UNIT O & M COSTS, MILLS/KWH(E)          2.48
     VARIABLE UNIT O & M COSTS, MILLS/KWH(E)       2.12
     TOTAL UNIT O & M COSTS, MILLS/KWH(E)          4.60




     HEATING VALUE OF COAL, BTU/LB        11026.
     COAL BURNED, TONS/YEAR             2189465.
     PERCENT ASH                           11.60
     COST OF ASH DISPOSAL, $/TON            4.84
     PERCENT SULFUR                         3.50
     SULFUR (ORIGINAL),TONS/YR            76631.
     TONS LIMESTONE PER TON SULFUR          4.00
     TONS/YEAR LIMESTONE                 306525.
     COST OF LIMESTONE, $/TON              12.10
     COST OF SLUDGE DISPOSAL, $/DRY TON    14.52
```

TABLE 7-12

ENERGY ECONOMIC DATA BASE
(Constant $1980)

SUMMARY OF ANNUAL NONFUEL OPERATION AND MAINTENANCE COSTS FOR BASE-LOAD STEAM-ELECTRIC POWER PLANTS IN 1980.0

PLANT TYPE IS CGCC
WITH NATURAL DRAFT DRY COOLING TOWER
NUMBER OF UNITS PER STATION 1
WITH FGD SYSTEMS
THERMAL INPUT PER UNIT IS 1523 MWt
PLANT NET HEAT RATE 8250
PLANT NET EFFICIENCY, PERCENT 41.37
EACH UNIT IS 630 MWe NET RATING
ANNUAL NET GENERATION, MILLION kWh 3863
WITH A PLANT FACTOR OF 0.70

STAFF, $1000/YR	5058.	
MAINTENANCE MATERIAL, $1000/YR	1866.	
FIXED		1406.
VARIABLE		460.
SUPPLIES AND EXPENSES, $1000/YR	2569.	
FIXED		1404.
VARIABLE - PLANT		354.
- ASH & SULFUR DISPOSAL		811.
ADMINISTRATIVE AND GENERAL, $1000/YR	992.	
TOTAL FIXED COSTS, $1000/YR		8860.
TOTAL VARIABLE COSTS, $1000/YR		1625.
TOTAL ANNUAL O&M COSTS, $1000/YR		10485.
FIXED UNIT O&M COSTS, MILLS/kWh (E)		2.29
VARIABLE UNIT O&M COSTS, MILLS/kWh (E)		.42
TOTAL UNIT O&M COSTS, MILLS/kWh (E)		2.71

TABLE 7-13
ENERGY ECONOMIC DATA BASE

Effective Date - 1/1/80

STAFF REQUIREMENT FOR LWR POWER PLANTS

	UNIT SIZE RANGE MW(E)							
	400-700				701-1600			
	NO. UNITS PER SITE				NO. UNITS PER SITE			
	1	2	3	4	1	2	3	4
PLANT MANAGER'S OFFICE								
MANAGER	1	1	1	1	1	1	1	1
ASSISTANT	1	2	3	4	3	2	3	4
QUALITY ASSURANCE	3	4	5	6	3	4	5	6
ENVIRONMENTAL CONTROL	1	1	1	1	1	1	1	1
PUBLIC RELATIONS	1	1	1	1	1	1	1	1
TRAINING	1	1	2	2	12	1	2	2
SAFETY	1	1	1	1	1	1	1	1
ADMIN. & SERVICES	13	15	17	19	13	15	17	19
HEALTH SERVICES	1	1	1	2	1	1	1	2
SECURITY	56	56	56	66	105	56	56	66
SUBTOTAL	79	83	88	103	141	83	88	103
OPERATIONS								
SUPERVISION (EXC. SHIFT)	2	2	4	4	2	2	4	4
SHIFTS	28	48	68	88	53	58	83	108
SUBTOTAL	30	50	72	92	55	60	87	112
MAINTENANCE								
SUPERVISION	8	8	10	12	9	8	10	12
CRAFTS	14	22	30	38	38	26	36	46
PEAK MAINT. ANNUALIZED	55	110	165	220	66	110	165	220
SUBTOTAL	77	140	205	270	113	144	211	278
TECHNICAL AND ENGINEERING								
REACTOR	1	2	3	4	1	2	3	4
RADIO-CHEMICAL	2	2	3	4	2	2	3	4
I & C	2	2	3	4	2	2	3	4
PERFORM., REPORTS, TECH.	17	21	25	29	17	21	25	29
SUBTOTAL	22	27	34	41	22	27	34	41
TOTAL	208	300	399	506	331	314	420	534
LESS SECURITY	152	244	343	440	226	258	364	468
LESS SEC., PEAK MAINT	97	134	178	220	160	148	199	248

TABLE 7-14
ENERGY ECONOMIC DATA BASE

Effective Date - 1/1/80

STAFF REQUIREMENT FOR HTGR POWER PLANTS

	UNIT SIZE RANGE MW(E) 700-1600			
	NO. UNITS PER SITE			
	1	2	3	4
PLANT MANAGER'S OFFICE				
MANAGER	1	1	1	1
ASSISTANT	3	2	3	4
QUALITY ASSURANCE	3	4	5	6
ENVIRONMENTAL CONTROL	1	1	1	1
PUBLIC RELATIONS	1	1	1	1
TRAINING	12	1	2	2
SAFETY	1	1	1	1
ADMIN. & SERVICES	13	15	17	19
HEALTH SERVICES	1	1	1	2
SECURITY	105	56	56	66
SUBTOTAL	141	83	88	103
OPERATIONS				
SUPERVISION (EXC. SHIFT)	2	2	4	4
SHIFTS	53	58	83	108
SUBTOTAL	55	60	87	112
MAINTENANCE				
SUPERVISION	9	8	10	12
CRAFTS	38	26	36	46
PEAK MAINT. ANNUALIZED	66	110	165	220
SUBTOTAL	113	144	211	278
TECHNICAL AND ENGINEERING				
REACTOR	1	2	3	4
RADIO-CHEMICAL	2	2	3	4
I & C	2	2	3	4
PERFORM., REPORTS, TECH.	17	21	25	29
SUBTOTAL	22	27	34	41
TOTAL	331	314	420	534
LESS SECURITY	226	258	364	468
LESS SEC., PEAK MAINT	160	148	199	248

TABLE 7-15
ENERGY ECONOMIC DATA BASE

Effective Date - 1/1/80

STAFF REQUIREMENT FOR PHWR POWER PLANTS

	UNIT SIZE RANGE MW(E) 700-1600			
	NO. UNITS PER SITE			
	1	2	3	4
PLANT MANAGER'S OFFICE				
MANAGER	1	1	1	1
ASSISTANT	3	2	3	4
QUALITY ASSURANCE	3	4	5	6
ENVIRONMENTAL CONTROL	1	1	1	1
PUBLIC RELATIONS	1	1	1	1
TRAINING	12	1	2	2
SAFETY	1	1	1	1
ADMIN. & SERVICES	13	15	17	19
HEALTH SERVICES	1	1	1	2
SECURITY	105	56	56	66
SUBTOTAL	141	83	88	103
OPERATIONS				
SUPERVISION (EXC. SHIFT)	2	2	4	4
SHIFTS	53	58	83	108
SUBTOTAL	55	60	87	112
MAINTENANCE				
SUPERVISION	9	8	10	12
CRAFTS	38	26	36	46
PEAK MAINT. ANNUALIZED	47	72	118	154
SUBTOTAL	94	106	164	212
TECHNICAL AND ENGINEERING				
REACTOR	1	2	3	4
RADIO-CHEMICAL	2	2	3	4
I & C	2	2	3	4
PERFORM., REPORTS, TECH.	17	21	25	29
SUBTOTAL	22	27	34	41
TOTAL	312	276	373	468
LESS SECURITY	207	220	317	402
LESS SEC., PEAK MAINT	160	148	199	248

TABLE 7-16

ENERGY ECONOMIC DATA BASE

STAFF REQUIREMENT FOR HTGR-PROCESS STEAM COGENERATION POWER PLANTS

UNIT SIZE MW(t)*
1170
NO. UNITS PER SITE

	1	2	3	4
PLANT MANAGER'S OFFICE				
MANAGER	1			
ASSISTANT	3			
QUALITY ASSURANCE	3			
ENVIRONMENTAL CONTROL	1			
PUBLIC RELATIONS	1			
TRAINING	12			
SAFETY	1			
ADMIN. & SERVICES	13			
HEALTH SERVICES	1			
SECURITY	53			
SUBTOTAL	89			
OPERATIONS				
SUPERVISION (EXC. SHIFT)	2			
SHIFTS	27			
SUBTOTAL	29			
MAINTENANCE				
SUPERVISION	5			
CRAFTS	19			
PEAK MAINT. ANNUALIZED	33			
SUBTOTAL	57			
TECHNICAL AND ENGINEERING				
REACTOR	1			
RADIO-CHEMICAL	2			
I & C	2			
PERFORM., REPORTS, TECH	6			
SUBTOTAL	11			
TOTAL	186			
LESS SECURITY	133			
LESS SEC., PEAK MAINT	100			

*Process Steam - Cogeneration Plant

TABLE 7-17
ENERGY ECONOMIC DATA BASE

Effective Date - 1/1/80

STAFF REQUIREMENT FOR LMFBR POWER PLANTS

	UNIT SIZE RANGE MW(E) 700-1600			
	NO. UNITS PER SITE			
	1	2	3	4
PLANT MANAGER'S OFFICE				
MANAGER	1	1	1	1
ASSISTANT	3	2	3	4
QUALITY ASSURANCE	3	4	5	6
ENVIRONMENTAL CONTROL	1	1	1	1
PUBLIC RELATIONS	1	1	1	1
TRAINING	12	1	2	2
SAFETY	1	1	1	1
ADMIN. & SERVICES	13	15	17	19
HEALTH SERVICES	1	1	1	2
SECURITY	115	66	66	76
SUBTOTAL	151	93	98	113
OPERATIONS				
SUPERVISION (EXC. SHIFT)	2	2	4	4
SHIFTS	53	58	83	108
SUBTOTAL	55	60	87	112
MAINTENANCE				
SUPERVISION	9	8	10	12
CRAFTS	38	26	36	46
PEAK MAINT. ANNUALIZED	66	110	165	220
SUBTOTAL	113	144	211	278
TECHNICAL AND ENGINEERING				
REACTOR	1	2	3	4
RADIO-CHEMICAL	2	2	3	4
I & C	2	2	3	4
PERFORM., REPORTS, TECH.	17	21	25	29
SUBTOTAL	22	27	34	41
TOTAL	341	324	430	544
	===	===	===	===
LESS SECURITY	226	258	364	468
LESS SEC., PEAK MAINT	160	148	199	248

TABLE 7-18
ENERGY ECONOMIC DATA BASE

Effective Date - 1/1/80

STAFF REQUIREMENT FOR COAL-FIRED POWER PLANTS WITH FGD SYSTEMS

	UNIT SIZE RANGE MW(E)							
	400-700				701-1600			
	NO. UNITS PER SITE				NO. UNITS PER SITE			
	1	2	3	4	1	2	3	4
PLANT MANAGER'S OFFICE								
MANAGER	1	1	1	1	1	1	1	1
ASSISTANT	1	2	3	4	1	2	3	4
ENVIRONMENTAL CONTROL	1	1	1	1	1	1	1	1
PUBLIC RELATIONS	1	1	1	1	1	1	1	1
TRAINING	1	1	1	1	1	1	1	1
SAFETY	1	1	1	1	1	1	1	1
ADMIN. & SERVICES	13	14	15	16	13	14	15	16
HEALTH SERVICES	1	1	1	2	1	1	1	2
SECURITY	7	7	9	14	7	7	9	14
SUBTOTAL	27	29	33	41	27	29	33	41
OPERATIONS								
SUPERVISION (EXC. SHIFT)	3	3	5	5	3	3	5	5
SHIFTS	45	50	60	65	45	50	60	65
FUEL AND LIMESTONE REC.	12	12	12	18	12	12	12	18
WASTE SYSTEMS	15	30	45	60	15	30	45	60
SUBTOTAL	75	95	122	148	75	95	122	148
MAINTENANCE								
SUPERVISION	8	8	10	12	8	8	10	12
CRAFTS	90	115	135	155	95	120	140	160
PEAK MAINT. ANNUALIZED	33	66	99	132	35	70	105	140
SUBTOTAL	131	189	244	299	138	198	255	312
TECHNICAL AND ENGINEERING								
WASTE	1	2	3	4	1	2	3	4
RADIO-CHEMICAL	2	2	3	4	2	2	3	4
I & C	2	2	3	4	2	2	3	4
PERFORM., REPORTS, TECH.	14	17	21	24	14	17	21	24
SUBTOTAL	19	23	30	36	19	23	30	36
TOTAL	252	336	429	524	259	345	440	537

SECTION 8

8.0 REFERENCES AND GLOSSARY

8.1 REFERENCES AND BIBLIOGRAPHY

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8.2 GLOSSARY OF ACRONYMS AND ABBREVIATIONS

8.2.1 *Governmental Organizations*

AEC	- Atomic Energy Commission (Succeeded first by ERDA and then by DOE)
ANL	- Argonne National Laboratory
BNL	- Brookhaven National Laboratory
COO	- Chicago Operations Office - DOE
DOD (DoD)	- Department of Defense
DOE (DoE)	- Department of Energy (Successor to ERDA and AEC)
DOI	- Department of the Interior
EIA	- Energy Information Administration
EPA	- Environmental Protection Agency
ERDA	- Energy Research and Development Administration (Succeeded AEC and was then superseded by DOE)
FEA	- Federal Energy Administration
FERC	- Federal Energy Regulatory Commission
HEDL	- Hanford Engineering Development Laboratory
LASL	- Los Alamos Scientific Laboratory
LLL	- Lawrence Livermore Laboratory
NRC	- Nuclear Regulatory Commission
ORNL	- Oak Ridge National Laboratory
SC	- Sandia Corporation
SL	- Sandia Laboratories
US	- United States

8.2.2 Other Organizations

ADL	- Arthur D. Little, Inc.
ASTM	- American Society for Testing Materials
CE	- Combustion Engineering, Inc.
EEI	- Edison Electric Institute
EPRI	- Edison Power Research Institute
GAC	- General Atomic Company
GE	- General Electric Company
NUS	- NUS Corporation (Formuerly Nuclear Utility Services Corporation)
UE&C	- United Engineers & Constructors Inc. (A Raytheon Subsidiary)
UMW	- United Mine Workers
WE WECO	- Westinghouse Electric Corporation

8.2.3 Technical Identification and Programs

BBL - Barrels

bbl/d - Barrels per day

BOP - Balance of Plant

Btu
BTU - British Thermal Unit
= 1055 Joules

BWR - Boiling Water Reactor

C - Temperature - Degrees Celsius
(sometimes - incorrectly - Centigrade)

CANDU - CANadian Deuterium Uranium
(Alternate designation for PHWR)

CAP - Net Electrical Capacity

CF - Capacity Factor

CGCC - Coal Gasification Combined Cycle Plant

CO - Carbon Monoxide

CO_2 - Carbon Dioxide

CONCICE - CONceptual Construction Investment Cost Estimate -
UE&C Proprietary Code

COS - Carbonyl Sulfide - Carbon Oxysulfide

CPGS - Comparison Power Generating Station

CRBR - Clinch River Breeder Reactor

CY
cy - Calendar Year

CY - Cubic Yard - yd^3

e_i - Escalation rate for money inflation - %/y

e_s - Escalation rate for scarcity - reduced
productivity - %/y

8.2.3 (Cont'd)

EBR - Experimental Breeder Reactor (Two versions: -I and -II)

EEDB - Energy Economic Data Base

EHS - Eastern High Sulfur Coal

F - Temperature - Degrees Fahrenheit

FBR - Fast Breeder Reactor

FCR - Fixed Charge Rate

FGD - Flue Gas De-Sulfurization

FIT - Federal Income Tax

FPGS - Fossil Fired Power (Electrical) Generating Station

FUELCOST-V - A NUS proprietary code

FY - Fiscal Year
fy

GCFR - Gas Cooled Fast (Breeder) Reactor (Sometimes GCFBR)

GCR - Gas Cooled Reactor - general designation for all gas-cooled reactor systems

GESSAR - General Electric Standard Safety Analysis Report

GSU - Generator Step-Up Transformer

GW - Gigawatt = 10^9 Watts

h - Hour

HLW - High Level Waste (Radioactive)

HM - Heavy Metal - fuels containing mixtures of U + Pu, U + Th, Pu + Th

HP - Horsepower

hr - Hour

HR - Net Station Heat Rate in Btu/kWh

HS - High Sulfur ($\geq$ 1.0%)

8.2.3 (Cont'd)

HSC - High Sulfur Coal

HS8 - High Sulfur 800 MWe Coal-Fired Power Generating Station

HS12 - High Sulfur 1200 MWe Coal-Fired Power Generating Station

HTGR - High Temperature Gas (Cooled) Reactor

H_2S - Hydrogen Sulfide

HWR - Heavy Water Reactor

I&C - Instrumentation and Control

in HgA - Inches of Mercury Pressure - Absolute
= 25.4 Torr

kgH - Kilograms Heavy Metal
kgHM

kgU - Kilograms Uranium

kV - Volts x 10^3 - Kilovolts

kVA - Volt Amperes x 10^3 - Kilovolt-Amperes

kW - Watts x 10^3 - Kilowatt = 3414 Btu/hr

kWh - Kilowatt-Hour - 3414 Btu

LB (lb.) - Pound(s)

LF - Linear Feet

LF - Levelization Factor

LMFBR - Liquid Metal Fast Breeder Reactor

LS - Low Sulfur ($\leq$1.0%)

LS8 - Low Sulfur 800 MWe Coal-Fired Power Generating Station

LS12 - Low Sulfur 1200 MWe Coal-Fired Power Generating Station

LT - Lot

LWR - Light Water Reactor (includes BWR and PWR)

8.2.3 (Cont'd)

m	- Minute
¢/MBtu	- Cents per Btu x 10^6
$/MBtu	- Dollars per Btu x 10^6
min	- Minute
m/kWh	- Mills per Kilowatt Hour - $ x 10^{-3} per kWh
mm Hg	- Millimeter of Mercury Pressure
MOX	- Mixed Oxide Fuel - Mixed UO_2 - PuO_2 Fuel
MT	- Metric Tons - 2205 Pounds
MTH MTHM	- Metric Tons of Heavy Metal - HM
MTU	- Metric Tons of Uranium
MVA	- Volt Amperes x 10^6
MW	- Watts x 10^6 - Megawatt
MWd/MT	- Megawatt-Days per Metric Ton
MWD/T	- Megawatt-Days per Ton
MWe	- MegaWatts (Watts x 10^6) - Electrical
MWt	- MegaWatts (Watts x 10^6) - Thermal
Na	- Element No. 11 - Sodium - Liquid Metal Coolant
NaK	- Sodium/Potassium - Liquid Metal Coolant Mixture
NASAP	- Nonproliferation Alternative Systems Assessment Program

NASAP Codes
- (DE) - Denatured (U-233/U-235 mixed with U-238)
- (HE) - High Enrichment
- (LE) - Low Enrichment (in U-235)
- (ME) - Medium Enrichment

8.2.3 (Cont'd)

NASAP CODES (Continued)

- (NAT) - Natural Uranium - 0.7 w/o U-235
- Pu - Plutonium (Fissile Pu)
- RE - Reprocess
- T - Throwaway
- Th - Thorium
- 20% - 20 Weight Percent U-235
- U - Uranium
- U5 - Uranium-235
- U3 - Uranium-233

NNS - Non-Nuclear Safety

Np - Element No. 93, Neptunium - Does not occur in nature - intermediate in formation of Pu-239

NPGS - Nuclear Power (Electrical) Generating Station

NS - Nuclear Safety

O&M - Operation and Maintenance

OMCOST - An ORNL code for Operation and Maintenance costs

Pa - Element No. 91 - Protactinium

PEGASUS - Power Plant Economic Generator And Scale-Up System - UE&C Proprietary Code

PHS - Pittsburgh High Sulfur (Steam) Coal

PHWR - Pressurized Heavy Water Reactor

PLBR - Prototype Large Breeder Reactor

PSI (psi) - Pounds per Square Inch

PSIA (psia) - Pounds per Square Inch - Absolute

PSIG (psig) - Pounds per Square Inch - Gauge (14.7 psia = 0 psig)

Pu - Element No. 94 - Plutonium - Does not occur in nature; two isotopes thermally fissile Pu-239, Pu-241

8.2.3 (Cont'd)

PuO_2 - Plutonium Dioxide

Pu_2O_3 - Plutonium Sesquioxide

Pu-241 - Thermally Fissile Isotopes of Pu produced by neutron
Pu-239 capture in U-238

PWR - Pressurized Water Reactor

QA - Quality Assurance

QC - Quality Control

r - Revolutions
rev

RESAR - Westinghouse Reference Safety Analysis Report

ROI - Return on Investment

RPCW - Reactor Plant Cooling Water

RPM - Revolutions per Minute
r/m

s - Second

SCF - Standard Cubic Feet - one cubic foot of gas at 0°C and 760 Torr

SCFD Standard Cubic Feet (per) Day
SCF/D - (Also SCFM (per minute) and SCFH (per hour)
scf/d @ 760 Torr and 0°C)

sec - Second

SF - Square Feet - ft^2

SO_2 - Sulfur Dioxide

SRC - Solvent Refined Coal

ST - Tons - a short ton = 2000 pounds

SWU - Separative Work Unit - for Uranium Enrichment

TEC - Thermal Energy Costs

Th - Element No. 90, Thorium - fertile Th-232 - the naturally occuring Th isotope $\sim$100% abundance

8.2.3 (Cont'd)

TM-xxxx - Technical Memorandum

\$/t-mi - Dollars per Ton Mile (coal transportation)

TN - Ton(s) - A short ton = 2000 pounds

Torr - Torricelli - 1 mm mercury; 760 Torr = 1 atmosphere = 14.7 pounds/in.^{2}

U - Element No. 92 - Uranium

UC - Uranium Monocarbide (also uranium carbide)

UC_2 - Uranium Dicarbide

U_2C_3 - Uranium Sesquioxide

UF_6 - Uranium Hexafloride (Gas)

UO_2 - Uranium Dioxide - Fuel

U_3O_8 - Triuranium Octoxide - Raw Uranium Oxide Yellowcake - Uranium Oxide

U-233 - Thermally Fissile Isotope of Uranium produced by neutron irradiation of Th-232

U-235 - Thermally Fissile Isotope of Uranium; only naturally occurring fissile element - abundance 0.7%

U-238 - Not Thermally Fissile Isotope of Uranium; most abundant naturally occurring, abundance 99.3% fertile target for production of thermally fissile Pu-239

Watt - Btu/HR x 3.414 Watts/hr = Btu

W(e) - Watts - Electrical

W(+) - Watts - Thermal

WLS - Western Low Sulfur Coal

$\left.\begin{array}{l}\text{Y}\\\text{yr}\end{array}\right\}$ - Year = 8760 Hours = 3.154×10^7 sec.

APPENDIX - A1

PHASE III FINAL REPORT AND THIRD UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

APPENDIX A-1

DESCRIPTION OF STANDARD HYPOTHETICAL MIDDLETOWN SITE FOR NUCLEAR POWER PLANTS

SITE DESCRIPTION

A1.1 GENERAL

This site description provides the site and environmental data, derived from Appendix A of "Guide for Economic Evaluation of Nuclear Reactor Plant Designs", USAEC Report NUS-531, modified to reflect current requirements. These data form the bases of the criteria used for designing the facility and for evaluating the routine and accidental release of radioactive liquids and gases to the environment.

A1.2 TOPOGRAPHY AND GENERAL SITE CHARACTERISTICS

The site is located on the east bank of the North River at a distance of twenty-five miles south of Middletown, the nearest large city. The North River flows from north to south and is one-half mile (2600 ft) wide adjacent to the plant site. A flood plain extends from both river banks an average distance of one-half mile, ending with hilltops generally 150 to 250 ft above the river level. Beyond this area, the topography is gently rolling, with no major critical topographical features. The plant site itself extends from river level to elevations of 50 ft above river level. The containment building, other seismic Category I structures and the switchyard are located on level ground at an elevation of 18 ft above the mean river level. This elevation is ten feet above the 100-year maximum river level, according to U.S. Army Corps of Engineers' studies of the area.

In order to optimize land area requirements for the nuclear power plant site, maximum use of the river location is employed. The containment structure is located approximately 400 ft from the east bank of the river. The site land area is taken as approximately 500 acres.

A1.3 SITE ACCESS

Highway access is provided to the hypothetical site by five miles of secondary road connecting to a state highway; this road is in good condition and needs no additional improvements. Railroad access is provided by the construction of a spur which intersects the B&M Railroad. The length of the required spur from the main line to the plant site is assumed to be five miles in length. The North River is navigable throughout the year with a 40 ft wide by 12 ft deep channel. The distance from the shoreline to the center of the ship channel is 2000 ft. All plant shipments are assumed to be made overland except that heavy equipment (such as reactor vessel and generator stator) may be transported by barge. The Middletown Municipal Airport is located three miles west of the State highway, 15 miles south of Middletown, and ten miles north of the site.

A1.4 POPULATION DENSITY AND LAND USE

The hypothetical site is near a large city (Middletown, 250,000 population) but in an area of low population density. Variation in population with distance from the site boundary is:

Miles	Cumulative Population
0.5	0
1.0	310
2.0	1,370
5.0	5,020
10.0	28,600
20.0	133,000
30.0	1,010,000

There are five industrial manufacturing plants within 15 miles of the hypothetical site. Four are small plants, employing less than 100 people each. The fifth, near the airport, employs 2,500 people. Closely populated areas are found only in the centers of the small towns so that the local land area used for housing is small. The remaining land, including that across the river, is used as forest or cultivated crop land, except for railroads and highways.

A1.5 NEARBY FACILITIES

Utilities are available as follows:

- Natural gas service is available two miles from the site boundary on the same side of the river.
- Communication lines are furnished to the project boundaries at no cost.
- Power and water for construction activities are available at the southwest corner of the site boundary.
- Two independent offsite power sources (one at 500 kV and one at 230 kV) are available at the switchyard.

A1.6 METEOROLOGY AND CLIMATOLOGY

A1.6.1 Ambient Temperatures

The winters in the Middletown area are moderately cold, with average temperatures in the low 30s. The summers are fairly humid with average temperatures in the low 70s, and with high temperatures averaging around 82°F. The historic maximum wet bulb and dry bulb temperatures are 78°F and 99°F respectively.

The year-round temperature duration curves for the dry bulb temperatures and coincident wet bulb temperatures are shown in Figure A1.1.

A1.6.2 Prevailing Wind

According to Weather Bureau records at the Middletown Airport, located ten miles north of the site on a low plateau just east of the North River, surface winds are predominantly southwesterly 4 - 10 knots during the warm months of the year, and westerly 6 - 13 knots during the cool months.

There are no large diurnal variations in wind speed or direction. Observations of wind velocities at altitudes indicate a gradual increase in mean velocity and a gradual veering of the prevailing wind direction from southwest and west near the surface to westerly and northwesterly aloft.

In addition to the above, studies of the area indicate that there is a significant channeling of the winds below the surrounding hills into the north-south orientation of the North River. It is estimated that winds within the river valley blow approximately parallel to the valley orientation in excess of 50 percent of the time.

A1.6.3 Atmospheric Diffusion Properties

The transport and dilution of radioactive materials in the form of aerosols, vapors or gases released into the atmosphere from the Middletown nuclear power station are a function of the state of the atmosphere along the plume path, the topography of the region, and the characteristics of the effluents themselves. For a routine airborne release, the concentration of radioactive materials in the surrounding region depends on the amount of effluent released, the height of the release, the wind speed, atmospheric stability, and airflow patterns of the site, and various effluent removal mechanisms. Geographic features such as hills and valleys influence diffusion and airflow patterns.

Of the diffusion models that have been developed, the straight-line trajectory model is utilized to calculate the atmospheric diffusion from the Middletown site.

The straight-line trajectory model assumes that the airflow transports and diffuses effluents along a straight line through the entire region of interest in the airflow direction at the release point. The version of this model which is used is the Gaussian straight-line trajectory model. In this model, the wind speed and atmospheric stability at the release point are assumed to determine the atmospheric diffusion characteristics in the direction of airflow.

A long-term continuous release is assumed whose effluent is distributed evenly across a 22-1/2 degree sector. The model treats elevated-only, ground-level only, or mixed elevated-ground level releases, as determined by the interaction of plant characteristics and wind speeds.

For elevated releases, the basic equation, modified from Turner (1970), is:

$$\frac{\bar{X}}{Q}(x,k) = \frac{2.032 \cdot RF_k(x)}{x} \sum_{ij} \frac{DEPL_{ijk}(x) \cdot DEC_i(x) \cdot f_{ijk} \exp - \left(\frac{1}{2} \; \frac{h_e^2}{\sigma^2_{zj}(x)} \right)}{\bar{u}_i \, \sigma_{zj}(x)} \qquad (1)$$

where

$\frac{\bar{X}}{Q}(x,k)$ = average effluent concentration normalized by source strength at distance x and direction k;

$\bar{u}_i$ = mid-point values of the ith wind speed class;

$\sigma_{zj}(x)$ = vertical (z) spread of effluent at distance x for the jth stability class;

f_{ijk} = joint probability of the ith wind speed class, jth stability class, and kth wind direction;

x = downwind distance from release point or building;

h_e = effective plume height;

$DEC_i(x)$ = reduction factor due to radioactive decay at distance x for the ith wind speed class;

$DEPL_{ijk}(x)$ = reduction factor due to plume depletion at distance x for the ith wind speed class, jth stability class, and kth wind direction; and

$RF_k(x)$ = correction factor for air recirculation and stagnation at distance x and kth wind direction.

Ground release concentrations are calculated using the following two equations modified from Turner (1970):

$$\frac{\bar{X}}{Q}(x,k) = \frac{2.032}{x} RF_k(x) \sum_{ij} DEPL_{ijk}(x) \cdot DEC_i(x) \cdot f_{ijk} \left[\bar{u}_i \left(\sigma_{zj}^2(x) + D_z^2/\pi \right)^{1/2} \right]^{-1} \quad (2)$$

$$\frac{\bar{X}}{Q}(x,k) = \frac{2.032}{x} RF_k(x) \sum_{ij} DEPL_{ijk}(x) \cdot DEC_i(x) \cdot f_{ijk} \left(\sqrt{3}\, \bar{u}_i\, \sigma_{zj}(x) \right)^{-1} \quad (3)$$

Where D_z is the building height which is used to describe the dilution due to the building wake, from Yanskey, et al (1966). Equation 3 represents the maximum building wake dilution allowed; the higher value of $\overline{X/Q}$ calculated from Equations 2 and 3 is utilized.

Values of $\frac{\bar{X}}{Q}(x,k)$ are calculated at 22 downwind distances between 0.25 and 50 miles. Each of the 16 directional sectors are divided into 10 downwind segments and an average value is determined for each sector as follows:

$$(X/Q)_{seg} = \frac{R_1\ (X/Q)_{R_1} + r_1\ (X/Q)_{r_1} + \cdots + r_n\ (X/Q)_{r_n} + R_2\ (X/Q)_{R_2}}{R_1 + r_1 + \cdots + r_n + R_2} \qquad (4)$$

where

$\overline{(X/Q)}_{seg}$ = average value of $\overline{X/Q}$ for the segment;

$\overline{(X/Q)}_r$ = $\frac{\overline{X}}{Q}(x = r, k)$ calculated at distance r;

R_1, R_2 = the downwind distance of the segment boundaries; and

$r_1 \ldots r_2$ = selected radii between R_1 and R_2.

The effluent plume is depleted via dry deposition using Figures 2 through 5 of Regulatory Guide 1.111, Rev. 1 (1977). These depletion factors are adjusted for changes in topography.

From Slade (1968) the reduction factor due to radioactive decay is:

$$DEC = EXP\ (-.693\, t_i / T) \qquad (5)$$

where

$$t_i = x/(86400\, \bar{u}_i), \qquad (6)$$

such that DEC = reduction factor due to radioactive decay;

T = half life, in days, of the radioactive material;

t_i = travel time, in days;

x = travel distance, in meters; and

$\bar{u}_i$ = midpoint of the windspeed class, in meters/second.

Finally, for the Middletown site, the $\overline{X/Q}$ values are amended so that they are not substantially underestimated due to the effects of the regional recirculation and stagnation of the air. For downvalley airflow, the relative concentrations are multiplied by five for distances less than 20 miles. For upvalley airflow, the concentrations are multiplied by 1.5 for all distances.

The relative deposition per unit area, $\overline{D/Q}$, is calculated by sector for 22 downwind distances and 10 downwind segments between 0.25 and 50 miles. Elevated-only, ground-level only, or mixed elevated-ground level release are utilized depending on the ratio of the effluent exit velocity to the exit level windspeed.

For a 22-1/2 degree sector, the basic equation to calculate the average D/Q for a specified downwind distance is:

$$\frac{\bar{D}}{Q}(x,k) = \frac{RF_k(x) \cdot \sum_{ij} D_{ij} \, f_{ijk}}{(2\pi/16)x} \tag{7}$$

where

$\frac{\bar{D}}{Q}(x,k)$ = average relative deposition per unit area at a downwind distance x and direction k, in meters^{-2};

D_{ij} = the relative deposition rate from Figures 6 through 9 of Regulatory Guide 1.111 for the ith wind speed class (since plume height is dependent on windspeed) and jth stability class, in meters^{-1};

f_{ijk} = joint probability of the ith windspeed class, jth stability class, and kth wind direction;

x = downwind distance, in meters; and

$RF_k(x)$ = correction factor for air recirculation and stagnation at distance x and kth wind direction.

Equation 4 is used to calculate average values of D/Q for the downwind segments, with D replacing X in the equation.

A1.6.4 Severe Meteorological Phenomena

A maximum instantaneous wind velocity of 100 mph has been recorded at the site. During the past 50 years, three tropical storms, all of them in the final dissipation stages, have passed within 50 miles of the site. Some heavy precipitation and winds in excess of 40 miles per hour were recorded, but no significant damage other than to crops resulted.

The area near the site experiences an average of 35 thunderstorms a year, with maximum frequency in early summer. High winds near 60 mph, heavy precipitation, and hail are recorded about once every four years.

In forty years of record keeping, there have been twenty tornadoes reported within fifty miles of the site. This moderately high frequency of tornado activity indicates a need to design Seismic Category I structures at the site for the possibility of an on-site tornado occurrence. Maximum tornado frequency occurs in May and June.

During the past forty years, there have been ten storms in which freezing rain has caused power transmission line disruptions. Most of these storms have occurred in early December.

A1.6.5 Potential Accident Release Meteorology

In the event of an accidental release of fission products to the atmosphere, transport and diffusion is determined by the meteorological conditions at the site for the duration of the accident, which is assumed to be 30 days.

The methodology required to calculate radiation dosages from accidental releases involves a series of procedures. The dosages are based upon a ground level release only. Each directional sector from the plant requires a separate X/Q value for the EAB (Exclusion Area Boundary) and the LPZ (Low Population Zone) distances. To evaluate the accident dosages, both the short-term ($\leq$ 2 hrs) and the annual X/Q values are calculated. The annual X/Q value methodology is taken from Regulatory Guide 1.111, Section C.1.c with the effective height defined as:

$$h_e = h_s - h_t$$

where

h_s = stack height

h_t = terrain height

The short-term X/Q values are derived from the conditional equations

$$X/Q = 1/(\bar{u}_{10}\ \pi\ \Sigma_y\ \sigma_z) \tag{1}$$

$$X/Q = 1/\left[\bar{u}_{10}(\pi\ \sigma_y\ \sigma_z + A/2)\right] \tag{2}$$

$$X/Q = 1/(\bar{u}_{10}(3\pi\ \sigma_y\ \sigma_z)) \tag{3}$$

with

$\bar{u}_{10}$ = wind speed at ten meters above ground level,

σ_y, σ_z = horizontal and vertical dispersion coefficients,

A = minimum cross-sectional area of building from which effluent is released,

Σ_y = lateral plume spread; a function of atmospheric stability, wind speed and downwind distance.

For distances greater than 800 meters, $\Sigma_y = (M-1)\sigma_{y_{800\ m}} + \sigma_y$;

M is a function of atmospheric stability and wind speed, as presented in Regulatory Guide 1.145 (1979), Figure 1. For distances less than 800 meters, $\Sigma_y = M\sigma_y$.

The choice of the proper equation determining short-term χ/Q values depends upon the procedure below:

1. The higher χ/Q value is chosen between equations (2) and (3).
2. If the wind speed is less than 6m/sec and the stability class is greater than or equal to D (i.e.; D, E, F or G stabilities), then the lower χ/Q value given by equation (1) or by the higher value of equation (2) or (3) is chosen.

In other words, the values computed from equations (2) and (3) are compared and the higher value is selected. Then, if the meteorological conditions given in Item 2 above are true, the selected value computed from equation (2) or (3) is compared with the value from equation (1), and the lower of these two values is chosen.

The χ/Q value selected as the accident dosage is a function of the effective probability level P_e given by

$$P_e = \frac{P(N/n)}{S} \tag{4}$$

where

P = probability level which is mandated as five percent for a conservative estimate and 50 percent for realistic.

N = total number of valid observations.

n = total number of valid observations within a given sector.

S = number of sectors.

The short-term χ/Q values for each meteorological condition during a given time period are tallied in a cumulative distribution table and normalized to 100 percent. The χ/Q distributions for each direction are plotted on cumulative probability paper. The conservative and realistic average short-term χ/Q values are selected from the graph using the effective probability values. Logarithmic interpolation is performed between the graph-selected χ/Q values and the annual average χ/Q values at time intervals of eight hours, 16 hours, three days and 26 days for each sector and distance of interest. For each distance, the χ/Q accident values for the 16 directions are compared and the highest value is selected.

A1.7 HYDROLOGY

The North River provides an adequate source of raw make-up water for the station. The average maximum temperature is 75°F, and the average minimum is 39°F. The mean annual temperature is 57°F.

U.S. Army Corps of Engineers' studies indicate that the 100 year maximum flood level rose to eight feet above the mean river level. There are no dams near the site whose failure could cause the river to rise above the eight foot level.

A1.8 GEOLOGY AND SEISMOLOGY

A1.8.1 Soil Profiles and Load Bearing Characteristics

Soil profiles for the site show alluvial soil and rock fill to a depth of eight feet; Brassfield limestone to a depth of 30 ft; blue weathered shale and fossiliferous Richmond limestone to a depth of 50 ft; and bedrock over a depth of 50 ft. Allowable soil bearing is 6,000 psf and rock bearing characteristics are 18,000 psf and 15,000 psf for Brassfield and Richmond strata, respectively. No underground cavities exist in the limestone.

A1.8.2 Seismology

The site is located in a generally seismically inactive region. Historical records show three earthquakes have occurred in the region between 1870 and 1975. A safe shutdown earthquake (SSE) with a horizontal ground acceleration of 0.25 g provides conservative design margin. For design purposes, the horizontal and vertical component Design Response Spectra given in NRC Regulatory Guide 1.60, Rev. 1, December 1973, are linearly scaled to a horizontal ground acceleration of 0.25 g.

A1.9 SEWAGE AND RADIOACTIVE WASTE DISPOSAL

A1.9.1 Sewage

All sewage receive primary and secondary treatment prior to discharge into the North River.

A1.9.2 Gaseous and Liquid Radioactive Wastes

The gaseous and liquid effluent releases from this plant comply with 10 CFR Part 20 and the intent of Appendix I of 10 CFR Part 50.

A1.9.3 Solid Radioactive Wastes

Storage on site for decay is permissible but no ultimate disposal on site is planned.

References

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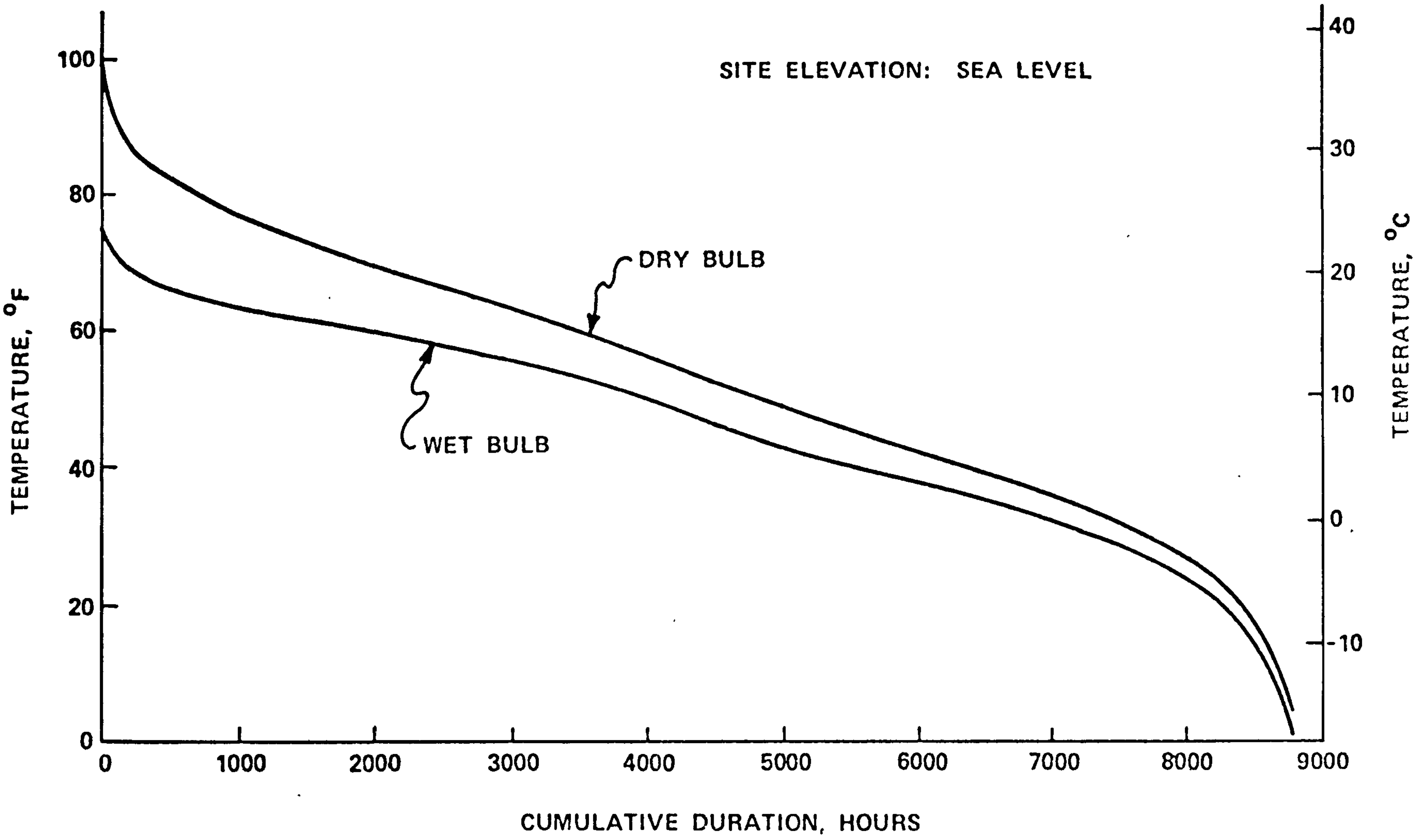
Yanskey, G. R., Markee, E. H., Jr., and Richter, A. P., Climatography of the National Reactor Testing Station, 1960, Idaho Operations Office, USAEC, IDO-12048, Idaho Falls, Idaho.

U.S. Nuclear Regulatory Commission, Regulatory Guide 1.145, Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants, July 1979, USNRC Office of Standards Development, Washington, D.C.

FIGURE A1.1

TEMPERATURE DURATION CURVES; MIDDLETOWN, U.S.A.



APPENDIX - A2

PHASE III FINAL REPORT AND THIRD UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

APPENDIX A-2

DESCRIPTION OF STANDARD HYPOTHETICAL MIDDLETOWN SITE FOR COAL-FIRED POWER PLANTS

SITE DESCRIPTION

A2.1 GENERAL

This site description provides the site and environmental data as derived from Appendix A of "Guide for Economic Evaluation of Nuclear Reactor Plant Designs", USAEC Report NUS-531, and modified to reflect coal plant siting. These data form the bases of the criteria used for designing the facility and for evaluating the release of liquids and gases to the environment.

A2.2 TOPOGRAPHY AND GENERAL SITE CHARACTERISTICS

The site is located on the east bank of the North River at a distance of approximately twenty-five miles south of Middletown, the nearest large city. The North River flows from north to south and is one-half mile (2600 ft) wide adjacent to the plant site. A flood plain extends from both river banks an average distance of one-half mile, ending with hilltops generally 150 to 250 ft above the river level. Beyond this area, the topography is gently rolling, with no major critical topographical features. The plant site itself extends from river level to elevations of 50 ft above river level. The primary structures and the switchyard are located on level ground at an elevation of 18 ft above the mean river level. This elevation is ten feet above the 100 year maximum river level, according to U.S. Army Corps of Engineers' studies of the area.

In order to optimize land area requirements for the coal fueled plant site, maximum use of the river location is employed. The primary structure is located 1200 ft from the east bank of the river. The site land area is approximately 500 acres. An additional 2,000 acres, approximately six miles from the plant site, are available for solid waste disposal.

A2.3 SITE ACCESS

Highway access is provided to the hypothetical site by five miles of secondary road connecting to a State highway. This road is in good condition and needs no additional improvements. Railroad access is provided by constructing a railroad spur which intersects the B&M Railroad. The length of the required spur from the main line to the plant site is assumed to be five miles in length. The North River is navigable throughout the year with a 40 ft wide by 12 ft deep channel. The distance from the shoreline to the center of the ship channel is 2,000 ft. All plant shipments are assumed to be made overland except that heavy equipment may be transported by barge. The Middletown Municipal Airport is located three miles west of the State highway, 15 miles south of Middletown, and ten miles north of the site.

A2.4 POPULATION DENSITY AND LAND USE

The hypothetical site is near a large city (Middletown, of 250,000 population) but in an area of low population density. Variation in population with distance from the site boundary is:

Miles	Cumulative Population
0.5	0
1.0	310
2.0	1,370
5.0	5,020
10.0	28,600
20.0	133,000
30.0	1,010,000

There are five industrial manufacturing plants within 15 miles of the hypothetical site. Four are small plants employing less than 100 people each. The fifth, near the airport, employs 2,500 people. Closely populated areas are found only in the centers of the small towns, so the total land area used for housing is small. The remaining land, including that across the river, is used as forest or cultivated crop land, except for railroads and highways.

A2.5 NEARBY FACILITIES

Utilities are available as follows:

- Natural gas service is available two miles from the site boundary on the same side of the river.
- Communication lines will be furnished to the project boundaries at no cost.
- Power and water for construction activities are available at the southwest corner of the side boundary.
- Two connections to the utility grid (one at 500 kV for the generator connection and one at 230 kV for the reserve auxiliary transformer connection) are available at the switchyard.

A2.6 METEOROLOGY AND CLIMATOLOGY

A2.6.1 Ambient Temperatures

The winters in the Middletown area are moderately cold, with average temperatures in the low 30s. The summers are fairly humid with average temperatures in the low 70s, and with high temperatures averaging around 82°F. The historic maximum wet bulb and dry bulb temperatures are 78°F and 99°F respectively.

The year-round temperature duration curves for the dry bulb temperatures and coincident wet bulb temperatures are shown in Figure A2.1.

A2.6.2 Prevailing Wind

According to Weather Bureau records at the Middletown Airport, located ten miles North of the site on a low plateau just east of the North River, surface winds are predominantly southwesterly 4-10 knots during the warm months of the year, and westerly 6-13 knots during the cool months.

There are no large diurnal variations in wind speed or direction. Observations of wind velocities at altitudes indicate a gradual increase in mean velocity and a gradual veering of the prevailing wind direction from southwest and west near the surface to westerly and northwesterly aloft.

In addition to the above, studies of the area indicate that there is a significant channeling of the winds below the surrounding hills into the north-south orientation of the North River. It is estimated that these winds within the river valley blow approximately parallel to the valley orientation in excess of 50 percent of the time.

A2.6.3 Atmospheric Diffusion Properties

The transport and dilution of materials in the form of aerosols, vapors, or gases released into the atmosphere from the Middletown coal power station are a function of the state of the atmosphere along the plume path, the topography of the region, and the characteristics of the effluents themselves. For a routine airborne release, the concentration of materials in the surrounding region depends on the amount of effluent released, the height of the release, the windspeed, atmospheric stability, and airflow patterns of the site, and various effluent removal mechanisms. Geographic features such as hills and valleys influence diffusion and airflow patterns.

Of the diffusion models that have been developed, the straight line trajectory model is utilized to calculate the atmospheric diffusion from the Middletown site.

The straight-line trajectory model assumes that the airflow transports and diffuses effluents along a straight line through the entire region of interest in the airflow direction at the release point. The version of this model which is used is the Gaussian straight-line trajectory model. In this model, the windspeed and atmospheric stability at the release point are assumed to determine the atmospheric diffusion characteristics in the direction of airflow.

A2.6.4 Severe Meteorological Phenomena

A maximum instantaneous wind velocity of 100 mph has been recorded at the site. During the past 50 years, three tropical storms, all of them in the final dissipation stages, have passed within 50 miles of the site. Some heavy precipitation and winds in excess of 40 miles/h were recorded, but no significant damage other than to crops resulted.

The area near the site experiences an average of 35 thunderstorms a year, with maximum frequency in early summer. High winds near 60 mph, heavy precipitation, and hail are recorded about once every four years.

In forty years of record, there have been twenty tornadoes reported within fifty miles of the site. Maximum tornado frequency occurs during the months of May and June.

During the past forty years, there have been ten storms in which freezing rain has caused power transmission line disruptions. Most of these storms have occurred early in December.

A2.6.5 Ambient Background Concentrations

Background concentrations of SO_2, NO_x and particulates are typical of a rural area approximately 30 miles from a major industrial metropolitan center. They are considered when determining the plant's adherence to the guidelines.

A2.6.6 Air Quality Estimation

Ambient pollutant levels are estimated through the application of atmospheric diffusion models. The estimates are based primarily upon the pollutant emissions, meteorology, topography, and background concentration as previously described. Modeling techniques described in the Turner Atmospheric Dispersion Workbook are used for concentration estimates.*

A2.7 HYDROLOGY

The North River provides an adequate source of raw makeup water for the station. The average maximum temperature is 75°F and the average minimum is 39°F. The mean annual temperature is 57°F.

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* Turner, D. B., "Workbook of Atmospheric Dispersion Estimates", Public Health Service Publication No. 999-AP-26, U.S. Department of Health, Education, and Welfare, Public Health Service, Consumer Protection and Environmental Health Service, National Air Pollution Control Administration, Cincinnati, Ohio, Revised 1969.

U.S. Army Corps of Engineers' studies indicate that the 100 year maximum flood level rose to eight feet above the mean river level. There are no dams near the site whose failure could cause the river to rise above the eight foot level.

A2.8 GEOLOGY AND SEISMOLOGY

A2.8.1 Soil Profiles and Load Bearing Characteristics

Soil profiles for the site show alluvial soil and rock fill to a depth of eight feet; Brassfield limestone to a depth of 30 ft; blue weathered shale and fossiliferous Richmond limestone to a depth of 50 ft; and bedrock over a depth of 50 ft. Allowable soil bearing is 6,000 psf and rock bearing characteristics are 18,000 psf and 15,000 psf for Brassfield and Richmond strata, respectively. No underground cavities exist in the limestone.

A2.8.2 Seismology

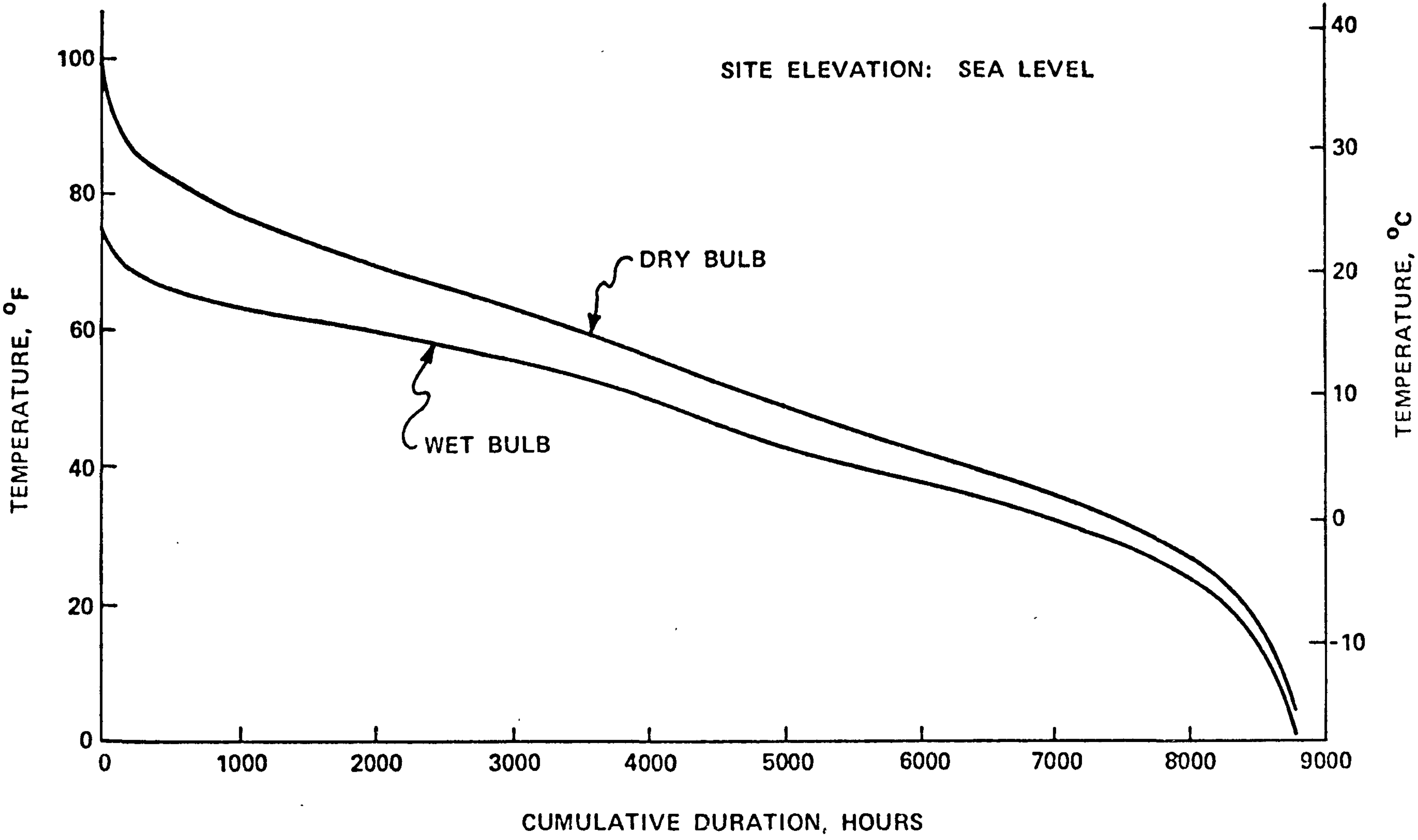
The site is located in a generally seismically inactive region. Historical records show three earthquakes have occurred in the region between 1870 and 1975.

A2.9 SEWAGE AND LIQUID EFFLUENTS

All sewage receives primary and secondary treatment prior to discharge into the North River. Other wastewater is discharged in compliance with EPA effluent standards as promulgated in 40 CFR 423.

FIGURE A2.1

TEMPERATURE DURATION CURVES; MIDDLETOWN, U.S.A.



APPENDIX - B

PHASE III FINAL REPORT AND THIRD UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

APPENDIX B

FIXED CHARGE RATES
(without Inflation)

B.1 GENERAL

Fixed charges consist of many components which vary markedly with such factors as charter and financial structure of electric utilities, local conditions, accounting methods, etc. Therefore, although in generalized studies an "average" fixed charge rate may be used, in practice that average will probably not apply to any individual company. The following discussion introduces the concepts involved and addresses methods of calculation of fixed charges applicable to investor-owned utilities.

For every investment made in a capital asset, the owner company commits itself to a program of payments over the life of that asset. These payments, or charges against income which the company expects to realize from its investment, are generally fixed in nature, related only to the actual initial investment, and independent of the actual usage of the asset. These payments are commonly called fixed charges (also referred to as annual or carrying charges) and represent the absolute minimum revenue requirements which the investment must command.

Because the investment in plant is recovered over its life by periodic depreciation or amortization charges, the net investment declines and consequently the fixed charges, as a percent of initial investment, vary from year to year. Therefore, it is convenient to know a "levelized" fixed charge value, which will incorporate not only the actual year by year values of fixed charges, but also the time variance in payments. This levelized annual value (or uniform annual equivalent) permits the engineer to make economic comparisons of alternative investment plans which may have quite different time schedules of fixed charge payments.

The levelized annual value is calculated as a weighted average of the actual year by year values. The weighting factors represent the time value of money and are called present-worth factors. The present-worth factor, akin to compound interest, is calculated from the expression $\frac{1}{(1 + R)^n}$ where "R" is the weighted cost of capital (1) or rate of return expressed as a decimal, and "n" is in years. To illustrate the concept, it is necessary to consider the total assets of the company as a bank or pool of money, where money borrowed is charged interest or money deposited in advance earns interest. Under this arrangement, consider the present worth of \$100 spent "n" years from now, where the weighted cost of capital is 3.50 percent per year:

n	Present-Worth
0	\$100.00
1	\$ 96.62 = $\frac{100}{1.035}$
5	\$ 84.20 = $\frac{100}{1.035^5}$

The table gives substance to the intuitive feeling that a plan involving an expenditure in the future is less costly than one which requires the same amount of money to be spent earlier. In the example, \$84.20 now in hand and earning 3.50 percent interest will support a \$100 expenditure to be made five years from now, whereas the same \$100 spent one year from now has a higher present value - \$96.62.

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(1) The weighted cost of capital used in this analysis is the same as the weighted rate of return component of the fixed charge rate developed in Section B.2.1. This is typical of the approach used by the majority of investor owned utilities. However, it should be noted that some utilities use a lower rate, the after-tax weighted cost of capital.

The fixed charges on investment plus operating and maintenance expenses represent the total revenue requirements needed to support the project, and can, therefore, be used for economic comparisons of alternative investment plans. The plan having the smallest revenue requirement yields the lowest costs to the consumer or, where income is fixed, the greatest net return for the company.

Fixed charges include the following basic items:

1. Return on investment - and/or - cost of borrowed money.
2. Depreciation - or - amortization - or - repayment of principal.
3. Taxes on income.
4. State and local taxes
5. Insurance
6. Interim replacements.

Since the components of fixed charges are all related only to the initial investment, it is usually more convenient to work with fixed charge rates rather than actual dollars. The levelized annual rate, consisting of the summation of individual rates in the above areas and levelized by present-worth methods, can then be applied to the alternative investments to yield the uniform annual equivalent total fixed charges in dollars.

The concept of capital recovery encompasses the first two components of fixed charges tabulated above, namely return on investment (rate of return) and depreciation (commonly referred to as interest and principal). The capital recovery rate is a levelized annual charge and is a function of the weighted rate of return and the life of the asset (book life for accounting purposes).

It is calculated from the expression $\frac{R\ (1 + R)^n}{(1 + R)^n - 1}$ where "R" is the rate of return expressed as a decimal and "n" is the life of the asset in years. Capital recovery factors are tabulated in many interest tables. The factor gives that annual charge which would pay all cost of money and fully recover the invested capital over the life of the asset in equal payments. Again using the money pool concept, any schedule of payments which accomplishes the same results over the same period will have the same present-worth as the uniform annual payment schedule. For instance, the capital recovery factor for 3.50 percent and 30 years is 0.0544. This means that a payment of $5.44 per $100 of investment, made each year for 30 years, would fully support return plus depreciation.

Now for the same case, consider paying interest on the full investment each year, and putting an amount into the interest-bearing money pool such that at the end of 30 years we could withdraw $100 to retire the principal. That annual deposit can be calculated from the expression $\frac{R}{(1 + R)^n - 1}$ which is called a sinking fund factor. For our example, it comes out to be 0.0194 or $1.94 per $100 of investment. Therefore, the total $5.44 annual capital recovery can be considered to consist of:

	$3.50 (3.50%)	return
+	1.94	sinking fund depreciation
	$5.44	annual capital recovery

On the other hand, we may choose to retire the $100 principal in 30 equal annual installments of $3.33, which represents a straight line depreciation rate of 3.33 percent ($\frac{1}{n} = \frac{1}{30} = 0.033$). It is now necessary to pay interest or return on only the net investment (outstanding balance). The interest payments therefore decrease annually as shown below:

Year	Net Investment	Interest at 3.50%
1	$100.00	$3.50
10	70.00	2.45
20	36.67	1.28
30	3.33	0.12

If we compute the present-worth of all interest payments over the full 30 years, and then the uniform annual interest, the levelized payment is $2.11. Therefore, the $5.44 annual capital recovery can be considered to consist of:

$2.11 (2.11%)	levelized return
+ 3.33	straight line depreciation
$5.44	annual capital recovery

However, the more common presentation is in the former format, i.e., return plus sinking fund depreciation.

In summary, it can be demonstrated that any pay-back schedule results in the same levelized annual total for return plus depreciation which is readily found by using the capital recovery factor.

The various components of fixed charges as they apply to private (investor owned) utilities, are discussed in Section B.2.

B.2 INVESTOR-OWNED UTILITIES

B.2.1 Return

The weighted rate of return is the average cost of money to the utility and is a composite of interest on debt and earnings for equity. Debt money comes from bondholders, while equity money is supplied by the stockholder. For a particular project, the economic analysis must be based on the average capital structure of the company, since in actual operation the investment under study will become just a part of total investment in the business.

For investor-owned utilities a 50/50 debt-equity ratio is not uncommon, and the range of 40/60 to 60/40 probably includes most companies. Most indentures of trust limit the debt to not more than 2/3 of added property. In some states, the percentage of total capital raised by debt is limited by law. State and Federal Regulatory Commissions also have some control.

Having established the debt-equity ratio, the interest or earnings on each component must be determined. Here the bond interest rate, to be used in studies, must be that which would have to be paid for new bonds, not an average of all outstanding debt, which might be considerably lower. The interest rate must also be commensurate with risk, i.e., a company with traditionally high debt financing will require the bondholders to incur higher risk, and they in turn will command higher rates. Equity earnings must also reflect the risk involved, and must be in proper perspective to debt interest. The weighted rate of return, illustrated in the example below, must also be checked for its reasonableness. In practice, return of the regulated electric utility industry is controlled within rather close limits.

EXAMPLE OF WEIGHTED RATE OF RETURN
(Without Inflation)

Capitalization Ratios[2] (Average 1955-1978)	Calculated Required Yields[3] Without Inflation (Average 1955-1978)	Weighted Rate Of Return (Average 1955-1978)	
52.6% Bonds	2.5%	0.013	Debt
10.9% Preferred Stock	2.7%	0.003	Equity
36.5% Common Stock	5.1%	0.019	Equity
	Total:	0.035 or 3.5%	

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[2] Capitalization Ratios

Ratios were obtained from DOE/EIA-0044, "Statistics of Privately Owned Electric Utilities in the United States - 1978 and earlier editions," for the years 1955-1978 and averaged.

[3] Calculated Required Yields Without Inflation

Required yields without inflation were calculated for each year over the period 1955-1978 and averaged, for bonds, preferred stock and common stock. The sources of the data, and the procedure used for calculating the yields without inflation are as follows:

a) Bond and Preferred Stock Yields (With Inflation)

Yields with inflation were obtained from "Moody's Public Utility Manual -1979;" Table entitled "The Market For New Utility Capital" page a3 for the year 1955-1978.

b) Common Stock Yields (With Inflation)

Total yields with inflation were calculated from the following expression for the years 1955-1978:

$$\text{Total Yield With Inflation} = \frac{D}{P} + g$$

where: $\frac{D}{P}$ is the dividend divided by market price per share

g is the expected growth in dividend per year, which equals (Retained Earnings) ÷ (Book Value)

The data necessary for calculations, such as Market Prices, Earnings, Dividends, Payout Ratios and Book Values were obtained from "Moody's Public Utility Manual - 1979," Tables entitled "Utility Common Stocks - End-of-Month Averages," page a10, and "Selected Statistics On Moody's 24 Electric Utilities," pages a12 and a13.

c) Calculating Yields Without Inflation

The above Bond, Preferred Stock and Common Stock yields with inflation were converted to yields without inflation by the following expression:

$$\text{Yield Without Inflation} = (1 + d)/(1 + i) - 1$$

where: d is the yield with inflation

i is the annual rate of general inflation as measured by the implicit price deflator (IPD) for gross national product, obtained from "Business Statistics," 1979 edition, U.S. Department of Commerce/Bureau of Economic Analysis, for years 1955-1978.

B.2.2 Depreciation

Depreciation or amortization represents retirement of principal. For book purposes (plant valuation), property is depreciated lineraly over its book life. This straight line method can be represented by an annual charge at the rate of $\frac{1}{n}$, as discussed earlier, or in levelized form by the appropriate sinking fund factor. The life selected should be the best estimate of life expectancy considering both physical deterioration and economic obsolescence factors. Commonly used lives of fossil-fired and nuclear plants are approximately 30 years. In comparison, hydroelectric installations are often assigned lives of 40 to 50 years or more.

Some components of the total investment cost of a generating plant are for non-depreciable property, the prime example of which is land. In some very detailed economic studies the cost of land and other non-depreciable components of capital investment, such as materials and supplies and working capital, are segregated and are handled by a different fixed charge rate, which does not include depreciation and hence does not decline over the years. However, in many economic studies this distinction is not made, because the resulting error is not significant unless land is responsible for an unusually high percentage of the total capital cost.

B.2.3 Taxes on Income

Of the revenue required to cover fixed charges, all components, except equity earnings, are expense items which are deductible from gross income for income tax purposes. However, to any requirement of revenue for equity earnings must also be added the necessary revenue to pay the income tax. For example, at the present corporate federal income tax rate of 46 percent, it would take

$100 in gross revenue to net $54 of equity return. Each year federal income tax liability declines with net investment. The levelized annual income tax rate can be calculated from the levelized equity earnings, as shown below in an example using previously cited sample data:

$$\bar{t} = \frac{T}{(1 - T)} \left(CRF - \frac{1}{n}\right) \left(\frac{R - bi}{R}\right)$$

where T = federal income tax rate, here 0.46

and where $\left(CRF - \frac{1}{n}\right)$ = levelized return, computed previously as the difference between capital recovery factor and straight line depreciation rate, here 5.44 - 3.33 = 2.11 for 3.50 percent return and 30 year life.

and where $\left(\frac{R - bi}{R}\right)$ = the fraction of levelized return which is equity earnings.

R = overall return, here 0.035
b = bond ratio, here 0.526
i = bond interest, here 0.025

Levelized income tax $\bar{t} = \left(\frac{0.46}{0.54}\right) (0.0211) \left(\frac{0.035 - 0.0132}{0.035}\right) = 0.0112$ or 1.12%

State income taxes, where applicable, can generally be handled in a similar fashion, as can any other taxes on income. Calculations often can be simplified by working with a composite tax rate which is the sum of federal plus state plus other income tax rates. In this study, however, "Taxes on Income" are restricted to federal taxes only.

While the industry almost universally uses the straight-line method for book depreciation, liberalized or accelerated depreciation methods are commonly used for tax purposes. These methods do not reduce the total tax dollars paid over the life of the asset, but they do lead to reduction of the levelized annual tax charge by deferring some of the taxes in the early years to later payments. There are two commonly used methods of calculating accelerated tax depreciation. They are sum-of-years-digits (SYD) and double rate declining balance (DRDB or DDB).

With SYD, the annual tax depreciation rate is a fraction whose denominator is the summation of all the numbers from one to plant life in years. The numerators decrease from plant life in years down to one. For 30 years, $\Sigma_1^{30} n = 465$. Therefore, the first year depreciation rate is $\frac{30}{465}$ second year $\frac{29}{465}$ ...down to $\frac{1}{465}$ in the last year. It is obvious that

$$\frac{30}{465} + \frac{29}{465} + \frac{28}{465} + \cdots + \frac{3}{465} + \frac{2}{465} + \frac{1}{465} = 100\%$$

Double declining balance tax depreciation is calculated each year as twice the straight line rate times net investment. For example, for 30 years life, the normal straight line rate is $\frac{1}{30} = 3.33$ percent and the DDB rate is 6.67 percent. The computation procedure is as follows:

Year	Net Investment - %	DDB Depreciation - %
1	100.00	6.67
2	93.33	6.23
3	87.10	5.81
4	81.29	5.42

If this computation were continued for 30 years, the summation of annual depreciation entries in the DDB column will not yield 1.00 or 100 percent. It is therefore necessary to switch to the straight line method about halfway through plant life.

There are rather complex formulae for computing the levelized annual value of accelerated depreciation. These are presented in the sample calculations at the end of this discussion in Section B.3. Also given is a formula, which is used to levelize income tax using previously calculated levelized accelerated depreciation. The tax formula reflects the fact that the tax saving attributable to accelerated depreciation is $\frac{T}{1 - T}$ times the difference between straight line and the levelized annual tax depreciation.

The federal investment tax credit (10 percent of qualified investment deductible from income tax in the first year only) also produces a slight reduction in the levelized income tax charge. This reduction is calculated as the annual capital recovery of the present worth of the 10 percent credit in year one, and is calculated to be 0.0039 or 0.39 percent as shown in Section B.3.4.

Calculation of fixed charges on a flow-through basis (benefits passed on to consumers), incorporating liberalized tax depreciation and the 10 percent credit as used by most companies, yields minimum revenue requirements since the income tax component is reduced.

B.2.4 State and Local Taxes

There are a variety of other types of taxation which are encountered in the investor-owned utilities industry. The more important ones are property, franchise and gross revenue taxes. Property taxes are levied by the local community, and the rate is applied to the original (undepreciated) value of the asset.

In several of the states where the franchise tax is paid, the levy is on net income. Therefore, it is treated as a state income tax, which has been discussed previously.

The gross revenue or gross receipts tax, on the other hand, is levied on all revenue which the utility collects without deductions or exemptions. The tax then is a revenue requirement in itself, and when used must be added to the subtotal of all other fixed charges. It must be noted that unlike other types of taxation, the gross receipts tax revenue requirement must also be added to operation, maintenance and fuel expenses in economic studies. However, since in comparison of alternatives, the effect of a gross revenue tax is to increase the differential costs between plans by the tax rate percentage, it is sometimes handled just that way, instead of carrying it through individual plan fixed charge rate and operating expense calculations.

The fixed charge rate of 2.56 percent for state and local taxes, shown in Section B.2.7, is based upon information reported in DOE/EIA-044(78), "Statistics of Privately Owned Electric Utilities In The United States - 1978." It is an average for the years 1972 through 1978 (the last seven years of published data), and does not reflect the effects of general inflation over the life of the plant.

B.2.5 Insurance

Insurance coverage for power plants include both property damage and public liability. Liability coverage is not directly related to plant investment and is therefore included in O&M costs. The fixed charge rate of 0.06 percent for property damage, shown in Section B.2.7, is based upon data reported in DOE/EIA-0044(78). It is an average of the ratios of the property insurance paid by privately-owned utilities to their total investment in plant and equipment, for the years 1972 through 1978.

In total, annual charges for insurance usually amount to less than one percent of the capital investment, and in some cases are even considered negligible in developing the total fixed charge rate.

B.2.6 Interim Replacements

Some utilities include a rate for interim replacements in their fixed charges. The charges represent large expenditures for replacing major equipment components of the asset during its life, where failure of such components would impair the integrity of the asset. Interim replacement charges, as used here, do not include normal maintenance costs or cost of additions made after the original construction. When used, the most commonly applied rate is 0.35 percent annually, which is based upon fossil-fueled power station experience. Long term experience upon which to base the value of this allowance for nuclear plants is lacking. However, it is believed that the 0.35 percent value is conservative for them, since safety-related nuclear components are subject to more stringent design specifications and quality control inspections.

The fixed charge rate of 0.35 percent for interim replacements, shown in Section B.2.7, does not reflect the effects of general inflation over the life of the plant.

B.2.7 Typical Fixed Charges for Investor-Owned Utility Nuclear and Fossil Power Générating Stations

While it has been stated that there is in essence no such thing as an "average" fixed charge rate, it is nevertheless recognized that such a value is often desired. In this case, an inflation-free value of 8.67 percent, subject to additions and adjustments based upon the particular area or project under consideration, is suggested for a privately-owned utility. The levelized 8.67 percent rate (without inflation) is made up as follows:

Return:	52.6% Bonds	@ 2.5%	=	1.3
	10.9% Preferred Stock	@ 2.7%	=	0.3
	36.5% Common Stock	@ 5.1%	=	1.9
	Weighted Rate of Return			3.5 percent
	Depreciation (30 year sinking fund)			1.94
	Federal Income Tax (including 10% credit and based on SYD depreciation)			0.26
	State and Local Taxes			2.56
	Insurance			0.06
	Interim Replacements			0.35
				8.67 percent

B.3 FORMULAE AND SAMPLE CALCULATIONS FOR LEVELIZED VALUE OF ACCELERATED TAX DEPRECIATION

Note: All sample calculations are based on the following parameters:

3.5% Weighted Rate of Return (R = .035)

52.6/47.4 Debt/Equity Ratio (b = .526) (Debt/Capital Structure Ratio)

2.5% Bond Interest (i = .025)

30 Year Life (n = 30)

B.3.1 Double Declining Balance (DDB) Depreciation

$$\bar{D} = \text{SFF} \left[\frac{\frac{2}{n}(\text{CAF}) + R \left(1 - \frac{2}{n}\right)^{n}}{R + \frac{2}{n}} \right]$$

Where: $\bar{D}$ = Levelized annual depreciation

SFF= Sinking fund factor (SFF = .194 from interest tables for 30 year life and 3.5 percent return)

n = Life (n = 30)

CAF= Single payment compound amount factor (CAF = 2.81 from tables)

R = Rate of Return (R = .035)

Sample calculation:

$$\bar{D} = .0194 \left[\frac{\frac{2}{30}(2.81) + .035 \left(1 - \frac{2}{30}\right)^{30}}{.035 + \frac{2}{30}} \right] = .0366 \text{ or } 3.66\%$$

B.3.2 Sum of Years Digits (SYD) Depreciation

$$\overline{D} = \frac{2\left(CRF - \frac{1}{n}\right)}{R\ (N + 1)}$$

Where: $\overline{D}$ = Levelized annual depreciation

CRF = Capital recovery factor (CRF = .0544) from interest tables for 30 year life and 3.5 percent return

n = Life (n = 30)

R = Weighted Rate Of Return (R = .035)

Sample calculation:

$$\overline{D} = \frac{2\left(.0544 - \frac{1}{30}\right)}{.035\ (30 + 1)} = .0388 \text{ or } 3.88$$

B.3.3 Federal Income Tax

$$\overline{t} = \frac{T}{1 - T}\left[R - d - \frac{bi}{R}\ (R - d_o)\right]$$

Where: $\overline{t}$ = Levelized annual federal income tax

T = Federal income tax rate (T = .46) currently 46 percent

R = Rate of return (R = .035)

d = $\overline{D}$ - SFF or Difference between levelized depreciation for a particular method and sinking fund depreciation

b = Bond ratio (b = .526)

i = Bond interest rate (i = .025)

d_o = $\frac{1}{n}$ - SFF or Difference between straight line and sinking fund depreciation

Sample calculations:

A. With straight line tax depreciation (not accelerated)

$$d = d_o = \frac{1}{n} - SFF = \frac{1}{30} - .0194 = .0139$$

$$\bar{t} = \frac{.46}{1 - .46} \left[.035 - .0139 - \frac{(.526)(.025)}{.035} (.035 - .0139) \right] = .0112 \text{ or } 1.12\%$$

B. With double declining balance tax depreciation

$$d = \bar{D} - SFF = .0366 - .0194 = .0172$$

$$d_o = \frac{1}{n} - SFF = .0139 \text{ as above}$$

$$\bar{t} = \frac{.46}{1 - .46} \left[.035 - .0172 - \frac{(.526)(.025)}{.035} (.035 - .0139) \right] = .0084 \text{ or } 0.84\%$$

C. With SYD tax depreciation

$$d = \bar{D} - SFF = .0388 - .0194 = .0194$$

$$d_o = \frac{1}{n} - SFF = .0139 \text{ as above}$$

$$\bar{t} = \frac{.46}{1 - .46} \left[.035 - .0194 - \frac{(.526)(.025)}{.035} (.035 - .0139) \right] = .0065 \text{ or } 0.65\%$$

B.3.4 Levelized Effect of 10 Percent Investment Tax Credit in First Year

$$\bar{t}_c^{(4)} = .10\ (PWF_1)\ (CRF)\ (.75)$$

Where: $\bar{t}_c$ = Levelized effect of 10 percent tax credit in year one

PWF_1 = Single payment present-worth factor for year one

CRF = Capital recovery factor

.75 = Portion of investment qualified for investment tax credit

$$\bar{t}_c = .10\ \frac{1}{1.035}\ (.0544)(.75) = .0039 = 0.39\%$$

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(4) At times a before tax investment tax credit is utilized to offset the levelized annual federal income tax component of the fixed charge rate. This has the effect of slightly reducing the fixed charge rate.

B.3.5 Summary of Sample Calculations

Tax Depreciation Method	Levelized Annual Depreciation in Percent	Levelized Annual Federal Income Tax in Percent: Tax	Levelized Annual Federal Income Tax in Percent: 10% Credit in Year 1-Levelized	Levelized Annual Federal Income Tax in Percent: Net Tax
	$\bar{D}$	$\bar{t}$	$\bar{t}_c$	$\bar{t} - \bar{t}_c$
Straight Line	3.33	1.12	0.39	0.73
Double Declining Balance	3.66	0.84	0.39	0.45
Sum of Years Digits	3.88	0.65	0.39	0.26

APPENDIX - C1

PHASE III FINAL REPORT AND THIRD UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

APPENDIX C1

TECHNICAL MODEL INITIAL UPDATE

This appendix contains Sections 5.4.1 through 5.4.9 (pages 5-4 through 5-23) of the "Final Report and Initial Update of the Energy Economic Data Base (EEDB) Program-Phase I", UE&C-DOE-790930. The purpose of including this material in the "Phase III Final Report and Third Update of the Energy Economic Data Base (EEDB) Program" is to provide a convenient reference to the changes made to the Base Data Studies and Reports during the Initial Update. Appendix C2 contains similar material for the Second Update.

5.4.1 EEDB Model Number A1, Model Type BWR, EEDB Initial Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost -
Boiling Water Reactor Plant (NUREG-0242, COO-2477-6)

ACCOUNT 214 Security Building

Plant security is revised to meet the requirements of Regulatory Guide 1.17, "Protection of Nuclear Plants Against Industrial Sabotage" (Revision 1, 6/73). The security building and upgraded security system are added to meet plant physical security requirements as currently interpreted by UE&C. The building provides a controlled means of access to the plant to prevent industrial sabotage or the theft of nuclear materials. It is a reinforced concrete, Seismic Category I, structure located at grade. The building is 53 feet wide, 63 feet long and one story or 20 feet high, with a volume of approximately 66,800 cubic feet.

The upgraded security system costs are included in Account 253.22.

ACCOUNT 218A Control Room/Diesel-Generator Building

The control building and electrical tunnels are modified to meet the requirements of Regulatory Guide 1.120, "Fire Protection Guidelines for Nuclear Power Plants" (Revision 1, 11/77). The control building is modified by adding a fourth floor above the control room for cable spreading. This modification provides over and under cable spreading areas for the control room which allows each electrical channel to have its own spreading area separated by three-hour rated fire walls. The electrical tunnels are also modified to separate each channel with three-hour rated fire walls.

ACCOUNT 218T Ultimate Heat Sink Structure

The ultimate heat sink basin capacity is increased from 7 to 30 days storage to meet the requirements of Regulatory Guide 1.27, "Ultimate Heat Sinks for Nuclear Power Plants" (Revision 2, 1/76). No change is made to the superstructure which includes the north and south bays and cooling towers.

ACCOUNT 224 Radwaste Processing

The liquid, gaseous and solid waste systems are upgraded to improve system performance and operability.

ACCOUNT 225 Fuel Handling and Storage

The spent fuel pool cooling system is changed from one loop with redundant components to two separate redundant loops. This revision is made to preclude the loss of spent fuel pool cooling in the event of a pipe or valve failure in a single loop.

ACCOUNT 226 Other Reactor Equipment

The boron recycle system is upgraded, consistent with changes made to the liquid radwaste system (see Account 224 above), to improve system performance and operability.

ACCOUNT 234 Feed Heating System

The two turbine driven boiler feed-water pumps are increased from 57 percent capacity to 80 percent capacity each to prevent reactor trip from the loss of one pump.

ACCOUNT 252 Air, Water and Steam Service System

The plant fire protection system is modified to meet the requirements of the additional floor in the control building and additional separation in the electrical tunnels (see Account 218A above).

ACCOUNT 253 Communications Equipment

The communications system is modified to meet the requirements of the additional floor in the control building and additional separation in the electrical tunnels (see Account 218A above). The security system is revised to meet the requirements of Regulatory Guide 1.17 (see Account 214 above).

5.4.2 EEDB Model Number A2, Model Type HTGR, EEDB Initial Update

Base Data Study: 3360 MWt HTGR-Steam Cycle Reference Plant Design
(General Atomic Company-SC 558623)

ACCOUNT 211 Yardwork

The Yardwork account is modified to adjust for the "Middletown" site conditions described in Appendix A-1 and a single unit design versus the first of two units design of the Base Data Study. Excavation quantities are changed to reflect a rock site from the firm soil site of the Base Data Study.

ACCOUNT 214 Security Building

Same as subsection 5.4.1, BWR, Account 214 modification.

ACCOUNT 215 Reactor Service Building, ACCOUNT 217 Fuel Storage Building ACCOUNT 218E Helium Storage Area, ACCOUNT 218I Access Building, ACCOUNT 218S Holding Pond, ACCOUNT 261.1 Makeup Water Intake and Discharge Structures

These structures are reduced in size to reflect a single unit design. Fuel storage is set at 0.3 core in containerized fuel modules.

ACCOUNT 224 Radwaste Processing, ACCOUNT 225 Nuclear Fuel Handling and Storage

These systems and components are reduced in size and/or number to reflect a single unit design.

ACCOUNT 226 Other Reactor Plant Equipment

The helium storage and transfer system is reduced in size to reflect a single unit design. The nuclear service water cross connection between Units 1 and 2 is deleted.

ACCOUNT 233 Condensing System

The bulk chemical storage tanks for the condensate polishing system are reduced in capacity to reflect a single unit design.

ACCOUNT 24 Electric Plant Equipment

Offsite power connections are changed from 345 kV and 115 kV to 500 kV and 230 kV respectively.

ACCOUNT 252 Auxiliary Water and Steam Service System

The auxiliary steam system interconnecting piping between Units 1 and 2 is deleted.

5.4.3 EEDB Model Number A3, Model Type PWR, EEDB Initial Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - Pressurized Water Reactor Plant (NUREG-0241, COO-2477-5)

ACCOUNT 214 Security Building

Same as subsection 5.4.1, BWR, Account 214 modification.

ACCOUNT 218A Control Room/Diesel-Generator Building

Same as subsection 5.4.1, BWR, Account 218A modification.

ACCOUNT 218T Ultimate Heat Sink Structure

Same as subsection 5.4.1, BWR, Account 218T modification.

ACCOUNT 224 Radwaste Processing

Same as subsection 5.4.1, BWR, Account 224 modification. Additionally, a flash tank and pumps are added to the steam generator blowdown system to balance steam flow rates from the steam generators.

ACCOUNT 225 Fuel Handling and Storage

Same as subsection 5.4.1, BWR, Account 225 modification.

ACCOUNT 226 Other Reactor Plant Equipment

Same as subsection 5.4.1, BWR, Account 226 modification.

ACCOUNT 234 Feed-Heating System

Same as subsection 5.4.1, BWR, Account 234 modification.

ACCOUNT 252 Air, Water and Steam Service System

Same as subsection 5.4.1, BWR, Account 252 modification.

ACCOUNT 253 Communications Equipment

Same as subsection 5.4.1, BWR, Account 253 modification.

5.4.4 EEDB Model Number A4, Model Type PHWR, EEDB Initial Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - Pressurized Heavy Water Reactor Plant (COO-2477-13)

ACCOUNT 211 Yardwork

Excavation quantities are reduced to reflect replacement of PWR scaled buildings with unique PHWR design buildings.

ACCOUNT 212 Reactor Containment Building, ACCOUNT 215 Reactor Service and Fuel Handling Building

Material quantities are revised to reflect replacement of PWR scaled buildings with unique PHWR design buildings.

ACCOUNT 214 Security Building

Same as subsection 5.4.1, BWR, Account 214 modification.

ACCOUNT 218A Control Room/Diesel-Generator Building

Same as subsection 5.4.1, BWR, Account 218A modification.

ACCOUNT 218T Ultimate Heat Sink Structure

Same as subsection 5.4.1, BWR, Account 218T modification.

ACCOUNT 23 Turbine Plant Equipment, ACCOUNT 24 Electric Plant Equipment, ACCOUNT 25 Miscellaneous Plant Equipment, ACCOUNT 26 Main Condenser Heat Rejection System

System design is revised to reflect replacement of PWR designs with unique PHWR designs based on ongoing DOE studies.

5.4.5 EEDB Model Number B1, Model Type GCFR, EEDB Initial Update

Base Data Study: Capital Cost - Gas Cooled Fast Reactor Plant
(COO-2477-16)

ACCOUNT 212 Reactor Containment Building

Design of secondary containment is modified to improve constructibility and decrease cost.

ACCOUNT 214 Security Building

Same as subsection 5.4.1, BWR, Account 214 modification.

ACCOUNT 222 Main Heat Transfer System

Estimate for manhours to install steam generators is improved.

ACCOUNT 223 Safeguards Cooling System

Design conservatism is reduced to reflect current practice by replacing two 100 percent pumps in each of two loops of the Core Auxiliary Cooling Water (CACW) system with one 50 percent pump per loop.

ACCOUNT 226 Other Reactor Plant Equipment

Design of Reactor Plant Cooling Water (RPCW) system is improved to reflect current practice by adding one RPCW heat exchanger.

ACCOUNT 227 Instrumentation and Control

Instrumentation and Control quantities are revised to reflect current practice for reactor plant diagnostic and instrumentation tubing.

ACCOUNT 233 Condensing System

Instrumentation and Control material and labor manhours for the condensate polishing system are reduced to reflect current practice.

ACCOUNT 234 Feed Heating System

Design conservatism is reduced to reflect current practice by deleting one of four emergency feed-water pumps and drives. Labor manhours for installation of a booster pump is increased to provide technical model consistency.

ACCOUNT 237 Turbine Plant Miscellaneous Items

Pipe Insulation, Account 237.31, is deleted to provide technical model consistency and eliminate double accounting. Pipe insulation is included in the individual piping system accounts.

5.4.6 EEDB Model Number B2, Model Type LMFBR, EEDB Initial Update

Base Data Study: Technical Comparison of Prototype Large Breeder Reactor (PLBR) Phase II Competing Designs (31-109-38-3547)

In the case of the LMFBR, the Base Data Studies could not be used directly as for the other Nuclear Plant Models for the following reasons:

1. PLBR Phase II Competing Designs were not structured in a uniform code-of-accounts for either technical or cost tabulation.
2. PLBR Phase II Competing Designs varied widely and were, therefore, difficult to compare or consolidate.
3. Quantities, commodities and costs varied widely and appeared to be overly conservative for an nth-of-a-kind plant when compared at the component level with other reactor types.

For the purposes of the EEDB Initial Update, it was desirable to include an LMFBR NPGS based on target costs of a commercially viable reactor, deployed in a time frame when the target goals have a high probability of being realized.

LMFBR NPGS Target Economics Philosophy

For the LMFBR NPGS to become an economically viable concept, certain cost criteria need to be met. Namely, the sum of the three cost factors contributing to energy cost (Capital, Fuel Cycle, and O&M) must combine to provide an energy cost equal to or less than competing forms of energy production.

The Light Water Reactor Nuclear Power Generating Station as represented by the PWR NPGS is chosen as the present competition for the LMFBR NPGS. The current EEDB goal is to eliminate cost over-conservatism and cost uncertainties which have prevailed over the past few years by developing a commercial cost estimate for a LMFBR NPGS, based upon an nth-of-a-kind unit, designed to commercial type nuclear standards and regulations. The year 2001 is selected as the target date when the LMFBR NPGS should become competitive. This date takes into account the present research and development requirements of the concept, as well as allowing for the predicted increase in the cost of uranium to a minimum value of \$62 per pound (in constant \$1978), where a break-even point is more likely.

A review of Tables 4-6 and 5-3 provides insight into the required relative target cost of the LMFBR vs. the PWR to achieve a m/kWh break-even energy cost. A goal of LMFBR NPGS capital cost equal to about 1.25 times the PWR cost is established. This ratio equates to a maximum delta of approximately 135 \$/kWe (in \$1978) by which the Base Construction Cost of a 3800 MWt LMFBR NPGS can exceed that of a PWR NPGS of the same thermal capacity.

To achieve these goals a set of target costs is established which, if met, would create a competitive LMFBR. The largest legally licensable plant (3800 MWt) is selected since the economy of scale will have a positive effect in achieving the goal. Basic ground-rules to govern the cost estimating are also established to ensure that the costs reflect a realistic commercial concept within the bounds of current regulations.

The method utilized to evaluate and control the costs is to compare the LMFBR cost estimates on a commodity basis, such as $\$/Ft^2$, \$/HP, etc., with that of the PWR. When a significant difference is noted without reasonable technical justification, additional attention is focused to bring the cost to a reasonable value. In this manner, costs estimated on an overly-pessimistic basis can be improved.

In future work, an effort should be made to define concept improvements, which although not necessarily licensable at the present time, can reasonably be assumed to be licensable by the year 2000. Items such as expansion joints instead of expansion loops in sodium piping and new cost saving materials need to be evaluated for further cost improvements.

LMFBR NPGS Cost Basis

To implement the Target Economics philosophy, a 1390 MWe, loop type, LMFBR central station power plant is selected for the study. Using the experience gained from the Base Data Studies, UE&C designed the Balance of Plant systems, and retained Combustion Engineering, Inc. to develop a Nuclear Steam Supply System, in accordance with the above philosophy.

The plant design incorporates a 3800 MWt (1390 MWe), 850°F, 2200 psig LMFBR Nuclear Steam Supply System, which is described in Combustion Engineering, Inc. Report CE-FBR-78-532, "NSSS Capital Costs for a Mature LMFBR Industry." A copy of this report may be found in Appendix D-1.

Further discussion of the Target Economics Philosophy for the LMFBR NPGS is included in Appendix D-2.

A plant size of 3800 MWt is selected to achieve the maximum benefit of economy of scale within the current regulatory limit. Other design features to minimize costs that are incorporated, within the limits of current regulatory requirements, are as follows:

- The safety related NSSS buildings are clustered around the containment building and share a common base mat founded on rock.

- The reactor plant incorporates four primary and four secondary loops with four intermediate heat exchangers and four primary and four secondary pumps. Four primary loop check valves are located within the reactor vessel.

- The steam generation system is of the Benson Cycle type, utilizing two single wall tube steam generators for each of the four loops.

- The turbine plant consists of a cross-compound turbine with four double flow low pressure stages. The inlet conditions to the high pressure turbine are 850°F @ 2200 psia.

- The safety related decay heat removal function is fulfilled by two 100 percent Auxiliary Heat Transfer Systems which cool the primary sodium directly from the reactor vessel without requiring the primary loops to be operating.

- The secondary loops provide no emergency function and are classified non-nuclear downstream of the external isolation valves at the containment.

- The steam generators are classified as non-nuclear, and the steam generator buildings are non-Seismic Category I.

- Fuel handling is of the "under-the-head" type with 1/3 core storage inside the containment structure, isolated from the primary containment volume to permit fuel transfer during normal reactor operations.

- Guard vessels for the primary system have been eliminated by the utilization of filler block around the reactor vessel, and siphon breaker lines.

For the EEDB Initial Update sodium, NaK and Dowtherm inventories are not included.

Results

The LMFBR/PWR capital cost ($/kW basis) ratio goal of 1.25 is not realized during this first attempt at target economics. However, a cost ratio of 1.32 (refer to Table 5-3) is achieved. This ratio achieves a slightly lower than break-even cost for the LMFBR vs. the PWR, because a uranium cost of approximately $62 per pound (constant $1978) is used in the fuel cycle study for the year 2001. (Refer to Table 4-7)

5.4.7 EEDB Model Number C1, Model Type HS12, EEDB Initial Update
EEDB Model Number C3, Model Type LS12, EEDB Initial Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - High and Low Sulfur Coal Plants - 1200 MWe (Nominal) (NUREG-0243, COO-2477-7)

ACCOUNT 219 Stack Structure

The stack height is increased from 600 feet to 750 feet to meet the requirements of the Clean Air Act Amendments of 1977. The stack structure is changed from a brick to steel liner due to the increase in height.

ACCOUNT 223 Ash and Dust Handling System

The ash and dust handling systems are upgraded to improve system performance and operability.

ACCOUNT 233 Condensing Systems

The condenser design is upgraded to improve system heat rate.

Licensability

As discussed in subsection 4.5.1, these coal-fired power plants are not designed to meet the proposed revisions to the emission standards current on January 1, 1978. However, cost adders are given in subsection 4.5.1 to permit the adjustment of the EEDB Initial Update capital costs, to reflect the impact of including these proposed changes.

It should be pointed out, there is some doubt that coal-fired power plants designed to meet emission standards requirements current for January 1, 1978, can be sited where desired in all cases. The most desirable location may be a lightly to heavily industrialized area. For such sites, where topographical features are not optimum, there is a probability that additional capital expenditures may be required for the plant to remain in compliance continuously. Appendix D-3 addresses this subject in greater detail. No attempt has been made, during this initial update, to predict levels of potential additional capital expenditure requirements, because the emission standards are currently in a state of change.

5.4.8 EEDB Model Number C2, Model Type HS8, EEDB Initial Update EEDB Model Number C4, Model Type LS8, EEDB Initial Update

Base Data Study: Commercial Electric Power Cost Studies - Capital Cost - Low and High Sulfur Coal Plants - 800 MWe (Nominal) (NUREG-0244, COO-2477-8)

ACCOUNT 219 Stack Structures

Same as subsection 5.4.7, HS12/LS12, Account 219 modification.

ACCOUNT 223 Ash and Dust Handling System

Same as subsection 5.4.7, HS12/LS12, Account 223 modification.

ACCOUNT 233 Condensing System

Same as subsection 5.4.7, HS12/LS12, Account 233 modification.

Licensability

Same as subsection 5.4.7, HS12/LS12, Licensability.

5.4.9 EEDB Model Number D1, Model Type CGCC, EEDB Initial Update

Base Data Study: Study of Electric Plant Applications for Low Btu Gasification of Coal for Electric Power Generation (FE-1545-59)

The technical description and cost estimate for the coal gasification power plant are based on a conceptual balance-of-plant study performed by UE&C for Combustion Engineering, Inc. This study has been extended to a complete plant under the Energy Economic Data Base program. Combustion Engineering provided costs and design data for several systems.

Combustion Engineering has been developing this concept since 1970, supported in part by the Department of Energy and the Electric Power Research Institute. A process demonstration unit is now operating, and demonstration plant preliminary designs are being prepared.

Except for the gasification process unit and the gas turbines, all plant components are readily available commercial equipment which are commonly used in power plants or natural gas processing facilities. The gasifier itself is very similar to pulverized coal-fired boilers. The gas turbines utilize current technology but are not now on the market. Because the plant produces elemental sulfur as a by-product, the environmental effects are significantly less than direct coal-fired plants with SO_2 scrubbers.

Technical Description

This plant is a combined cycle electric power plant which is fired by gasified coal. The coal is gasified in an air-blown, entrained bed gasifier. The resulting gas, which has a low heating value, is cleaned and the sulfur is removed using the Stretford process. The clean gas is compressed and burned in gas turbines, which generate a total of 283 MWe. The exhaust gas from the gas turbines passes through waste heat boilers to produce steam, which drives a 372 MWe steam turbine-generator. The net plant output is 630 MWe.

The net station heat rate is 8250 Btu/kWh. Plant thermal efficiency is about 41 percent.

Coal Handling System

The coal handling system is standard for a power plant of this size. Railroad cars dump to a hopper-type unloader. The coal is stacked out, reclaimed by lowering wells, crushed, and pulverized. Thaw sheds, car shakers, and distribution and sampling systems are included. Coal storage space holds a 90-day reserve.

The plant uses 195 tons per hour of Pittsburgh Steam coal (13,480 Btu/lb-Dry, 2.6 percent sulfur, 2.4 percent moisture). However, the entrained bed gasifier can handle most types of coal.

Ash Handling System

The ash handling system is a standard system handling 18 tons per hour of molten slag.

Gasifier

The two gasifiers are air-blown, entrained bed gasifiers. They are similar to standard water-wall boilers and have superheater and reheater sections. The gasifier provides about one-half of the steam produced in the plant.

The gasifier produces 2.3 million pounds per hour of fuel gas, a mixture of carbon monoxide, carbon dioxide, methane, hydrogen, and nitrogen. Sulfur in the gas is 90 percent H_2S and 10 percent carbonyl sulfide (COS). The heating value of the gas is assumed to be about 110 Btu/SCF, although recent pilot plant data has been reported in the 120 to 140 Btu/SCF range.

Gas Clean-up System

Cyclones remove most of the particulates in the raw gas, which are recycled into the gasifier. Fine cleaning is accomplished with a wet scrubber, with wastes recycled to the gasifier. The H_2S is then removed by the Stretford process. About 90 tons per day of elemental sulfur are produced, with a small waste stream, which is also recycled to the gasifier.

In this plant, the COS is burned with the fuel gas, producing SO_2 which is released. Because only 10 percent of the sulfur occurs as COS, the plant will comply with regulations requiring 90 percent sulfur removal. If this level of SO_2 removal violates future regulations, the COS can be shifted to H_2S before Stretford processing.

Gas Turbine-Generators

Four gas turbine-generator units compress and burn the fuel gas, with a net output of 70.8 MWe each. The gas turbines are rated at an inlet temperature of 2200°F, which is somewhat higher than currently available turbines. Reducing the inlet temperature would cause a reduction in plant efficiency.

Waste Heat Boilers

Four waste heat boilers convert the exhaust heat to steam. Primary steam production is about 500,000 lb/hr at 2600 psig and 1000°F. Reheat to 1000°F is included, and low pressure steam is produced in another section.

Steam Turbine-Generator

The standard steam turbine-generator system produces 372 MWe. The design steam flow is 1.99 million pounds per hour, with a back pressure of 2.0 inches of mercury. The generator is rated at 410 MVA.

Cooling System

The main cooling system utilizes a wet, natural draft, hyperbolic cooling tower, approximately 300 feet in diameter and 400 feet high.

Waste Treatment

The waste treatment system handles the relatively small quantity of waste from the cooling and ash handling systems. The system includes filtration, neutralizing, and a sediment basin.

Economic Description

The costs estimated for the coal gasification combined cycle power plant are an extension of studies performed for DOE and EPRI by Combustion Engineering, Inc. United Engineers & Constructors Inc. estimated balance-of-plant costs for C-E.

The cost design basis is not entirely consistent with the other plants estimated for the EEDB Initial Update; however, the differences are considered to be negligible.

APPENDIX - C2

PHASE III FINAL REPORT AND THIRD UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

APPENDIX C2

TECHNICAL MODEL SECOND UPDATE

This appendix contains Sections 5.4.2.1, 5.4.2.2, 5.4.2, and 5.4.3 (pages 5-5 through 5-7 of the Phase II Final Report and Second Update of Energy Economic Data Base (EEDB) Program", UE&C/DOE-810430. The purpose of including this material in the "Phase III Final Report and Third Update of the Energy Economic Data Base (EEDB) Program" is to provide a convenient reference to the changes made to the Base Data Studies and Reports and Initial Update (1978) modifications during the Second Update (1979). Appendix C1 contains similar material for the Initial Update.

5.4.2 Specific Modifications

5.4.2.1 EEDB Model Number A5, Model Type LMFBR, EEDB Second Update

Base Data Study: NSSS Capital Costs for a Mature LMFBR Industry (Combustion Engineering, Inc. CE-FBR-78-532)

The NSSS for the Initial Update is based on the cost estimate provided by the Base Data Study. Due to limited time and funding, the Balance of Plant (BOP) for the Initial Update cost estimate is based on numerous assumptions and scaling of structure and system costs of other EEDB models.

The 1978 cost included 1/3 core fuel storage, and a scaled fossil plant type cross-compound turbine generator based on an estimated plant efficiency of 36.6%. Total net output was 1390 MWe.

For the EEDB Second Update, the entire plant was reviewed and a conceptual design prepared sufficient for detailed costing basis. Structures were designed where necessary, and commodities of all structures were determined. BOP systems were designed, as necessary, in sufficient detail for detailed cost estimates and mini-specification development.

The NSSS for 1979 was based on the Base Data Study, escalated to 1979 dollars. This also included a 1/3 core storage. The BOP was based on a steam cycle proposed by Brown Boveri. This steam cycle included a two stage steam reheat with a large tandem-compound turbine-generator with a plant efficiency of 38.3%. This increased the net electric output from 1390 MWe reported in the Initial Update cost estimate to 1457 MWe for the Second Update.

During the Second Update, a Topical Report was prepared on a new approach to the LMFBR Demonstration Program. The report discusses the feasibility of building a 1500 MWe demonstration LMFBR NPGS, utilizing a nominal 750 MWe conceptual design as an intermediate step. This report is presented in Appendix E.

The basic Target Economic philosophy, described in Appendix C, remains as the basis for the LMFBR NPGS cost estimate. The principle result of the effort described above is to expand the detail for the LMFBR Technical and Cost Models to the ninth-digit level of detail. This expansion provides a more detailed equipment list with mini-specifications, a more detailed cost breakdown and sufficient detail to provide a material and commodity tabulation.

5.4.2.2 EEDB Model Number D2, Model Type CLIQ, EEDB and Second Update

Base Data Study: Recycle SRC Processing for Liquid and Solid Fuels,
Gulf Mineral Resources Company

This Model has been deleted from the EEDB because adequate data for an update is not available.

5.4.3 Ongoing Modifications

During the course of preparing the Second Update of the EEDB, it became apparent that modiciations were required for some of the Technical Models that would take more effort than could be allotted to the resources available for a single update. Consequently, these efforts are spread over Second and Third Updates but, although they are initiated in the Second

Update, the results will not be reported until the Third Update is completed

Among these efforts are the following:

- Replacement of the 3360 MWe HTGR NPGS (Model A2) with a smaller sized unit, consistent with the current thinking and emphasis of General Atomic Company and Gas Cooled Reactor Associates (a Utility Sponsored HTGR NPGS Development Group).
- Replacement of the 1162 MWe PHWR NPGS (Model A4) based on the Canadian CANDU design with a large PHWR NPGS based on a U.S. design.
- Continued upgrading of the LMFBR NPGS (Model A5) to reflect information contained in current commercialization studies, within the framework of the Target Economic approach, and to incorporate under-the-head refueling and one-and-one-third core storage.
- Evaluation of the Flue Gas Desulfurization system design for the High Sulfur Coal FPGS (Models C1 and C2), with respect to the revised New Source Performance Standards.
- Addition of the Flue Gas Desulfurization Systems to the Low Sulfur Coal FPGS (Models C3 and C4), to meet the revised New Source Performance Standards.
- Reevaluation of the major cost drivers which comprise 85% of the plant cost; specifically Structures, Nuclear Steam Supply Systems, Turbine-Generator Units, Piping Systems, and Electric and Instrumentation and Control Systems.
- Evaluation of installation labor hours to reflect the growing realization in the industry that these hours may be understated for NPGS.

APPENDIX - D

PHASE III FINAL REPORT AND THIRD UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

APPENDIX D

U.S. NUCLEAR REGULATORY COMMISSION

REGULATORY GUIDE REVIEW

This list shows the revision of Regulatory Guides in effect on January 1976, January 1979, and January 1980. Each guide is noted as follows:

0 - revision 0, or original issue
1, 2 or N - revision in effect
NI - not issued.

A column entitled, "Relates To," shows:

D - related to design and/or licensing
C - related to construction
O - related to operation
NA - not applicable to nuclear power reactors
CI - Regulatory Guide revision has a significant cost impact.

REGULATORY GUIDES

Division 1 Regulatory Guides
Power Reactors

Number	Title	Revision in Effect			Relates* to
		1/76	1/79	1/80	
1.1	Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal System Pumps	0	0	0	D
1.2	Thermal Shock to Reactor Pressure Vessels	0	0	0	D
1.3	Assumptions Used for Evaluating the Potential Radiological Consequence of a Loss of Coolant Accident for Boiling Water Reactors	2	2	2	D
1.4	Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors	2	2	2	D
1.5	Assumptions Used for Evaluating the Potential Radiological Consequences of a Steam Line Break Accident for Boiling Water Reactors	0	0	0	D
1.6	Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems	0	0	0	D
1.7	Control of Combustible Gas Concentrations in Containment Following a Loss of Coolant Accident	0	2	2	D
	Supplement to Safety Guide 7, Backfitting Considerations	0	0	0	D
1.8	Personnel Selection and Training	1	1	1	0
1.9	Selection of Diesel Generator Set Capacity for Standby Power Supplies	0	1	2	D
1.10	Mechanical (Cadweld) Splices in Reinforcing Bars of Category I Concrete Structures	1	1	1	D
1.11	Instrument Lines Penetrating Primary Reactor Containment	0	0	0	D
	Supplement to Safety Guide 11, Backfitting Considerations	0	0	0	D

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*Refer to page D-1

Number	Title	Revision in Effect 1/76	Revision in Effect 1/79	Revision in Effect 1/80	Relates* to
1.12	Instrumentation for Earthquakes	1	1	1	D
1.13	Spent Fuel Storage Facility Design Basis	1	1	1	D
1.14	Reactor Coolant Pump Flywheel Integrity	1	1	1	D
1.15	Testing of Reinforcing Bars for Category I Concrete Structures	1	1	1	C
1.16	Reporting of Operating Information - Appendix A Technical Specifications	4	4	4	0
1.17	Protection of Nuclear Plants Against Industrial Sabotage	1	1	1	D, O (CI)
1.18	Structural Acceptance Test for Concrete Primary Reactor Containments	1	1	1	C
1.19	Nondestructive Examination of Primary Containment Liner Welds	1	1	1	C
1.20	Comprehensive Vibration Assessment Program for Reactor Internals During Preoperational and Initial Startup Testing	1	2	2	0
1.21	Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactivity in Liquid and Gaseous Effluents from Light Water Nuclear Power Plants	1	1	1	0
1.22	Periodic Testing of Protection System Actuation Functions	0	0	0	0
1.23	Onsite Meteorological Programs	0	0	0	0
1.24	Assumptions Used for Evaluating the Potential Radiological Consequences of a Pressurized Water Reactor Gas Storage Tank Failure	0	0	0	D
1.25	Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors	0	0	0	D

Number	Title	Revision in Effect 1/76	Revision in Effect 1/79	Revision in Effect 1/80	Relates* to
1.26	Quality Group Classifications and Standards for Water-, Steam- and Radio-Waste-Containing Components of Nuclear Power Plants	2	3	3	D
1.27	Ultimate Heat Sink for Nuclear Power Plants	1	2	2	D
1.28	Quality Assurance Program Requirements (Design and Construction)	0	1	2	D, C
1.29	Seismic Design Classification	1	3	3	D
1.30	Quality Assurance Requirements for the Installation, Inspection, and Testing of Instrumentation and Electric Equipment	0	0	0	C
1.31	Control of Ferrite Content in Stainless Steel Weld Metal	1	3	3	C
1.32	Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants	1	2	2	D
1.33	Quality Assurance Program Requirements (Operation)	0	2	2	0
1.34	Control of Electroslag Weld Properties	0	0	0	C
1.35	Inservice Inspection of Ungrouted Tendons in Prestressed Concrete Containment Structures	2	2	2	C
1.36	Nonmetallic Thermal Insulation for Austenitic Stainless Steel	0	0	0	D
1.37	Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plants	0	0	0	C
1.38	Quality Assurance Requirements for Packaging, Shipping, Receiving, Storage, and Handling of Items for Water-Cooled Nuclear Power Plants	1	2	2	C
1.39	Housekeeping Requirements for Water-Cooled Nuclear Power Plants	1	2	2	C, O

Number	Title	Revision in Effect 1/76	1/79	1/80	Relates* to
1.40	Qualification Tests of Continuous-Duty Motors Installed Inside the Containment of Water-Cooled Nuclear Power Plants	0	0	0	D
1.41	Preoperational Testing of Redundant Onsite Electric Power Systems to Verify Proper Load Group Assignments	0	0	0	C
1.42	Interim Licensing Policy on As-Low-As-Practicable for Gaseous Radio-Iodine Releases from Light-Water-Cooled Nuclear Power Reactors	0	(Withdrawn 3/22/76)	-	-
1.43	Control of Stainless Steel Weld Cladding of Low-Alloy Steel Components	0	0	0	C
1.44	Control of the Use of Sensitized Stainless Steel	0	0	0	C
1.45	Reactor Coolant Pressure Boundary Leakage Detection Systems	0	0	0	D
1.46	Protection Against Pipe Whip Inside Containment	0	0	0	D
1.47	Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems	0	0	0	D, O
1.48	Design Limits and Loading Combinations for Seismic Category I Fluid System Components	0	0	0	D
1.49	Power Levels of Nuclear Power Plants	1	1	1	D
1.50	Control of Preheat Temperature for Welding of Low-Alloy Steel	0	0	0	C
1.51	Inservice Inspection of ASME Code Class 2 and 3 Nuclear Power Plant Components	(Withdrawn 7/21/75)		-	-
1.52	Design, Testing, and Maintenance Criteria for Engineered-Safety-Feature Atmosphere Cleanup System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants	NI	2	2	D, O
1.53	Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems	0	0	0	D

		Revision in Effect			Relates* to
Number	Title	1/76	1/79	1/80	
1.54	Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants	0	0	0	D, C
1.55	Concrete Placement in Category I Structures	0	0	0	C
1.56	Maintenance of Water Purity in Boiling Water Reactors	0	1	1	O
1.57	Design Limits and Loading Combinations for Metal Primary Reactor Containment System Components	0	0	0	D
1.58	Qualification of Nuclear Power Plant Inspection, Examination, and Testing Personnel	0	0	0	C
1.59	Design Basis Floods for Nuclear Power Plants	1	2	2	D
1.60	Design Response Spectra for Seismic Design of Nuclear Power Plants	1	1	1	D
1.61	Damping Values for Seismic Design of Nuclear Power Plants	0	0	0	D
1.62	Manual Initiation of Protective Actions	0	0	0	D, O
1.63	Electric Penetration Assembles in Containment Structures for Light-Water-Cooled Nuclear Power Plants	0	2	2	D
1.64	Quality Assurance Requirements for the Design of Nuclear Power Plants	1	2	2	D
1.65	Materials and Inspection for Reactor Vessel Closure Studs	0	0	0	D, C, O
1.66	Nondestructive Examination of Tubular Products	0	(Withdrawn - 10/6/77)		-
1.67	Installation of Overpressure Protective Devices	0	D	0	D, C
1.68	Initial Test Programs for Water-Cooled Reactor Power Plants	0	2	2	C, O
1.68.1	Preoperational and Initial Startup Testing of Feedwater and Condensate Systems for Boiling Water Reactor Power Plants	NI	1	1	C, O

Number	Title	Revision in Effect 1/76	1/79	1/80	Relates* to
1.68.2	Initial Startup Test Program to Demonstrate Remote Shutdown Capability for Water-Cooled Nuclear Power Plants	NI	1	1	C, O
1.69	Concrete Radiation Shields for Nuclear Power Plants	0	0	0	D
1.70	Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants-LWR Edition	2	3	3	D
1.71	Welder Qualification for Areas of Limited Accessibility	0	0	0	C
1.72	Spray Pond Piping Made from Fiberglass-Reinforced Thermosetting Resin	0	2	2	D
1.73	Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants	0	0	0	C
1.74	Quality Assurance Terms and Definitions	0	0	0	D, C, O
1.75	Physical Independence of Electric Systems	1	2	2	D
1.76	Design Basis Tornado for Nuclear Power Plants	0	0	0	D
1.77	Assumptions Used for Evaluating a Control Rod Ejection Accident for Pressurized Water Reactors	0	0	0	D
1.78	Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release	0	0	0	D
1.79	Preoperational Testing of Emergency Core Cooling Systems for Pressurized Water Reactors	1	1	1	C, O
1.80	Preoperational Testing of Instrument Air Systems	0	0	0	C, O
1.81	Shared Emergency and Shutdown Electric Systems for Multi-Unit Plants	1	1	1	D
1.82	Sumps for Emergency Core Cooling and Containment Spray Systems	0	0	0	D

Number	Title	Revision in Effect			Relates* to
		1/76	1/79	1/80	
1.83	Inservice Inspection of Pressurized Water Reactor Steam Generator Tubes	1	1	1	O
1.84	Code Case Acceptability - ASME Section III Design and Fabrication	8	14	16	D, C, O
1.85	Code Case Acceptability - ASME Section III Materials	8	14	16	D, C, O
1.86	Termination of Operating Licenses for Nuclear Reactors	0	0	0	O
1.87	Guidance for Construction of Class 1 Components in Elevated-Temperature Reactors (Supplement to ASME Section III Code Classes 1592, 1593, 1594, 1595 and 1596)	1	1	1	D
1.88	Collection, Storage, and Maintenance of Nuclear Power Plant Quality Assurance Records	1	2	2	D, C, O
1.89	Qualification of Class 1E Equipment for Nuclear Power Plants	0	0	0	D, C
1.90	Inservice Inspection of Prestressed Concrete Containment Structures with Grouted Tendons	0	1	1	D, C, O
1.91	Evaluation of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plant Sites	0	1	1	D
1.92	Combining Modal Responses and Spatial Components in Seismic Response Analysis	0	1	1	D
1.93	Availability of Electric Power Sources	0	0	0	D
1.94	Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants	0	1	1	C
1.95	Protection of Nuclear Power Plant Control Room Operators Against an Accidental Chlorine Release	0	1	1	D

Number	Title	Revision in Effect			Relates* to
		1/76	1/79	1/80	
1.96	Design of Main Steam Isolation Valve Leakage Control Systems for Boiling Water Reactor Nuclear Power Plants	0	1	1	D
1.97	Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant Conditions During and Following an Accident	0	1	1	D, O
1.98	Assumptions Used for Evaluating the Potential Radiological Consequences of a Radioactive Offgas System Failure in a Boiling Water Reactor	NI	0	0	D
1.99	Effects of Residual Elements on Predicted Radiation Damage to Reactor Vessel Materials	0	1	1	D
1.100	Seismic Qualification of Electric Equipment for Nuclear Power Plants	0	1	1	D, C
1.101	Emergency Planning for Nuclear Power Plants	0	1	1	D, C
1.102	Flood Protection for Nuclear Power Plants	0	1	1	D
1.103	Post-Tensioned Prestressing Systems for Concrete Reactor Vessels and Containments	0	1	1	D
1.104	Overhead Crane Handling Systems for Nuclear Power Plants	NI	0	(Withdrawn - 8/16/79)	-
1.105	Instrument Setpoints	0	1	1	D, O
1.106	Thermal Overload Protection for Electric Motors on Motor-Operated Valves	0	1	1	D
1.107	Qualifications for Cement Grouting for Prestressing Tendons in Containment Structures	0	1	1	C
1.108	Periodic Testing of Diesel Generator Units Used as Cnsite Electric Power Systems at Nuclear Power Plants	0	1	1	O
1.109	Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I	NI	1	1	D

Number	Title	Revision in Effect			Relates* to
		1/76	1/79	1/80	
1.110	Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors	NI	0	0	D
1.111	Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors	NI	1	1	D, O
1.112	Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors	NI	0	0	D, O
1.113	Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I	NI	1	1	D, O
1.114	Guidance on Being Operator at the Controls of a Nuclear Power Plant	NI	1	1	O
1.115	Protection Against Low-Trajectory Turbine Missiles	NI	1	1	D
1.116	Quality Assurance Requirements for Installation, Inspection, and Testing of Mechanical Equipment and Systems	NI	0	0	C
1.117	Tornado Design Classification	NI	1	1	D
1.118	Periodic Testing of Electric Power and Protective Systems	NI	2	2	O
1.119	Surveillance Program for New Fuel Assembly Designs	NI	(Withdrawn 6/20/77)	-	-
1.120	Fire Protection Guidelines for Nuclear Power Plants	NI	1	1	D(CI)
1.121	Bases for Plugging Degraded PWR Steam Generator Tubes	NI	0	0	C
1.122	Development of Floor Design Response Spectra for Seismic Design of Floor-Supported Equipment or Components	NI	1	1	D
1.123	Quality Assurance Requirements for Control of Procurement of Items and Services for Nuclear Power Plants	NI	1	1	D, C

Number	Title	Revision in Effect 1/76	1/79	1/80	Relates* to
1.124	Service Limits and Loading Combinations for Class 1 Linear Type Component Supports	NI	1	1	D
1.125	Physical Models for Design and Operation of Hydraulic Structures and Systems for Nuclear Power Plants	NI	1	1	D
1.126	An Acceptable Model and Related Statistical Methods for the Analysis of Fuel Densification	NI	1	1	O
1.127	Inspection of Water Control Structures Associated with Nuclear Power Plants	NI	1	1	C, O
1.128	Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants	NI	1	1	D, C(CI)
1.129	Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants	NI	1	1	O
1.130	Design Limits and Loading Combinations for Class 1 Plate-and-Shell-Type Component Supports	NI	1	1	D
1.131	Qualification Tests of Electric Cables, Field Splices, and Connections for Light-Water-Cooled Nuclear Power Plants	NI	0	0	C
1.132	Site Investigations for Foundations of Nuclear Power Plants	NI	0	1	D
1.133	Loose-Part Detection Program for the Primary System of Light-Water-Cooled Reactors	NI	0	0	D, C, O
1.134	Medical Certification and Monitoring of Personnel Requiring Operator Licenses	NI	0	1	O
1.135	Normal Water Level and Discharge at Nuclear Power Plants	NI	0	0	O
1.136	Material for Concrete Containments	NI	1	1	C
1.137	Fuel-Oil Systems for Standby Diesel Generators	NI	0	1	D

Number	Title	Revision in Effect			Relates* to
		1/76	1/79	1/80	
1.138	Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants	NI	0	0	D
1.139	Guidance for Residual Heat Removal	NI	0	0	D
1.140	Design, Testing and Maintenance Criteria for Normal Ventilation Exhaust System, Air Filtration and Absorption Units of Light-Water-Cooled Nuclear Power Plants	NI	0	1	D
1.141	Containment Isolation Provisions for Fluid Systems	NI	0	0	D
1.142	Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments)	NI	0	0	D
1.143	Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants	NI	0	1	D
1.144	Auditing of Quality Assurance Programs for Nuclear Power Plants	NI	NI	0	0
1.145	Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants	NI	NI	0	D

REGULATORY GUIDES

Division 2 Regulatory Guides
Research and Test Reactors

Number	Title	Revision in Effect			Relates* to
		1/76	1/79	1/80	
2.1	Shield Test Program for Evaluation of Installed Biological Shielding in Research and Training Reactors	0	0	0	NA
2.2	Development of Technical Specifications for Experiments in Research Reactors	0	0	0	NA
2.3	Quality Verification for Plate-Type Uranium-Aluminum Fuel Elements for Use in Research Reactors	0	1	1	NA
2.4	Review of Experiments for Research Reactors	NI	0	0	NA
2.5	Quality Assurance Program Requirements for Research Reactors	NI	0	0	NA
2.6	Emergency Planning for Research Reactors	NI	NI	0	NA

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*Refer to page D-1

REGULATORY GUIDES

Division 3 Regulatory Guides
Fuels and Materials Facilities

Number	Title	Revision in Effect			Relates* to
		1/76	1/79	1/80	
3.1	Use of Borosilicate-Class Rashig Rings as a Neutron Absorber in Solutions of Fissile Material	0	0	0	NA
3.2	Efficiency Testing of Air-Cleaning Systems Containing Devices for Removal of Particles	0	0	0	NA
3.3	Quality Assurance Program Requirements for Fuel Reprocessing Plants and for Plutonium Processing and Fuel Fabrication Plants	1	1	1	NA
3.4	Nuclear Criticality in Safety Operations with Fissionable Materials Outside Reactors	0	1	1	NA
3.5	Standard Format and Content of License Applications for Uranium Mills	0	1	1	NA
3.6	Guide to Content of Technical Specifications for Fuel Reprocessing Plants	0	0	0	NA
3.7	Monitoring of Combustible Gases and Vapors in Plutonium Processing and Fuel Fabrication Plants	0	0	0	NA
3.8	Preparation of Environmental Reports for Uranium Mills	0	1	1	NA
3.9	Concrete Radiation Shields	0	0	0	NA
3.10	Liquid Waste Treatment System Design Guide for Plutonium Processing and Fuel Fabrication Plants	0	0	0	NA
3.11	Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills	1	2	2	NA
3.12	General Design Guide for Ventilation Systems of Plutonium Processing and Fuel Fabrication Plants	0	0	0	NA
3.13	Guide for Acceptable Waste Storage Methods at UF_6 Production Plants	0	0	0	NA

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*Refer to page D-1

Number	Title	Revision in Effect			Relates * to
		1/76	1/79	1/80	
3.14	Seismic Design Classification for Plutonium Processing and Fuel Fabrication Plants	0	0	0	NA
3.15	Standard Format and Content of License Applications for Storage Only of Unirradiated Reactor Fuel and Associated Radioactive Material	0	0	0	NA
3.16	General Fire Protection Guide for Plutonium Processing and Fuel Fabrication Plants	0	0	0	NA
3.17	Earthquake Instrumentation for Fuel Reprocessing Plants	0	0	0	NA
3.18	Confinement Barriers and Systems for Fuel Reprocessing Plants	0	0	0	NA
3.19	Reporting of Operating Information for Fuel Reprocessing Plants	0	0	0	NA
3.20	Process Offgas Systems for Fuel Reprocessing Plants	0	0	0	NA
3.21	Quality Assurance Requirements for Protective Coatings Applied to Fuel Reprocessing Plants and to Plutonium Processing and Fuel Fabrication Plants	0	0	0	NA
3.22	Periodic Testing of Fuel Reprocessing Plant Protection System Actuation Functions	0	0	0	NA
3.23	Stabilization of Uranium-Thorium Milling Waste Retention Systems	0	0	0	NA
3.24	Guidance on the License Application, Siting, Design, and Plant Protection for an Independent Spent Fuel Storage Installation	0	0	0	NA
3.25	Standard Format and Content of Safety Analysis Reports for Uranium Enrichment Facilities	0	0	0	NA
3.26	Standard Format and Content of Safety Analysis Reports for Fuel Reprocessing Plants	0	0	0	NA

Number	Title	Revision in Effect			Relates* to
		1/76	1/79	1/80	
3.27	Nondestructive Examination of Welds in the Liners of Concrete Barriers in Fuel Reprocessing Plants	0	1	1	NA
3.28	Welder Qualification for Welding in Areas of Limited Accessibility in Fuel Reprocessing Plants in Plutonium Processing and Fuel Fabrication Plants	0	0	0	NA
3.29	Preheat and Interpass Temperature Control for the Welding of Low-Alloy Steel for Use in Fuel Reprocessing Plants and in Plutonium Processing and Fuel Fabrication Plants	0	0	0	NA
3.30	Selection, Application, and Inspection of Protective Coatings (Paints) for Fuel Reprocessing Plants	0	0	0	NA
3.31	Emergency Water Supply Systems for Fuel Reprocessing Plants	0	0	0	NA
3.32	General Design Guide for Ventilation Systems for Fuel Reprocessing Plants	0	0	0	NA
3.33	Assumptions Used for Evaluating the Potential Radiological Consequences of Accidental Nuclear Criticality in a Fuel Reprocessing Plant	NI	0	0	NA
3.34	Assumptions Used for Evaluating the Potential Radiological Consequences of Accidental Nuclear Criticality in a Uranium Fuel Fabrication Plant	NI	0	1	NA
3.35	Assumptions Used for Evaluating the Potential Radiological Consequences of Accidental Nuclear Criticality in a Plutonium Processing and Fuel Fabrication Plant	NI	0	1	NA
3.36	Nondestructive Examination of Tubular Products for Use in Fuel Reprocessing Plants and in Plutonium Processing and Fuel Fabrication Plants	0	0	(Withdrawn - 1/24/79)	-
3.37	Guidance for Avoiding Intergranular Corrosion and Stress Corrosion in Austenitic Stainless Steel Components of Fuel Reprocessing Plants	0	0	0	NA

Number	Title	Revision in Effect 1/76	1/79	1/80	Relates* to
3.38	General File Protection Guide for Fuel Reprocessing Plants	NI	0	0	NA
3.39	Standard Format and Content of License Applications for Plutonium Processing and Fuel Fabrication Plants	0	0	0	NA
3.40	Design Basis Floods for Fuel Reprocessing Plants and for Plutonium Processing and Fuel Fabrication Plants	NI	1	1	NA
3.41	Validation of Calculational Methods for Nuclear Criticality Safety	NI	1	1	NA
3.42	Emergency Planning for Fuel Cycle Facilities and Plants Licensed Under 10 CFR Parts 50 and 70	NI	0	1	NA
3.43	Nuclear Criticality Safety in the Storage of Fissile Materials	NI	0	1	NA
3.44	Standard Format and Content for the Safety Analysis Report to be Included in a License Application for the Storage of Spent Fuel	NI	0	1	NA

REGULATORY GUIDES

Division 4 Regulatory Guides
Environmental and Siting Guides

Number	Title	Revision in Effect			Relates* to
		1/76	1/79	1/80	
4.1	Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants	0	1	1	0
4.2	Preparation of Environmental Reports for Nuclear Power Stations	1	2	2	D
4.3	Measurements of Radionuclides in the Environment-Analysis of I-131 in Milk	0	(Withdrawn 12/9/76)	-	-
4.4	Reporting Procedures for Mathematical Models Selected to Predict Heated Effluent Dispersion in Natural Water Bodies	0	0	0	0
4.5	Measurements of Radionuclides in the Environment-Sampling and Analysis of Plutonium in Soil	0	0	0	0
4.6	Measurements of Radionuclides in the Environment-Strontium-89 and Strontium-90 Analysis	0	0	0	0
4.7	General Site Suitability Criteria for Nuclear Power Stations	1	1	1	D
4.8	Environmental Technical Specifications for Nuclear Power Plants	0	0	0	0
4.9	Preparation of Environmental Reports for Commercial Uranium Enrichment Facilities	1	1	1	NA
4.10	Irreversible and Irretrievable Commitments of Material Resources	0	(Withdrawn 11/17/77)	-	-
4.11	Terrestrial Environmental Studies for Nuclear Power Stations	0	1	1	D
4.13	Performance, Testing, and Procedural Specifications for Thermoluminescence Dosimetry: Environmental Applications	NI	1	1	0
4.14	Measuring, Evaluating, and Reporting Radioactivity in Releases of Radioactive Materials in Liquids and Airborne Effluents from Uranium Mills	NI	0	0	0

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*Refer to page D-1

Number	Title	Revision in Effect 1/76	Revision in Effect 1/79	Revision in Effect 1/80	Relates* to
4.15	Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment	NI	0	1	0
4.16	Measuring, Evaluating and Reporting Radioactivity in Releases of Radioactive Materials in Liquid and Airborne Effluents from Nuclear Fuel Processing and Fabrication Plants	NI	0	0	0

REGULATORY GUIDES

Division 5 Regulatory Guides
Materials and Plant Protection

Number	Title	Revision in Effect 1/76	1/79	1/80	Relates* to
5.1	Serial Numbering of Light-Water-Power Reactor Fuel Assemblies	0	0	0	0
5.2	Classification of Unirradiated Plutonium and Uranium Scrap	0	0	(Withdrawn 9/26/79)	-
5.3	Statistical Terminology and Notation for Special Nuclear Materials Control Accountability	0	0	0	0
5.4	Standard Analytical Methods for the Measurement of Uranium Tetrafluoride (UF_4) and Uranium Hexafluoride (UF_6)	0	0	0	NA
5.5	Standard Methods for Chemical, Mass Spectrometric, and Spectrochemical Analysis of Nuclear-Grade Uranium Dioxide Powders and Pellets	0	0	0	NA
5.6	Standard Methods for Chemical, Mass Spectrochemical Analysis of Nuclear-Grade Plutonium Dioxide Powders and Pellets and Nuclear Grade Mixed Oxides (U, Pu, O_2)	0	0	0	NA
5.7	Control of Personnel Access to Protected Areas, Vital Areas, and Material	0	0	0	D, C, O(CI)
5.8	Design Considerations for Minimizing Residual Holdup of Special Nuclear Material in Drying and Fluidized Bed Operations	1	1	1	NA
5.9	Specifications of Ge(Li) Spectroscopy Systems for Material Protection Measurements - Part I: Data Acquisition	1	1	1	NA
5.10	Selection and Use of Pressure-Sensitive Seals on Containers for Onsite Storage of Special Nuclear Materials	0	0	0	0
5.11	Nondestructive Assay of Special Nuclear Material Contained in Scrap and Waste	0	0	0	NA

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*Refer to page D-1

Number	Title	Revision in Effect 1/76	1/79	1/80	Relates* to
5.12	General Use of Locks in the Protection and Control of Facilities and Special Nuclear Materials	0	0	0	D, 0
5.13	Conduct of Nuclear Material Physical Inventories	0	0	0	0
5.14	Visual Surveillance of Individuals in Material Access Areas	0	0	0	0
5.15	Security Seals for the Protection and Control of Special Nuclear Material	0	0	0	0
5.16	Standard Methods for Chemical, Mass Spectrometric, Spectrochemical, Nuclear and Radiochemical Analysis of Nuclear-Grade Plutonium Nitrate Solutions and Plutonium Metal	1	1	1	NA
5.17	Truck Identification Markings	0	0	0	0
5.18	Limit of Error Concepts and Principles of Calculation in Nuclear Materials Control	0	0	0	NA
5.19	Methods for the Accountability of Plutonium Nitrate Solutions	0	0	0	NA
5.20	Training, Equipping, and Qualifying of Guards and Watchmen	0	0	0	0
5.21	Nondestructive Uranium-235 Enrichment Assay by Gamma-Ray Spectrometry	0	0	0	NA
5.22	Assessment of the Assumption of Normality (Employing Individual Observed Values)	0	0	0	NA
5.23	In-Situ Assay of Plutonium Residual Holdup	0	0	0	NA
5.24	Analysis and Use of Process Data for the Protection of Special Nuclear Material in Equipment for Wet Process Operations	0	0	0	NA
5.25	Design Considerations for Minimizing Residual Holdup of Special Nuclear Material in Equipment for Wet Process Operations	0	0	0	NA
5.26	Selection of Material Balance Areas and Item Control Areas	1	1	1	NA

Number	Title	Revision in Effect			Relates* to
		1/76	1/79	1/80	
5.27	SNM Doorway Monitors	0	0	0	D, O
5.28	Evaluation of Shipper-Receiver Differences in the Transfer of Special Nuclear Material	0	0	0	O
5.29	Nuclear Material Control Systems for Nuclear Power Plants	1	1	1	D, O
5.30	Materials Protection Contingency Measures for Uranium and Plutonium Fuel Manufacturing Plants	0	0	0	NA
5.31	Specially Designed Vehicle with Armed Guards for Road Shipments of Special Nuclear Material	1	1	1	O
5.32	Communication with Transport Vehicles	1	1	1	O
5.33	Statistical Evaluation of Material Unaccounted For	0	0	0	O
5.34	Nondestructive Assay of Plutonium in Scrap by Spontaneous Fission Detection	0	0	0	NA
5.35	Calorimetric Assay for Plutonium	0	(Withdrawn 8/18/77)	-	-
5.36	Recommended Practice for Dealing With Outlying Observations	0	0	0	NA
5.37	In-Situ Assay of Enriched Uranium Residual Holdup	0	0	0	NA
5.38	Nondestructive Assay of High-Enrichment Uranium Fuel Plates by Gamma-Ray Spectrometry	0	0	0	NA
5.39	General Methods for the Analysis of Uranyl Nitrate Solutions for Assay, Isotopic Distribution, and Impurity Determinations	0	0	0	NA
5.40	Methods for the Accountability of Plutonium Dioxide Powder	0	0	0	NA
5.42	Design Considerations for Minimizing Residual Holdup of Special Nuclear Material in Equipment for Dry Process Operations	0	0	0	NA

Number	Title	Revision in Effect 1/76	Revision in Effect 1/79	Revision in Effect 1/80	Relates* to
5.43	Plant Security Force Duties	0	0	0	O
5.44	Perimeter Intrusion Alarm Systems	0	1	1	D, O
5.45	Standard Format and Content for the Special Nuclear Material Control and Accounting Section of a Special Nuclear Material License Application	0	0	0	O
5.47	Control and Accountability of Plutonium in Waste Material	0	0	0	NA
5.48	Design Considerations - Systems for Measuring the Mass of Liquids	0	0	0	NA
5.49	Internal Transfers of Special Nuclear Material	0	0	0	O
5.51	Management Review of Nuclear Material Control and Accounting Systems	0	0	0	O
5.52	Standard Format and Content for the Physical Protection Section of a License Application (for Facilities Other than Nuclear Power Plants)	NI	1	1	NA
5.53	Qualification, Calibration, and Error Estimation Methods for Nondestructive Assay	0	0	0	NA
5.54	Standard Format and Content of Safeguards Contingency Plans for Nuclear Power Plants	NI	0	0	O
5.55	Standard Format and Content of Safeguards Contingency Plans for Fuel Cycle Facilities	NI	0	0	NA
5.56	Standard Format and Content of Safeguards Contingency Plans for Transportation	NI	0	0	NA
5.57	Shipping and Receiving Control of Special Nuclear Material	NI	0	0	O
5.58	Considerations for Establishing Traceability of Special Nuclear Materials Accounting Measurements	NI	0	0	O

REGULATORY GUIDES

Division 6 Regulatory Guides
Products

Number	Title	Revision in Effect 1/76	1/79	1/80	Relates* to
6.1	Leak Testing Radioactive Brachytherapy Sources	1	1	1	NA
6.2	Integrity and Test Specifications for Selected Brachytherapy Sources	1	1	1	NA
6.3	Design, Construction, and Use of Radioisotopic Power Generators for Certain Land and Sea Applications	0	0	0	NA
6.4	Classification of Containment Properties of Sealed Radioactive Sources Contained in Certain Devices to be Distributed for Use Under General License	1	1	1	NA
6.5	General Safety Standard for Installations Using Nonmedical Sealed Gamma-Ray Sources	0	0	0	NA
6.6	Acceptance Sampling Procedures for Exempted and Generally Licensed Items Containing Byproduct Material	0	0	0	NA
6.7	Preparation to an Environmental Report to Support a Rule Making Petition Seeking an Exemption for a Radionuclide-Containing Product	0	1	1	NA
6.8	Identification Plaque for Irretrievable Well-Logging Sources	NI	0	0	NA

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*Refer to page D-1

REGULATORY GUIDES

Division 7 Regulatory Guides
Transportation

Number	Title	Revision in Effect 1/76	1/79	1/80	Relates* to
7.1	Administrative Guide for Packaging and Transporting Radioactive Material	0	0	0	O
7.2	Packaging and Transportation of Radioactively Contaminated Biological Materials	0	0	0	NA
7.3	Procedures for Picking Up and Receiving Packages of Radioactive Materials	0	0	0	O
7.4	Leakage Tests on Packages for Shipment of Radioactive Materials	0	0	0	O
7.5	Administrative Guide for Obtaining Exemptions from Certain NRC Requirements over Radioactive Material Shipments	0	0	0	O
7.6	Stress Allowables for the Design of Shipping Cask Containment Vessels	NI	1	1	D
7.7	Administrative Guide for Verifying Compliance with Packaging Requirements for Shipments of Radioactive Materials	NI	0	0	O
7.8	Load Combinations for the Structural Analysis of Shipping Casks	NI	1	0	D
7.9	Standard Format and Content of Part 71 Applications for Approval of Packaging of Type B, Large Quantity, and Fissile Radioactive Material	NI	NI	0	O

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*Refer to page D-1

REGULATORY GUIDES

Division 8 Regulatory Guides
Occupational Health

Number	Title	Revision in Effect			Relates* to
		1/76	1/79	1/80	
8.1	Radiation Symbol	0	0	0	0
8.2	Administrative Practices in Radiation Monitoring	0	0	0	0
8.3	Film Badge Performance Criteria	0	0	0	0
8.4	Direct-Reading and Indirect-Reading Pocket Dosimeters	0	0	0	0
8.5	Immediate Evacuation Signal	0	0	0	0
8.6	Standard Test Procedure for Geiger-Muller Counters	0	0	0	0
8.7	Occupational Radiation Exposure Records Systems	0	0	0	0
8.8	Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations will be as Low as is Reasonably Achievable	1	3	3	D, 0
8.9	Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program	0	0	0	0
8.10	Operating Philosophy for Maintaining Occupational Radiation Exposures as Low as is Reasonably Achievable (Nuclear Power Reactors)	1	1	1	0
8.11	Application of Bioassay for Uranium	0	0	0	0
8.12	Criticality Accident Alarm Systems	0	0	0	0
8.13	Instruction Concerning Prenatal Radiation Exposure	1	1	1	0
8.14	Personnel Neutron Dosimeters	0	1	1	0
8.15	Acceptable Programs for Respiratory Protection	NI	0	0	0

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*Refer to page D-1

Number	Title	Revision in Effect			Relates* to
		1/76	1/79	1/80	
8.18	Information Relevant to Ensuring that Occupational Radiation Exposures at Medical Institutions will be as Low as Reasonably Achievable	NI	0	0	NA
8.19	Occupational Radiation Dose Assessment in Light-Water Reactor Power Plants Design Stage Man-Rem Estimates	NI	0	1	D, O
8.20	Application of Bioassay for I-125 and I-131	NI	0	1	O
8.21	Health Physics Surveys for By-Product Material at NRC-Licensed Processing and Manufacturing Plants	NI	0	1	O
8.22	Bioassay at Uranium Mills	NI	0	0	NA
8.24	Health Physics Surveys During Enriched Uranium-235 Processing and Fuel Fabrication	NI	0	1	NA

REGULATORY GUIDES

Division 9 Regulatory Guides
Antitrust Review

Number	Title	Revision in Effect			Relates* to
		1/76	1/79	1/80	
9.1	Regulatory Staff Position Statement on Antitrust Matters	0	0	0	D
9.2	Information Needed by the NRC Staff in Connection with its Antitrust Review of Construction Permit Applications for Nuclear Power Plants	0	1	1	D
9.3	Information Needed by the NRC Staff in Connection with its Antitrust Review of Operating License Applications for Nuclear Power Plants	0	0	0	D
9.4	Suggested Format for Cash Flow Statements Submitted as Guarantees of Payment of Retrospective Payments	NI	0	0	0

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*Refer to page D-1

REGULATORY GUIDES

Division 10 Regulatory Guides
General Guides

Number	Title	Revision in Effect			Relates* to
		1/76	1/79	1/80	
10.1	Compilation of Reporting Requirements for Persons Subject to NRC Regulations	1	3	3	0
10.2	Guidance to Academic Institutions Applying for Specific Byproduct Material Licenses of Limited Scope	0	1	1	NA
10.3	Guide for the Preparation of Applications for Special Nuclear Material Licenses of Less than Critical Mass Quantities	0	1	1	0
10.4	Guide for the Preparation of Applications for Licenses to Process Source Material	0	1	1	0
10.5	Guide for the Preparation of Applications for Type A Licenses of Broad Scope for Byproduct Material	NI	0	0	0
10.6	Guide for the Preparation of Applications for the Use of Sealed Sources and Devices for the Performance of Industrial Radiography	NI	0	0	C
10.7	Guide for the Preparation of Applications for Licenses for Laboratory Use of Small Quantities of Byproduct Material	NI	0	1	NA
10.8	Guide for the Preparation of Applications for Medical Programs	NI	NI	0	NA

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*Refer to page D-1

APPENDIX - E

PHASE III FINAL REPORT AND THIRD UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

September 25, 1980

CE-ADD-80-310

NSSS CAPITAL COSTS FOR A MATURE LMFBR INDUSTRY - ADDENDUM

Prepared by
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Acknowledgements

The work documented in this report was performed under the direction of S. U. Zaman. D. Mehta performed the cost updating of the reference Target Plant.

INDEX

LIST OF FIGURES

LIST OF TABLES

I. SUMMARY

1.0 Introduction

In the document "NSSS Capital Costs for a Mature LMFBR Industry", Shakir U. Zaman, CE-FBR-78-532, 10-23-78(1), the conceptual design of a commercial LMFBR (C-E Target Plant) and its NSSS capital costs were developed and compared to those of a comparably sized LWR (C-E System 80). This work was done in support of the United Engineers and Constructors Contract EN-78-C-02-4954 with the Department of Energy. The objective of that contract, as described in the above document, was to "... provide the Department of Energy/Office of Program Planning and Analysis - Nuclear Energy Programs with periodic updates of technical, capital cost, fuel cycle cost, and operating and maintenance cost information."

In accordance with that contract and with the subsequent "Addendum to P.O. No. H.O. 53461(2)", additional work has been performed in the areas of Target Plant conceptual design and capital cost updates. It is the purpose of this report (intended as a supplement to reference (1)) to document the nature and status of this work.

2.0 Work Scope

Work performed in support of this follow-on effort was concentrated in two areas: 1) an update of Target Plant capital costs reflecting pricing increases in the period 1/78 - 1/80; and 2) a conceptual design update of selected Target Plant components utilizing results of the AI/C-E CDS Phase I effort.

2.1 Capital Cost Update

Price increases in the period 1/78 - 1/80 reflect cost escalation in both materials and labor. A composite cost escalation figure was employed which is equivalent to 45% of the materials escalation plus 55% of the labor escalation. In general this sum is in the range of 18-21%. Individual escalation figures were obtained for most of the larger items through responsible C-E departments. For smaller items, an average escalation figure was estimated based on configuration.

The composite cost escalation figures have been applied to the Target Plant capital cost estimate figures reported in Reference (1). The result was an up-to-date costing of the reference Target Plant. These costs were then revised to supply cost estimates for the updated target plant components outlined in the following section and described in Section II. These costs have been approximated using cost figures for similar reference components as a basis, and adjusting for differences in configuration and size. Table 1-1 contains cost estimate highlights for the updated Target Plant. A more detailed breakdown of component costs is provided in Section III.

2.2 Conceptual Design Update

Two major design modifications have been performed on the Target Plant: 1) the reference Target Plant reactor vessel and internals have been replaced with components based on those developed during the AI/C-E CDS Phase I effort, and 2) the reference fuel handling system has been replaced, again with CDS-based components.

The updated reactor vessel is larger than the reference vessel (37'-6" OD vs. 27'-5" OD), and employs a surrounding guard vessel in place of the reference cavity filter block system. Reactor internals modifications may be summarized as follows:

- A downcomer inlet piping system replaces the low-mounted inlet nozzles of the reference design.
- A single instrument tree assembly, similar to the one employed in the CDS vessel, replaces the individual CRITA units.
- The combination core support/inlet plenum assembly of the reference design has been replaced with the separate core support structure and inlet manifold assembly utilized in the CDS Phase I loop vessel.
- A CDS-type splitter valve system replaces the separate low pressure inlet piping of the reference design for purposes of coolant flow distribution.

TABLE 1.1

COST ESTIMATE SUMMARY

		COSTS (Thousands of Dollars)
220A.211	Reactor Vessels	46,963
220A.212	Reactor Vessel Internals	26,038
220A.213	Control Rod System	3,249
220A.221	Primary Heat Transport System	69,393
220A.222	Intermediate Heat Transport System	28,184
220A.23	Steam Generation System	58,489
220A.24	Safeguards System	11,323
220A.25	Fuel Handling and Storage System	39,031
220A.26	Other Equipment	34,750
220A.27	Instrumentation + Controls	22,855
	220A.2 NSSS Costs	340,275

The reactor core assembly, as well as the principle NSSS Parameters listed in Table 1.1 of Reference (1), remain unchanged.

The major layout change in the Fuel Handling system involves removal of the Ex-Vessel Storage Tank from inside to outside of the Reactor Containment Building. The EVST design is based on that developed for the EPRI 1000 MWe Pool Plant Study(3). In addition, the reference straight-pull ex-vessel handling machine with in-vessel transfer mechanism has been replaced with the double inclined track, hoist-tilt mechanism with traversing trolleys developed for the CDS Phase I loop vessel fuel handling system. More detailed descriptions of the reactor and fuel handling systems are provided in Section II. Revised equipment lists are provided in Section IV.

The Primary Heat Transport System piping required some redesign in order to accommodate the updated reactor vessel. The larger vessel OD necessitated shorter piping runs to the pump and IHX, and the addition of in-vessel downcomer piping effectively removed an expansion loop from each of the IHX-to-vessel piping runs. A modified piping layout was therefore developed and analyzed for thermal stresses using MEC-21. Also, as was mentioned above, the low pressure inlet piping has been eliminated through the addition of in-vessel splitter valves. These modifications are pictured in Section V, and listed in Section IV.

The relocation of the Ex-Vessel Storage Tank will necessitate modifications to the Target Plant layout in the area of the Reactor Service Building. This is shown schematically in Figure 1.1 in Section II. Details of the design modifications have not yet been developed.

It should be emphasized that the majority of the design work performed for this follow-on study is conceptual in nature; with an eye towards providing NSSS capital cost estimates for a representative LMFBR. It is intended to serve as a basis for possible design development in the future.

II. PLANT DESIGN DESCRIPTION

1.0 Plant Arrangement

The Target Plant arrangement, shown in Figure 1.1, has been modified to accommodate the removal of the ex-vessel storage tank from inside to outside of the reactor containment building. Details of this modification have not yet been developed.

2.0 Reactor Assembly

The Target Plant reactor arrangement, shown in Figures 2-1 and 2-2, features the schedule and cost advantages of complete vendor shop fabrication. The compact design not only results in lower reactor assembly costs but also reduces the size of the reactor containment building which houses the PHTS.

The reactor vessel is top supported and is surrounded by a top supported guard vessel which has no penetrations. The reactor vessel nozzles are arranged so that all of the piping passes straight out horizontally above the top of the guard vessel. The inerted space between the vessels permits remote visual inspection and is narrow to restrict sodium level reduction under postulated reactor vessel leak conditions. Heat loss into the reactor cavity cooling system is restricted by external insulation on the guard vessel. The reactor vessel is cooled internally by a sodium bypass flow similar to that of CRBR.

The vessel cover is supported at the vessel support flange and consists of a fixed deck which carries the fuel transfer cell. The deck, a solid carbon steel structure, provides a seal against cover gas leakage, provides biological shielding, and is maintained at a relatively cool temperature by reflective insulation below and passive convective cooling above. It supports a central, compact triple rotating plug which incorporates improvements (relative to the CRBR design) in maintainability. This plug design was developed under an earlier DOE-funded program.

The rotating plug system is designed to move the CRBR-type IVTM between any removable core assembly position to a station outside the core barrel. From

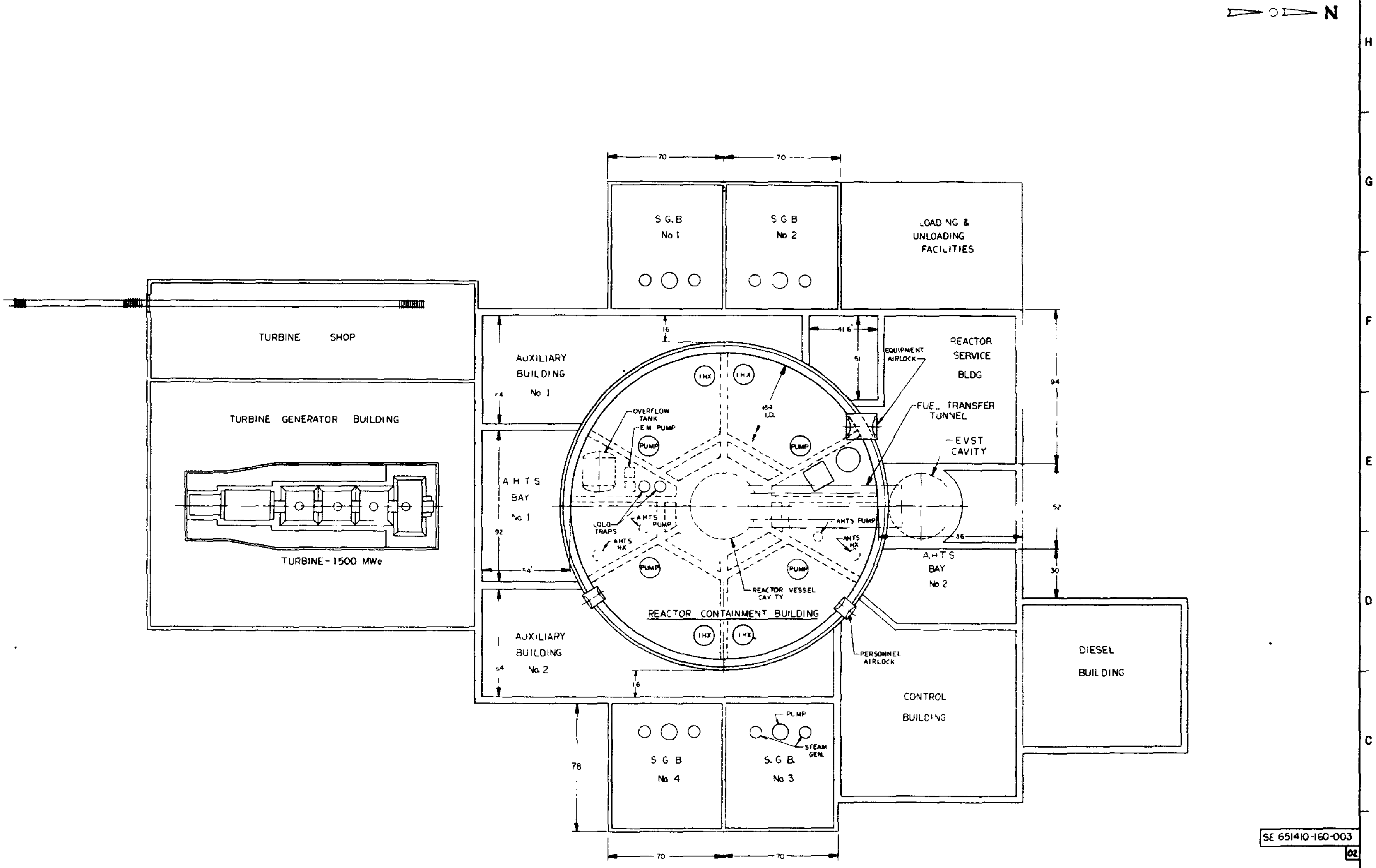


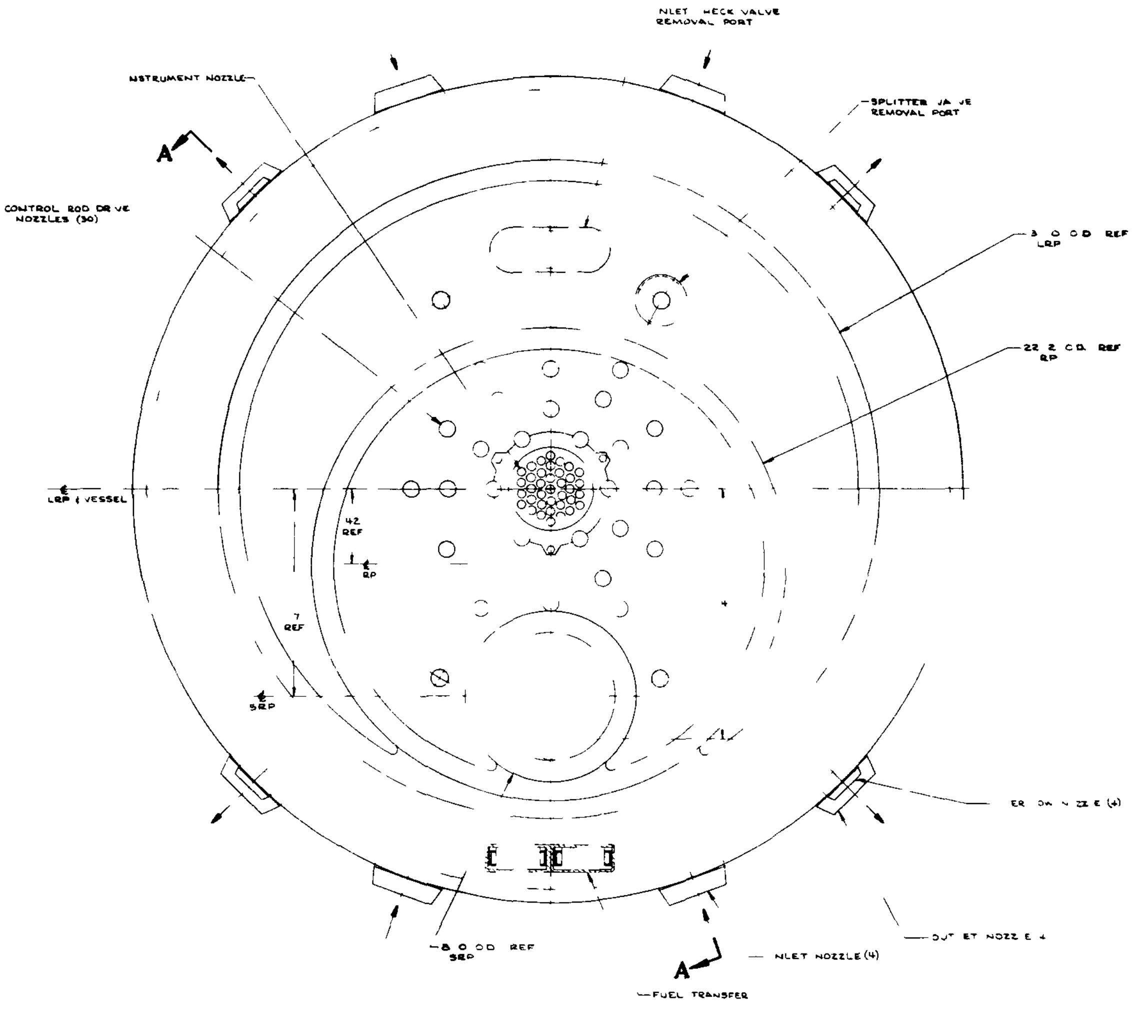
FIGURE 1-1

POWER SYSTEMS
COMBUSTION ENGINEERING, INC.
NUCLEAR POWER SYSTEMS

DRAWN BY J.COLTURI
CHECKER
APPROVALS

TARGET PLANT
LAYOUT

651410
1" = 20'-0"
SE-651410-160-003
02



PLAN VIEW

SE 6514_0 60-026
SHT 2 OF 2

FIGURE 2 1

POWER SYSTEMS

TARGET PLANT
REACTOR VESSEL ASSY

SE-651410 160-026

SHEET 2 OF 2

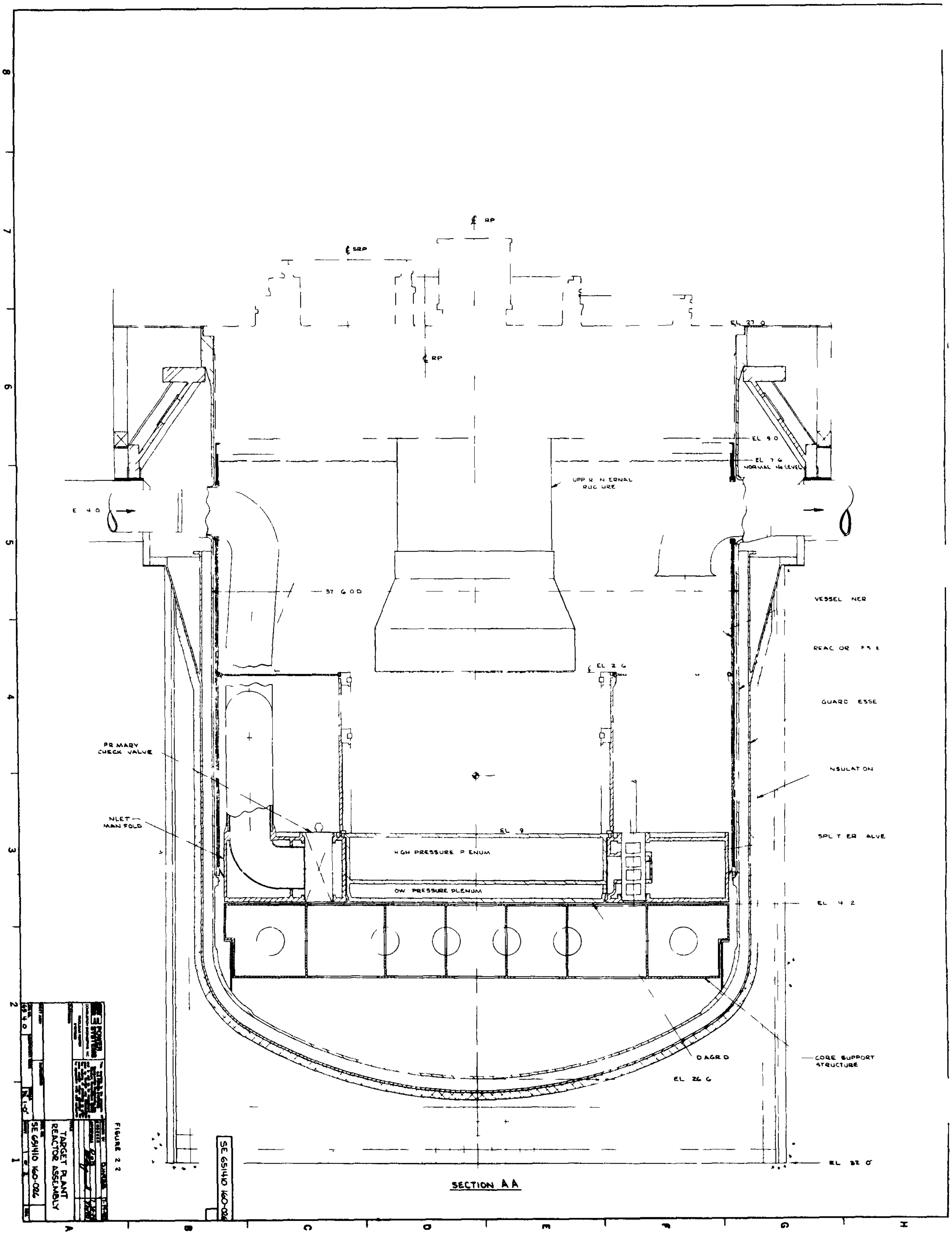


FIGURE 2 2

TARGET PLANT REACTOR ASSEMBLY

SE 65140 160-026

there, two twin-bucket modified A-frame fuel handling ramps connect transfer stations outside the reactor core barrel with the fuel transfer cell above the deck. The A-frame concept is similar to that developed for the French Phenix reactor and which is being repeated in the Super Phenix reactor. The intermediate rotating plug (IRP) supports the control rod drive mechanisms above the plug and the upper internals structure (UIS) below. During reactor operation, the UIS is centered over the reactor core where it provides support for the control rod drivelines and the core exit instrumentation. During refueling, it is raised, after disconnecting the control rod and flow splitter valve drivelines, to allow plug rotation and servicing of the reactor core by the IVTM. Also attached to the UIS is a Failed Element Detection and Location (FEDAL) system which has both global and local detection capabilities. This allows failed fuel assemblies to be located quickly and removed before undue contamination of maintainable system components occurs.

Coolant from each of the four PHTS loops enters the vessel at the inlet nozzles and passes to the reactor inlet plenum via downcomer piping runs. Check valves in the inlet plenum protect against postulated large pipe leaks and allow N-1 operation of the pumps. Flow splitter valves in the plenum allow the proportion of total flow to the blanket assemblies to be varied as their relative power increases.

2.1 Reactor and Guard Vessels

The reactor vessel diameter has been held to a size considered to be shop fabricable and barge shippable to sites located on or near navigable waterways. Of course, it could also be assembled in an onsite shop, if for some reason this were necessary.

2.1.1 Reactor Vessel

The reactor vessel is basically a 2.00-in. thick vertically oriented, cylindrical tank, 37'-6" outside diameter, with a mounting flange at the upper end and a torispherical bottom head.

The outside surface of the primary tank is smooth and continuous. Where variations in thickness occur (e.g., cylindrical shell to torus knuckle), the thicker plates are tapered at the inside edges on a slope no greater than 1:3. The weld seams are full penetration, double-vee. Weld beads are deposited alternately inside and outside to control weld distortion.

The reactor vessel material is SA-240, Type 304 stainless steel, including the mounting flange. There are no bimetallic welds and no heat-treat requirements.

There are twelve major nozzles in the reactor vessel as listed below:

Four Sodium Inlet Nozzles - 36-in. diameter each
Four Sodium Outlet Nozzles - 44-in. diameter each
Four Overflow Nozzles - 18-in. diameter each

Auxiliary small nozzles for cold trapping, fill and drain, etc., have not yet been fully identified. All penetrations through the reactor vessel shell are above the guard vessel elevation.

2.1.2 Guard Vessel

The guard vessel is basically a vertically oriented cylindrical vessel, 38' - 10" ID, with a torispherical bottom head to match the reactor vessel contour. All shell courses are 1-in. thick. The weld seams are full penetration, double-vee, and the weld beads are deposited alternately inside and outside to control weld distortion (as with the reactor vessel).

The guard vessel material is SA-516-Grade 70 carbon steel and therefore welding will not require preheat or post-weld heat treatment.

2.1.3 Vessel Cooling System

The vessel cooling system for the loop reactor vessel consists of a bypass flow annulus through which 3% of the total reactor flow is diverted. Inside the bypass flow liner, a second thermal liner provides a stagnant sodium-filled annulus to soften thermal transients and reduce the radial gradient through the bypass flow liner. The stagnant liner is in 90° segments with a

1-in. gap between them to allow for differential thermal expansion in the radial direction.

The liners are extended into the nozzles by slip joint designs which allow for relative motion caused by differential thermal expansion. Planned flow leakage from the low-pressure plenum into the bottom head region enters the bypass flow annulus through 240 - 2-in. diameter holes in the thermal liner support ring. The bypass sodium flows upward through the annulus and exits through windows in the thermal liners at the normal sodium level.

Multiple reflective insulation contained in a sealed annular ring extends downward from the reactor cover insulation to an elevation of 19 ft to effectively lengthen the unheated portion of the vessel shell and reduce the axial gradient. Also, a sufficient amount of heat is radiated from the vessel shell to the support cone to drop the temperature of the upper vessel and reduce the gradient near the flange.

The reactor guard vessel is insulated on its outside diameter with 6 in. of aluminum silica blanket. Its purpose is not to control the vessel gradients, but rather to limit the heat loss to the cavity cooling system.

2.2 Reactor Core Assembly

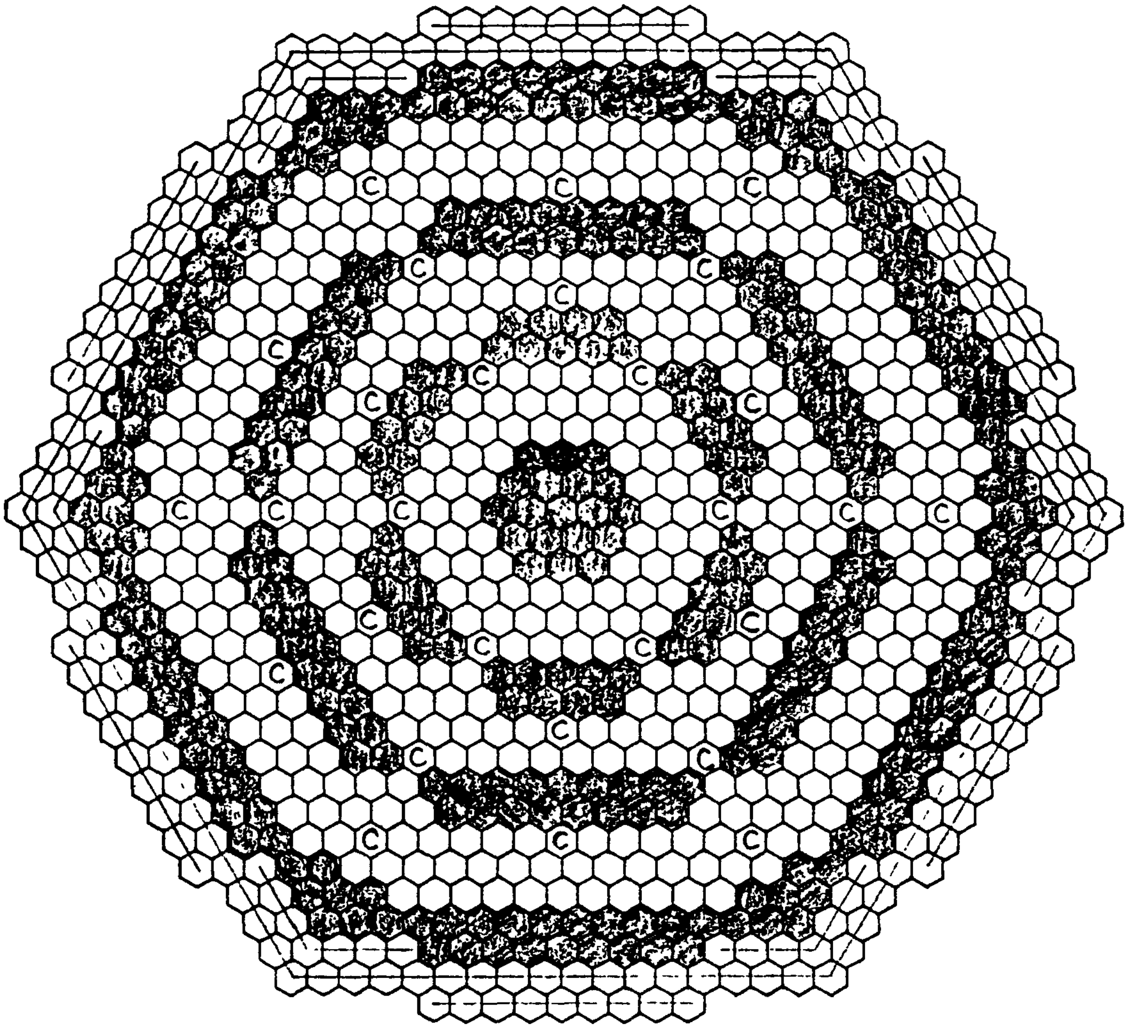
2.2.1 Reactor Core

The reference core plan is shown in Figure 2-3. The core support structure (diagrid) is designed with changeable inserts which allow rearrangement of the core during construction or during service without loss of discrimination. Such a rearrangement would be restricted only by the permanence of the control rod drive positions as determined by the IRP and upper internals structure. The insert concept allows the option of a further stage of orificing upstream of the assemblies.

2.2.2 Core Restraint

The passive core support concept is based on that developed for CRBR and employs a scaled-up version of the CRBR core restraint. Removable core

FIGURE 2.3 CORE PLAN



TYPE OF ASSEMBLY		NUMBER
FUEL	⬡	438
BLANKET	⬢	307
CONTROL ROD	©	30
SHIELDING	⊖	198
		973 TOTAL

assemblies are supported at three locations as shown in Figure 2-2. Core restraint former rings, mounted inside the core barrel, are contoured on the inside to the outline formed by the outer surfaces of the upper and lower load pads of the outer row of removable radial shield assemblies. The rings are located at two elevations above the core and control bowing of the reactor assemblies thereby contributing to the stable control of reactivity as the reactor power and coolant temperature are changed. In addition, they provide the lateral support required for the reactor assemblies to withstand seismic events. The third support location is at the lower end of each assembly where an insert in the diagrid supplies a pin-ended fixity during reactor operation. A small gap is provided in the cold condition between the core former rings and the shield assemblies to facilitate replacement of reactor assemblies at refueling. Additional fixed shielding is attached to the inside of the core barrel to further reduce the incident fast flux on that structure.

2.2.3 Core Radial Shielding

The core radial shielding must provide protection for the core former structure.

Stainless steel is currently specified as the material for all of the core radial shielding; however, other materials with stronger moderating and absorbing properties, such as graphite and boron, are under study for application in combination with steel. Radial shielding consists of 6 in. of steel surrounding the radial reflectors and inboard of the core former structure. The shielding is surrounded by a barrel which provides seismic restraint in addition to providing shielding in its own right. The barrel will also serve to support the inner edge of the baffle separating the hot and cold pools.

Cooling of the radial shielding in the area of highest gamma heating will be from leakage flow around the reactor assemblies.

2.2.4 Hot-Cold Pool Separation

The horizontal baffle shown in Figure 2-2 forms the upper boundary of the core barrel-reactor vessel annulus and physically separates hot sodium in the outlet plenum from the cooler sodium in the core barrel-reactor vessel annulus. The barrel allows the sodium in the core barrel-reactor vessel to develop an acceptably low-temperature gradient across components below the baffle.

The horizontal baffle design is based upon that of CRBR and incorporates a single 1.5-in. thick, simply-supported base plate restrained on the outer diameter by a segmented ring outer edge attachment. Each outer ring segment includes a top ring segment, a spacer block, with a bottom ring segment, all of which are bolted to the vessel liner flange with a single bolt that extends through the ring segments and spacer block and into the vessel liner flange. At the inner diameter, the base plate is supported on a ledge on the liner barrel wall. It is held vertically by ring segments and located radially by pins inserted into each ring segment. Circumferential motion of the base plate relative to the barrel is restrained through a key. Radial movement of the base plate is not restricted. Wear-resistant surfaces are provided on both sides of the plate at the inner and outer diameters and on the ring segments to accommodate relative radial and angular rotation displacements due to thermal and seismic effects at the outside diameter, and angular rotation displacements due to thermal effects at the inside diameter.

The base plate normally operates with a temperature difference through the thickness. Since the upper surface is hotter, the plate will tend to develop an upwardly convex spherical curvature. The plate edges, however, are restrained vertically to the relative vertical thermal displacement between the vessel thermal liner flange and the core barrel ledge. As a result of the vertical restraint, a thermally induced vertical downward force will act on the vessel liner flange and an equal upward force will act on the core barrel.

These vertical reaction forces provide a positive seal at the base plate outer and inner diameters. During downshock transients, the direction of the holddown forces can reverse due to the reversal of the through-the-thickness temperature gradient. The core barrel ledge will be in compression (down load) and the upward load at the vessel liner flange is carried through the top ring segments.

2.2.5 Inlet Plenum

2.2.5.1 Diagrid Assembly

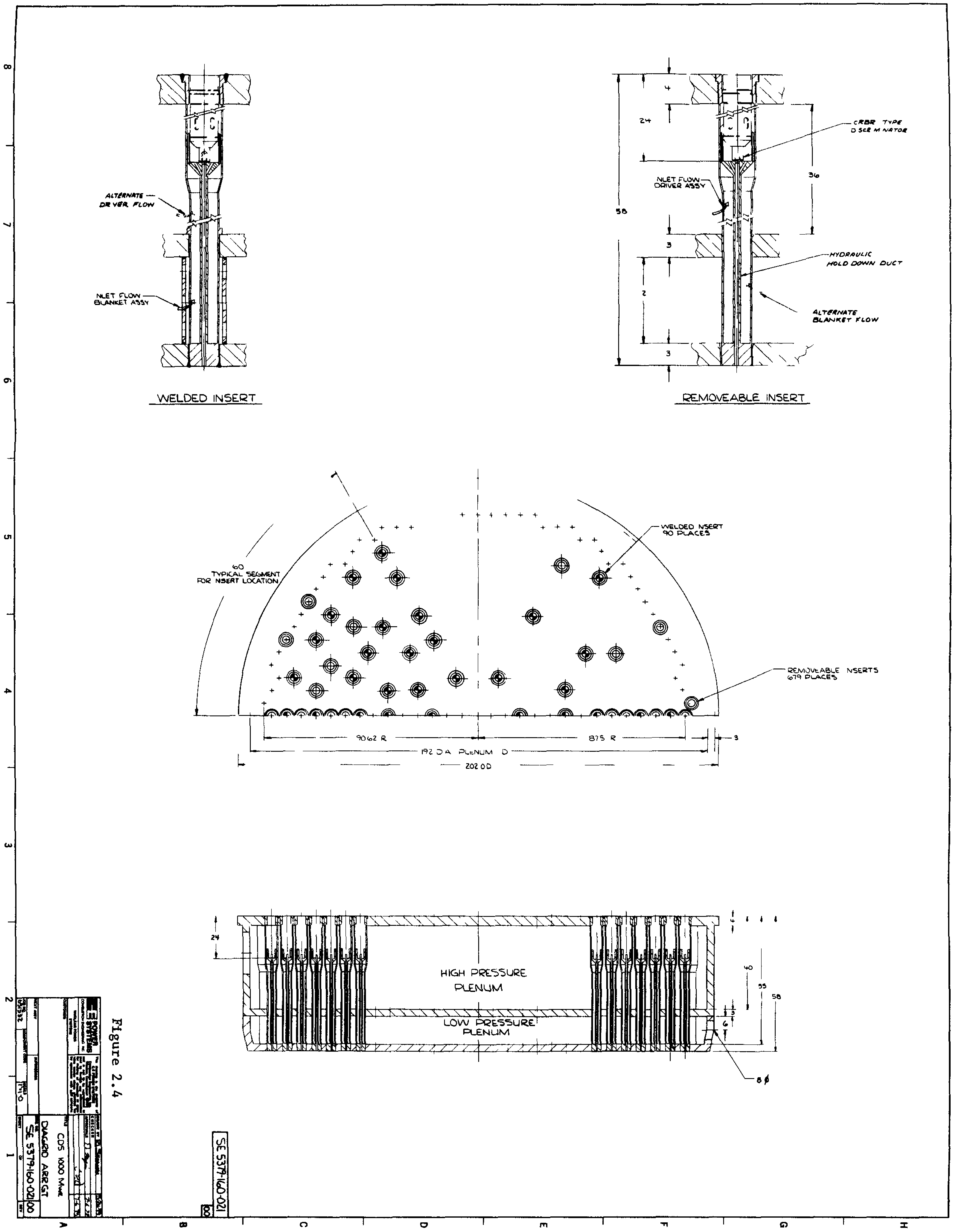
The diagrid, shown in Figure 2-4, locates the lower end of the core assemblies to which it distributes the coolant flow. It consists of two plenums separated by horizontal perforated plates. Tubular inserts, which penetrate all three plates, seal off the perforations and serve as receptacles for the core assemblies. They contain CRBR-type discrimination features according to assembly type. The blanket receptacles have lateral orifices into the lower (blanket) plenum and the driver fuel receptacles are similarly connected to the upper (driver) plenum. The inserts are secured at the upper end by a detented bayonet feature and are also hydraulically balanced. They are removable, with special tools to allow rearrangement of the core, as noted in Section 2.2.1. Some insert positions are in the form of permanent ties to support the flat plates against pressure and core loads.

The entire diagrid is removable, being secured by keys at its upper flange and on the underside by bayonet lugs which engage the core support structure. The bayonent lugs are released by rotation of the diagrid.

2.2.5.2 Inlet Manifold

The inlet manifold, shown in Figure 2-2, is a fixed annular duct, divided into two compartments, which surrounds and hydraulically connects with the removable diagrid. Its main function is to distribute and promote mixing of the reactor coolant flow to the two diagrid plenums from the four inlet downcomer pipes. Removable flow splitter valves are provided to vary the flow to the diagrid blanket plenum. The inlet manifold also serves as a housing for the primary system check valves which provide protection against postulated pipe breaks at any location in the PHTS.

The coolant flow enters the manifold via the downcomer pipes and is directed horizontally through the primary system check valves into the open, outer compartments of the manifold. It is then split and directed circumferentially towards the flow from the adjacent primary loop inlets. The merging flows pass into the inner compartment of the manifold where they feed the


WELDED INSERT
ALTERNATE DRIVER FLOW
NLET FLOW BLANKET ASSY
REMOVEABLE INSERT
CRBR TYPE DSCRIMINATOR
NLET FLOW DRIVER ASSY
HYDRAULIC HOLD DOWN DUCT
ALTERNATE BLANKET FLOW
4
24
36
58
3
2
3
60 TYPICAL SEGMENT FOR NSERT LOCATION
WELDED NSERT 90 PLACES
REMOVEABLE NSERTS 679 PLACES
90.62 R
87.5 R
3
192 DIA PLENUM D
202 OD
HIGH PRESSURE PLENUM
LOW PRESSURE PLENUM
24
40
55
58
3
6
8 ϕ
SE 5379-160-021
00
POWER SYSTEMS
CDS 1000 MWE
DIAGRID ARRGT
SE 5379-160-021
00
A
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5
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8

Figure 2.4

circumferentially oriented orifices connecting with the diagrid driver assembly plenum. Flow to the diagrid blanket assembly plenum passes through the four splitter valves shown. Although the "double globe valve" geometry is provided by the permanent manifold structure, the wearing parts of the valve are contained entirely within the removable cylindrical assembly. The primary system check valves are also self-contained and removable. All have hydraulic holddown and sealing features to reduce leakage.

The structural design concept for the inlet manifold is a box ring. The box ring, when used as a pressure vessel shape, may require internal baffling against thermal transients.

2.2.5.3 Flow Splitter Valves

The cyclic power shift from the driver fuel to the blanket assemblies requires a corresponding shift in the coolant flow rate to those assemblies. This is accomplished by adjusting four flow-splitter valves which control the flow between the driver fuel plenum and the blanket inlet plenum. These are situated in the inlet manifold, as shown in Figure 2-5, at the points of entry of the four inlet pipes. This location promotes good flow distribution to both driver and blanket plena even for the N-1 loop operation condition. The positions of the actuators, which are vertically above the valves, are also shown in Figure 2-6 relative to the rotating plugs.

A complete discussion of the factors which led to the selection of these positions for the valves and actuators is beyond the scope of this document. However, the principle reasons for selecting the sites shown may be summarized as follows:

1) The inlet plenum provides a secure housing for the valves and thus improves reliability relative to pipeline locations which introduced difficult and unreliable pipe support and horizontal baffle penetration problems.

2) The location provides good hydraulics (flow distribution and pressure drop).

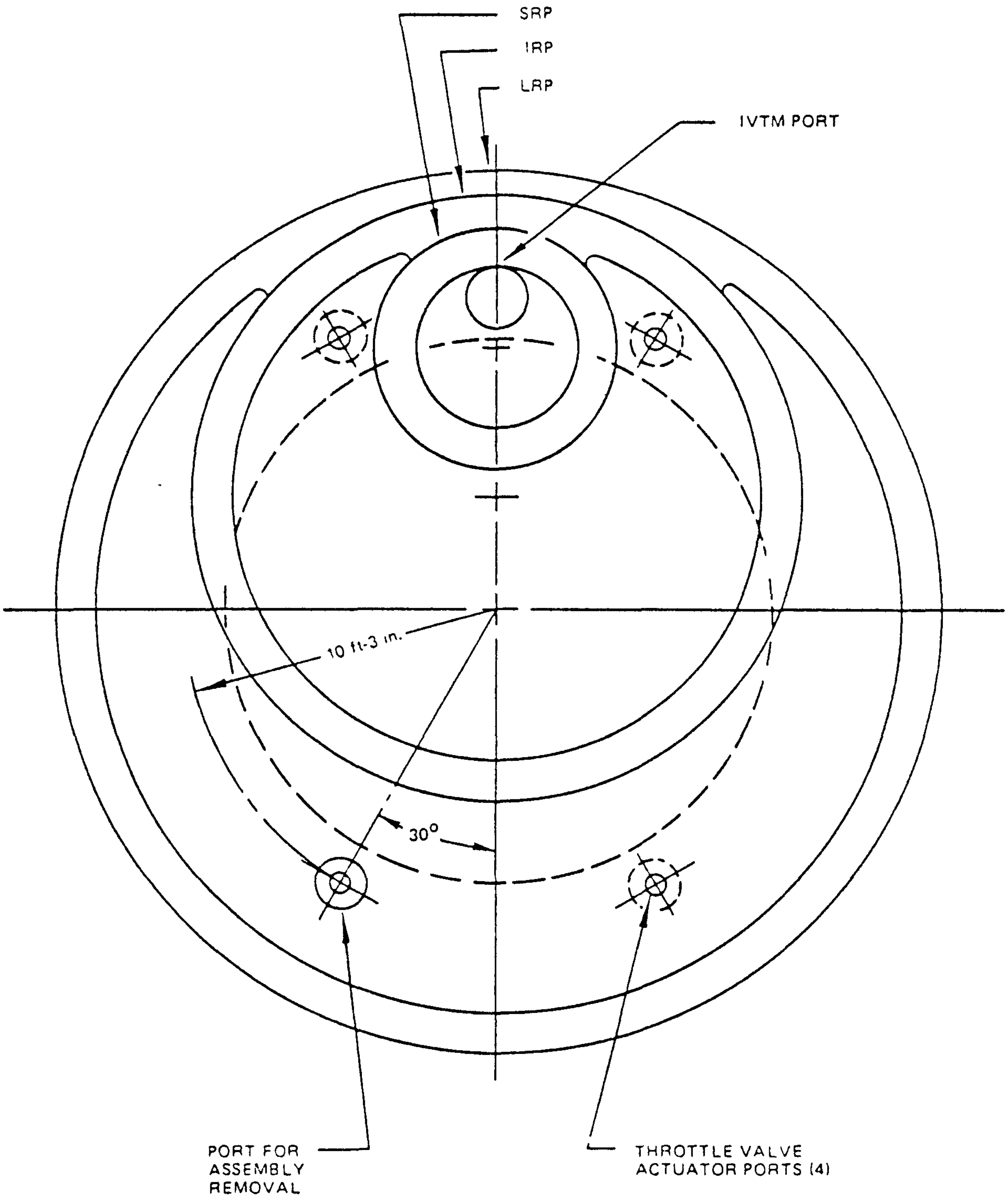


Figure 2-5 Splitter Valve Locations

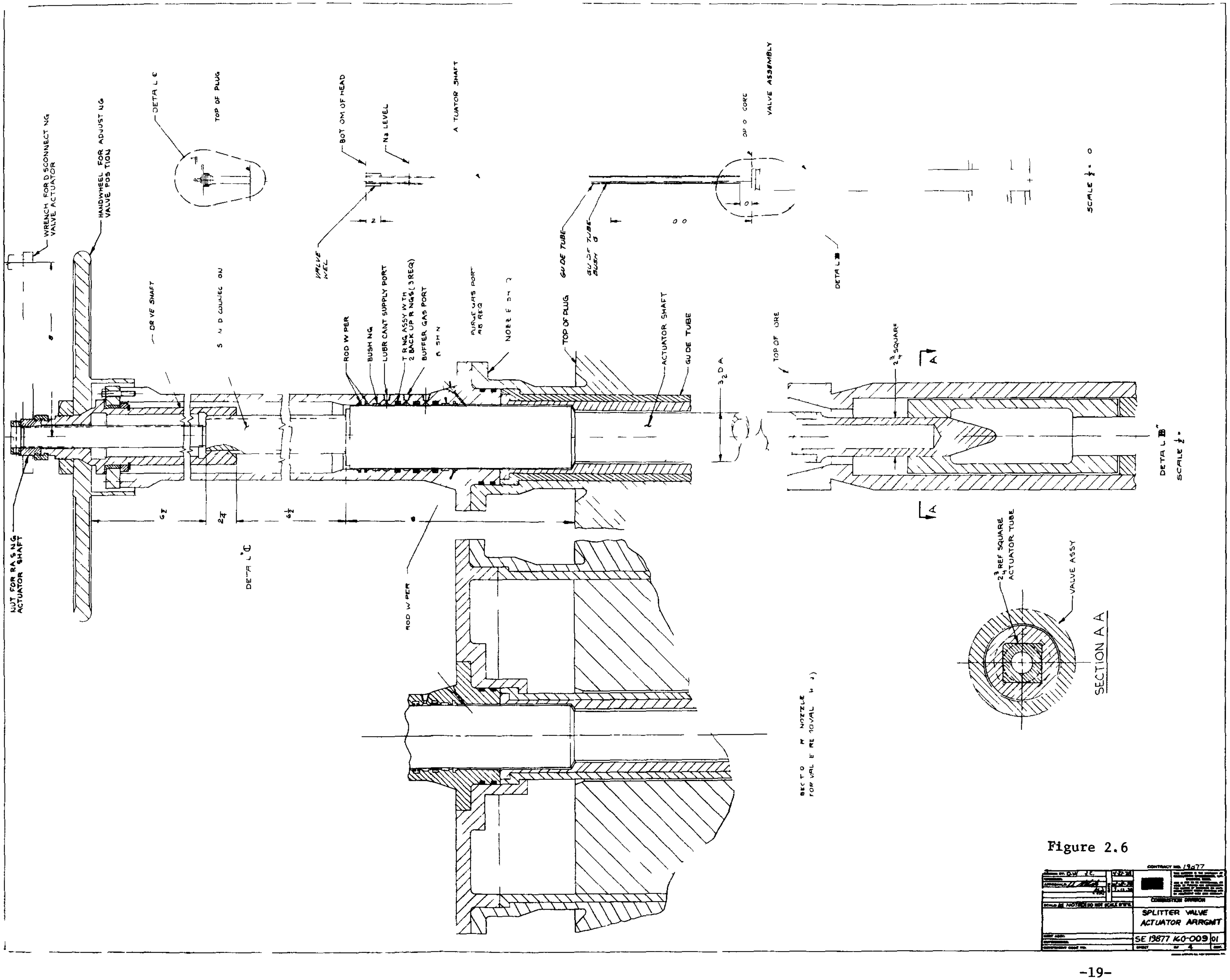

NUT FOR RAISING ACTUATOR SHAFT
WRENCH FOR DISCONNECTING VALVE ACTUATOR
HANDWHEEL FOR ADJUSTING VALVE POSITION
DRIVE SHAFT
S N D COUPLING ON
DETAIL C
DETAIL E
TOP OF PLUG
VALVE WEL
BOTTOM OF HEAD
N2 LEVEL
2
ROD WIPER
BUSHING
LUBRICANT SUPPLY PORT
O RING ASSY WITH 2 BACK UP RINGS (3 REQ)
BUFFER GAS PORT
A SH N
PURGE GAS PORT AS REQ
NOTE E SH 2
ACTUATOR SHAFT
TOP OF PLUG
GUIDE TUBE
GUIDE TUBE BUSHING
ACTUATOR SHAFT
GUIDE TUBE
$3\frac{1}{2}$ DIA
TOP OF CORE
DETAIL B
TOP OF CORE
VALVE ASSEMBLY
$2\frac{3}{4}$ SQUARE
A
A
DETAIL B
SCALE $\frac{1}{2}$ =
SCALE $\frac{1}{2}$ = 0
$6\frac{1}{2}$
$2\frac{1}{4}$
$6\frac{1}{2}$
ROD WIPER
SECTION N NOZZLE FOR VALVE REMOVAL
$2\frac{3}{4}$ REF SQUARE ACTUATOR TUBE
VALVE ASSY
SECTION A A
CONTRACT NO. 19877
COMBUSTION DIVISION
SPLITTER VALVE ACTUATOR ARRGMT
SE 19877 K0-009 01
4

Figure 2.6

3) Good straight line access for driveline and valve maintenance is achieved, and, coupled with use of rotating plugs, reduces the number of cover access plugs from four to one.

4) The judgment that the use of robust, simple driveline disconnects (4) before and after refueling is a minor disadvantage relative to those of alternate arrangements studied.

The details of the valve actuators and driveline disconnect features are shown in Figure 2-6. Alignment of the driveline with the lower valve assembly before reconnection is assured by a fixed guide tube shown. The valve itself and the plenum weldment detail are shown in Figure 2-7. The valve is a modified plug type which is hydraulically balanced both axially and laterally, so as to minimize the friction torque on the drive. It is contained within a removable housing which extends to the core top elevation. In addition to its considerable self weight, it also incorporates a hydraulic balance feature. The valve has a minimum flow area (9 degree angle shown) which protects against maladjustment.

2.2.5.4 Primary Check Valves

The primary check valve, shown in Figure 2-8, is located in the inlet plenum. There is one valve for each primary inlet pipe. The primary check valve is designed as a self-contained unit, and is removable through a port in the large rotating plug. Each unit consists of an open-ended housing supporting a hinged, tilting disc and a dashpot. The front plate of this housing is intended to make a contact seal against an extension on the inlet piping, while the top and bottom plates seat against the top and bottom of the inlet plenum. The valve disc is hinged from the front plate and opens with forward flow to an angle of about 36 degrees. Pressure drop across the valve under normal flow is about 10 psi. Under reverse flow conditions, the disc closes and seats against the front plate of the valve housing. The dashpot, supported on the bottom plate of the housing, damps the motion of the disc during valve closure. The configurations of the disc, disc hinging system, and dashpot were scaled up

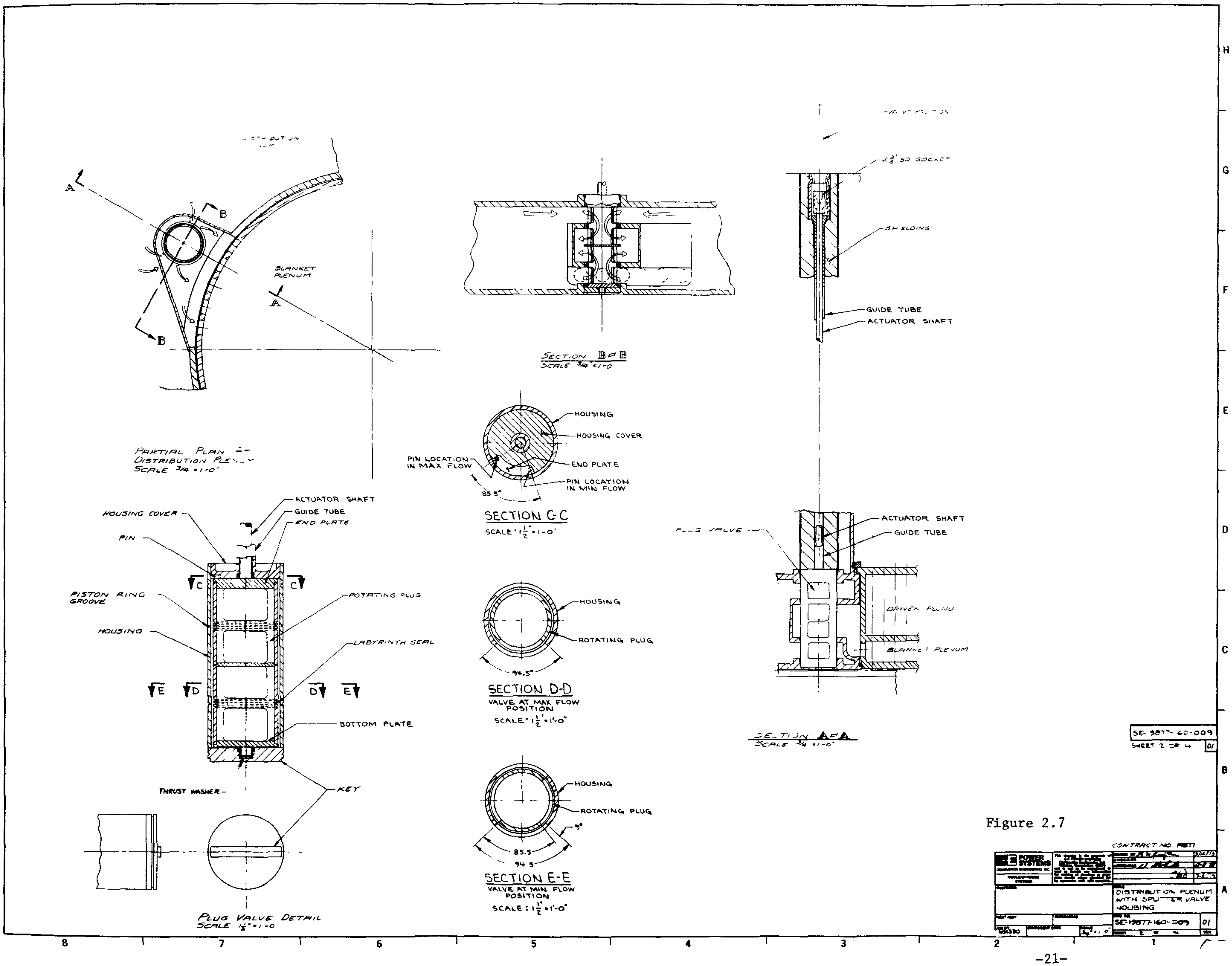

A
B
BLANKET PLENUM
PARTIAL PLAN
DISTRIBUTION PLE...
SCALE 3/4 =1-0"
SECTION B-B
SCALE 3/4"=1-0
2 3/4" SQ SOCKET
SHIELDING
GUIDE TUBE
ACTUATOR SHAFT
HOUSING
HOUSING COVER
END PLATE
PIN LOCATION IN MAX FLOW
PIN LOCATION IN MIN FLOW
85.5°
SECTION C-C
SCALE - 1 1/2" = 1-0'
ACTUATOR SHAFT
GUIDE TUBE
END PLATE
HOUSING COVER
PIN
PISTON RING GROOVE
HOUSING
ROTATING PLUG
LABYRINTH SEAL
BOTTOM PLATE
C
D
E
THRUST WASHER
KEY
PLUG VALVE DETAIL
SCALE 1/2"=1-0
HOUSING
ROTATING PLUG
94.5°
SECTION D-D
VALVE AT MAX FLOW POSITION
SCALE - 1 1/2" = 1'-0"
HOUSING
ROTATING PLUG
9°
85.5
94.5
SECTION E-E
VALVE AT MIN FLOW POSITION
SCALE : 1 1/2" = 1'-0"
PLUG VALVE
ACTUATOR SHAFT
GUIDE TUBE
DRIVER PLENUM
BLANKET PLENUM
SECTION A-A
SCALE 3/4 = 1-0"
SE-19877-60-009
SHEET 2 OF 4
01
CONTRACT NO 76811
POWER SYSTEMS
COMBUSTION ENGINEERING, INC
NUCLEAR POWER SYSTEMS
5/16/79
DISTRIBUTION PLENUM WITH SPLITTER VALVE HOUSING
SE-19877-160-009
01
3/4" = 1'-0"
H
G
F
E
D
C
B
A
8
7
6
5
4
3
2
1

Figure 2.7

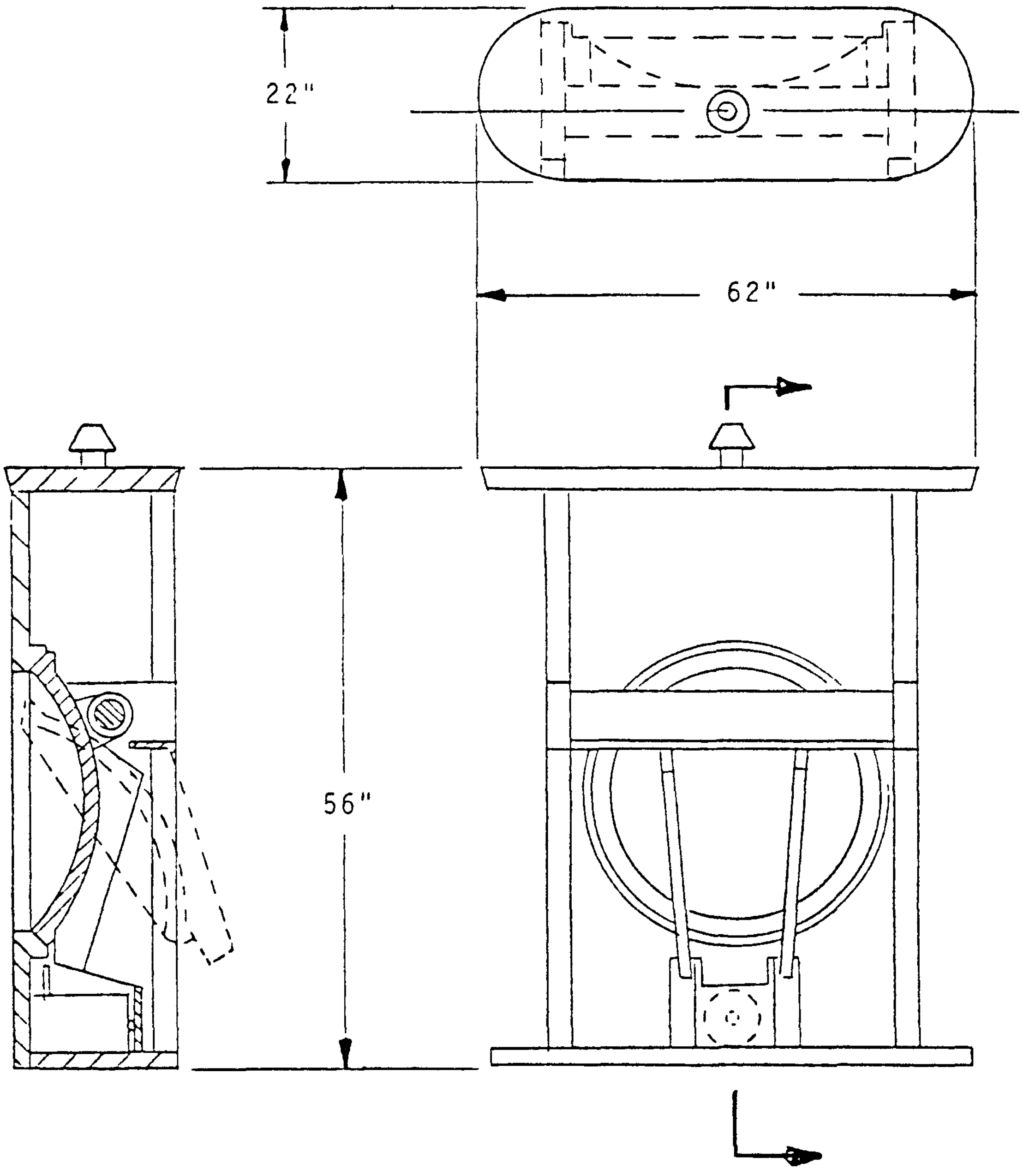


Figure 2-8 Primary Check Valve

from those in the CRBRP check valve. A contact collar has been added to the dashpot plunger, permitting use of shorter contact arms on the disc, which in turn allows for greater disc excursion in the limited space available.

2.2.6 Core Support Structure (CSS)

The reference core support design evolved from consideration of: (1) the need for a stiff structure to minimize seismic motion, (2) the need to accommodate and minimize differential expansion effects on the structure. Additional requirements were the provision of a strongback support for the relatively flexible and partially removable inlet plenum assembly and the support of the inlet piping. As the design proceeded, safety and long-term reliability were emphasized leading to a design with a very low probability of any failure and early warning of incipient "core drop" progression.

As a result of these considerations, the core support concept selected consists of the structurally efficient and externally inspectable (In-Service Inspection) bottom head of the primary tank, described in Section 4.1, and the internal CSS. The total span (37' - 6") between them is approached by that of the CSS which is attached to the bottom head by a 35-ft diameter flex skirt. The location of the CSS at the bottom of the cold pool provides the most favorable thermal environment. The inlet plenum assembly, which is interposed between the core structure and the CSS, is distinguished from the latter because its structural function is pressure containment rather than structural bridging.

The arrangement of the CSS is shown in Figure 2-9. It consists of a grid of fabricated I-beams, the outer ends of which are built into a box beam ring girder. The box beam distributes the load from the grid to the vessel with a minimum of moment transmission via a support skirt. This skirt also accommodates the differential expansion occuring during a cold pool up-transient. The dimensions of the design were derived from the results of a structural optimization procedure tempered by the requirements for low stress intensities (including those in the inlet plenum assembly), high stiffness, fabrication access, and behavior under postulated progressive weld failure.

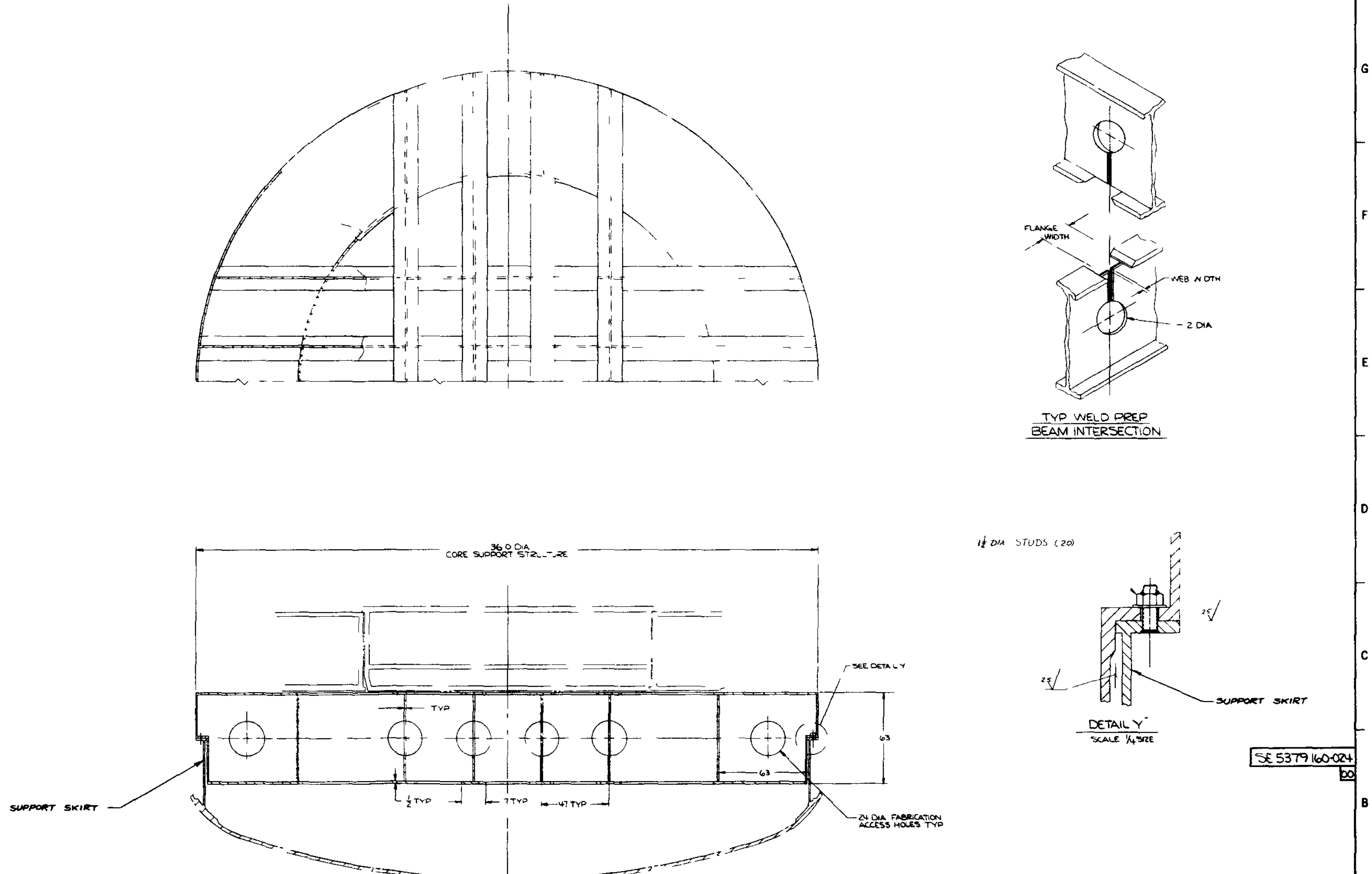

FLANGE WIDTH
WEB WIDTH
2 DIA
TYP WELD PREP
BEAM INTERSECTION
36.0 DIA
CORE SUPPORT STRUCTURE
SEE DETAIL Y
TYP
63
63
SUPPORT SKIRT
½ TYP
7 TYP
47 TYP
24 DIA FABRICATION
ACCESS HOLES TYP
1½ DIA STUDS (20)
25
25
SUPPORT SKIRT
DETAIL Y
SCALE ¼ SIZE
SE 5379 160-024
00

Figure 2.9

POWER SYSTEMS
COMBUSTION ENGINEERING, INC.
NUCLEAR POWER SYSTEMS
5-24-73
7/6/73
7-6-73
TITLE
CDS 1000 MWE
CORE SUPPORT STRUCTURE
SE 5379-160-024
00
651632
½"-1-0"

Vendor shop fabrication is simplified by preparing the I-beams with eggcrate slots (see Figure 2-9). The mechanically interlocked grid provides inherently good alignment and minimal weld distortion. The plates forming the box ring are then added. Installation of the CSS to the support skirt is simplified by stud attachment at the machined flanges shown. Access holes are provided in the low stresses areas of the structure to allow double-sided welding and radiographic inspection.

Although the design calculations show low stress intensities, even under seismic and thermal shcok loads, there is a concern that unexpected failures could develop and progess to a dangerous core drop condition, since this internal structure is not subject to routine ISI. Following the criteria for avoiding this condition, the design incorporates redundant load paths through mechanically interlocked members so that weld failure at a joint results in increased deflection without collapse. An elasto-plastic analysis of the structure, having arbitrarily failed welds, was performed to show that it would have considerable residual strength even with deflections in excess of 2 in. The increased control rod insertion accompanying such a deflection would thus alert the operators to the need for special attention to the system. The combined effect of joint redundancy and weld crack stopping features serves to limit the magnitude of incremental deflections to well within the specified limit of 0.25 in.

2.2.7 Internal Piping

The internal piping in the vessel consists of the following:

1) Four 36-in. cold leg inlet downcomers
2) Four 44-in. hot leg dip lines
3) Three 18-in. hot leg overflow outlets

The use of internal dip lines and internal inlet downcomers greatly simplifies the design of the guard vessel and permits a more compact PHTS piping arrangement.

The cold leg piping shown in Figure 2-3 consists of a welded piping run between each inlet nozzle and the corresponding check valve receptacle in the inlet manifold. Each run includes a horizontal piping section for accommodation of thermal expansion, as well as external baffling to reduce thermal stresses due to the reactor coolant temperature rise.

The hot leg dip lines (shown in Figure 2-2) are adequately submerged at the lowest level of primary system operation to prevent gas entrainment but do not allow the reactor vessel to be pumped out below the level needed for flow into the DRHX. The dip lines have bell-mouthed entries to reduce the entrance pressure losses.

The pump overflow pipes, located as shown in Figure 2-1, form extensions to the reactor vessel nozzles similar to those of the hot leg dip.

2.2.8 Upper Internal Structure

The upper intenal structure (UIS), mounted to the IRP, is shown in Figure 2-10. The structure supports the control rod driveline guide tubes and the instrument conduits, each containing 19 drywell instrument tubes. These penetrate and are located by the IRP, containing a movable plug which is sealed by a bellows and allows the core exit instrumentation to be raised to clear the core structure before plug rotation.

Also mounted on the IRP is the outer flow shroud, which provides lateral support for the internal structure and consists of a perforated upper support cylinder rigidly attached to the IRP, and a lower bell-shaped shroud connected to the IRP by four lifting shafts. During reactor operation, these shafts bear down with a constant force on the lower shroud, which rests upon the core barrel where its four lateral seismic restraint lugs are located in radial grooves. Radial clearance at the telescoping interface accommodates differential movement, from thermal expansion and seismic deflections, between the upper and lower shroud sections. During a refueling shutdown, and prior to operation of the rotating plugs, the UIS must be raised to clear the core by a minimum of 10 in. to ensure reliable verification by the core sweep of adequate clearance. This is effected by operating the jacks shown at the upper ends of the lifting shafts. These raise the lower shroud and the connected core outlet instruments.

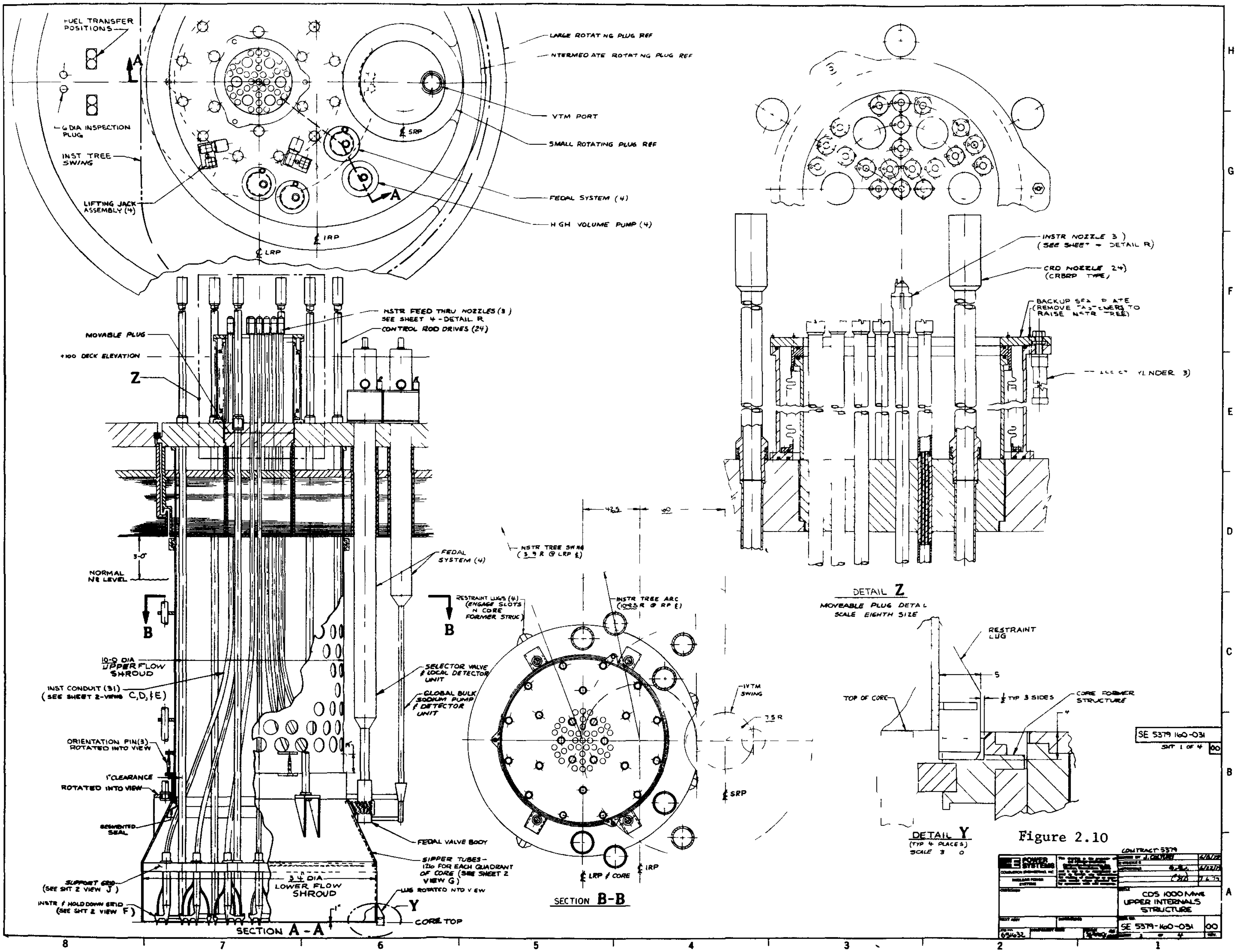

FUEL TRANSFER POSITIONS
A
6 DIA INSPECTION PLUG
INST TREE SWING
LIFTING JACK ASSEMBLY (4)
LARGE ROTATING PLUG REF
INTERMEDIATE ROTATING PLUG REF
VTM PORT
SMALL ROTATING PLUG REF
FEDAL SYSTEM (4)
HIGH VOLUME PUMP (4)
℄ SRP
℄ IRP
℄ LRP
INSTR FEED THRU NOZZLES (3) SEE SHEET 4 - DETAIL R
CONTROL ROD DRIVES (24)
MOVABLE PLUG
+100 DECK ELEVATION
Z
3-0"
NORMAL N₂ LEVEL
B
B
FEDAL SYSTEM (4)
10-0 DIA UPPER FLOW SHROUD
INST CONDUIT (31) (SEE SHEET 2-VIEWS C, D, & E)
ORIENTATION PIN(3) ROTATED INTO VIEW
1" CLEARANCE
ROTATED INTO VIEW
SEGMENTED SEAL
SUPPORT GRID (SEE SHT 2 VIEW J)
INSTR & HOLDDOWN GRID (SEE SHT 2 VIEW F)
SELECTOR VALVE & LOCAL DETECTOR UNIT
GLOBAL BULK SODIUM PUMP & DETECTOR UNIT
FEDAL VALVE BODY
SIPPER TUBES - 126 FOR EACH QUADRANT OF CORE (SEE SHEET 2 VIEW G)
3-4" DIA LOWER FLOW SHROUD
LUG ROTATED INTO VIEW
Y
1"
CORE TOP
SECTION A-A
INSTR TREE SWING (3 9R @ LRP ℄)
42.5
60
RESTRAINT LUGS (4) (ENGAGE SLOTS IN CORE FORMER STRUC)
INSTR TREE ARC (10-25R @ RP ℄)
IVTM SWING
7.5R
℄ SRP
℄ LRP & CORE
℄ IRP
SECTION B-B
INSTR NOZZLE (3) (SEE SHEET 4 - DETAIL R)
CRD NOZZLE (24) (CRBRP TYPE)
BACKUP SEAL PLATE (REMOVE FASTENERS TO RAISE INSTR TREE)
SELECT CYLINDER (3)
DETAIL Z
MOVEABLE PLUG DETAIL
SCALE EIGHTH SIZE
RESTRAINT LUG
TOP OF CORE
5
1/2 TYP 3 SIDES
CORE FORMER STRUCTURE
4
DETAIL Y
(TYP 4 PLACES)
SCALE 3 0
SE 5379-160-031
SHT 1 OF 4
00
CONTRACT 5379
J. COLTURI
6/6/77
6/22/77
7/6/77
POWER SYSTEMS
COMBUSTION ENGINEERING INC
NUCLEAR POWER SYSTEMS
CDS 1000 MWE UPPER INTERNALS STRUCTURE
SE 5379-160-031
00
654632
H
G
F
E
D
C
B
A
8
7
6
5
4
3
2
1

Figure 2.10

The primary purpose of the flow shrouds is to channel flow from all of the blanket and driver fuel assemblies in order to promote mixing and mitigate the effects of core outlet temperature transients on the PHTS. To these ends, the core outlet flow is collected and mixed by the lower flow shroud and its internal structures, the flow then being directed upward into the upper support cylinder, and then out through the performations into the surrounding pool, where further mixing is promoted by the associated flow jets. In addition, the seal formed at the lower shroud interface with the core, combined with the segmented apron seal at its interface with the upper shroud, serves to maintain the mixing function (even for the low-velocity, relatively cold outlet flow associated with a reactor scram, which would otherwise largely escape, without mixing, at the bottom of the UIS).

Core assembly exit instrumentation support, and secondary holddown, is provided by an array of grids. Each standard grid covers a maximum of 19 core assemblies. These grids are, in turn, supported by an upper continuous grid which is attached at its perimeter to the lower flow shroud. This support grid (Type 316 stainless steel) is protected from thermal striping by the channel-shaped liner (Inconel-718) shown, which also houses the horizontal failed-element-detection-and-location (FEDAL) sipper tubing running to the four peripheral selector valves. Below this level, each FEDAL tube is brought together with an instrument tube inside a common conduit, where they are protected from fluid drag forces (including flow-induced vibration) as they pass to their associated core assembly position. This conduit must accommodate the instrument tube curvature, which has been selected for acceptable friction forces during instrument replacement, and so is placed around the inner tubes using a clamshell construction.

At each fuel and blanket assembly, an instrument tube projects 4 in. into the top of the assembly side by side with a FEDAL sipper tube. The instrument tubes are routed into the grid support tube and then upward through conduits to instrument feedthroughs grouped in a close pattern around the inner ring of control rod drives above the top of the shield. The conduits protect the instrument tubes from flow impingement, thus preventing vibration. Guide tubes are provided for the control rod drive lines to facilitate their installation and to protect the units from flow-induced vibrations.

The instrument guide tubes exiting the IRP are grouped in a closely spaced array around the UIS vertical centerline. In order to avoid the need for separate seals to accommodate the lifting operation described above, the guide tubes are welded into a vertically movable plug having a single bellows seal. This latter is backed by static O-ring seals during reactor operation and has bolted flanges to facilitate replacement. When the lower shroud is raised, the instrument guide tubes and those control rod driveline guide tubes, which fall within the central region, rise together with the movable plug. An array of pneumatic cylinders provide a counterbalance force to relieve the axial load on the guide tubes as they are raised a distance of 14 in.

2.3 Reactor Cover

The reactor cover forms the top closure of the reactor vessel. The cover seals the primary coolant cover gas, provides radiation and thermal protection for the operating floor, and supports the components extending into the reactor vessel from the top.

The reactor cover consists of:

1) Deck - A stationary annular assembly supported by the reactor vessel flange that supports the rotatable plugs at its inner edge. The deck also includes two ports for a slanted track system for transferring core assemblies into and out of the reactor vessel.

2) Triple Rotatable Plugs (TRP) - A three plug (large-LRP, intermediate-IRP, and small-SRP) assembly, which is a basic feature of the in-vessel fuel handling system. The fuel handling system uses a single straight-pull IVTM to move core assemblies between their position in the core lattice and the transfer station located within the core radial shielding. Positioning of the IVTM is achieved by relative rotations of the three plugs.

2.3.1 Deck

The deck covers the area from the 37' - 2" ID reactor vessel to the 29' - 7" diameter opening for the TRP. Additional small penetrations, which are not yet sized or located, will be provided for in-vessel instrumentation, preheaters, etc.

The bottom surface of the deck is 18 in. above the sodium pool surface at nominal full power operation sodium temperatures. The overall thickness of the deck is 8 ft., consiting of 4 ft. of thermal insulation at the bottom, a 6-in. thick shield plate just above the insulation, a 15-in. void space which is currently being reserved for Core Disruptive Accident (CDS) energy absorbtion material, if required, then a 24-in. thick structural headplate at the top.

The deck is supported by a flange extension of the headplate which rests on a shelf incorporated in the reactor vessel support flange. This interface must include provisions for: 1) differential thermal displacement, 2) seismic and CDS uplift loads and seismic horizontal loads, and 3) a welded seal with compliance to accommodate thermal displacement. Figure 2-11 illustrates the concept currently under consideration.

2.3.2 Rotatable Plugs

The reactor cover includes a TRP system that is a basic feature of the under-the-head in-vessel fuel transfer system that applies a straight push-pull IVTM for movement of core assemblies within the reactor vessel. The adoption of triple rotatable plugs and the straight line push-pull IVTM are in accordance with the CDS fuel handling consensus agreement.

The LRP is located concentric to the centerline of the reactor vessel and core; and the IRP and SRP are located eccentrically within the large plug. Each of the plugs is mounted on bearings; thus, by appropriate rotation of the plugs, the IVTM located in the SRP can address all of the core assembly locations, the fuel transfer positions which are the exchange point to the slanted track ex-vessel fuel transfer system, and four locations provided for in-vessel storage of core assemblies.

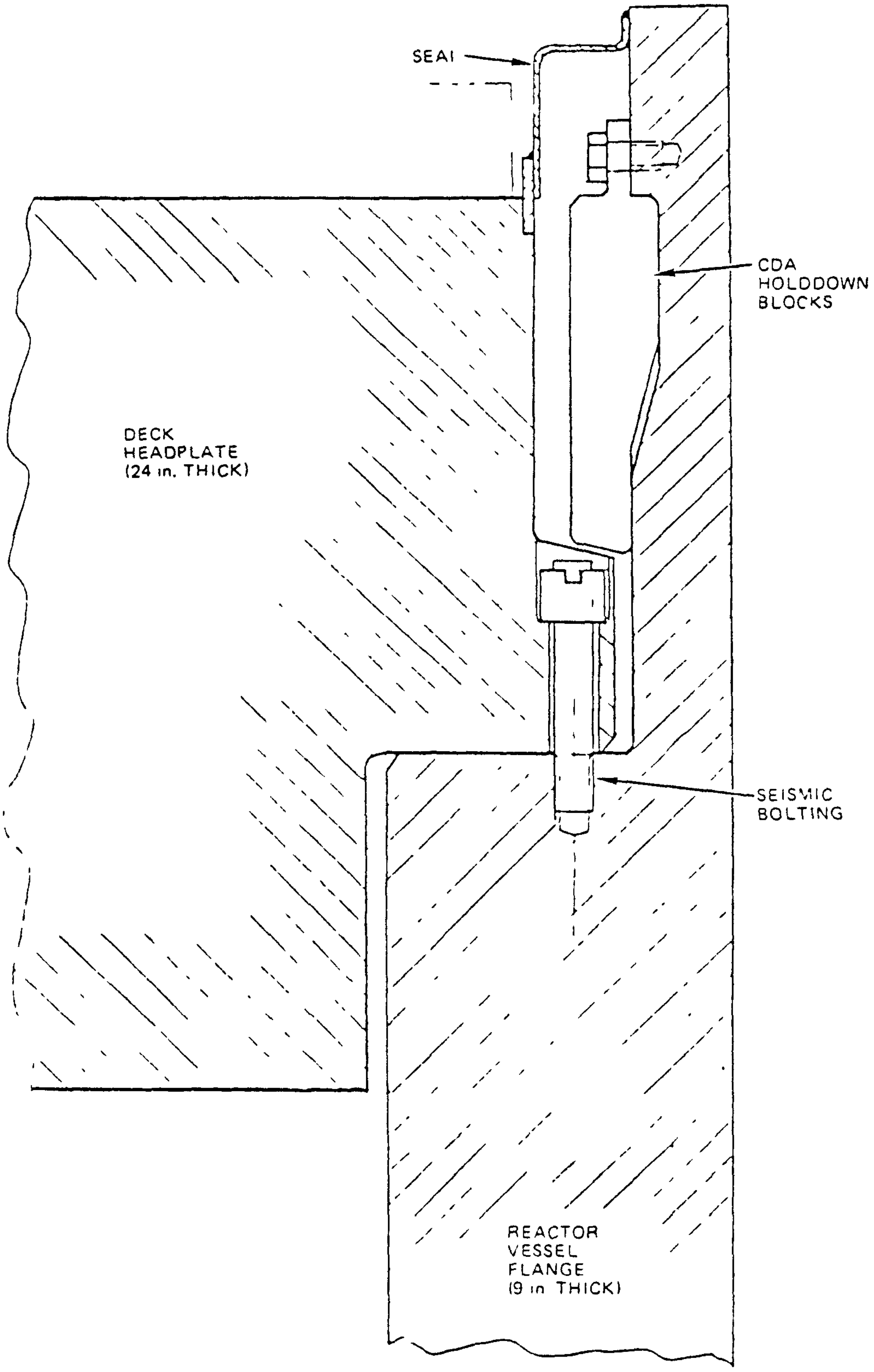


Figure 2-11 Deck Support Detail

This TRP system configuration and design incorporates two unique features which are the key to limiting the diameter of the LRP, thus enabling the design of a loop reactor with in-vessel downcomer high-pressure piping within the size limit of a shop fabricable vessel. These are:

1) location of the fuel transfer positions just outside the core barrel and

2) the vertically staggered arrangement of the bearings and seals for the LRP, IRP, and SRP at their close approach side as described in Section 2.3.3.

The basic design of the rotatable plugs is shown by Figure 2-12. The top element of each plug is a 20-in. thick carbon steel headplate which is the primary plug structure and containment member. The insulation at the bottom of the plug consists of a 1-in. support and seismic splash protection plate, plus 54.0.1-in. thick stainless steel reflective plates spaced 0.75-in. apart. A 6-in. thick plate located just above the reflective insulation provides additional shielding. The total height of the plugs is 8' - 0", thereby providing a 20-in. space, between the headplate and lower shield plate, for incorporation of CDS energy absorbtion material if required.

The required 30-in. of steel shielding is provided by the combined thicknesses of the headplate, lower shield plate, and the material of the thermal insulation.

2.3.3 Seals and Bearings

Each of the rotatable plugs includes a seal and bearing system as shown on Figure 2-13. The dynamic seal for each of the plugs is a series pair of inflatable elastomer seals that engage a seal striker blade as illustrated by Figure 2-14. The buffer gas between the seals is maintained at a small positive pressure relative to the normal cover gas and Head Access Area (HAA) pressures so that any bypass leakage will be clean gas into the cover gas or into the HAA. Low pressure alarms on buffer gas pressure provide a continuous monitoring of seal status.

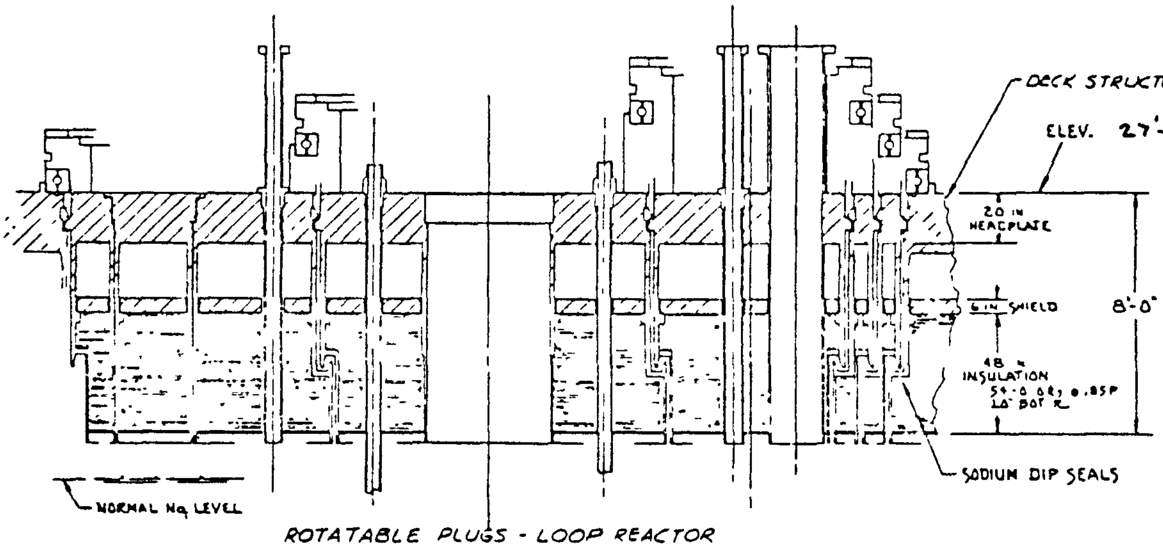


Figure 2-12 Rotating Plug Details

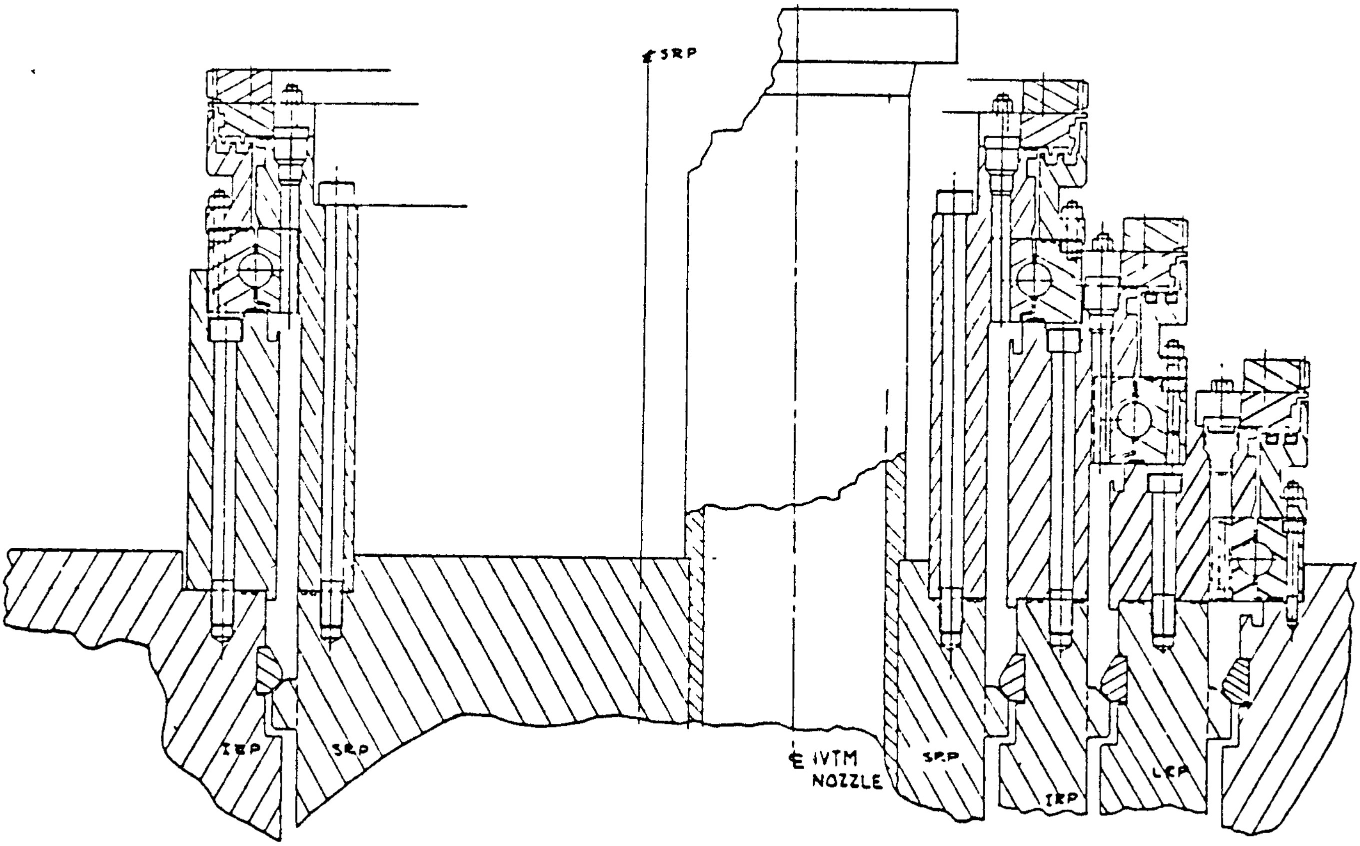


Figure 2-13 Rotating Plug and Bearing Detail

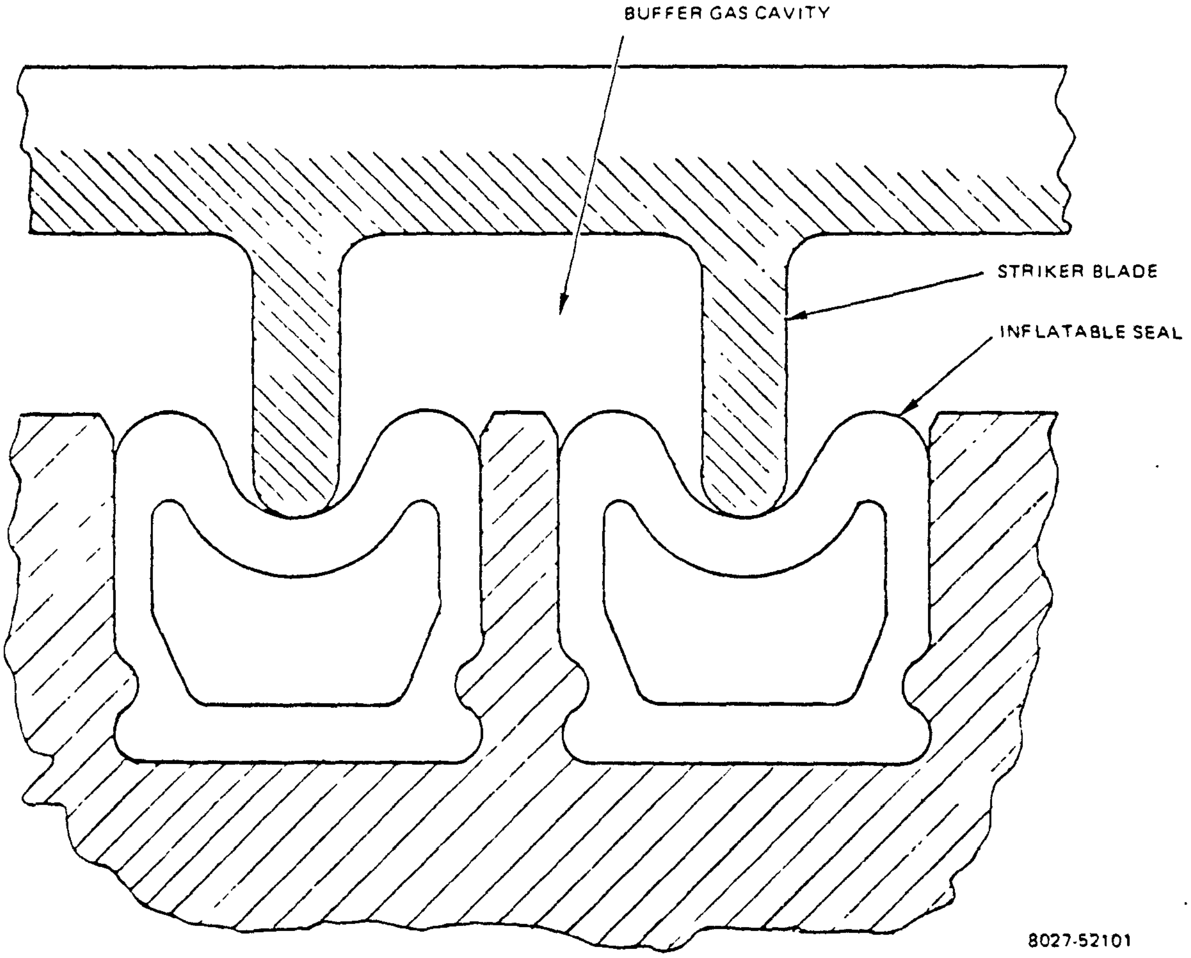


Figure 2-14 Inflatable Elastomer Seals

Each of the plugs rotates on vertically split race, radial-thrust-type ball bearings designed for both upward and downward, plus horizontal, loadings to accommodate all deadweight and seismic forces. The race profiles are compensated to accommodate differences in radial expansion due to temperature mismatch of the inner and outer races. The bearings will be lubricated with radiation-resistant, non-bleed grease and a nonelastomer grease seal will be included in the design. Relubrication ports will also be provided.

Key features of the integrated rotatable plug seal and bearing system are listed as follows:

1) Vertically split race ball bearing.

2) Dual inflatable dynamic containment seals with buffered interspace.

3) Plug support ring and bearing outer race sealed to headplates or support flanges by O-rings; these are not expected to require disassembly during plant lifetime. All other static seals are elastomer O-rings. All employ dual rings and interspace buffering.

4) Air seal above inflatable seals prevent contamination of seal lubricant and ozone attack of the containment seal.

5) Annulus inspection-maintenance ports provided to allow determination of extent of sodium frost accumulation, and for insertion or actuation of frost scraping devices; port closure design allows access without breaking containment.

6) Tolerance shims at all part-to-part interfaces to minmize tolerance requirements.

7) Over-pressure seal to provide containment for pressures that exceed inflatable seal inflation pressure.

8) Hold-down keys to limit the upward displacement of the plug in the event of large upward forces.

The primary seals described above are supplemented by sodium dip seals, located at approximately the mid-height of the plug insulation. The specific elevation of the dip seals is selected to obtain as low a temperature as possible during reactor operation. This provides minimum sodium vapor pressure and subsequent sodium frost deposition rate in the cold regions of the upper annulus, but maintains a safe margin above the freezing temperature when the system is cooled for refueling.

As shown on Figure 2-13, a vertical stacking arrangement of the bearings and seals for the three plugs (LRP, IRP, SRP) is used at the close approach area of the plugs. This arrangement minimizes the dimension from the IVTM port to the outer edge of the LRP bearing-seal assembly and is a key feature in minimizing the diameter of the TRP system within the constraints of the geometric requirements of in-vessel fuel transfer.

3.0 Fuel Handling System

The Fuel Handling System (FHS) consists of a number of subsystems and components that replace spent fuel assemblies, irradiated blanket assemblies, and control rod absorbers in a manner that assures fast and safe reactor refueling without containinating the RCB or the Fuel Handling Building (FHB). The FHS has features for safeguarding and surveillance of fuel at all times in the reactor plant.

Fuel handling is accomplished in two phases: 1) exchanging spent fuel in the reactor with new fuel from ex-vessel storage, and 2) replacing the spent fuel in ex-vessel storage with new fuel from incoming shipping containers. The first operation requires reactor shutdown, whereas the second can be performed during reactor operation. Locating the spent fuel storage area outside the RCB assures that maintenance and operation of ex-containment facilities will not interfere with reactor operation.

A normal refueling is assumed to consist of replacing about one-third of the active core every year. This consists of about 146 fuel assemblies, 102 blanket assemblies may also be replaced. This amounts to at least 258 core assemblies replaced each year.

During reactor refueling, only four subsystems are utilized. The control system which operates, integrates, and interlocks the mechanical equipment, the IVTM that transfers fuel within the reactor vessel, the EVST that stores the spent fuel removed from the reactor and the new fuel to be put into the reactor under sodium, and the FTC which transfers fuel between the reactor vessel and the EVST.

During fuel shipment in and out of the plant, the control system, the EVST and FHC, and shipping cask area are used.

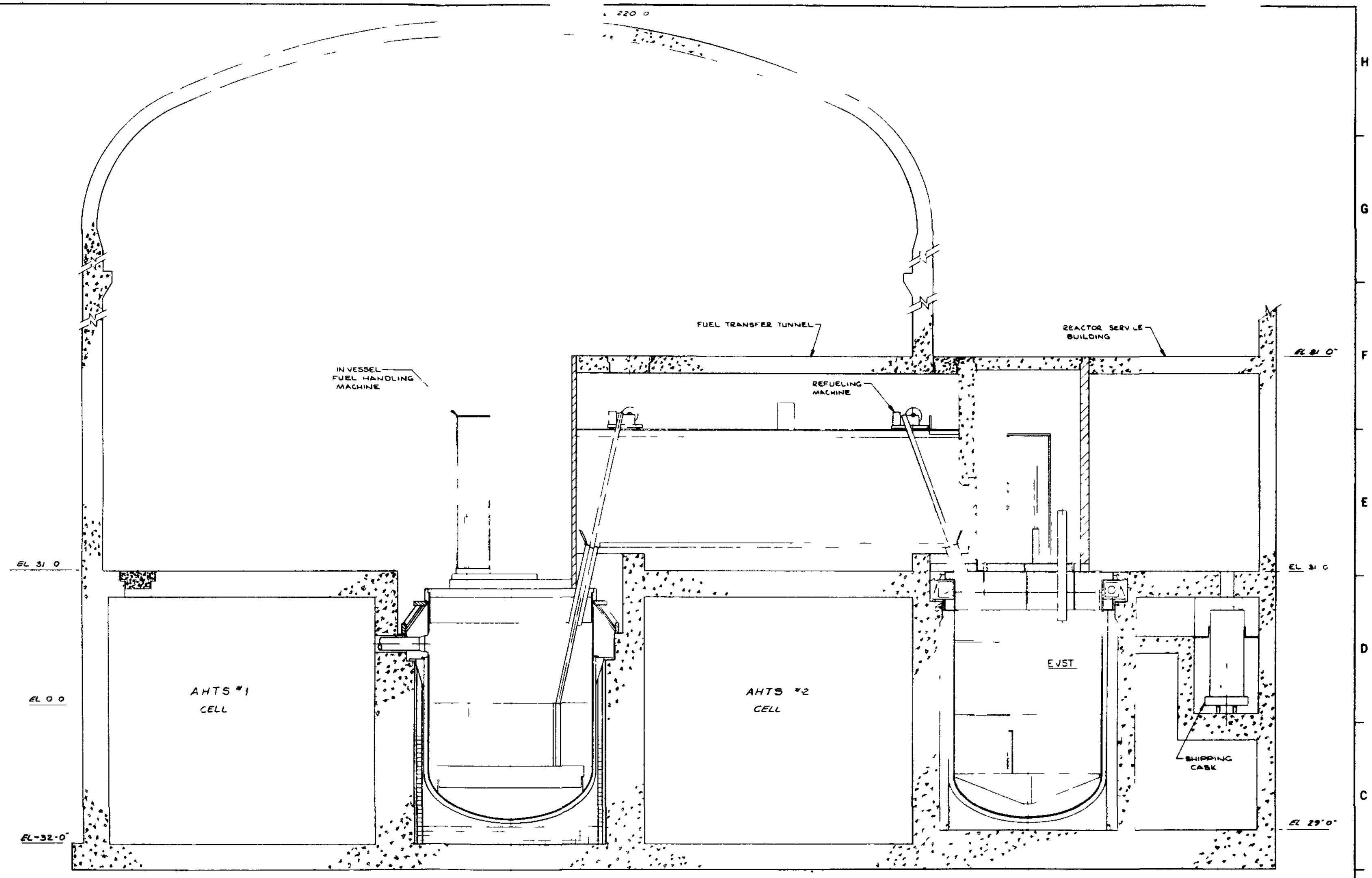
During reactor operation, the FTC is sealed from the reactor building containment and the IVTM stowed and supported.

Refueling will be initiated about 2 days after reactor shutdown. This allows time for reactor cooldown, control rod drive line disconnection, instrument tree lifting, and preparation and checkout of the refueling equipment. Reactor refueling will be accomplished on a one-for-one basis at a rate of less than 1 h per exchange, e.g., a spent fuel assembly will be removed from the core and will be replaced with a new fuel assembly before the next spent fuel assembly is removed. Upon completion of refueling, the reactor fuel transfer ports will be cleaned, plugged, sealed, and checked, the instrument tree lowered, and the control rod drive lines reconnected. These operations require a period of about 2 days to complete the refueling operation. The total time for normal core refueling is $\sim$ 12 days.

The FHS is shown in Figure 3-1. The relationship between the FHS and the reactor containment building is also shown. The flow of fuel between the shipping area and the EVST and between the EVST and the reactor core is shown by the arrows on Figure 3-1.

The general features of the FHS are illustrated in Figure 3-1. The FHS components include:

1) A straight pull IVTM, mounted on the smallest of the three rotatable plugs, is used for in-reactor vessel fuel handling. An ultrasonic-type device is used as a core sweep before initial



SE-651410-160-028

SECTION BB
SEE DWG SE 651410 60 029)

FIGURE 3-1

POWER SYSTEMS
COMBUSTION ENGINEERING INC

DRAWN BY J CRAWFORD 2-17-80
CHECKER
APPROVALS
CUST 65140
TITLE ELEVATION
REACTOR CONTAINMENT
BLDG REFUELING
SCALE 1/10
SE-65140-160-028

plug rotation. The IVTM identifies fuel assemblies, holds down adjacent assemblies, and maintains fuel under sodium. The drives are accessible in air.

2) For ex-reactor vessel fuel handling, two traversing trolley mounted hoist-tilt devices in an inerted atmosphere FTC, two fuel transfer buckets, a track system and ports that lead from the FTC through the fixed deck to the reactor vessel, and a track system and port from the FTC to the fuel storage vessel are employed. The buckets are attached to the hoist chains to eliminate a grappling operation. The fuel is maintained below sodium level in the buckets. Each bucket has two positions for convenient fuel exchange. The drives are accessible in air.

3) An EVST, located outside containment in the FHB in a confinement-type structure, is used for under-sodium storage of fuel, blanket, and other core assemblies. Included in the EVST is a fuel transfer arm (FTA) mounted on a rotatable plug over the storage area. The EVST storage capacity is one annual refueling plus one full reactor core unload of fuel, blanket, and control rods (plus a few). The FTA and a reader device can identify core assemblies. A spare arm is mounted in place for redundancy. The FTA and rotatable plug drives are accessible in air. The EVST is shown in Figure 3-2.

4) An FHC, located in the fuel handling building, transfers assemblies between the EVST, in-cell fuel canistering, in-cell storage, in-cell new fuel inspection, and the transfer port to the fuel shipping casks or containers. The cell has adequate dry storage for a core load of new fuel or the shield assemblies of a core unload. The bridge-mounted fuel handler can gas cool bare fuel assemblies and handle canisters. There are no spent fuel cleaning or inspection facilities although spent fuel can be observed. A fuel grapple maintenance station is located under the cell in the cask tunnel.

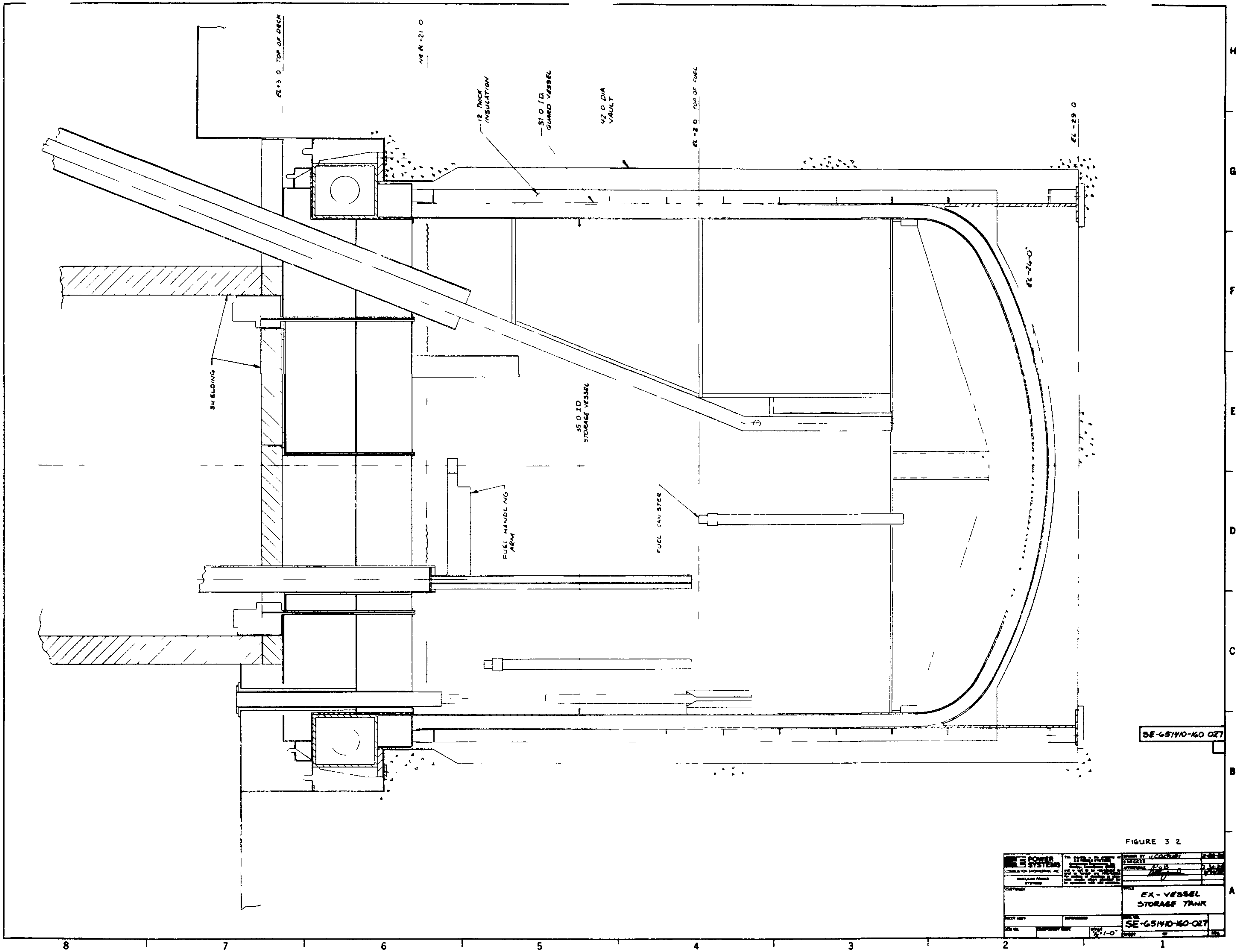


FIGURE 3 2

EX - VESSEL STORAGE TANK

5) A central fuel handling system control area, located in the FHB, integrates control of the rotating plugs, the IVTM and fuel handling components within the FTC, EVST, and FHC. This system also offers complete fuel surveillance and accountability at all stages of fuel location and integrates the FHS to the entire reactor facility for operational safety and security.

6) The spent fuel shipping cask is uprighted on its railroad car and moved under the FHC where it is loaded for shipment. For offsite shipment, the fuel is first canistered in sodium, sealed, and then installed in the helium gas shipping cask. The cask can accommodate 8 to 12 fuel assemblies of about 8 kW decay energy each.

III. COST ESTIMATE

A summary of the cost estimates for the Nuclear Steam Supply System is given in Table 3.1.

TABLE 3.1

COST ESTIMATE SUMMARY

1390 MWe LIQUID METAL FAST BREEDER REACTOR PLANT

		QUANTITY	COST (DOLLARS) (THOUSANDS)
220A.21	Reactor Equipment		
220A.211	Reactor Vessels		
220A.2111	Reactor Vessel Shell	1	21,098
220A.2112	Vessel Head + Accessories		
220A.21121	Vessel Closure Head	1	19,469
220A.21122	Heating + Cooling Equipment	Not Included	
220A.21123	Gears + Misc. Equipment	1 set	26
220A.21124	Plug Drive + Control	1 set	708
220A.21125	Rotary Seals + Maintenance Tools	1 set	35
220A.21126	Bearings	1 set	250
220A.21127	Shielding	187,000 lbs.	530
200A.21128	Insulation	Included in 220A.21121	
220A.2113	Guard Vessel	1	4,847
	220A.211 Reactor Vessels Total		46,963

TABLE 3.1 (Continued)

		QUANTITY	COST (DOLLARS) (THOUSANDS)
220A.212	Reactor Vessel Internals		
220A.2121	Lower Internals		
	Core Support Structure	1	7,288
	Distribution Plenum	1	8,005
220A.2122	Upper Internals		
	Instrument Tree Assembly	1	3,852
220A.2123	Core Restraint/Core Barrel	1 set	1,604
220A.2124	Inlet Piping	4 runs	1,050
220A.2125	Assemblies		
220A.21251	Core Assemblies	Not Included	
220A.21252	Blanket Assemblies	Not Included	
220A.21252	Reflector + Shield	Not Included	
220A.21254	Fuel Transfer Assemblies	Not Included	
220A.21255	Instrumentation Assemblies	61	1,966
220A.25256	Check Valves	4	593
	Splitter Valves	4	1,680
	220A.212 Reactor Vessel Internals Total		26,038
220A.213	Control Rod System		
220A.2131	Control Rods	Not Included	
220A.2132	Control Rod Drives	30	3,249
	220A.213 Control Rod System Total		3,249

TABLE 3.1 (Continued)

		QUANTITY	COST (DOLLARS) (THOUSANDS)
220A.22	Heat Transport Systems		
220A.221	Primary Heat Transport system		
220A.2211	Pumps	4	15,898
	Motors	4	2,498
	Control (Variable Speed Drives)	4	3,497
	Pony Motors	4	250
220A.2212	Primary Piping System		
220A.22121	Piping		
	Large Diameter Piping	2100'	15,394
	Intermediate Diameter Piping	400'	390
	Small Diameter Piping	736'	238
	Supports (Materials only)		3,522
220A.22122	Valves		
	Small Valves	36	1,751
220A.2213	Intermediate Heat Exchanger	4	25,955
220A.2214	Guard Vessels	Not Applicable	
220A.2215	Heating System	Included in 220A.262	
220A.2216	Insulation	Not Included	
	220A.221 Primary Heat Transport System	TOTAL	69,393

TABLE 3.1 (Continued)

		QUANTITY	COST (DOLLARS) (THOUSANDS)
220A.222	Intermediate Heat Transport System		
220A.2221	Pump + Motor + Control		
	Pumps	4	12,138
	Motors	4	2,248
	Control (Variable Speed Drive)	4	3,497
	Pony Motors		250
220A.22221	Int. Piping System		
	Large Diameter Piping	3120'	3,329
	Small Diameter Piping	2088'	106
	Supports (Material)		1,875
220A.22222	Valves		
	Large Valves	8	1,778
	Small Valves	56	2,043
220A.2224	Tanks		
	Expansion Tanks	4	920
220A.2225	Heating System	Included in 220A.262	
220A.2226	Insulation	Not Included	
	220A.222 Intermediate Heat Transport System Total		28,184

TABLE 3.1 (Continued)

		QUANTITY	COST (DOLLARS) (THOUSANDS)
220A.223	Steam Generation System		
220A.2232	Steam Generators		
220A.22321	Evaporators	8	50,808
220A.22322	Superheaters	Included above	
220A.22323	Steam Drums	Not Applicable	
220A.2233	Na/H_2O Reaction Protection System		
220A.22331	Centrifuges, Tanks	12	6,542
220A.22332	Piping + Valves		
	Piping	764'	426
	Valves	50	713
220A.2236	Insulation	Not Included	
	220A.223 Steam Generation System Total		58,489
	220A.22 Heat Transport Systems		156,066

TABLE 3.1 (Continued)

		QUANTITY	COST (DOLLARS) (THOUSANDS)
220A.23	Safeguards Systems		
220A.231	Backup Heat Removal System		
220A.2311	Pumps, Fans + Motors	8	2,440
220A.2311	Heat Exchange Equipment	6	4,909
220A.2313	Tanks	2	186
220A.2314	Piping + Valves		
	Piping	1014'	1,162
	Valves	18	2,626
	220A.231 Backup Heat Removal System		
	220A.23 Safeguards Systems Total		11,323

TABLE 3.1 (Continued)

		QUANTITY	COST (DOLLARS) (THOUSANDS)
220A.25	Fuel Handling and Storage		
220A.251	Rec., Storage and Shipping		
	New Fuel Handling Crane	1 set	78
	New Fuel Storage Racks	1 set	441
220A.252	Ex-Vessel Storage Tank	1	22,674
	Guard Vessel	1	6,314
220A.253	Ex-Vessel Handling Mechanisms		
	EVHM Trolley + Rails	2 sets	30
	EVHM	2	3,206
	Spent Fuel Cask Cart	1	212
220A.254	Transfer Mechanisms		
	Transfer Tracks	2 sets	45
	Transfer Buckets	2	22
220A.255	In-vessel Handling Mechanisms	1	1,320
220A.256	Fuel Handling Cells		
	New Fuel Conveyor + Tubes	1 set	71
	Cell Equipment	1 set	57
220A.257	Piping + Valves		
	Piping	2440'	1,045
	Valves	14	293
	Supports (Materials Only)		931

TABLE 3.1 (Continued)

		QUANTITY	COST (DOLLARS) (THOUSANDS)
220A.258	Misc. Equipment		
	Tanks	2	13
	Pumps	6	750
	HX		623
	Cold Traps		906
	220A.25 Fuel Handling and Storage Total		39,031

TABLE 3.1 (Continued)

		QUANTITY	COST (DOLLARS) (THOUSANDS)
220A.26	Other Equipment		
220A.261	Inert Gas Receiv. + Process		
220A.2611	Pumps, Compressors + Drives	5	504
220A.2612	Gas Supply/Storage Tanks	27	2,458
220A.2613	Gas Purification Units	70	2,705
220A.2615	Piping, Valves + Fittings		4,176
	220A.261 Inert Gas Receiv. + Process Total		9,843
220A.262	Special Heating Systems		
220A.2621	Trace Heater System		7,546
	220A.262 Special Heating Systems Total		7,546
220A.264	Sodium Storage, Relief, Makeup		12,286
220A.265	Sodium Purification System		5,075
220A.266	NA Leak Detection System	Included in 220A.27	
220A.267	Auxiliaries Cooling Equipment	Not Included	
220A.268	Maintenance Equipment	Not Included	
	220A.26 Other Equipment Total		34,750
220A.27	Instrumentation + Controls		22,855
	220A.2 Distributed NSSS Cost		340,275

SECTION IV

EQUIPMENT LIST

This section describes, in detail, the major components of the LMFBR Target Plant design developed by C-E for this study. Each of component is described in terms of quantity, type, orientation, capacity, design pressure, design temperature, etc., in sufficient detail to permit preparation of the cost estimates given in Section 3 of this report. The components are listed in accordance with an expanded AEC code-of-accounts (UASEC Report NUS-531), in the following Table 4.1 which permits correlation and cross referencing with the detailed cost estimates.

TABLE 4.1

EQUIPMENT LIST

220A.2111 REACTOR VESSEL

DESCRIPTION	LMFBR TARGET PLANT
Number of Components per Plant	1
Design and Operating Conditions	
Design Pressure/Temperature (Inlet Plenum)	165 Pisia/700°F
Design Pressure/Temperature (Outlet Plenum)	40 Psia/975°F
Flow Rate	143.2 x 10^6 lbm/hr
Fluid	Na
Inlet Temperature/Outlet Temperature	650°F/950°F
Heat Load	3800 MWt
Safety Class	Section III Class I
Physical Size and Weight	
Maximum Diameter (Shell)	37'-6"
Ovarall Length	53'-7"
Dry Weight	1,088,200 lbs.
Materials	
Shell	SA-240, Type 304
Flange	SA-508, Cl.3
Shell to Flange Transition	SB-168
Thermal Liner	SA-240, Type 304
COMPONENT SHELLS	
Shell Plate Thickness	
Upper Cylindrical Region	2.00"
Lower Cylindrical Region	2.00"
Lower Head	2.00"
Internal Cladding	
Location	None
Material/Thickness	None
Nozzles	
Inlet - Quantity/I.D.	4.35.00"
Outlet - Quantity/I.D.	4.43.00"
Other - Quantity	16

TABLE 4.1 (Continued)

DESCRIPTION	LMFBR TARGET PLANT
Penetrations in Lower Head - Quanity	None
Linear Feet of Welds	1085 ft.
Upper Flange	
Inside Diameter	37'-2"
Outside Diameter	38'-8"
Height	3'-0"
THERMAL LINERS	
Quantity	2
Outside Diameter	36'-11" & 36'-7"
Thickness	1.00"
Length	20'-6"
SUPPORT SYSTEM	
Flange	
Inside Diameter	38'-4"
Outside Diameter	44'-4"
Height	12.00"
Skirt	
Mean Diameter	44'-0"
Thickness	3.5"
Height	6'-6"
CONSTITUENT WEIGHTS	
Weight of Shell	
Shell Plate	421,000 lbs.
Nozzles	17,200 lbs.
Weld Metal	25,600 lbs.
Upper Flange	134,800 lbs.
Total Weight of Shell	598,600 lbs.
Weight of Support Skirt anf Flange	
Flange Weight	195,900 lbs.
Skirt Weight	93,700 lbs.
Total Support Skirt and Flange Weight	289,600 lbs.
Weight of Thermal Liner	
Total Weight of Thermal Liner	200,000 lbs.

TABLE 4.1 (Continued)

DESCRIPTION	LMFBR TARGET PLANT
Weight of Miscellaneous Items	
Total Weight of Miscellaneous Items	30,300 lbs.

TABLE 4.1 (Continued)

220A.2112 CLOSURE HEAD

DESCRIPTION	LMFBR TARGET PLANT
Number of Components per Loop	1
Component Type or Configuration	Flat W/3 Rotaging Plugs
Design and Operating Conditions	
Design Pressure/Temperature (Strucutre)	40 Psia/200°F
Design Pressure/Temperature (Insulation)	40 Psia/975°F
Safety Class	Section III Class I
Physical Sizes and Weights	
Flange Outside Diameter	38'-6"
Flange Inside Diameter	26'-8"
Flange Height	24.00"
Head Radius (Inner)	Flat
Heat Thickness	24.00"
Large Rotating Plug Diameter	31'-0"
Intermediate Rotating Plug Diameter	22'-2"
Small Rotating Plug Diameter	11'-0"
Thickness of Biological Shielding	6"
Overall Height	12'-8"
Total Weight	2,000,000 lbs.
Material	
Flange	SA-508, Class 3
Head	SA-508, Class 3
Biological Shielding	SA-508, Class 3
Thermal Shielding	SA-240, Type 304
Seals	
Quantity	3 Sets
Type	Inflatable and Dip Seals
Material	Silicon Rubber and Liquid Me
Number of Cpntrol Rod Penetrations	30
Number of Bearings, Drives, and Controls	3

TABLE 4.1 (Continued)

DESCRIPTION	LMFBR TARGET PLANT
Bearings	
Quantity	3
Type	Roller
Diameters	31'-0", 22'-2", 8'-0"
Drive and Motor and Control	
Quantity	6
Type	Reduction Gears
Control	Servo Control

TABLE 4.1 (Continued)

220A.2113 GUARD VESSEL

DESCRIPTION	LMFBR TARGET PLANT
Number of Components per Plant	1
Design and Operating Conditions	
Design Pressure/Temperature	14.7 psia/700°F
Safety Class	Section III Class III
Physical Size and Weight	
Maximum Diameter	39'-4"
Shell Thickness	1.00"
Overall Length	38'-9"
Weight	250,000 lbs.
Material	SA-516 Carbon Steel

TABLE 4.1 (Continued)

220A.212 REACTOR VESSEL INTERNALS

DESCRIPTION	LMFBR TARGET PLANT
Number of Components	1
Design Pressure	40/165 Psia
Design Temperature	975/675°F
Fluid	Sodium
Flow Rate	143.2×10^6 lbm/hr
Material	304 SS
Lower Internals	
Core Barrel, Size	233"ϕ x 138" x 1"t
Weight	78,444 lbs.
Core Support Structure, Size	36' OD, 24" ID, 5'-3" high
Weight	264,000 lbs.
Distribution Plenum, Size	36' OD, 16'-10" ID, 5" high
Weight	290,000 lbs.
Upper Internals	
Instrument Tree Assembly	
Quantity	1
Size	15' DIA. x 20' high
Weight	160,000 lbs.
Inlet Piping (in-vessel)	
Number of runs	4
Dimensions (one run)	36" OD, 60' long
Weight	47,000 lbs Total
Check Valve, Size	36"ϕ
Quantity	4
Type	Swing Disc
Weight	24,000 lbs.
Splitter Valve, Size	21" DIA x 58" high
Quantity	4
Type	Mechanically actuated
Weight (total)	68,000 lbs.
Total Weight (Internals)	931,444 lbs.
Feet of Weld	80,000 ft.

TABLE 4.1 (Continued)

DESCRIPTION	LMFBR TARGET PLANT
CONTROL ROD DRIVES	
Quantity	30
Type	Telescoping Servo Drive
Size	30' x 12"ϕ
Control	Pneumatic
Stroke	48"

TABLE 4.1 (Continued)

220A.2211 PRIMARY PUMP AND MOTOR AND CONTROL

DESCRIPTION	LMFBR TARGET PLANT
Quantity	4
Design Pressure/Temperature	165 Psia/950°F
Type	Centrifugal/Single Stage
Orientation	Vertical
Flow Rate	35.8 x 10^6 lbs/hr
Speed	690 rpm
TDH	363 ft.
BHP	9000 HP
NPSH	30 ft
Efficiency	80%
Material	SS
Safety Class	I
Pump Casing	304 SS
Diameter	12'
Length	27'
Weight	149,000 lbs.
Pump Shaft	304 SS
Diameter	12"
Length	20'-8"
Weight	12,000 lbs.
Impeller	304 SS
Diameter	68"
Weight	8000 lbs.
Bearings	
Number	2
Type	Hydrostatic

TABLE 4.1 (Continued)

DESCRIPTION	LMFBR TARGET PLANT
Shielding	Shots
Weight	
Pump Supports	
Type	Flange Mounted (Fixed)
Weight	
Motors	
Type	Induction AC
Rating	9000 HP
Speed Control	
Type	Motor/Generator
Rating	9000 HP
Total Weight (Pump Only)	302,000 lbs.

TABLE 4.1 (Continued)

220A.22121 PRIMARY PIPING

DESCRIPTION	LMFBR TARGET PLANT
Design Temperature (Hot Leg)	975°F
Design Temperature (Cold Leg)	675°F
Design Pressure (HP)	165 Psia
Design Pressure (LP)	40 Psia
Safety Class	I
Material	316SS/304SS
Large Piping	
Size	44" OD x 5/8"t
Length	760'
Elbows	36
Flow	35.8×10^6 lbs/hr
Size	36" OD x 1/2"t
Length	1348'
Elbows	64
Medium Piping	LP, Siphon, Overflow
Diameter	8"-14" Schedule 40
Length	400'
Small Piping	Drain and Vent
Diameter	6" and Smaller Schedule 40
Length	736'

TABLE 4.1 (Continued)

220A.22122 PRIMARY VALVES

DESCRIPTION	LMFBR TARGET PLANT
Throttle/Check Valves	
Quantity	4
Type	Needle
Size	14"
Material	304SS
Drain Valves	
Quantity	22
Type	Wedge/Disc
Size	6"
Siphon Breaker Diodes	
Quantity	4
Type	Nozzles
Size	8"
IHX Vent Line Orifices	
Quantity	4
Type	Orifice Plates
Size	1"

TABLE 4.1 (Continued)

220A.2213 INTERMEDIATE HEAT EXCHANGER

DESCRIPTION	LMFBR TARGET PLANT
Number of Components per Plant	4
Component Type or Configuration	St. Tube/St. Shell
Flow Characteristics	Counterflow
Orientation	Vertical
Shell Size Design and Operating Conditions	
Design Pressure/Design Temperature	165 Psia/975°F
Flow Rate	35.8 x 10^6 lbm/hr
Fluid	Na
Inlet Temperature/Outlet Temperature	950°F/650°F
Tube Side Design and Operating Conditions	
Design Pressure/Design Temperature	165 Psia/975°F
Flow Rate	33.4 x 10^6 lbm/hr
Fluid	Na
Inlet Temperature/Outlet Temperature	590°F/910°F
Net Load Per Component	950 MWt
Safety Class	Section III Class I
Physical Size and Weight	
Maximum Diameter (Shell)	12'-3.19"
Overall Length	64'-1.00"
Dry Weight - Per Component/Per Plant	639,400/2,557,600 lbs
Materials	
Shell Plate	SA-240, Type 304
Tubesheets	SA-182, Type 304
Tubes	SA-213, Type 304
COMPONENT SHELL	
Shell Plate Thicknesses	
Cylindrical Shell Region	3.00"
Upper Hemispherical Head	3.00"
Lower Hemispherical Head (Inner)	3.00"
Lower Hemispherical Head (Outer)	3.00"

TABLE 4.1 (Continued)

DESCRIPTION	LMFBR TARGET PLANT
Nozzles	
Shell Side Inlet - Quantity/I.D.	1/35.00"
Shell Side Outlet - Quantity/I.D.	1/35.00"
Tube Side Inlet - Quantity/I.D.	1/35.00"
Tube Side Outlet - Quantity/I.D.	1/35.00"
Lineal Feet of Welds	510 ft.
COMPONENT TUBE BUNDLE	
Number of Tubes - Per Component/Per Plant	3,846/15,384
Mean Heated Length	45'-0.00"
Tube Side - O.D./Wall Thickness/Pitch	1.25"/0.045"/1.697"
Heat Transfer Area - Per Component/Per Plant	56,600 ft.^{2}/226,400 ft.^{2}
Tube Support Concept	Eggcrates w/baffles
Type of Tube to Tubesheet Weld	Rolled and Seal Welded
Tube Bundle Shroud (Outer)	
Inside Diameter	123.19"
Thickness	1.00"
Length	41'-3.5"
Tube Bundle Shroud (Inner)	
Inside Diameter	39.25"
Thickness	0.63"
Length	37'-7.0"
Downcomer	
Inside Diameter	36.00"
Thickness	0.63"
Length	57'-0.0'
Upper Thermal Liner	
Inside Diameter	34.50"
Thickness	0.50"
Length	9'-2.0"
COMPONENT TUBESHEETS	
Number Per Component	2
Finished Diameter - Upper/Lower	133.12"/133.12"
Finished Thickness - Upper/Lower	12.00"/12.00"

TABLE 4.1 (Continued)

DESCRIPTION	LMFBR TARGET PLANT
<u>CONSTITUENT WEIGHTS</u>	
Weight of Shell (Pressure Boundary)	
Plate Material	297,300 lbs.
Nozzles	10,100 lbs.
Weld Metal	7,800 lbs.
Total Weight of Shell	315,200 lbs.
Weight of Tube Bundle	
Tubing	107,200 lbs.
Tube Supports and Baffles	15,400 lbs.
Shrouds	67,100 lbs.
Downcomer	12,900 lbs.
Total Weight of Tube Bundle	202,600 lbs.
Weight of Tubesheets	
Upper Tubesheet	27,900 lbs.
Lower Tubesheet	29,800 lbs.
Total Weight of Tubesheets	57,700 lbs.
Weight of Miscellaneous Items	
Total Weight of Miscellaneous Items	63,900 lbs.

TABLE 4.1 (Continued)

220A.2221 SECONDARY PUMP AND MOTOR AND CONTROL

DESCRIPTION	LMFBR TARGET PLANT
Pump	
Quantity	4
Design Pressure/Temperature	300 Psia/625°F
Type	Centrifugal
Orientation	Vertical
Flow Rate	33.4 x 10^6 lbs/hr
Speed	700 rpm
TDH	291 ft.
BHP	6700 HP
NPSH	148 ft.
Efficiency	85%
Material	304SS
Safety Class	NNS
Pump Casing	304SS
Diameter	12 ft.
Length	21 ft.
Weight	116,000 lbs.
Pump Shaft	304SS
Diameter	12"
Length	15 ft.
Weight	8,700 lbs.
Impeller	304SS
Diameter	68"
Weight	8,000 lbs.
Bearings	304SS
Number	2
Type	Hydrostatic
Shielding	Not Required
Weight	
Pump Supports	
Type	Flange, Fixed
Weight	

TABLE 4.1-(Continued)

DESCRIPTION	LMFBR TARGET PLANT
Motors	
Type	AC-Induction
Rating	7000 HP
Speed Control	
Type	Motor/Generator
Rate	7000 HP
Total Weight (Pump Only)	284,000 lbs.

TABLE 4.1 (Continued)

220A.22221 SECONDARY PIPING

DESCRIPTION	LMFBR TARGET PLANT
Safety Class	NNS
Design Pressure	300 Psia
Design Temperature (Hot/Cold)	950/625^{o}F
Material	304SS
Large Piping	
Diameter	36" O.D. x 1/2"t
Length	1600'
Elbows	72
Diameter	26" O.D. x 1/2"t
Length	1520'
Elbows	68
all Piping	
Diameter	6" and Smaller, Schedule 40
Length	2088'

TABLE 4.1 (Continued)

220A.22222 SECONDARY VALVES

DESCRIPTION	LMFBR TARGET PLANT
Design Pressure	300 Psia
Design Temperature	950/625°F
Material	304SS
Safety Class	NNS
Large Valves	
Quantity	8
Size	36"
Type	Isolation
Small Valves	
Quantity	56
Size	6" and Smaller
Type	Isolation

TABLE 4.1 (Continued)

220A.2224 SECONDARY EXPANSION TANK

DESCRIPTION	LMFBR TARGET PLANT
Number of Components per Plant	4
Design and Operation Conditions	
Design Pressure/Temperature	300 Psia/600°F
Fluid	Na
Heat Input Capacity	None
Safety Class	NNS
Physical Size and Height	
Maximum Diameter (Shell)	123.26"
Overall Length	15'-11.63"
Dry Weight	47,900 lbs.
Material	
Shell Plate	304SS
Support Skirt	None
Support Flange	304SS
COMPONENT SHELLS	
Shell Plate Thicknesses	
Cylindrical Shell Region	1.63"
Upper and Lower Heads	1.63"
Internal Cladding	
Location	None
Material/Thickness	None
Nozzles and Manways	
Total Number	6
Range of Inside Diameters	2.00" thru 4.00"
Manway - Quantity/Size	1/16.00"
Heater Penetrations - Quantity	None
Instrument Nozzles - Quantity	None
Lineal Feet of Welds	135 ft.

TABLE 4.1 (Continued)

DESCRIPTION	LMFBR TARGET PLANT
CONSTITUENT WEIGHTS	
Weight of Shell	
Shell Plate	35,300 lbs.
Nozzles and Manways	850 lbs.
Weld Metal	650 lbs.
Support Skirt	None
Support Flange	11,000 lbs.
Total Weight of Shell	47,800 lbs.
Weight of Miscellaneous Parts	
Total Weight of Miscellaneous Parts	100 lbs.

TABLE 4.1 (Continued)

220A.2232 STEAM GENERATOR

DESCRIPTION	LMFBR TARGET PLANT
Number of Components Per Plant	8
Component Type or Configuration	St. Tube/St. Tube
Flow Characteristics	Counterflow
Orientation	Vertical
Shell Side Design and Operating Conditions	
Design Pressure/Design Temperature	300 Psia/935°F
Flow Rate	16.70 x 10^6 lbm/hr
Fluid	Na
Inlet Temperature/Outer Temperature	910°F/590°F
Tubeside Design and Operating Conditions	
Design Pressure/Design Temperature	2275 Psia/875°F
Flow Rate	1.78 x 10^6 lbm/hr
Fluid	H_2O
Inlet Temperature/Outlet Temperature	470°F/854°F
Heat Load Per Component	475 MWT
Safety Class	NNS-ASME Section VIII
Physical Size and Weight	
Maximum Diameter (Shell)	106.75"
Overall Length	88'-8.0"
Dry Weight - Per Component/Per Plant	648,000/5,184,000 lbs.
Materials	2-1/2 Cr-1Mo
Shell Plate	SA-387, GR. 22, CL. 1
Tubesheet(s)	SA-336 F22
Tubes	SA-213, GR. T22
COMPONENT SHELLS	
Shell Plate Thicknesses	
Upper Cylindrical Shell Region	2.50"
Conical Transition Shell Course	None
Lower Cylindrical Shell Region	1.50"
Steam Outlet Hemispherical Head	5.50"
Upper Sodium Hemispherical Head	1.50"
Lower Hemispherical Head	5.00"

TABLE 4.1 (Continued)

DESCRIPTION	LMFBR TARGET PLANT
Internal Cladding	
Location	None
Material/Thickness	None
Nozzles	
Shell Side Inlet - Quantity/I.D.	1/25.00"
Shell Side Outlet - Quantity/I.D.	1/25.00"
Tube Side Inlet - Quantity/I.D.	1/18.00"
Tube Side Outlet - Quantity/I.D.	1/18.00"
Access Ports or Manways - Quantity/I.D.	2/24.00"
Lineal Feet of Welds	310 ft.
TUBE BUNDLES	
Number of Tubes - Per Component/Per Plant	3,547/28,376
Mean Heated Length	72'-0"
Tube Size - O.D./Wall Thickness/Pitch	0.75"/0.125"/1.250"
Heat Transfer Area - Per Component/Per Plant	50,145 Ft^2/401,160 Ft^2
Tube Support Concept	Drilled Plates
Type of Tube-to-Tubesheet Weld	Face and Back Side
Tube Bundle Shroud	
Inside Diameter	80.88"
Thickness	1.00"
Length	67'-6.00"
TUBE SHEETS	
Number Per Component	2
Finished Diameter - Upper/Lower	101.00"/101.00"
Finished Thickness - Upper/Lower	26.00"/23.00"
Clad Material/Clad Thickness	None/None
CONSTITUENT WEIGHTS	
Weight of Shell (Pressure Boundary)	
Plate Material	161,000 lbs.
Nozzles, Access Ports, Manways, Etc.	18,300 lbs.

TABLE 4.1(Continued)

DESCRIPTION	LMFBR TARGET PLANT
Weight of Weld Metal	2,400 lbs.
Total Weight of Shell	181,700 lbs.
Weight of Tube Bundle	
Tubing	226,700 lbs.
Tube Supports	30,300 lbs.
Shrouds	66,100 lbs.
Total Weight of Tube Bundle	323,100 lbs.
Weight of Tubesheets	
Upper	49,100 lbs.
Lower	36,600 lbs.
Total Weight of Tubesheets	82,700 lbs.
Weight of Steam Separation Equipment	
Weight of Separators	None
Weight of Dryers	None
Weight of Supports	None
Total Weight of Steam Separator Equipment	None
Miscellaneous Parts	
Total Weight of Miscellaneous Parts	60,500 lbs.

TABLE 4.1 (Continued)

220A.2233 Na/H_2O REACTION PROTECTION

DESCRIPTION	LMFBR TARGET PLANT
Rupture Disks	
Quantity	16
Type	
Material	304SS
Weight	
Reaction Products Sep. Tanks	
Quantity	4
Diameter	12'
Length	24'
Volume	70,000 gallons
Material	304SS
Weight	87,000 lbs
Steam Water Dump Tanks (4)	
Sodium Dump Tanks (4)	
Quantity	8
Diameter	14'
Length	15'
Volume	12,760 gallons
Material	304SS
Weight	18,000 lbs.
Large Piping	
Diameter	26"
Length	764'
Material	Carbon Steel
Small Piping	
Diameter	6" and Smaller
Length	1292'
Material	Carbon Steel
Valves	
Quantity	36
Type	Gate
Size	6" and Smaller - 20 10" - 8 26" - 8

TABLE 4.1 (Continued)

220A.231 SAFEGUARDS SYSTEM

DESCRIPTION	LMFBR TARGET PLANT
Decay Heat Removal Pumps	
Quantity	2
Type	EM
Fluid	Na
Flow	5200 GPM
Head	140 ft.
Design Pressure/Design Temperature	100 Psia/970°F
Safety Class	2
Materials	304SS
Rating	540 HP
Quantity	2
Type	EM
Fluid	NaK
Flow	7086 GPM
Head	67 ft.
Design Pressure/Design Temperature	200 Psia/650°F
Safety Class	2
Material	304SS
Rating	352 HP
AHTS Fans	
Quantity	4
Type	Centrifugal
Flow	2.5 x 10^5 CFM
Rating	1250 HP
AHTS Heat Exchangers	
Quantity	2
Type	Shell/Tube
Fluid	Na/NaK
Safety Class	1
Flow	5200/7086 GPM
Design Pressure	200 Psia
Design Temperature	1050°F
Thermal Rating	194 x 10^6 BTU/HR
Material	304SS
Ht. Area, $Ft.^2$	2,500 each

TABLE 4.1 (Continued)

DESCRIPTION	LMFBR TARGET PLANT
AHTS ABHX	
Quantity	4
Type	Forced Convection
Fluid	NaK/Air
Flow	3543 GPM/2.5 x 10^5 CFM
Design Pressure/Design Temperature	200 Psia/1050°F
Safety Class	2
Thermal Rating	97 x 10^6 Btu/hr
Material	304SS
Ht. Area, Ft.^{2}	3,981 each
Piping	
2" and smaller	50' Schedule 40
10"	620'-10" Schedule 40 (Na)
12"	344'-12" Schedule 40 (NaK)
Valves	
Quantity	18
Type	Isolation
Size	10" to 12"
Tanks	
Quantity	2
Type	NaK Expansion
Fluid	NaK
Design Pressure	200 Psia
Design Temperature	700°F
Size	15' x 5'ϕ
Volume	2,400 gallons
Material	304SS
Weight	8000 lbs.

TABLE 4.1 (Continued)

220A.25 REFUELING SYSTEMS - RECEIVING, STORAGE AND SHIPPING

DESCRIPTION	LMFBR TARGET PLANT
New Fuel Handling Crane	
Travel (ft.)	50 (Bridge), 30 (Trolley)
Hoist Capacity (ton)	0.50
Lift (ft.)	20 Approximately
Classification	
No. of Drives	3
Weight (lb.)	4,000
New Fuel Storage Racks	
Dimensions	6.25" FTF, 14' High
Capacity	298 Fuel Assemblies
Classification	
Weight (lb.)	700 lbs. per cell

TABLE 4.1 (Continued)

220A.25 REFUELING SYSTEMS - EX-VESSEL STORAGE TANK

DESCRIPTION	LMFBR TARGET PLANT
Number of Components per Plant	1
Design Pressure/Temperature	Vertical
Fluid Contained	Na
Safety Class	2
Physical Size and Weight (Assembled)	
Maximum Shell Diameter	36'
Overall Length	53'
Total Weight	1,300,000 lbs.*
Materials for Tank	
Shell	SA-240, Type 304
Flange	SA-508, Class 2
Materials for Closure Head	
Structural Cover	SA-533, GR. B. CL. 1
Materials for Guard Vessel	SA-516 carbon steel
COMPONENT SHELL	
Shell Plate Thicknesses	
Upper Cylindrical Region	1.00"
Lower Cylindrical Region	1.00"
Lower Head	1.00"
Nozzles	
Total Number	11
Range of Inside Diameters	1.96" thru 4.02"

* Does not include weight of drive mechanisms or storage tubes.

TABLE 4.1 (Continued)

DESCRIPTION	LMFBR TARGET PLANT
SUPPORT FLANGE	
Type	Box Beam
Size	42'-6"OD, 35'-2"ID, 2½" thick
CLOSURE HEAD	
Structural Cover Thickness	5'
Thermal Shielding	
Type	Canned Steel Wool
Thickness	4'
No. of Penetrations	36
Type of Seals	Metal Diaphram
Rotating Plug Diameter	22'
Transfer Arm	
Number	2
Length	8'-3"
DRIVE MECHANISMS	
Bearings	1(22"OD)
Motors	3
CONSTITUENT WEIGHTS	
Total Weight of Tank	500,000 lbs.
Total Weight of Closure Head	600,000 lbs.
Total Weight of Support Flange	200,000 lbs.
GUARD VESSEL	
Dimensions	
Diameter	38'
Height	44'-8"
Thickness	1.00"
Weight	362,000 lbs.

TABLE 4.1 (Continued)

220A.25 REFUELING SYSTEMS - EX-VESSEL HANDLING MECHANISMS

DESCRIPTION	LMFBR TARGET PLANT
EVHM Trolley Line	
Number of Runs	2
Track Length/Gauge	89'/2' Centers
Load (tons)	16 on Rails
Classification	
Weight (lbs)	4,000 Total
Spent Fuel Rails	
Track Length (ft.)	50
Grapple Guide (ft.)	28
Load (tons)	37 on Rails
Classification	
Weight (lbs.)	2,500 Total
EVHM	
Number	2
Dimensions	2'x8'x5'
Stroke (ft.)	50 (Maximum)
Motors (number)	4
Drives (number)	6
Classification	
Weight (tons)	16 Total
Spent Fuel Cask Cart	
Dimensions	12'-0"x12'-0"x22'-0" High
Motors (number)	4
Drives (number)	1 Cart, 1 Welder Head, 1 Welding Power Supply
Classification	
Weight (lbs.)	24,000 (less cask)
Fuel Transfer Tracks (R.V.-EVST)	
Number of runs	2
Track Length/gauge	168'/2' Centers
Weight (lbs.)	8,000 Total

TABLE 4.1 (Continued)

DESCRIPTION	LMFBR TARGET PLANT
Fuel Transfer Buckets	
Number	2
Dimensions	15'x10"x20"x0.25" thick
Weight (lbs.)	2,000 Total
FHC Handling Machine	
Dimensions	5'x8'x5' High
Stroke	30'
Motors	2
Drives	3
Weight (tons)	16

TABLE 4.1 (Continued)

220A.25 REFUELING SYSTEMS - IN-VESSEL HANDLING MECHANISMS

DESCRIPTION	LMFBR TARGET PLANT
IVHM	
Dimensions	12' Diameter x 32' long (lower) 6'-6" Square x 26' long (upper)
Lift (ft.)	27 for Removal
Stroke (in.)	170
Drives (number)	4
Weight (lb.)	17,500

TABLE 4.1 (Continued)

220A.25 REFUELING SYSTEM - FUEL HANDLING CELLS

DESCRIPTION	LMFBR TARGET PLANT
New Fuel Conveyor and Tubes	
Track Length (ft.)	85 (Approximately)
Load	8 Assemblies @ 400 lb. each
	11" long
Weight (lb.)	7,000
Environmental Change	
Cell Equipment	
Hoist	1/2 Ton, 20' Lift
Shuttle	1/2 Ton Capacity; 10' Travel Manual Drive
Fuel Guide	Fixed Lead in for Floor Valve
Weight (lbs.)	1,500

TABLE 4.1 (Continued)

220A.25 REFUELING SYSTEMS - PIPING AND VALVES

DESCRIPTION	LMFBR TARGET PLANT
Floor Valves	
Number	4
Dimensions	3.5' Diameter x 12" High + Actuator
Classification	
Weight (lbs.)	5,200

TABLE 4.1 (Continued)

220A.25 REFUELING SYSTEMS - MISCELLANEOUS EQUIPMENT

DESCRIPTION	LMFBR TARGET PLANT
Tanks	
Quantity	2
Type	EVST NaK Exp. Tanks
Fluid	NaK
Design Pressure	65 Psia
Design Temperature	200°F
Size	5' x 2.5' ϕ
Volume	150 gallons
Material	Carbon Steel
Weight	
Pumps	
Quantity	2
Type	EM
Fluid	Radioactive Na
Flow	981 GPM
Head	100 ft.
Design Pressure	100 Psia
Design Temperature	550°F
Material	304SS
Weight	
Rating	46 HP
Quantity	2
Type	EM
Fluid	NaK
Flow	1141 GPM
Head	100 ft.
Design Pressure	100 Psia
Design Temperature	470°F
Material	304SS
Weight	
Rating	75 HP
Quantity	2
Type	ABHX Compressor
Fluid	Air
Flow	3.22 x 10^4 CFM
Coolant	
Rating	

TABLE 4.1 (Continued)

220A.25 FUEL HANDLING AND STORAGE

DESCRIPTION	LMFBR TARGET PLANT
Heat Exchangers	
Quantity	2
Type	EVST Heat Exchanger Shell/Tube
Fluid	NaK/Na
Flow	1141/701 GPM
Design Pressure	200/200 Psia
Design Temperature	485/535°F
Thermal Rating	11.9 x 10^6 BTU/HR
Material	304 SS
Weight	
Heat Transfer Area	305 Ft.^{2}
Quantity	2
Type	EVST Air Blast Heat Exchanger Shell/Tube
Fluid	Air/NaK
Flow	4.12 x 10^4 CFM/981 GPM
Design Pressure	15/200 Psia
Design Temperature	450/550°F
Thermal Rating	11.9 x 10^6 BTU/HR
Material	304 SS
Weight	
Heat Transfer Area	946 Ft.^{2}
Quantity	2
Type	EVST Cold Trap, Regenerative Shell/Tube
Fluid	Radioactive Na
Flow	100/100 GPM
Design Pressure	200/200 Psia
Design Temperature	535/485°F
Thermal Rating	1.87 x 10^6 BTU/HR
Material	304 SS
Weight	
Heat Transfer Area	32 Ft.^{2}
Purification	
Quantity	2
Type	EVST Cold Traps
Fluid	Radioactive Coolant
Flow	100 GPM
Design Pressure	100 Psia
Design Temperature	400°F
Mesh	
Material	304 SS
Weight	

TABLE 4.1 (Continued)

DESCRIPTION	LMFBR TARGET PLANT
Quantity	2
Type	NaK Diffusion Traps
Fluid	NaK
Flow	
Design Pressure	25 Psia
Design Temperature	250°F
Mesh	
Material	Carbon Steel
Weight	

TABLE 4.1 (Continued)

220A.2611 INERT GAS RECEIVING AND PROCESSING

DESCRIPTION	LMFBR TARGET PLANT
Compressors	
Quantity	3
Type	RAPS Compressors
Design Pressure	9 Inlet/135 Discharge Psia
Design Temperature	120°F
Flow	25 CFM
Material	304SS
Rating	
Quantity	2
Type	CAPS Compressors
Design Pressure	9 Inlet/135 Discharge Psia
Design Temperature	120°F
Flow	50 CFM
Material	304SS
Rating	

TABLE 4.1 (Continued)

220A.2612 GAS SUPPLY STORAGE SYSTEMS (TANKS)

DESCRIPTION	LMFBR TARGET PLANT	
	LIQUID	GASEOUS
Nitrogen Storage Tanks		
Quantity	3	3
Design Pressure/Temperature, Psia/^{o}F	125/-290	250/-290
Height/Diameter	20'/7'	15'/10'
Volume	6000 Gal.	6000 Gal.
Material	304SS	
Weight	24,000 lbs.	12,000 lbs.
Argon Storage Tank		
Quantity	9	
Design Pressure/Temperature	250/120 Psia/^{o}F	
Height/Diameter	7' x 6'	
Volume	1500 Gal.	
Material	304SS	
Weight	4000 lbs.	
Inert Gas Vacuum Tank		
Quantity	2	
Design Pressure/Temperature	150/120 Psia/^{o}F	
Height/Diameter	14' by 7'ϕ	
Volume	538 ft.^{3}	
Material	304SS	
Weight	10,000 lbs.	
Inert Gas Delay Tank		
Quantity	2	
Design Pressure/Temperature	150/120 Psia/^{o}F	
Height/Diameter	25'/7'ϕ	
Volume	960 Ft.^{3}	
Material	304SS	
Weight	20,000 lbs.	
Noble Gas Storage Tank		
Quantity	1	
Design Pressure/Temperature	150/120 Psia/^{o}F	
Height/Diameter	15'/5'	
Volume	300 Ft.^{3}	
Material	304SS	
Weight	2,200 lbs.	

TABLE 4.1(Continued)

DESCRIPTION	LMFBR TARGET PLANT
Recycle Argon Tank	
Quantity	1
Design Pressure/Temperature	150/120 Psia/°F
Height/Diameter	10' x 10'
Volume	750 $Ft.^3$
Material	304SS
Weight	8000 lbs.

TABLE 4.1 (Continued)

220A.2613 INERT GAS PURIFICATION SYSTEMS (UNITS)

DESCRIPTION	LMFBR TARGET PLANT
Nitrogen Vaporizer	
Quantity	10
Size	
Flow	5,000 SCFM
Material	304SS
Argon Vaporizer	
Quantity	9
Size	
Flow	5,000 SCFM
Material	304SS
Nitrogen Filter	
Quantity	2
Mesh	HEPA
Flow	500 SCFM
Material	304SS
Weight	500 lbs.
Argon Filter	
Quantity	2
Mesh	HEPA
Flow	250 SCFM
Material	304SS
Weight	500 lbs.
Vapor Traps	
Quantity	25
Capacity	5 SCFM
Material	304SS
Purification Unit	
Quantity	1

TABLE 4.1(Continued)

DESCRIPTION	LMFBR TARGET PLANT
Nitrogen/Argon Charcoal Beds	
Quantity	5
Design Pressure/Temperature	150/-340 Psia/°F
Diameter	14'
Height	28'
Volume	508 Ft.^{3}
Material	PCB Charcoal
Weight	10,000 lbs.
Distillation Unit	
Quantity	1
Design Pressure/Temperature	150/-320 Psia/°F
Diameter	----
Height	----
Flow	25 SCFM
Material	304SS
Weight	----
Heat Exchangers	
RAPS Regenerative Heat Exchanger	
Quantity	2
Design	Tube/Shell
Design Pressure	150 Psia
Design Temperature	120°F
Flow	25 SCFM
Thermal Rating	40,000 BTU/HR
Weight	
Heat Transfer Area	
Material	304SS
RAPS Argon Coolers	
Quantity	2
Design Pressure	150 Psia
Design Temperature	120°F
Flow	25 SCFM
Thermal Rating	40,000 BTU/HR
Weight	
Heat Transfer Area	
Material	304SS
CAPS Nitrogen Cooler	
Quantity	8
Design Pressure	150 Psia
Design Temperature	120°F
Flow	150 SCFM

TABLE 4.1 (Continued)

DESCRIPTION	LMFBR TARGET PLANT
Thermal Rating	10,000 BTU/HR
Weight	
Heat Transfer Area	
Material	304SS

TABLE 4.1 (Continued)

220A.2615 PIPING, VALVES, AND FITTINGS

DESCRIPTION	LMFBR TARGET PLANT
Valves	
Type	Plug
Size	2" and Smaller
Quantity	146
Material	304SS
Piping	
Diameter	2" and Smaller
Length	1700' CAPS
Material	Carbon Steel 2100' - PHTS Argon 304SS 1500' - IHTS Argon Carbon Steel
Freeze Vent	
Quantity	37
Size	3"ϕ x 30"
Material	304SS
Weight	450 lbs.
Type	Oil Trap
Quantity	8
Size	27 Ft.^{3}
Material	304SS
Weight	1000 lbs.

TABLE 4.1 (Continued)

220A.264 LIQUID METAL RECEIVING, STORAGE AND MAKEUP

DESCRIPTION	LMFBR TARGET PLANT
Tanks	
Quantity	8
Primary Na Storage	
Fluid	Primary Coolant
Design Pressure	15 Psia
Design Temperature	400°F
Size	25' x 20' x 3/4"
Volume	58,752 Gallon
Material	304SS
Weight	80,000 lbs.
Intermediate Na Storage Tanks	
Quantity	8
Fluid	Secondary Sodium
Design Pressure	175 Psia
Design Temperature	400°F
Size	25' x 20' x 3/4"
Volume	58,752 Gallon
Material	304SS
Weight	80,000 lbs.
NaK Storage Tanks	3
Fluid	NaK
Design Pressure	65 Psia
Design Temperature	400°F
Size	7'ϕ x 14'
Volume	3600 Gallons
Material	304SS
Weight	

TABLE 4.1 (Continued)

DESCRIPTION	LMFBR TARGET PLANT
Filters	
Quantity	2
Type	Sodium Particulate
Fluid	Sodium
Flow	180 GPM
Design Pressure	25 Psia
Design Temperature	350°F
Mesh	20 Micron
Material	304SS
Weight	
Quantity	1
Type	NaK Particulate
Fluid	NaK
Flow	180 GPM
Design Pressure	25 Psia
Design Temperature	70°F
Mesh	20 Micron
Material	304SS
Weight	
Valves	
Quantity/Type	9/2" Plug, NNS 48/2" Plug, SC3 16/3" Plug, NNS
Tanks (Oil Bubbler)	
Quantity	6
Design Pressure	20 Psia
Design Temperature	100°F
Size	3' x 3'ϕ
Volume	202 Gallons
Material	Carbon Steel
Weight	1000 lbs.
Piping	
Quantity/Size	1400'/3" SC3 1700'/3" NNS 150'/3" SC3

TABLE 4.1 (Continued)

220A.265 SODIUM PURIFICATION SYSTEM

DESCRIPTION	LMFBR TARGET PLANT
Pumps	
Overflow Pump	
Quantity	2
Type	EM
Fluid	Primary Sodium
Flow	350 GPM
Head	105 Ft.
Design Pressure	100 Psia
Design Temperature	970°F
Material	304SS
Weight	
Rating	30 HP
Primary Cold Trap Cooling Pumps	
Quantity	2
Fluid	NaK
Flow	160 GPM
Head	235 Ft.
Design Pressure	100 Psia
Design Temperature	600°F
Material	304SS
Weight	
Rating	30 HP
IHTS Cold Trap Pump	
Quantity	4
Fluid	Intermediate Sodium
Flow	70 GPM
Head	200 Ft.
Design Pressure	200 Psia
Design Temperature	640°F
Material	304SS
Weight	
Rating	10 HP

TABLE 4.1 (Continued)

DESCRIPTION	LMFBR TARGET PLANT
IHTS Cold Trap Cooling Pumps	
Quantity	2
Fluid	NaK
Flow	100 GPM
Head	200 Ft.
Design Pressure	200 Psia
Design Temperature	600°F
Material	304SS
Rating	15 HP
Heat Exchangers	
Quantity	2
Type	Primary Cold Trap Regenerative Shell/Tube
Fluid	Primary Na/Primary Na
Flow	100/100 GPM
Design Pressure	100 Psia
Design Temperature	970°F
Thermal Rating	$8.59 * 10^6$ BTU/HR
Material	304SS
Weight	
Heat Transfer Area	150 Ft.^{2}
Quantity	4
Type	Intermediate Sodium, Regenerative Shell/Tube
Fluid	Intermediate Na/Intermediate Na
Flow	100/100 GPM
Design Pressure	100 Psia
Design Temperature	640°F
Thermal Rating	$8.59 * 10^6$ BTU/HR
Material	304SS
Weight	
Heat Transfer Area	150 Ft.^{2}
Tanks	
Quantity	1
Primary Overflow	
Fluid	Primary Coolant
Design Pressure	5 Psia
Design Temperature	950°F
Size	25' x 20'ϕ
Volume	58,752 gallons
Material	304SS
Weight	

TABLE 4.1 (Continued)

DESCRIPTION	LMFBR TARGET PLANT
HTS NaK Expansion Tanks	
Quantity	4
Design Pressure/Temperature	65 Psia/400°F
Fluid	NaK
Size	2'ϕ x 3'
Volume	70 Gallons
Filters	
Quantity	3
Type	Primary Cold Traps
Fluid	Primary Coolant
Flow	100 GPM
Design Pressure	100 Psia
Design Temperature	400°F
Mesh	
Material	304SS
Weight	
Quantity	4
Intermediate Sodium Cold Trap	
Fluid	Intermediate Sodium
Flow	70 GPM
Design Pressure	200 Psia
Design Temperature	400°F
Mesh	
Material	304SS
Weight	
Quantity	5
NaK Diffusion Cold Trap	
Fluid	NaK
Flow	
Design Pressure	25 Psia
Design Temperature	250°F
Mesh	
Material	Carbon Steel
Weight	
Valves	
Quantity/Type	6/2" Globe, SC2 8/3" Globe, NNS
Piping	200'/3"ϕ - 304SS 400'/2"ϕ - 304SS

TABLE 4.1 (Continued)

220.27 INSTRUMENTATION AND CONTROL SYSTEM EQUIPMENT

DESCRIPTION	QUANTITY
Data Processing System	
Plant Monitoring Computer	1
Plant Protection System (PPS)	
Sensors	
BF_3 Counters	4
BF_3 Counter Preamps	4
Startup Channel Safety Channel Drawers	4
Fission Chambers (3 Section)	4
Fission Chamber Preamps	4
Wide Range Safety Channel Drawers	4
Isolation Amplifiers	4
PHTS EM Flowmeters - 36"	4
IHTS EM Flowmeters - 36"	4
IHTS Venturi Diff. Pressure Transmitters	4
PHTS Pressure Transmitters	32
PHTS Temperature Transmitters (RTD)	32
PHTS Level Transmitters	16
I/I Converters (Isolation)	320
Power Supplies	92
Indicators	92
Safety Process Protective Cabinets	4
Core Monitoring Computers	2
Plant Protection System Cabinets	4
Reactor Trip Switchgear System	2
Remote Display & Control Modules	4
Annunciators	48
Supplementary Reactor Protection System	
Sensors	
Temperature Transmitters (RTD)	48
Level Transmitters	16
SRPS Cabinets	4
SRPS Reactor Trip Switchgear Cabinets	4
Remote Display Modules	4
Annunciators	24
Containment Isolation System	
Sensors	
Gamma Monitors	8
Gas Monitors	8
Particulate Monitors	8
Cell Atmosphere Monitors	8
Cover Gas Monitors	8
ESF Logic Cabinets	4
Remote Display and Control Modules	4

TABLE 4.1 (Continued)

DESCRIPTION	QUANTITY
In-Vessel Flux Monitoring System	
Fission Chambers	3
Pre-Amplifiers	3
Subcriticality Monitors	3
Ex-Vessel Flux Monitoring System	
Bio Ion Chambers	2
Linear Control Channel Drawers	2
Vessel and Internals Monitoring	
Temperature Elements (In-Core TC)	1624
Level Transmitters	4
CEA Pos. Transmitters	60
In-Vessel Accelerometers	4
Temperature Indicators	24
Equipment Operating Surveillance	
Acoustic Transducers	40
Signal Conditioners	40
Pressure Transducers	40
Temp. Elements (TC)	112
Accelerometers	24
Speed Sensors	8
Torque Transmitters	8
Mass Spectrometers	2
Gamma Spectrometers	1
BF-3 Counters	8
Delayed Neutron Monitor	1
Data Handling System	1
LD Contact Detectors	24
LD Cable Detectors	12
Aerosol Monitors	4
Level Transmitters	8
Hydrogen Detectors	4
Hydrogen & Gas Chromatograph	1
Oxygen Detectors	4
Disc-Rupture Sensors	48
Pressure Elements (Disc)	12
Radiation Monitoring Equipment	
Plutonium Monitors	4
Radio Iodine Monitors	4
Tritium Monitors	4
Liquid Monitor	1
Gamma Area Monitors	20
Particulate Monitors (3 ch)	6
Health Physics Monitoring Package	1

TABLE 4.1 (Continued)

DESCRIPTION	QUANTITY
Control Systems	
Recorder Indicator Controllers	27
Controllers	13
Pressure Transmitters	5
Temperature Transmitters (RTD)	4
Process Instrumentation/PHTS and IHTS	
Temperature Elements (TC)	80
Pressure Transmitters	36
Level Transmitters	24
Process Instrumentation/SG Systems	
Temperature Transmitters (RTD)	8
Pressure Transmitters	32
Level Transmitters	64
Flow Transmitters	4
Temp. Rec. Controllers	8
Flow Rec. Controllers	24
Flow Meters	24
Level Rec. Controllers	16
Level Indicators	64
Pressure Indicators	32
Hand Ind. Controllers	72
Hand Switches	80
Annunciators	576
Control Switches	400
Temp. Indicators	8
Process Instrumentation/Intermediate Sodium Purification System	
Temperature Elements	41
Level Transmitter	4
Flow Transmitters	4
Temp. Indicators	21
Press. Indicators	15
Flow Indicators	10
Temp. Indicator Controllers	8
Level Indicators	4

TABLE 4.1 (Continued)

DESCRIPTION	QUANTITY
Process Instrumentation/Intermediate Sodium Purification System	
Temperature Elements	41
Level Transmitter	4
Flow Transmitters	4
Temp. Indicators	21
Press. Indicators	15
Flow Indicators	10
Temp. Indicator Controllers	8
Level Indicators	4
Process Instrumentation/Primary Sodium Purification System	
Pressure Indicators	12
Temp. Indicators	16
Pressure Transmitters	16
Flow Indicators	6
Level Indicators	4
Level Transmitters	6
Temp. Indicator Controllers	8
Flow Transmitters	12
Temp. Transmitters	44
Process Instrumentation/Sodium & NaK Receiving System	
Temp. Indicators	2
Pressure Indicators	3
Temp. Sensors (TC)	4
Pressure Transmitter	1
Process Instrumentation/Primary Sodium Storage and Processing	
Level Indicators	5
Level Transmitter	5
Temp. Elements	37
Temp. Transmitters	6
Flow Indicators	2
Flow Transmitters	2
Temp. Indicator Controllers	2
Process Instrumentation/Ex-Vessel Storage	
Temp. Indicators	4
Temp. Transmitters	8
Temp. Sensors	44
Level Indicators	5
Level Transmitters	5
Flow Indicators	2
Flow Transmitters	2
Temp. Indicator Controllers	2

TABLE 4.1 (Continued)

DESCRIPTION	QUANTITY
Process Instrumentation/Primary Sodium Cold Trap	
Temp. Elements (TC)	12
Temp. Transmitters	6
Temp. Indicators	4
Flow Transmitters	2
Temp. Indicator Controllers	2
Flow Indicator	1
Level Indicator	1
Level Transmitters	1
Process Instrumentation/Intermediate Sodium Processing System	
Temp. Indicators	4
Temp. Elements	80
Temp. Trans. (RTD)	36
Pressure Transmitters	8
Level Indicators	4
Level Transmitters	4
Flow Transmitters	8
Pressure Indicators	4
Pressure Transmitters	4
Component Control System	
Solid State Component Cabinet	1
Control Element Drive Mechanism Control System	
CEDMCS Cabinet	1
Piping and Equipment Electrical Heating System	
Heaters	50,000 ft.
Thermocouples	2,000
Temperature Controllers	750
Panels	250
Heat-Up Control Computer	1

TABLE 4.1 (Continued)

DESCRIPTION	QUANTITY
Remote Shutdown System	
Remote Hot Shutdown Panels	12
Handswitches	100
Temperature Indicators	16
Pressure Indicators	4
Level Indicators	6
Control Transfer Switch	1
PPS Status Panel	1
Temperature Recorders	4
Annunciators	40
Control Panels	
Control Panels	60

SECTION V

DRAWINGS

This section contains the drawings for the 1390 MWe Target Plant described in Section II. These drawings are the General Arrangement Drawings for the Target Plant.

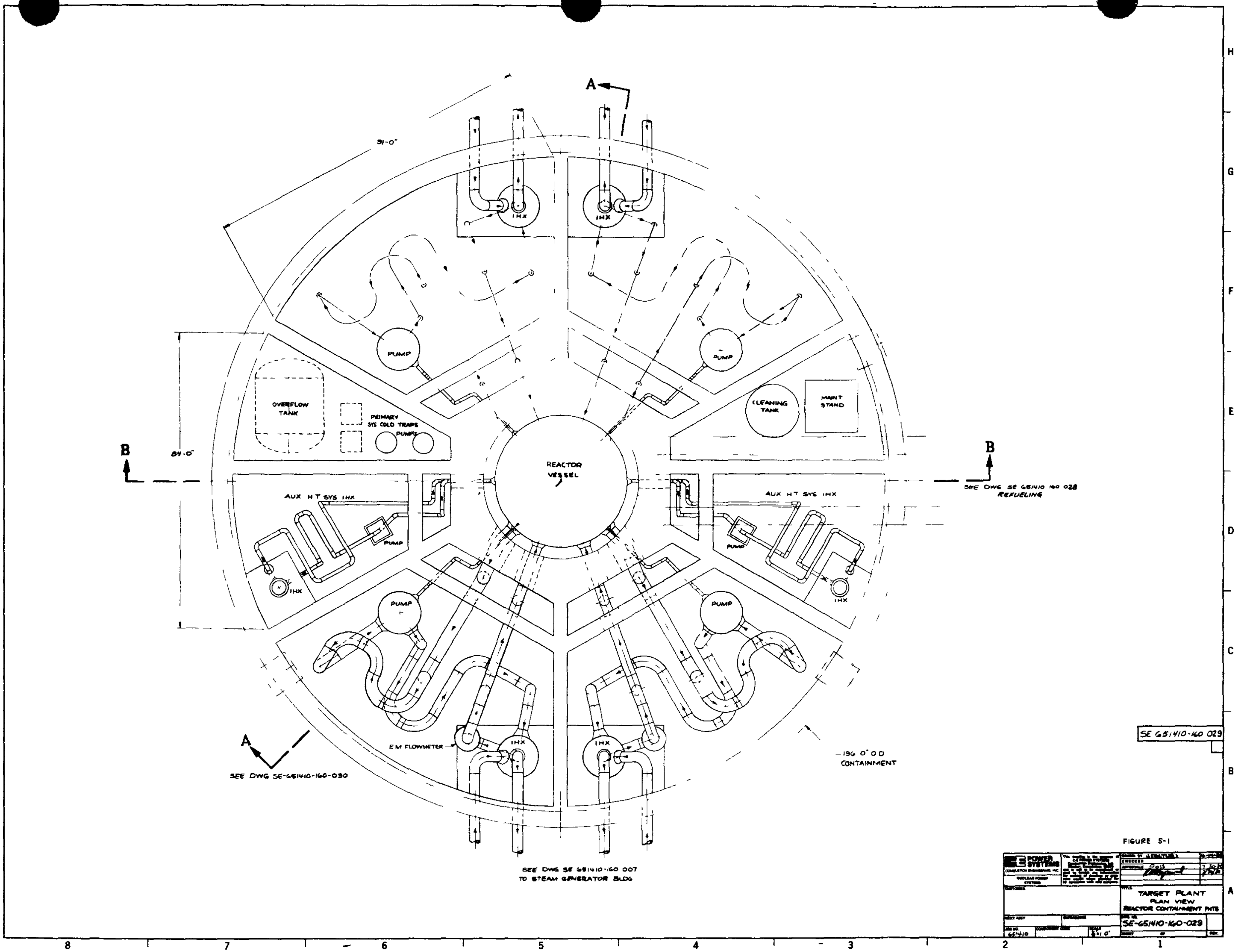
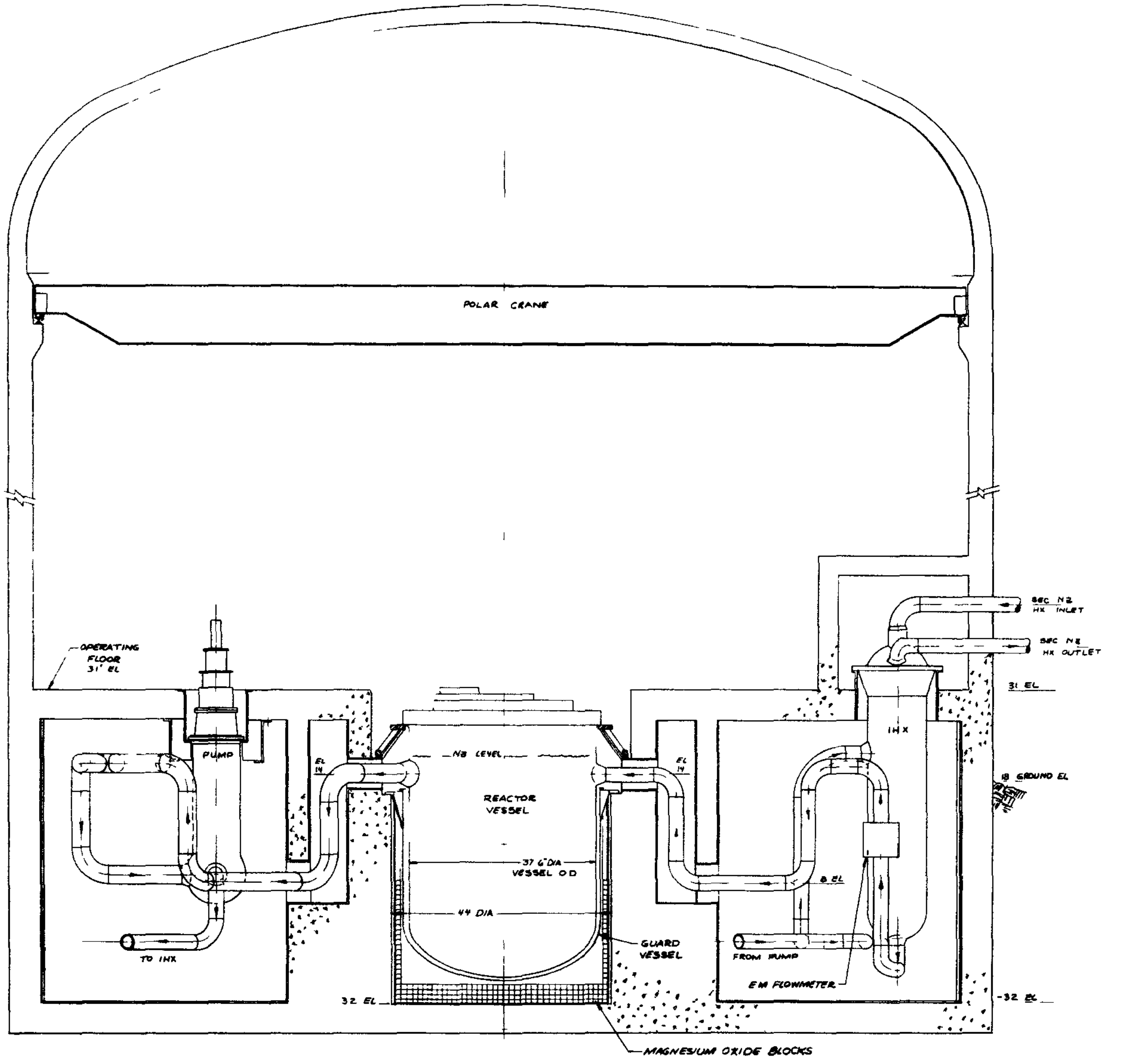

A
A
B
B
91-0"
84-0"
IHX
IHX
PUMP
PUMP
OVERFLOW TANK
PRIMARY SYS COLD TRAPS
PUMPS
CLEANING TANK
MAINT STAND
REACTOR VESSEL
AUX H T SYS IHX
AUX H T SYS IHX
PUMP
PUMP
IHX
IHX
SEE DWG SE 651410 160 028 REFUELING
PUMP
PUMP
EM FLOWMETER
IHX
IHX
SEE DWG SE-651410-160-030
-196' 0" O D CONTAINMENT
SE 651410-160 029
SEE DWG SE 651410-160 007 TO STEAM GENERATOR BLDG
H
G
F
E
D
C
B
A
8
7
6
5
4
3
2
1
POWER SYSTEMS
COMBUSTION ENGINEERING, INC
NUCLEAR POWER SYSTEMS
DRAWN BY
CHECKER
APPROVALS
CUSTOMER
TITLE
TARGET PLANT
PLAN VIEW
REACTOR CONTAINMENT PITS
NEXT ASSY
DWG NO.
SE-651410-160-029
JOB NO.
651410
SCALE
1/8"=1' 0"
SHEET
OF
REV.

FIGURE 5-1



SECTION A A
(SEE DWG SE 651411-160-029)

SE-651411-160-030

FIGURE 5 2

POWER SYSTEMS
COMBUSTION ENGINEERING, INC
NUCLEAR POWER SYSTEMS

TITLE
REACTOR CONTAINMENT
& PHTS-ELEVATION

DWG NO
SE-651411 160-030

SCALE
1/8"=1'-0"

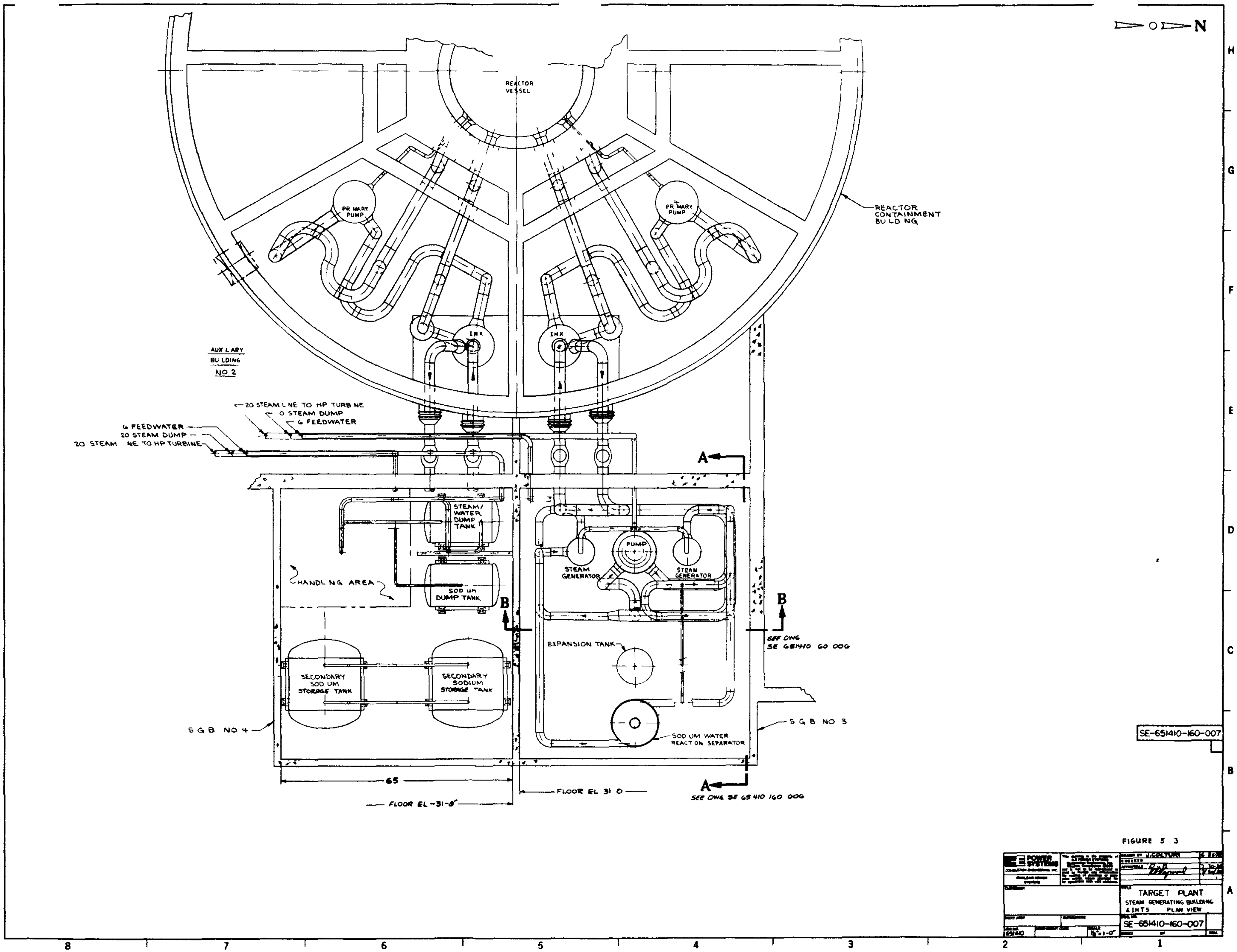

N
REACTOR VESSEL
PR MARY PUMP
PR MARY PUMP
REACTOR CONTAINMENT BU LD NG
IHX
IHX
AUX L ARY BU LDING NO 2
20 STEAM L NE TO HP TURB NE
0 STEAM DUMP
6 FEEDWATER
6 FEEDWATER
20 STEAM DUMP
20 STEAM NE TO HP TURBINE
A
A
B
B
STEAM/ WATER DUMP TANK
SOD UM DUMP TANK
HANDL NG AREA
PUMP
STEAM GENERATOR
STEAM GENERATOR
SEE DWG SE 651410 60 006
EXPANSION TANK
SECONDARY SOD UM STORAGE TANK
SECONDARY SODIUM STORAGE TANK
S G B NO 4
S G B NO 3
SOD UM WATER REACT ON SEPARATOR
65
FLOOR EL 31 0
FLOOR EL -31-6"
SEE DWG SE 65 410 160 006
SE-651410-160-007
H
G
F
E
D
C
B
A
8
7
6
5
4
3
2
1
POWER SYSTEMS
COMBUSTION ENGINEERING INC.
J. COLTUM
TARGET PLANT
STEAM GENERATING BUILDING & IHTS PLAN VIEW
SE-651410-160-007
651410
3/8"=1-0"

FIGURE 5 3

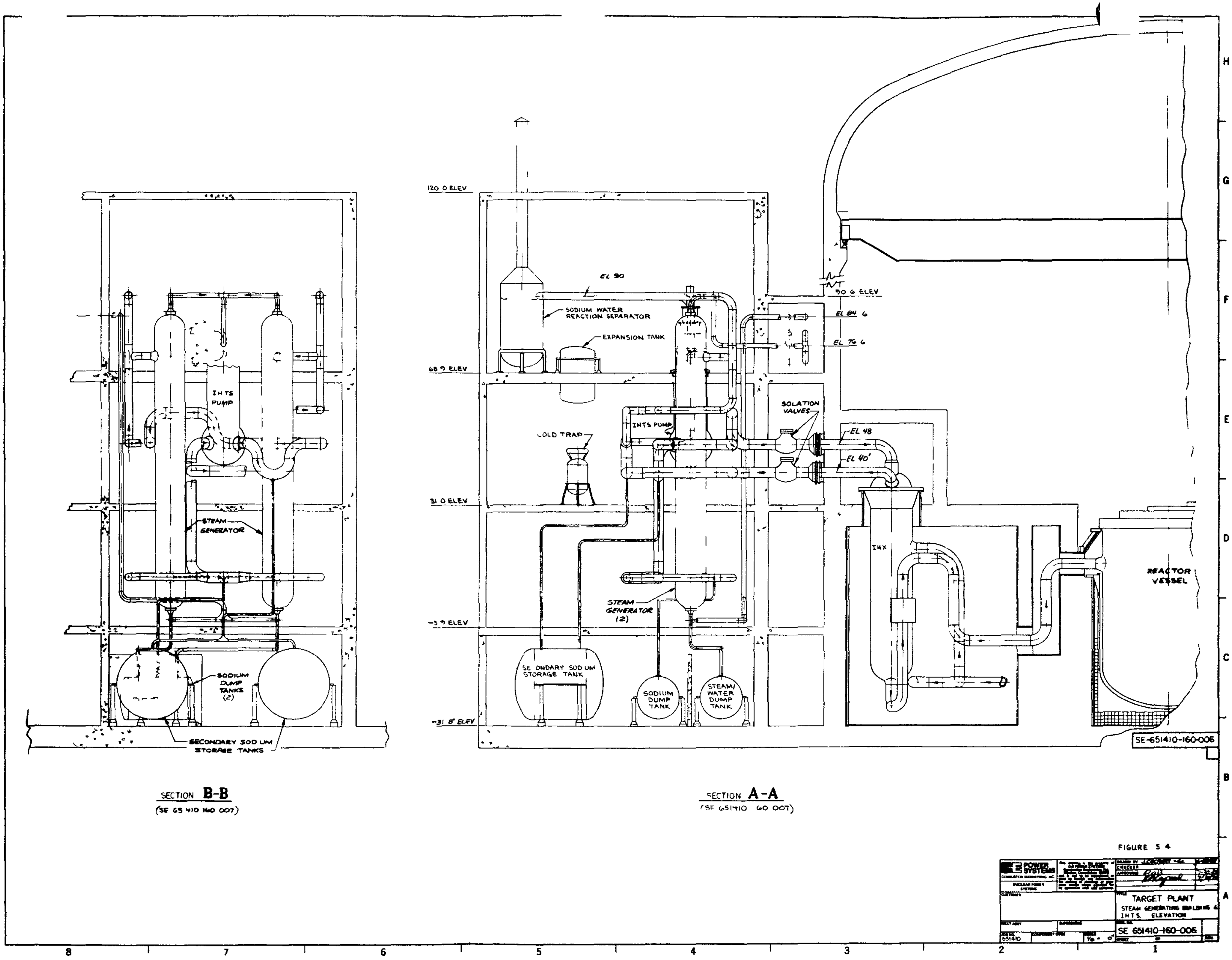

INTS PUMP
STEAM GENERATOR
SODIUM DUMP TANKS (2)
SECONDARY SOD UM STORAGE TANKS
SECTION B-B
(SE 65 410 160 007)
120 0 ELEV
EL 90
SODIUM WATER REACTION SEPARATOR
EXPANSION TANK
68 9 ELEV
COLD TRAP
INTS PUMP
31 0 ELEV
STEAM GENERATOR (2)
-3 9 ELEV
SE ONDARY SOD UM STORAGE TANK
SODIUM DUMP TANK
STEAM/WATER DUMP TANK
-31 8' ELEV
90 6 ELEV
EL 84 6
EL 76 6
SOLATION VALVES
EL 48
EL 40'
IHX
REACTOR VESSEL
SE-651410-160-006
SECTION A-A
(SF 651410 60 007)
H
G
F
E
D
C
B
A
8
7
6
5
4
3
2
1
POWER SYSTEMS
COMBUSTION ENGINEERING, INC
NUCLEAR POWER SYSTEMS
CUSTOMER
DRAWN BY
CHECKER
APPROVED
TITLE
TARGET PLANT
STEAM GENERATING BUILDING & IHTS. ELEVATION
SE 651410-160-006
651410
1/8" - 0"

FIGURE 5 4

REFERENCES

(1) "NSSS Capital Costs for a Mature LMFBR Industry", C-E-FBR-78-532, S. U. Zaman, 10-23-78.

(2) UE&C/GEI-EEDB-10, "Addendum to P.O. No. H.O. 53461", April 12, 1979.

(3) "LMFBR Pool Plant - 1000 MWe NSSS Plant Description", EPRI NP-1015 Volume 2, February 1979.

APPENDIX - F

PHASE III FINAL REPORT AND THIRD UPDATE OF THE ENERGY ECONOMIC DATA BASE (EEDB) PROGRAM

APPENDIX F

EEDB NUCLEAR FUEL CYCLE UPDATE PROCEDURE (APPROXIMATION FACTORS METHOD)

F.1 INTRODUCTION

F.1.1 Background

The Advanced Engineering Department of United Engineers & Constructors Inc. plans to continue to update the EEDB on a yearly basis through FY-1981 as a minimum, and on a semi-annual basis when necessary, under their contract with the U.S. Department of Energy (USDOE).

Fuel cost estimates are projected over the life of the power plant which, for nuclear power generating stations, is a period of thirty years from the commercial operation startup date. Since the commercial operation date for a nuclear plant is approximately twelve years from the start of the project, and since selection alternatives are evaluated several years before a power plant project is begun, fuel cost projections involve a period of almost half a century. The year-to-year variation in fuel costs may or may not affect long term projections, depending on the nature and character of the driving force which has caused the market change. Consequently, the need to update nuclear fuel cost projections on a periodic basis may be less compelling than for capital costs. Long term trends associated with the continuation of current market direction are often reported, rather than a prediction relative to the actual long term behavior.

F.1.2 EEDB Nuclear Fuel Cycle Cost Calculation Approach

Calculation of Nuclear Fuel Cycle Costs, for the EEDB consists of the following activities:

1. Projection of general economic parameters over the period of interest, including long term escalation, interest and discount rates.

2. Affirmation that the Approximation Factors Method* for determining nuclear fuel cycle costs is appropriate for the level of accuracy required and the availability of the input data.
3. Selection of the desired combination of reactor type and fuel cycle alternatives.
4. Acquisition of Mass flow data for the selected combinations of reactor type and fuel cycle alternatives.
5. Acquisition of input unit cost data projections for each step of each nuclear fuel cycle under consideration over the time period of interest.
6. Calculation of the direct and indirect cost components for each step in the reactor-cycle combination being analyzed for the period of interest.
7. Calculation of the levelized total nuclear fuel cycle cost for each cycle case being analyzed over the period of interest.

F.1.3 EEDB Nuclear Fuel Cycle Cost Task Organizational Structure

The first three activities in this calculation approach are carried out by the EEDB Program Manager, in consultation with various members of the EEDB project team and with the U.S. Department of Energy.

The calculation of the nuclear fuel cycle costs for the EEDB is completed in the remaining five activities by a cooperative effort of various EEDB project team members, under the overall supervision of the EEDB Program Manager.

A Senior Consulting Engineer is assigned by the EEDB Program Manager to act as task leader for and provide direct supervision of the nuclear fuel cycle cost effort. In the course of its completion, he utilizes and coordinates the skills of the EEDB Program's Engineering Economist, Consulting Engineers and Research Engineers.

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* The Approximation Factors Method is a means for approximating the direct and indirect cost components of the nuclear fuel cycle to the level of accuracy required for the EEDB Program. A description of the method and the reasons for its selection are given in Section 6.0 of the Second Update of the EEDB.

F.2 DEFINITION OF UPDATE SCOPE

The EEDB Program Manager, in conjunction with the U.S. Department of Energy, determines that the Approximation Factors Method of nuclear fuel cycle cost calculation is consistent with the objectives of the analysis and the combinations of reactor types and fuel cycles of interest for a given update. In addition, the EEDB Program Manager, with the EEDB Engineering Economist, determines the values for the escalation, interest and discount rates to be used over the time period of interest in the analysis.

This definition of the EEDB Program fuel cycle cost update scope is provided as input to the Nuclear Fuel Cycle Cost Task Leader.

F.3 ACQUISITION OF INPUT DATA

After receiving the scope of the fuel cycle cost update effort, the Nuclear Fuel Cycle Cost Task Leader's first activity is the assembly of appropriate input data. This data consists of two types, namely:

- Reactor/Cycle mass flow data
- Input unit cost projections for the materials and services associated with various fuel cycle steps.

F.3.1 Sources Of Input Data

F.3.1.1 Reactor/Cycle Mass Flow Data

The reactor/cycle mass flow data may already be included in the EEDB backup material, prepared for the Initial Update of the EEDB. The Nuclear Fuel Cycle Cost Task Leader will verify its adequacy, considering the current status of the reactor type/fuel cycle combination. If the data is inadequate, or not available in the existing backup material, he will acquire the data either from the literature, such as the NASAP study, or from United Engineers' contacts in the nuclear fuel industry.

F.3.1.2 Input Unit Costs

The input unit costs are acquired from a search of current literature. This search, however, is coupled with a selection process based on a review of the material found. The review examines the input data, methodology, and general approach utilized in developing the final input unit costs. The selection process is supervised by the Nuclear Fuel Cycle Cost Task Leader and reviewed by the EEDB Program Manager. Primary attention is focused on development of the input unit costs for the LWR cycles. If the search is unproductive for other reactor/cycle combinations, these unit costs are developed from the values for the LWR input unit costs.

F.3.2 Normalization Of Data

Information found in the literature frequently is based on values for technical or economic parameters which are different than those established as groundrules in the EEDB Program. This is particularly true of the input unit cost projections, because they may utilize different economic parameters such as escalation rate, interest rate and discount rate. Therefore, information selected from the literature is normalized as part of the EEDB fuel cycle cost calculations, so that it is consistent with the EEDB Program groundrules and assumptions.

F.3.3 EEDB Program Management Review

After the reactor cycle data and the input unit cost data are selected and normalized, the selection and normalization process is reviewed and approved by the EEDB Program Manager.

F.4 DIRECT AND INDIRECT COST COMPONENT PREPARATION

Before calculation of the direct cost component of the nuclear fuel cycle cost is undertaken, the basis of the approximation factors is reviewed for consistency with that of the various reactor/cycle combinations to be analyzed. If there is a discrepancy, or if approximation factors do not exist for the reactor/cycle combinations desired, than new approximation factors are developed.

Before the calculation of the indirect cost component is undertaken, the approximating expression for calculation of the indirect costs is reviewed to insure that it reflects the economic realities associated with the reactor/cycle combinations being analyzed. Another approximating expression is developed, if required.

Preparation of new approximation factors and approximating expressions is carried out by the Nuclear Fuel Cycle Cost Task Leader with the approval of the EEDB Program Manager.

F.5 CALCULATION OF TOTAL NUCLEAR FUEL CYCLE COST

The work sheets associated with the Approximate Factors Method of analysis are completed. The direct and indirect cost components are calculated using the prepared input data with the appropriate direct and indirect cost expressions. The subtotals of direct and indirect costs are completed for each component of each combination. These are summed to give a total Nuclear Fuel Cycle Cost for each reactor/cycle combination. In addition, subtotals for the total direct cost and total indirect cost are prepared. The calculations are numerically checked. The results of the calculation effort are summarized in a series of tables that are included in the EEDB update.

F.6 NUCLEAR FUEL CYCLE COST UPDATE DOCUMENTATION

F.6.1 Report Text

After the calculations are completed and the summary tables prepared, the total activity effort is documented by preparation of text for the EEDB update report. The text identifies the cases analyzed, the mass balance for each case, input unit cost data utilized, and the results. The input unit cost tables and summary results tables are included in the body of the update report. The text and tables are prepared by the Nuclear Fuel Cycle Cost Task Leader.

F.6.2 EEDB Program Management Review

The Nuclear Fuel Cycle Cost calculation results and the report text are reviewed and approved by the EEDB Program Manager.

F.6.3 Backup Data File

The nuclear fuel cycle cost calculations are organized and accumulated in note-books. These note-books, together with the case descriptions and mass balance data, are incorporated into the Backup Data File for that update.