Staff Investigation of Enrico Fermi 2 Nuclear Power Project

February 1984

Prepared for the
Michigan Public Service Commission
Lansing, Michigan

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Darrel
This is the report Jerry said we should get

Limit Fermi charge, state told

Report to PSC claims Edison mismanagement

By DAVID EVERETT
Free Press Staff Writer

The staff of the Michigan Public Service Commission recommended Friday that customers of Detroit Edison not be charged for nearly 12 percent of the cost of the utility's $3.07 billion Fermi II nuclear plant.

Citing mismanagement and unnecessary cost overruns, the staff is asking the commission to disallow more than $365 million of the cost of the plant near Monroe. It is about 98 percent complete.

Detroit Edison officials disputed the findings, saying that the Fermi project was properly managed and that costs were controlled better than at other nuclear plants nationwide.

THE PSC will hear both sides at upcoming hearings, with a decision on Edison's proposed $968 million-a-year rate increase expected later this year.

Edison's plan would raise the typical residential customer's bill by $13 a month. The PSC staff recommendation would limit the increase to $12 a month.

Friday's 521-page report is thought to be the PSC's most extensive staff study on utility construction costs. The report could set precedents for a similar study on the $4.43 billion Midland nuclear plant being built by Consumers Power Co.

The Fermi II project began in 1969 at a projected cost of $229 million.

THE LARGEST PART of the $365 million disallowance was $122 million for construction delays. The plant was supposed to be loaded with nuclear fuel in December, said Hasso Bhatia, project manager for the Fermi Study. Fuel loading now is scheduled for June.

Other proposed disallowances, each of which Edison challenges, involve staff charges of poor quality control or mismanagement on $58 million in piping work and mechanical installation, $48 million for engineering and design, $26 million for a radioactive waste system and $16 million for the plant's two huge water cooling towers. Part of the work had to be redone, Bhatia said, and the staff thought a single tower might have been more efficient.

A top Edison official pointed out that the report was only a staff document.

"That doesn't mean the commission will do what

Detroit Edison group vice-president Harry Tauber: "We believe that we have prudently managed this plant and done it effectively."

the staff is recommending," said Harry Tauber, group vice-president for Detroit Edison. "We believe that we have prudently managed this plant and done it effectively."

THE FERMI PLANT had several problems outside the control of the company during its construction, Tauber said. They included a long delay in getting a construction permit and increased regulation. Also, Detroit Edison had severe financial problems in 1974, and work on the Fermi plant was stopped for 2½ years, he said.

The staff report had high praise for the utility's engineering and environmental concern and complimented Edison's "excellent" communications between engineers and management. In the environmental area, the report said, Edison might even have gone too far.

STAFF INVESTIGATION OF ENRICO FERMI 2

NUCLEAR POWER PROJECT

Prepared for the

Michigan Public Service Commission

Lansing, Michigan

February 1984

FOREWORD

This report presents the findings of the Michigan Public Service Commission Staff Investigation into the management practices and prudency in the construction of the Enrico Fermi 2 Nuclear Project by the Detroit Edison Company. The investigation, conducted entirely by the Staff of the MPSC, is the first major effort of its kind by the Commission. Indeed, few similar efforts have been undertaken by the regulatory Commissions in the United States.

The investigation represents an alternate approach to an audit or a review typically performed by an outside consultant on the issue of prudent management at a major construction project. Further, as a departure from a typical study, it quantifies the effect of the imprudency on the project cost. Attempt has been made to present the report in non-technical, layman's terms. The investigation, however, involved many technical, engineering, financial, and management issues.

I wish to express sincere thanks to Ms. Heidi Rawson for typing of the original draft and for supervising the preparation of this final report. Her patience, hard work, and efficiency were a major factor in timely completion of this report.

Sincere thanks are also due to Adele Arnold, Susan DeLong and Pat Tooker for their valuable assistance in the preparation of this report.

Roger Fischer and John Abramson deserve special mention for many helpful suggestions and for providing the necessary resources for this investigation.

Hasso Bhatia, Ph.D.
Project Manager

ENRICO FERMI 2 STAFF REPORT

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ABBREVIATIONS AND ACRONYMS

ACRS	Advisory Committee on Reactor Safeguards
AFDC or AFUDC	Allowance for Funds Used During Construction
ANSI	American National Standards Institute
ANS	American Nuclear Society
ASTM	American Society for Testing Materials
ASME	American Society of Mechanical Engineers
ASA	American Standards Association
AE or A/E	Architect/Engineer
ALARA	As Low As Reasonably Achievable
AEC	Atomic Energy Commission
AIF	Atomic Industrial Forum
APDA	Atomic Power Development Associates, Inc.
ASLB	Atomic Safety & Licensing Board
ARMS	Automated Records Management System
BOP	Balance of Plant
BM or B/M	Bill of Material
BWR	Boiling Water Reactor
Btu	British Thermal Unit
CAIO or C&IO	Checkout and Initial Operation
CFR	Code of Federal Regulations
CAMEOS	Constructability, Availability, Maintainability, Economy, Operability, Safety
CM	Construction Manager (Daniel)
CRD	Control Rod Drive
CARS	Cost Analysis Reporting System
CPM	Critical Path Method

DIC	Daniel International
DCN	Design Change Notice
DCP	Design Change Package
DCR	Design Change Request
DI	Design Instruction
DTR	Design Team Report
DECo or DE	Detroit Edison Company
DDR	Deviation Disposition Request
DRYWL or DW	Drywell
EEI	Edison Electric Institute
EPRI	Electric Power Research Institute
ECCS	Emergency Core Cooling System
ERDA	Energy Research & Development Administration
ECN	Engineering Change Notice
ECO	Engineering Change Order
ECT	Engineering Construction Troy
EEL/GEC	English Electric, Ltd.
EF2	Enrico Fermi Unit 2
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FDI	Field Disposition Instruction (GE)
FDDR	Field Deviation Disposition Report (GE)
FEM	Field Engineering Memorandum
FMR	Field Modification Request
FSAR	Final Safety Analysis Report
FIVT	Flow Induced Vibration Testing

GC	General Contractor (Parsons)
GE	General Electric Co., Supplier of NSSS
GE (I&SE)	General Electric (Installation and Service Engineering)
HVAC	Heating, Ventilation and Air Conditioning
HPCI	High Pressure Core Injection (System)
hp	Horsepower, Unit of Power
IEEE	Institute of Electrical and Electronic Engineers
INPO	Institute of Nuclear Power Operations
I & C	Instrumentation and Controls
ILRT	Integrated Leak Rate Test
IAEA	International Atomic Energy Agency
kV	Kilovolt (10^3 volts), Unit of Electrical Potential
kWh	Kilowatt Hour, Unit of Electrical Energy
kW	Kilowatt (10^3 watts), Unit of Electrical Power
LCSR	Labor Cost Status Report
LLRT	Local Leak Rate Test
LOCA	Loss of Coolant Accident
MSIV	Main Steam Isolation Valve
MMS	Materials Management System
MW	Megawatt (10^6 watts)
MEPP	Michigan Electric Power Pool
MPSC	Michigan Public Service Commission
NUREG	NRC (Regulatory Guide)
NERC	National Electric Reliability Council

NEPA	National Environmental Protection Agency
NIPO	New Issues Program Office
NOC	Nuclear Operations Center
NRR	(Office of) Nuclear Reactor Regulation
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
NUS	NUS Corporation
P&ID	Piping and Instrumentation Diagram
PVDET	Piping Vibration and Dynamic Effects Test
PSAR	Preliminary Safety Analysis Report
PRET	Preoperational Test
PWR	Pressurized Water Reactor
PCIS	Primary Containment Isolation System
POJACS	Project Analysis and Control System (IBM Computer Program Used by Daniel Construction)
PMO	Project Management Organization
PM	Project Manager
PMNS	Project Master Network Schedule
PPM	Project Procedures Manual
PSA	Project Schedule Analysis
PSS	Project Summary Schedule
PURPA	Public Utility Reg. Policy Act
PAR	Purchase Analysis Report
P.O. or PO	Purchase Order
QA	Quality Assurance
QAL	Quality Assurance Level
QC	Quality Control

REM	Radiation Dose Equivalent for Man
Radwaste	Radioactive Waste
RB	Reactor Building
RBCCW	Reactor Building Closed Cooling Water
RCIC	Reactor Core Isolation Cooling (System)
RPV	Reactor Pressure Vessel
RHR	Residual Heat Removal
SAR	Safety Analysis Report
SER	Safety Evaluation Report
SRTF	Safety Review Task Force
SB/LG	Small Bore/Large Bore
SOP	Standard Operating Procedures
SU	Startup
STE	Startup Test Engineer
SALP	Systematic Assessment of Licensee Performance
SEP	Systematic Evaluation Program
SCO	System Completion Organization
TRC	Technical Review Committee (Responsible for C&IO and Preoperational Programs)
TB	Turbine Building
TG	Turbine-Generator
WCR	Work Change Request

MAJOR FERMI 2 EVENTS

Year	Events
1968	Fermi 2 approved by Board of Directors
	Prelimiary Engineering began
	Nuclear Steam Supply System (NSSS) and Turbine ordered
1969	Preliminary Safety Analysis Report (PSAR) filed
	Applied for Construction Permit
	Below-grade work began
	Original Conceptual Estimate $229 Million Fuel Load 1973 Commerical Operation Date (COD) 1974
	5-Volume Preliminary Safety Analysis Report (PSAR) filed
1970	Site Preparation work proceeds
	Decision made to install new radwaste system and closed cycle cooling with natural draft towers
1971	Drywell pedestal completed
	Ralph M. Parsons Corporation hired as construction manager
	1st Estimate Revision $269 Million Fuel Load 8/1973 COD 2/1974
	Calvert Cliffs decision: requires full consideration of environmental impact and public review
	2nd Estimate Revision $337 Million Fuel Load 9/1974 COD 2/1975
1972	Construction Permit issued
	Turbine foundation laid
	DECo 50.55e report of cracks in Reactor Building Base Slab

1972 (cont.)	3rd Estimate Revision $423 Million Fuel Load 4/1975 COD 10/1975
	4th Estimate Revision $452 Million Fuel Load 10/1975 COD 4/1976
	Closeout of 4/14/1972 cracks in Reactor Building Base Slab 50.55e report
1973	Drywell and Suppression Chamber completed
	DECo 50.55e report of Reactor Vessel Flange Distortion
	5th Estimate Revision $511 Million Fuel Load 10/1976 COD 4/1977
1974	Final Safety Analysis Report (FSAR) filed
	Reactor Pressure Vessel (RPV) is set
	Construction halted
	Notice of termination of Parsons contract
	Daniel International Corporation hired as construction manager
1975	Closeout of 8/27/1973 Reactor Vessel Flange Distortion 50.55e report
	6th Estimate Revision $914 Million Fuel Load 1/1980 COD 9/1980
1976	Turbine - Generator arrives on site
	20% of Fermi 2 sold
	Preparations to resume construction begin
	Daniel assumes role of construction manager on site

1977 Construction resumes

7th Estimate Revision $894 Million
Fuel Load 1/1980
COD 9/1980

1978 Construction escalated

8th Estimate Revision $894 Million
Fuel Load 6/1980
COD 12/1980

9th Estimate Revision $988 Million
Fuel Load 6/1980
COD 12/1980

1979 Three Mile Island (TMI) Accident

Three Mile Island (TMI) New Issues Task Force identifies 289 items

Physical Completion 80%

10th Estimate Revision $1.3 Billion
Fuel Load 5/1981
COD 3/1982

1980 Expansion of Fermi 2 scope due to TMI occurs

Torus Modification Plan approved

1981 System turnover begins

Advisory Committee for Reactor Safeguards (ACRS) hearing held

Safety Evaluation Report (SER) received

11th Estimate Revision $1.8 Billion
Fuel Load 11/1982
COD 11/1983

DECo 50.55e report of electrical cable pulling problems

12th Estimate Revision $2 Billion
Fuel Load 11/1982
COD 11/1983

1981 (cont.)	Physical Completion 85%
	Closeout of 1/8/1981 cable pulling problems 50.55e report
1982	RPV Hydrodynamic test
	Turbine on turning gear
	Preoperational tests begin
	Emergency Preparedness exercise completed
	ASLB decision
	13th Estimate Revision $2.35 Billion Fuel Load 6/1983 COD 11/1983
	Torus modifications complete
	NRC affirms ASLB & ASLAB decisions on operating license
	Flow Induced Vibration Test milestone was successfully completed
	Physical completion 94%
1983	Revised Estimate $2.7 Billion Fuel Load 12/1983 COD 6/1984
	Percentage Complete 96%
	RHR vibration problems addressed
	Drywell steel modifications (Phase II, IIA)
	INPO, CYGNA evaluations
	Progress in Pre-Op and Start-Up
	Performed IHSI treatment
	Fuel arrives on site
	Revised Estimate $3.075 Billion Fuel Load 6/1984 COD 12/1984

STAFF REPORT ON INVESTIGATION OF ENRICO FERMI 2 NUCLEAR UNIT

CHAPTER 1: INTRODUCTION

A. Background

In July 1968, Detroit Edison Company announced plans to build a large, commercial, light-water nuclear power plant on a 1120-acre site in French Township, Monroe County, Michigan. The initial estimates were that the plant would be completed in 1974 at a cost of $228 million. Early design and site preparation work began in 1969-70. In October, 1972, Detroit Edison obtained an AEC construction permit to proceed with construction. In 1974, due to alleged financial difficulties, the work was halted on the project. In 1976, Edison negotiated sale of a 20% share in the Fermi 2 plant to the Northern Michigan Cooperative and Wolverine Electric Cooperative (now merged as Wolverine Power Supply Cooperative).

In February 1977, construction activity resumed at the Fermi site. Now, in December, 1983, the plant is 98% complete and is scheduled to start commercial operation in December 1984. The current estimate of plant cost is $3.075 billion.

In July 1983, Detroit Edison filed a rate case requesting an increase in revenues to cover, among other things, the investment in the Fermi 2 project.

In preparation of the rate case presentation, the Staff of the Michigan Public Service Commission undertook this study to perform an in-depth evaluation of the management and verification of expenditures on the Fermi project.

B. Purpose and Scope

The purpose of this investigation by PSC Staff is to perform an in-depth evaluation of the management of the Fermi project by Detroit Edison to ensure that ratepayers of Detroit Edison shall not pay for imprudent and unreasonable costs incurred at the Fermi project. The scope of the study is to determine whether:

(a) Reasonable and prudent management techniques were utilized in the conduct of the Fermi project .

(b) There was adequate involvement and supervision by the senior management.

(c) The decision-making process was reasonable, prudent and incorporated the state-of-the-art techniques. This is evaluated by analyzing specific decisions taken vs. the alternatives available or considered.

(d) Detroit Edison had in place a system of controls, audits and verification procedures to ensure that expenditures were approved, incurred and recorded in accordance with established procedures, agreements and acceptable accounting standards.

(e) That there was adequate control exercised in contract evaluation, awards and contract administration.

(f) That there was adequate control and supervision to assure efficient utilization of workforce, equipment and other resources.

(g) That the planning, scheduling and information systems were efficiently utilized to coordinate work activities, material procurement, quality assurance, cost estimates, etc.

(h) That adequate and timely support was provided by Engineering and AE organizations during the project, and finally,

(i) To price out and recommend disallowances, if any, as a result of imprudent management.

Caveat

(a) All the above items were evaluated in light of circumstances, conditions and information available at the time the decisions were made by the Edison management. In other words, actions taken are assessed against the alternatives available at the time and not what may have developed later on. In general, a decision or action taken was considered reasonable if it was properly evaluated based on risk analysis, cost benefit, technical feasibility, practicality, experience and good judgment. If the decision later turned out to be wrong due to events or circumstances unforeseen, it was not treated as imprudent. However, reasonable anticipatory judgment was considered an essential part of prudent decision-making. This is particularly important in the nuclear industry where public attitudes, nuclear events and political factors heavily influence the nuclear policies and are strong leading indicators of things to come. It is also important to recognize that the nuclear industry has been in a state of flux and evolving throughout the period of the Fermi project.

(b) The investigation purposely ignores the question of "need for power" which led Detroit Edison to build Fermi 2 in the first place. Nor shall we look at the choice of nuclear vs. other options such as coal, oil, solar, windmill, and purchase power, etc. It is not our contention that these are not germaine to the issue, but simply that they are to be treated elsewhere outside the scope of this study.

(c) Finally, the staff evaluated some of the major plant parameters such as BWR vs. PWR, cooling towers, selection of NSSS supplier, turbine generator supplier, only insofar as they affected the cost, construction, and scheduling. No attempt was made to review technical feasibility, design criteria or engineering evaluation of the plant from operability, safety or licensability viewpoint.

Similarly, decisions such as plant size and location were not challenged.

C. Investigation Approach

The basic investigative tool was research and review of documents generated throughout the project history--both at site and at the Corporate Offices. These include project management reports, monthly progress reports, project forecasts, numerous reports generated by CARS (Cost Accounting & Reporting System), reports to senior management, Board of Directors, inter-office and contractor correspondence, Engineering Committee reports, problem evaluation and resolution reports, PAR data, PSAR/FSAR, unit labor cost and productivity measurement reports, third-party project evaluations and internal audit reports. This is only a partial list of the rather extensive information requests made and obtained from the Edison project organization. There were in excess of 400 formal requests made. Photographs taken throughout the project were also screened. It should be emphasized that there was excellent cooperation from the PMO and Edison management as far as information availability and accessability. Besides information and documents obtained from

Detroit Edison, a large number of reports, publications, and documents were reviewed in the course of this investigation. This includes NRC reports, guidelines, nuclear events at other plants, independent research reports, e.g., EPRI, nuclear publications. All in all, the Staff made an extensive research and review of documents.

Another powerful investigative tool used was the personal interviews with a large number of key individuals and managers associated, now and in the past, with the Fermi project. The range of interviewees includes the Chairman of the Board, Vice-Chairman, and Senior Management, all the way to the plant foremen, who were actually supervising the day-to-day construction activities. Numerous interviews were also conducted with major contractor managers including Daniel International (construction manager), Bechtel, Wismer Becker (piping), MAC (project consultants to DE), outside A-E organization (S & L, S & W and GE). We also met with NRC personnel assigned to the Fermi project to obtain their assessment of Fermi 2. In many cases, several follow-up interviews were held to obtain fuller explanation of events, circumstances and decisions. In our judgment, the interview process was a very important and necessary element of this investigation. We hasten to add, however, that Detroit Edison personnel are not innocent bystanders, but have deep interest in this investigation. We recognized this in analyzing their views and opinions.

Throughout this review, the MPSC advisory committee provided guidelines and policy directions. The investigation team, in turn, provided periodic updates and continuously consulted with the committee to draw on the vast knowledge and experience of its members.

D. Project Team

Project Manager: Dr. Hasso Bhatia
Financial Audits: Jim Mendenhall (Principal), Dave Flees, Nancy Katsarelas
Engineering: James Padgett (Principal), Tim Boyd, Rich Whale

John Abramson, Director of the Electric Division, was also the project director, who made many useful suggestions.

Advisory Committee

Roger Fischer	John Abramson
Ronald Callen	James Padgett
Michael Fielek	Hasso Bhatia
Donald Johns	Joseph Barden
William Celio	Thomas Cooper
Dr. Michel Hiser, Chairman	Lauchlin MacGregor

E. Organization of Report

The first two chapters provide the background, history and overview of the Fermi project. It reviews the general environment of the nuclear industry, project evolution, general Edison philosophy to design and construction management, safety issues, prior nuclear experience, major events, etc. Chapter 3 deals with specific management decisions, commitments, project support, evaluation of contractors, vendors, project organization, control, planning and scheduling functions. This is designed to identify the major issues, key events and decisions which had significant impact on the project. There is also a general evaluation of the project management.

The individual issues identified in earlier chapters are discussed in detail. The Staff also reviewed the nature of the issue, what or who caused it, how it was resolved and Staff assessment of whether the manage-ment took a reasonable and prudent action. Also, we shall provide our recommendation of whether the cost associated with the issue be disallowed. Effort will be made to quantify such a disallowance.

The final chapter summarizes the conclusions and findings. The disallowances developed in earlier chapters are summarized to formulate the staff recommendation.

F. General Word of Caution

It is useful to caution the reader of the limitations of this investigation and nature of this assignment. Building a large nuclear plant is no small task. It is a complex engineering and construction feat requiring sustained commitment of financial, manpower and material resources. In its engineering complexities, a nuclear plant rivals large governmental jobs such as space or defense programs. Yet, a nuclear project as a commercial venture is subject to financial constraints generally absent from similar public projects. The single-most factor affecting a commercial nuclear project is the regulation of the nuclear industry. As will become evident in this report, the Fermi project, like all other nuclear projects, has been subjected to countless regulations which evolved throughout the design and construction phase. The Fermi project could not escape impact of this unending stream of regulatory changes. The complex and difficult task of a nuclear plant places a singular responsibility on the managers of the electric utility. Thousands of decisions involving millions of dollars must be made during the 10 to 12 year project duration. Many of them posing hard choices, e.g., between economics and added safety; do it now or later; capital vs. operating costs, analyze what-if options. These choices demand experienced, competent managers who can weigh options, anticipate events, evaluate risks, make decisions, and face consequences, good or bad. In short, nuclear plant construction demands extraordinary talents, skilled judgment and tough decision makers. This is particularly so in the case of Detroit Edison who has not built a large commercial nuclear unit before.

Another inescapable fact of a nuclear project is that events are often not within control of the utility. The general economic and financial conditions, nuclear accidents and consequent regulations, political attitudes are all examples of factors not within control of the utility. While reasonable anticipation and allowance for these factors is required of a prudent management, overconcern, and thus provision for possible but improbable events, is clearly outside the realm of prudency.

The task of the investigative team is not made any simpler due to circumstances outlined in the foregoing. We are making an after-the-fact judgment of utility decisions ranging over ten to twelve years involving interplay of engineering feasibility, economic efficiency, safety constraints, resource availability and hundreds of other internal and external factors. Despite best efforts it is difficult, often impossible, to reconstruct conditions as they obtained then, in order to make a precise judgment on a specific decision or action. Nor does our team pretend to possess matching skills, and expertise for a one-to-one assessment of every project action. Our conclusions are, therefore, our best judgments given the facts as we could learn and analyze.

Similarly, an ideal goal would dictate an extensive and intensive investigation. But that would be foolhardy given our resources and time. In a review of this nature, one can quickly get mired into detail, diverge into endless pursuits and lose sight of the significant. The forest vs. trees syndrome is quite real in this case. Initial guidelines of $100 million as a threshold were found unrealistic and quickly abandoned. However, it did help us keep focus on the important and select targets.

We believe that this investigation is a happy blending of the depth and the breadth achievable within our resources. But we reserve that judgment for readers and future reviewers.

Chapter 2: OVERVIEW OF FERMI 2 PROJECT

A. Historic Perspective

Detroit Edison is the largest electric utility in Michigan serving 1.6 million customers in southeastern Michigan. Its current peak requirement is about 7,000 MW with annual output of 35 billion kwh in a normal year. Major generating facilities of Detroit Edison include a 3,000 MW coal plant at Monroe, 1,700 MW at St. Clair Units and 800 MW oil unit at Greenwood. Detroit Edison also owns a 49% share of the 1,800 MW pumped storage facility at Ludington. A pumped storage facility is designed to take advantage of a base load such as a nuclear unit during off-peak periods in order to meet on-peak loads during the day time. During the period of the 1960's, demand for electric power was growing at 7-7.5% per year throughout the industry. Detroit Edison was experiencing this overall growth rate with industrial demand growing at as high as 10.5% per year. Demand projection indicated that the historic growth rates of the 1960's would continue into the 1970's and beyond.

In 1967-68, as a part of its long-term planning strategy to meet growing customer loads, Detroit Edison considered nuclear options.

In July 1968, Detroit Edison announced that it would construct a 1,200 MW Class boiling water reactor at the 1120-acre site in Frenchtown, some 35 miles south of Detroit on the western shores of Lake Erie. Detroit Edison had built and operated an experimental non-conventional fast breeder nuclear unit, Fermi 1, at this site in the mid-60's. Detroit Edison had no experience in design, construction or operation of a large scale commercial nuclear unit at the time of announcement of Fermi 2. At this time, the Company was planning to embark upon a major program of nuclear plants as their primary new source of power supply.

In the late 1960's and early 1970's, Edison announced a second nuclear unit, Fermi 3, and two more nuclear units: Greenwood 2 and 3. While nuclear power was the wave of the future, Detroit Edison seems to have taken a particular fancy to this new power source. The driving force at Edison was its then Chairman, Mr. Walker Cisler, who had been a leader in the electric industry for many years. The Edison nuclear program got a further nudge from a study in 1970 by Doxiadis Associates, (Emergence and Growth of an Urban Region), which predicted a very dense population corridor, a megalopolis between Detroit and Chicago. Edison's nuclear program was designed to serve this expected growth.

B. Nuclear Industry

A brief background and state of the U.S. nuclear industry is in order.

Viability of nuclear power was demonstrated during the 1950's, first in Europe, then in the United States. The first commercial nuclear plant was the Shippingport reactor built in 1957--a 60 MW PWR. In 1960, Dresden 1 began operation for Commonwealth Edison. It was a 200 MW BWR.

Most commonly used nuclear reactors in the United States are called the "Light Water Reactors" since they use ordinary water as coolant. Two types of LWRs are the Boiling Water Reactor (BWR) and Pressurized Water Reactor (PWR). In a BWR, water passes through the fuel core and is allowed to boil into steam, which in turn is run through the turbine to generate electricity. The condensate steam is then returned to the reactor as ordinary water. In a PWR, water is held under higher pressure to prevent boiling. Heat from the pressurized water is extracted by a steam generator. This steam then is run through a turbine to generate electricity. In a PWR, the water from a reactor does not run through the full steam cycle. In general, therefore, in a PWR the radioactive area is confined to the reactor building while in a BWR, the balance of the plant (BOP) also is exposed to a radioactive environment.

The early nuclear reactors built for submarine and experimental uses were of PWR design. In 1960, General Electric designed and constructed the first BWR at Dresden. Since then, the two designs have been almost evenly distributed--with slight preference for PWR's. Utilities with multiple plants, such as Commonwealth Edison and TVA, have maintained a mix of both types. Some consider PWR's as a more proven design. Construction-wise, they appear to be equally complex.

The major suppliers of nuclear reactors in the U.S. were Westinghouse, Babcock & Wilcox, Combustion Engineering and General Electric. GE is the sole supplier of BWR reactors. An NSSS system is the basic nuclear plant component consisting of a reactor vessel and the auxiliary systems, e.g., primary cooling system. In the early 60's, NSSS suppliers were promoting commercial nuclear power by offering turnkey projects; i.e., they will design, build and start the nuclear units for a fixed price. Often they will subsidize the projects and assume all risks in order to encourage nuclear power in the utility industry. Several utilities took advantage of such promotional offers.

In the late 1960's, recognizing that industry was beginning to mature and to minimize their risks, the NSSS suppliers discontinued the turnkey projects. They were also feeling pressures from other design and construction firms that NSSS suppliers were getting too big a piece of the action out of the growing and profitable nuclear pie. The major NSSS suppliers, therefore, no longer offered to design and build the entire power plants. The utilities had to separately contract for AE, construction and component vendors. The nuclear industry, however, continued to grow at a rapid pace. In 1966-67, 51 new units were ordered. Units built up to 1970 were in the 400 to 800 MW range. In 1968, the larger size up to 1,250 MW were being ordered.

Nuclear units built and operational in 1970 cost an average of $200/kw with construction duration of about 50 months. For planning purposes, utilities were assuming a $250/kw and 50-60 month construction schedule for plants operational by 1975. It appears that given the relative prosperity and stability of the electric industry, these were reasonable rough estimates. By January 1970, there were 16 operating plants with more than 5000 MW capacity, 69 were under construction and a total of 101 units had been ordered. Between January 1970 and January 1973, seventy-three new NSSS orders were placed. The booming nuclear industry also created critical demand for qualified engineers, project managers, welders, quality assurance personnel, planners, and construction craft people. In many cases, demand exceeded supply, and turnover became a serious concern impacting projects including Fermi 2.

Demand for skilled manpower, material and general inflation affected construction costs and schedules throughout the industry. Vendors were unable to meet delivery schedules, large AE firms were turning down jobs.

The period 1975-1980 was the most critical for the nuclear industry in the United States. The climate for new nuclear power plants declined rapidly and by 1980 had completely soured and come to a virtual halt. A number of factors contributed to this development.

1. 1973-74 Oil Embargo

Rapid escalation in oil prices and subsequent emphasis on conservation lessened demand for all energy. Ironically, to prevent future embargoes energy independence was emphasized, leading to construction of more nuclear plants. Nuclear power was considered as America's answer to oil embargoes. As it turned out, the result of the oil embargo was sharply higher energy prices, unprecedented inflation and interest rates, which adversely affected labor, construction and material costs--main input factors of a nuclear project.

2. Concern for Public Safety and Environment

The growing environmental concerns subsequent to passage of NEPA in 1970, began to concentrate on nuclear power. In 1971, the Calvert Cliff decision requiring environmental impact statements (EIS) for nuclear projects added a new dimension to nuclear licensing. The thermal discharge into lakes and rivers was severely restricted and monitored. The two major issues raised by nuclear opponents were nuclear proliferation and nuclear waste disposal. The fear of sabotage, theft and international terrorist acts involving deadly nuclear material were a prime concern. This also created opposition to the nuclear reprocessing option which would have improved the economics of nuclear power. In 1977, the Carter Administration decided against nuclear reprocessing options in response to the critics. In 1981, President Reagan lifted this ban. No reprocessing, however, has taken place due to political and economic uncertainties.

Nuclear waste disposal has been a far more nagging and touchy issue. There are no facilities for permanent disposal of high-level, radioactive, toxic wastes produced at commercial nuclear plants. Currently, the spent nuclear wastes are stored on-site, in fuel pools, in hope of eventual permanent disposal at a geologic facility. The wastes contain extremely "hot" plutonium and other material which will remain radioactive for thousands of years. Special sites must be located and built for this purpose. States are reluctant to allow these facilities to be built on their lands. It is a national issue. Inability to develop permanent storage has caused some states, such as Wisconsin and California, to ban further development of nuclear power in their states.

In 1982, a significant step was taken in this direction. The Federal government has offered to take charge and responsibility for permanent storage and maintenance of waste disposal. While this helps the current nuclear plants, it may be too late for the revival of the nuclear industry.

3. Licensing and Regulation

The Atomic Energy Commission (AEC) was created in the 1950's to license and regulate construction and operation of power plants. Their primary purpose was to ensure protection of public health and safety. Title 10 of the Federal Code of Regulations prepared in 1957, had two important sections, (a) 10CFR50: Domestic licensing of production and utilization facilities; and (b) 10CFR20: Standards for protection against radiation. These were the two basic documents guiding the nuclear industry. In 1971, there was a major code revision and AEC published 10CFR50 Appendix A: General Design Criteria. About this time, the AEC also began issuing regulatory guides, interpretation, bulletins and other criteria. The number of regulatory guides grew rapidly in the period 1970 through 1978. In 1977, after the Browns Ferry accident, the NRC issued Appendix R: Separation Criteria for Fire Protection. While, by 1978 the total new guides and regulations began to taper off, the intensity of NRC enforcement and attention increased significantly.

In 1974, the AEC was reorganized to separate the regulatory function from the nuclear promotion function. The former function was vested with the Nuclear Regulatory Commission (NRC).

The rapid growth and expanded enforcement activities of the NRC have had significant impact on cost and construction duration of nuclear plants. It has also reduced the economic advantages of nuclear power over other alternatives.

Besides its own rules, there are other groups, agencies and institutional standards that are applied to the nuclear industry by the NRC. These include ASME Class 1 Standards, ANSI, AWS (American Welding Society) and IEEE. Formed after the Three Mile Island (TMI) incident, the Institute of Nuclear Power Operations (INPO) is an industry owners organization performing self-evaluation and operations performance criteria. Recently, the NRC has insisted on Independent Design Verification (IDV) of critical systems to ensure safety of as-built equipment.

4. Nuclear Events

In the period 1975-80, two major nuclear accidents severely crippled the nuclear development. In 1975, fire occurred at the TVA's Browns Ferry Unit in Alabama. The fire in the cable room damaged important control cables. The fire was brought under control and the plant safely shut down. But the accident brought to light some basic shortcomings in the design of the cable room and electrical systems. The NRC issued Appendix R, mandating extensive redesign and use of cable separation criteria for fire protection and safe plant shutdown controls.

Browns Ferry was the first major accident at a commercial nuclear plant. Although no one was injured and no radiation leaked, public fear and concern for nuclear power safety increased.

The second, and psychologically much more damaging, was the accident at Metropolitan Edison's Three Mile Island Unit 2, near Harrisburg, Pennsylvania in March, 1979.

At TMI, a relatively minor mechanical failure was aggravated by human misjudgment and interference. The critical core cooling water levels were allowed to fall, uncovering the core for a brief period and destroying all the fuel. More importantly, operators and experts were unable to judge the condition of the plant for several days, and large quantities of radioactive water and gases were allowed to leak. Fear of a hydrogen bubble explosion (later found to be false and theoretically impossible), inadequate plans for evacuation of population, and lack of communication by the utility all contributed to a major nuclear catastrophe.

Perhaps the most significant impact of the TMI accident was not what it did to the public in real terms, but what it did to the utility - General Public Utility - and to the industry as a whole. The accident was an economic disaster for GPU.

The massive clean-up effort, still in progress, may run upwards of a billion dollars. The replacement power costs amounts to several million dollars per month. The undamaged sister unit, TMI-1, could not be operated--the NRC would not permit it. What was at first a minor series of operator errors had brought economic ruin to the utility.

The effect on utilities operating or building nuclear units was also severe, particularly on the latter ones. The NRC came back with a vengeance requiring new criteria for operator training and procedures, control room modifications, Emergency Response Information Systems (ERIS). The NRC came up with a 500-page TMI action plan. In the meantime, new licensing activities were stopped to make an assessment of the nuclear industry. The worst affected were the plants under construction and ready to receive an operating license--Fermi 2 among them.

The industry itself got a rude awakening of the woefully inadequate and complacent operating procedures--which could self-destruct a utility. Industry groups such as INPO, and the Nuclear Safety Analysis Center (NSAC) were formed to develop self-evaluation programs. Out of fear of economic ruin, an industry-owned insurance group was also formed.

Browns Ferry and TMI were illustrative to the industry that a new thinking was in order. The former was an accident started by human error but solved by Automatic Scram

Controls. The latter was a system failure, turned into a disaster by human interference.

5. The primary economic advantage of nuclear power over fossil-plants is the relatively low operating costs. However, this presumes high operating capacity factors. The history of nuclear operations has demonstrated less than satisfactory performance. Some plants have been shut down for long periods due to retrofits, regulatory required maintenance and general equipment problems, e.g., tube failures, defective equipment and long lead time of critical parts, resulting in costly downtime. In their economic analysis, capacity factors of 65% or higher were assumed. The average industry experience has been in the mid 50's. Moreover, security, safety and other surveillance requirements have significantly added to the operating costs of nuclear power plants, further reducing their economic advantage.

The problems listed above have created uncertainty for the future of the nuclear industry. Operating plants are operating under a constant threat of new regulations or costly operator errors; utilities with units under construction are struggling to complete and operate the units so as to stop revenue drain, AFUDC and start earning on their investment. No utility is even conceiving of starting a new nuclear project under the current conditions.

In what may be the ultimate irony, the economic outlook for a new nuclear project is more favorable today than it has been any time in the past ten years. This is for a variety of reasons. The inflation rate has slowed down considerably. The economic recession and unemployment has led to a surplus of skilled labor. The large constructors and AE firms are begging for projects. Finally, and most importantly, NRC regulation, although a lot more stringent, is relatively stable and less uncertain. All these conditions, in our judgement, are favorable for nuclear projects. Yet the shock of recent experience will keep any prudent utility from venturing into nuclear units for years to come.

C. Fermi 2 Project Evolution

Prior to announcing Fermi 2, Edison had evaluated bids for 800 MW PWR and 1,100 MW BWR units from four NSSS suppliers. The basic parameters were evaluated by a high-power Engineering Committee. Input to this committee was provided by the Generation Engineering Department of Detroit Edison. An independent AE firm of Sargent & Lundy (S&L) was also asked to evaluate the various bids.

In August 1968, Detroit Edison placed an order for a 1,154-MW BWR unit with GE with the option to buy a second unit (Fermi 3)--the unit was later upgraded to 1,200 MW. This GE unit is one of the earliest designs known as Mark I/BWR 4. This decision, Edison claims, was based on the excellent operating experience at GE's Dresden 1 unit owned by Commonwealth Edison, since 1960. Other factors considered were:

- short construction cycle of 4 to 5 years.
- lower purchased price based on comparative bids.
- to stay with the proven design (Mark I/BWR 4), even though GE was developing and offering a newer design.
- DE considered a BWR more reliable over a PWR from an operations and maintenance perspective due to higher operating pressures and use of steam generators in a PWR.

The NSSS decision shall be analyzed in detail in the following chapters.

The turbine-generator order was placed for a 1200 MW unit with English Electric Ltd. of England in 1969. At least 5 other bids were evaluated based on price, experience and financial status of the vendor before selecting English Electric. Although, English Electric offered a definite price advantage over other bids, this was the first such large size TG being built by English Electric.

The Edison decision was at some risk as to the performance of the unit. Further evaluation of this later.

Early in the project, Edison decided that construction of Fermi 2 should be assigned to a general contractor. Detroit Edison selected Ralph M. Parsons, a large construction firm with vast experience in petroleum and industrial projects, the Titan Missile program and other defense programs. Parsons had a good reputation in the business. Parsons was given responsibility for developing detailed cost estimates, scheduling, subcontractor bids and project Quality Control program. As it turned out later, Detroit Edison reversed itself and went to a construction manager concept, directly contracted for construction, took over the QA program and terminated Parsons' contract. The decision, which we consider significant, will be analyzed in detail.

Detroit Edison felt confident that it had a large pool of skilled and qualified engineers with experience in power plant design. Most recently, they had designed their four Monroe units--3,200 MW coal plant. With concept design from GE on NSSS and auxiliary systems and some assistance from outside AE firms on specialty jobs, Edison felt that they could handle the design and engineering functions. One of the key factors in this decision was that by being their own AE, they would develop intimate knowledge and understanding of the plant, a definite asset when in the operations/maintenance mode. Further, with more nuclear projects planned down the road, Edison was developing a formidable engineering force with nuclear expertise. The decision was made to be their own architect engineers. It was a deviation from industry practice at the time. This decision was one of the most critical and overambitious. DE had underestimated the task and overestimated its capability. But more on this in the next chapter. Unlike the construction decision, Detroit Edison remained its own AE throughout the project.

In November 1968, a Project Management Organization was formed, with Mr. Walter McCarthy (the current Chairman of the Board) as the Project Manager.

In April 1969, the Project Organization prepared and submitted the Preliminary Safety Analysis Report (PSAR) to the AEC. PSAR is the principal document laid out by the utility building a nuclear power plant. It provides considerable detail of the project parameters, site suitability, design criteria, safety and emergency procedures and detailed operating procedures. The PSAR runs into 5-volumes for Fermi and is a basic written document to convince the AEC that the utility can design, construct and safely operate a light-water reactor at the chosen site. Throughout, the project PSAR is updated. The final revision of it, called Final Safety Analysis Report (FSAR), is prepared towards completion of the project.

In April 1969, Edison applied for a construction permit. Soon after submission of the PSAR, Edison started site preparation work. Under a Limited Work Authorization from the AEC, all below grade work could be done by Edison at its own risk.

In December 1970, a suit was filed with the AEC by environmentalists claiming that the 1970 Environmental Protection Act required, among other things, that an Environmental Impact Statement must accompany the application for a nuclear power plant. Specifically, they brought up the case of Calvert Cliff Nuclear Unit under construction by Baltimore Gas & Electric. The court ruling in July 1971, in favor of environmentalists had a significant impact on nuclear construction permits.

Pending a construction permit, Edison was re-assessing some of its plant parameters. One of the major reviews was in the cooling mode for the condenser steam.

The original Fermi design was based on once-thru cooling (open cycle), using Lake Erie as the heat sink. Concern for thermal discharge and its impact on marine life led Edison to believe that the emerging regulations would not permit lake discharge. Edison considered other alternatives including a series of spray pond systems. Finally, in June, 1970, Edison decided to build the natural draft cooling towers in a

Closed Cycle Cooling System. This decision required major adjustments in the turbine generator operating conditions and the system output. The cooling tower decision was a major revision in the project which added to the cost, permited delay and plant derating. It will be analyzed in greater detail in the following chapters.

In October 1970, Detroit Edison was granted limited work authorization to proceed with construction at its own risk on all systems and work below grade. Detroit Edison started furiously working on substructures for the reactor building, circulating water system, turbine house, and other auxiliary structures. Photographs taken during the period show construction activity going on at a rapid pace. The construction activity continued on the erection of the turbine, reactor and auxiliary buildings and drywell pedestal during 1971-72.

In October 1972, the Fermi Project received an AEC construction permit. It is the company contention that, typically, the AEC construction permit was expected in 12 to 15 months. Due to environmental reasons and the Calvert Cliff decision, the Fermi permit was delayed by at least 30 months. This delay, Edison claims, forced them to reset their schedule for completion of the plant to April 1975 from February 1974. Further, Edison claims that, due to this delay, it became subject to many new regulations from the AEC.

The Staff has analyzed the construction permit delays and they will be discussed in this report. It suffices to say, for now, that there was significant construction activity taking place, pending a construction permit. This is further evidenced from the fact that in April 1972, Detroit Edison submitted a 10CFR50.55(e) violation, reporting cracks in the reactor building base slabs. The issue was closed out in November 1972. Prior to issuing the construction permit AEC had cited 12 PSAR open items which must be addressed by Edison.

Bulk construction continued into 1973 pursuant to AEC authorization. This period also saw a rapid growth in regulatory enforcement. Environmentalists with recent victory in Calvert Cliff were having an increasing impact on AEC thinking. The AEC was showing more serious interest on specific system design and construction methods. Regulatory guides were developed suggesting more specific solutions to design and construction problems. While not mandatory, regulatory guides were a strong recommendation and the project not following these must develop alternate methods acceptable to the AEC. While the AEC was ratcheting new regulations on some utilities, Fermi specifically was exempted from compliance with specific regulatory guides. In the most part, however, it appears that DECO attempted to comply with the guides. This issue merits further analysis.

During 1973-74, Edison was preparing to resolve PSAR open items including: Residential Heat Removal (RHR) system design and construction; radiological releases/source term calculation; design of sacrificial shield; Beach Barrier Design; Recirculation Pump/Motor overspeed missile; protection of spent fuel pool, etc. Edison engineers were busy in this period designing and redesigning systems to satisfy AEC. One of the key systems: Residual Heat Removal (RHR) systems was a major issue to be resolved. Initially, Detroit Edison's thought was to use the lake as the ultimate heat sink, but abandoned the idea. The AEC was not convinced that the lake would provide adequate water for RHR cooling. Next, a 50-acre pond was considered but again rejected on the grounds that such a pond could not withstand a postulated 50-ft. tidal wave and seismic conditions. Finally, Edison selected a RHR pond with mechanical draft cooling towers placed in an enclosed, separate building, designed to meet seismic standards. Fermi 2, it turns out, ended up with one of the most expensive RHR cooling systems in the industry. It, however, took advantage of the RHR design by housing the Emergency Diesel Generators (EDG) in the same building.

By the end of 1973, Edison had spent $212 million, with an estimated $300 million to go. Estimated project construction was 47% complete with engineering 65% completed.

One of the major restraints to field construction progress was that the engineering activities were falling behind. DE was beginning to find that engineering complexities and issue resolution were taking much longer and manpower resources were inadequate both in size and technical expertise. There was also a general shortage of manpower in the nuclear design area. Major portions of work were being contracted out to consultant firms such as Sargent & Lundy and, later, Stone & Webster. Designs for an auxiliary boiler house, turbine building structural steel, reactor building and particularly the hangar design were seriously impacting the project schedule and the cost.

At the same time, Edison was devoting considerable engineering effort to prepare PSAR for the Enrico Fermi 3 unit which was in the concept stages. Since the EF3 design had major deviations from EF2, for instance, the Mark-1 reactor was changed to Mark-3; a major new effort was being devoted to the EF3 project. A separate Project Management Organization was announced for EF3. It appears that EF3 put a further strain on a severely taxed engineering organization and some impact on EF2 progress.

Another problem area in 1973-74 was the delay in procurement and delivery of the major equipment and components. There were delays of several months in deliveries of pipe hangars, valves, I-R condenser tubes, control panels, nuclear piping, etc. Material shortages at Bethlehem Steel Corp. were causing allocation and delays in resteel for RHR and other buildings. Expediting functions were strengthened, but with little success. Energy shortages in England caused manufacturing delays in the turbine-generator.

Detroit Edison was also getting concerned regarding the project management, particularly in the area of quality control, scheduling, planning and project controls. By now, the schedule completion dates had been revised to April 1978.

In 1974, the Fermi project went through several major changes.

Daniel International, a large construction management organization, was hired to perform a review of the project management organization and various functions, estimate the percentage of completion, and to recommend changes in the project to improve performance. Daniel recommendations, which will be discussed in some detail later, included correcting serious deficiencies in the project planning and scheduling, engineering and procurement areas.

In July 1974, Edison decided to terminate Parsons as general contractor and hired Daniel International as the construction manager with overall responsibility for project planning, scheduling, contract administration and construction. Quality assurance was also a Daniel responsibility. Daniel, who was near completing the James A. Farley Nuclear Unit at Alabama Power, was considered a strong construction management organization with a good quality assurance program. Also, Detroit

Edison wanted to have more direct involvement in the project; selection of contractors, quality assurance and safety issues. The two functions not the responsibility of Daniel, however, were purchasing and engineering.

In 1974, Edison was also faced with serious financial conditions. In April 1974, Consolidated Edison shook the utility industry and investment community by skipping their regular common stock dividend. This spread doubts about the financial integrity of many electric utilities, especially those with large construction programs and oil generation. Detroit Edison, caught in this crisis, found itself in a serious cash crunch and decided to severely cut down on its capital programs. At this time, Edison was in the middle of several major projects: Fermi 2, Monroe 4, Greenwood 1, Superior Coal Dock, with Greenwood 2 & 3, Fermi 3, and Belle River 1 & 2 in the planning stages.

Detroit Edison claims that it was facing serious financial problems for several reasons, principal among them: inadequate rate relief, a credit squeeze from Wall Street, high fuel bills, and large construction expenditures.

Detroit Edison's top management decided to stop active construction indefinitely. The in-house engineering effort was to continue, however. The decision to halt construction had the most telling effect on project personnel, contractors and craft. Many fixed price contracts had to be cancelled with a heavy penalty, or renegotiated as cost reimbursable; much of the equipment under scheduled delivery had to be warehoused, often in inadequate, unprotected condition. Many skilled laborers, welders, electricians, and quality control inspectors had to be let go. Warranties on many components were allowed to expire--DE found it cheaper than to continue service warranties. Vendors such as GE insisted on delivery of components as per schedule and maintenance programs had to be developed for critical equipment. In short, the project was in total disarray. As will be analyzed further, this decision was the most crucial in the project history.

During the shutdown, which lasted until February 1977, new and much more stringent regulations came into existence. The nuclear accident at Browns Ferry in 1975 created a new environment for plant safety and fire protection. Reorganization of AEC functions into the Nuclear Regulatory Commission (NRC) and the Energy Research and Development Administration (ERDA), brought more vigorous enforcement of nuclear regulation. All in all, 1974 was a bad year for the electric industry; worse for Detroit Edison, and particularly disastrous for the Fermi project. From a relative prosperity in 1973, Detroit Edison had sunk into near financial bankruptcy in 1974. Two questions must be addressed here: (a) were the problems in 1974 a result of poor financial management and (b) did Edison make a bad decision in abruptly shutting off the Fermi Project, i.e., did Edison think through all the consequences of their action. Both of these questions will be analyzed in this report.

During the period of shutdown, which lasted until February 1977, major events affecting Fermi 2 were:

- termination of Parsons as general contractor and hiring of Daniel as construction manager (7/74).
- reactor pressure vessel was set in place (10/74).
- Final Safety Analysis Report (FSAR) was filed (10/74).
- project cost estimate revised to $910 million; schedule revised to fuel load date of January 1980 and commercial operation date of September 1980 (7/75).

- completion of reactor building (12/76).
- turbine-generator received from English Electric (7/76).
- cancelled Fermi 3 unit (6/75).
- negotiated sale of 20% interest in Fermi 2 to Northern-Michigan and Wolverine Electric Cooperatives. (Now merged as Wolverine Power Corp).

In the same period, several outside regulatory events also affected the project:

- fire at Browns Ferry lasting 8 hours and destroying 1,600 cables resulting in extensive separation criteria for redundant cable systems through Std-Review Plan and Appendix R.
- Rassmussen study on Reactor Safety was issued, criticized and finally disowned by AEC.
- AEC itself was reorganized into NRC and ERDA.
- protest resignations of 3 GE nuclear engineers, an NRC safety inspector at Indianpoint 3, and resignations of AEC chairman, commissioners and several NRC safety experts brought to much public attention problems within the nuclear industry and NRC enforcement. Congress raised issue of nuclear waste, Price-Anderson Act, non-proliferation, etc.
- NRC issued several new regulations and regulatory guides to supposedly improve plant safety, missile and pipe break protection from internal accidents.

It was estimated by Edison that construction shutdown and restoration would add at least $200 million to the project. Subsequent estimates, when all direct and indirect impacts are considered, may exceed $1 billion. At the time of shutdown, Edison estimated that the project was 43% complete with engineering about 70% done. Edison had planned to utilize the shutdown period to prepare more complete engineering packages. This would allow them to offer hard money contracts to constructors. Ironically, after the project resumed, most current hard money contracts were switched to cost plus.

Prior to shutdown, Mr. Wayne Jens, now V.P. for Nuclear Operations, was the Project Manager. In 1976, Mr. William Fahrner became the Project Manager. He continues as PM till this day.

Construction resumed at the Fermi site in February 1977. The revised estimate was in the range of $900 million with a completion date of September 1980. This is, in our view, the first definitive project estimate.

By the end of 1977, Edison reported 57% completion and actual expenditures of $515 million. The progress rate in this period was an acceptable 1.4% per month. (Generally, 1.5% completion per month is considered satisfactory in the nuclear construction. EF2 has had overall rate of about .75%.)

Construction activity picked up steadily in 1978-79. However, it was being seriously hampered by lack of engineering support. The project was running on so-called "hand-to-mouth" operation, as far as engineering and construction activities, i.e., construction was often held up for lack of engineering output. This was particularly so in the pipe and hangar design and the electrical areas. The craft productivity was dropping, hangar redesign was running as high as 25%, occassionally approaching a rejection rate of 50 to 60%. Temporary tubing and hangars were being installed to proceed with construction in many areas.

During this period, allegations were raised in the media against the project management for improper verification of piping material, hiring of unqualified personnel and even doctoring of some documents.

Edison instituted its own investigation to look into the allegations. The NRC also investigated the "falsified document" charge and found them baseless.

The schedule was steadily falling behind as productivity dropped, and there was general "low morale" on the project, tension between engineering and construction was growing. Many contractors who were earlier on a fixed cost basis now demanded and got cost reimbursible terms.

Due to a large number of contractors on the site, there was a problem with coordinating their activities and in allocating work priorities.

Between March 1977 and December 1979, the project cost estimate was revised from $894 million to $1.3 billion. The schedule, however, was revised to a March 1982, commercial operation date. The project's physical completion was reported as 82% by June, 1979. Between June, 1978 - June, 1979, 12% progress was achieved. This rate, though less than 1977-78, if it could be maintained, would have made 1982 C.O.D. achievable.

The project was preparing for start-up and pre-operational testing activities. For this purpose, system scoping packages were being prepared to explain to construction and design groups the system concepts as opposed to bulk construction. It is typical in a project at a 75-80% completion point that the project switch from a bulk construction into system mode. In 1978, the project prepared a material identification system called CCS - Component Control System. For the first time, the start-up activities were being integrated into the construction and engineering activities.

It seems that the start-up concept started quite early in the project. In 1973, Edison prepared the start-up manual and the start-up group was formed in 1974 to scope out the systems. The shutdown slowed these efforts, however. Edison's manual was used at the Shoreham Nuclear Plant during the Fermi shutdown and was brought back in 1977. There appeared to be some resistance in the Construction Organization to embrace the system approach while the construction was going on.

The start-up and pre-op testing is a critical stage in the life of nuclear plant construction. Edison, it appears, was keenly aware of the importance, criticality and complexity of this phase. There are several approaches one may take to accomplish this task. Since the bulk of the project had been completed with attendant investment, the start-up actions have to be not only technically sound, but must be done efficiently to minimize delays. The initial Edison approach was to perform the bulk of the start-up function by in-house personnel. As it turned out, Edison had to hire a considerable amount of outside expert help. Start-up has been for the past year or so, and is today, the single most critical path item to the project completion. How well the Fermi project handled this task, and what were the major roadblocks and restraints will be analyzed in detail.

A major setback to the project was the accident at Three Mile Island in March 1979. While the NRC was preparing its own action plan, Detroit Edison established a New Issues Task Force to assess the impact of TMI on the Fermi project. With the help of Stone & Webster, the engineering consulting firm, the Edison Nuclear Operations group identified 289 items impacting Fermi. Undoubtedly, TMI hurt Fermi at a very sensitive stage of construction. The NRC suspended all licensing activities while it developed the response to TMI. The Fermi operating license, under NRC review, was caught in this post-TMI whirlwind.

Edison made a reassessment of cost and schedule in December 1979, and estimated that as a result of TMI, plant cost would be at least $1.3 billion and would be completed after March 1982. Further, there was the strong likelihood that both the cost and schedule could rise much higher. The true impact of TMI on Fermi, however, became more clear in 1980 and 1981.

In 1979, Edison management expressed deep concern about the progress, direction and status of the project. It was becoming a drain on its financial and manpower resources, while showing no light at the end of the tunnel. The project was experiencing serious turnover of skilled personnel. The TMI accident only heightened this concern. The Company management hired an outside consulting firm, Management Analysis Corporation (MAC), to perform a diagnosis of the project and recommend improvements.

The consultant group identified some basic weaknesses in the organizational structures, engineering functions, planning and scheduling, quality assurance and the start-up functions. Among the major recommendations:

- move the project management office to the site.
- simplify the approval authority level.
- greater field engineering support.
- more rigorous performance evaluation of contractors and greater supervision of their work activities.
- evaluate cost projections and establish a prioritized systems plan based on financial considerations. Overall improve effectiveness on the job.

- greater accountability from construction manager (DIC).
- clarify the roles of CM, owner and contractors. Greater involvement and committment of upper management to the project.
- better project control, use of CPM network to improve planning and scheduling functions.
- strengthen QA/QC functions and emphasize need for good QA program on the project.

Fermi PMO was reorganized in 1980. The most significant change was that the QA organization was brought under the direct Detroit Edison umbrella--previously a Daniel responsibility. Also, the field engineering effort was strengthened. More Project Management personnel were brought on the site.

As the project moved towards completion in 1980, Edison began a systematic program of equipment and component inspection, necessary prior to the pre-operational testing. The Fermi project had been in progress almost 12 years. Much of the equipment had been delivered in the early 1970's based on the 1974 operational date. During shutdown, equipment was being received and stored without adequate warehouse facilities. Equipment installed had not been turned over for 5 to 10 years. During shutdown, Edison made a conscious decision to only maintain the major equipment based on cost-benefit analysis. Threshhold was $10,000 cost item.

In 1980, Edison started a massive effort of refurbishing the equipment. This inspection program also discovered numerous equipment deficiencies, performance and design deficiencies and general material degradations. Many components had to be refurbished in the warehouse or in the laydown areas prior to installation. Construction and the inspection activities had to leapfrog and often interfere with each other. Defective equipment had to be replaced--often impacting schedule due to long lead times. It was an agonizing, massive effort to upgrade the components and bring them into acceptable condition. In some cases, as in "Limitorque" motor operated valves, equipment had to be upgraded to meet the new environmental qualification standards. This applies to non-metallic material used in the valves and its inability to withstand harsh environment. Some defective equipment such as polishing demineralizer, MSIV, and core spray pump was attributed to manufacturing defects and backcharged to the vendor. By and large, the refurbishment program was extensive, expensive and impacted the start-up schedule. A detailed analysis will be performed on this issue.

In 1980, a team of Edison internal auditors issued a report on their investigation of the allegations on ABC's "20/20" and the local Bill Bonds show. The report found:

- Some improprieties in hiring practices by local hiring agents.
- Serious problems in hangar design, excessive rework, and redesign holding up progress. No adequate control on design process.
- Serious problems with document control and inadequate paperwork associated with construction.
- The electrical contractor's performance on cable pulling was seriously questioned. Investigation found Comstock was pulling cables too tight, stretching to fit the terminations. A professor from the University of Michigan was hired to further look into this allegation. A significant rework resulted from this finding.

Although Edison claimed that Fermi was its top priority, the financial resources allocated to the Fermi Construction were often inadequate to meet the scheduled operation date. This was especially so in the craft area. As one senior management person indicated, whenever there was a cash crunch, and there were several of these during 1979-80, manpower levels were reduced at Fermi 2. The Construction Manager (Daniel) often complained of this inadequacy. For instance, a 2500 craft need recommended by Daniel was met only with about 1,100. Overtime on job was at a minimum. Edison has claimed that although adequate resources were provided to the project, the inadequate rate relief and earnings did pose budgetary constraints, affecting all projects.

Another effect of insufficiency was that the overheads on the project increased in proportion to construction expenditures. So was the ratio of non-manual to the manual on site, compared to a typical job. This is further confirmed by the fact that percentage increase in construction expenditure, in spite of all the rework, scope changes, etc., is the lowest compared to other components such as engineering, other overheads, nuclear operations, etc. We shall elaborate on this further.

It must be said, in defense of the Company, that senior management was getting seriously concerned about the direction and progress of the project. This is evidenced from a number of investigations undertaken both in-house and out-of-house. In 1978, the Project Services Section of the Generation Construction Dept. conducted a project evaluation (Assign. #264), under direction of the Manager of Construction. This evaluation was done by three independent groups, including Bechtel. Construction Managers from Commonwealth Edison were brought on site to make a field inspection and assessment of the work completed, rate of progress and work to go. Edison also participated in a study conducted by the University of Texas, funded by D.O.E. to analyze the worker productivity at the job site and identify problem areas. Edison's own internal auditors and Daniel instituted work sampling studies to measure craft productivity. The firm of Management Analysis Corporation (MAC) was hired to perform periodic diagnostic assessments of the project. We shall discuss these reviews and generic problem areas elsewhere. It is sufficient to emphasize at this point that Edison management was continually assessing the project, taking actions to bring the project to a completion. The PMO was extensively reorganized.

By the end of 1980, Edison reported about 80% construction completion. However, other events were happening affecting project completion. High-level and low-level nuclear waste disposal became a controversial issue. With banning of reprocessing fuel in 1977, much larger high-level nuclear waste had to be stored away. At the same time, no satisfactory mode of permanent repositories were developed. Thus far, nuclear waste from operating plants is being temporarily stored in fuel pools on-site. These sites were getting filled and must be expanded. In 1982, Congress passed the Nuclear Waste Policy Act to resolve the issue. The Department of Energy will consider several sites including salt formations in the Great Lakes as possible storage sites.

However, in 1980, due to the uncertainty in this area, Edison decided to make extensive redesign and install high-density fuel racks to increase the on-site capacity for spent fuel storage. This added capacity will last until 1995.

Similarly, the transportation and burial problems for low-level waste became a serious concern in 1980. This was one reason for Edison's decision to modify the liquid and solid radwaste system. Also, an on-site storage was built for this purpose. The new radwaste system would greatly reduce the drumming needs and eliminate liquid waste. It should be noted that an on-site storage is not the common industry approach.

Also, seriously impacting the project progress were the new regulations resulting from the TMI accident. At least 100 changes in design, construction and operating procedures were recommended by the Edison task force, set up two weeks after TMI. Major changes:

- Modification in control room instrument consoles and panels.
- Computer analysis of accident data.
- Containment inerting system to prevent H_2 bubble during an accident.
- Sampling equipment in critical plant locations.
- Standby feed water pump added as a backup to ECCS, to ensure core coverage.
- Additional fire walls.
- A new technical support center and emergency operating facility.

As will be discussed later, not all these changes are attributable to TMI. Nevertheless, the plant design became much more complex. The implementation of these design changes was even more difficult since construction was essentially done. Retrofit and backfitting was costly and time consuming. Further, worker productivity suffered due to demoralizing effects of rework, difficult access to areas, working around the built areas, etc. In 1980, regulations and guidelines were also issued on environment qualifications of the safety equipment.

Electrical components, e.g. cables, switches, motors, sensors, breakers must be able to withstand harsh environments--both under normal operation and emergency conditions. Many components not meeting these qualifications had to be replaced--with far more expensive parts and with long lead times. This program was integrated with the refurbishment program mentioned earlier.

All in all, 1980 was a critical year for the Fermi project. By the end of 1980, the project schedule was revised to fuel load in December 1982 and C.O.D. in December 1983. The budget estimate of $1.8 billion was soon to be revised to $2.0 billion or more.

In 1981, Edison was getting alarmed and raising serious doubts whether the project would be completed in the foreseeable future. Systems supposedly completed and ready for testing were found having a large number of components damaged, missing or needing refurbishment. Punch list and pre-punchlist items were piling up: had 8,000 to 9,000 physical work items by mid-1981 and growing. Many items were to be ordered with long lead times. The P/L completion rates were 25% of the target rates. Hanger installation rates, especially for small bore pipes, were extremely slow. Incomplete punch list was holding up initial check-out and pre-op testing of components and system. Further, the paperwork on completed systems was not being furnished. Problems were also discovered in the RHR System, Control Rod Drive Assembly, Compressor and Fire Protection System. In general, the systems were not being turned over fast enough to the start-up group. Control room changes alone required 20,000 mhrs.

In 1981, major construction was also going on in the radwaste modification and on-site storage buildings. The project's top priority by the end of 1981 was to get the RPV hydro testing done. Project schedule showed 22 week negativity.

Mr. Harry Tauber, V.P. in charge of Fermi, made a personal investigation on the job to determine causes and cures for the frustration among site personnel. He reassured the project that "it was not a disaster though frustrating". He expressed general optimism that the project can be completed on schedule. Also, a team from MAC conducted another review on how to improve the system turn-over. A number of actions were taken as a result. The project was directed to prepare a task-by-task evaluation of critical path items in order to eliminate delays and to get back on target, i.e., December 1983 completion. The most significant change was formation of a new organization called System Completion Organization (SCO). This was to act as an intermediate group between construction and nuclear operations. The purpose of this group was to take over systems which were complete or near complete, identify and tag the missing components or physical activities remaining (called the punch list items), and to develop a schedule for the P/L completion. Although this group was not to do the construction, it would direct work to the appropriate contractor and coordinate completion. To assist this organization, experienced people were brought in who could target on specific activities.

Establishment of an organization such as SCO is a common practice on a nuclear project as the project moves from bulk construction to system completion. Other constructors, e.g., Bechtel and S & W, also use this approach. However, it is critical to choose the right moment in the phase of construction to establish SCO. First of all, one must have a fairly accurate assessment of the project status. Second, if SCO is established too soon, it can be very disruptive to the construction activity. Also, it takes away the accountability from the responsible contractors, and the construction manager, in this case. Thirdly, turnover of systems should be phased in, rather than all at once. This way, one can target on systems, identify generic deficiencies and plan completion. Taking all systems at once would merely transfer one construction organization into another and dilute its efforts.

In our judgment, creation of SCO in November 1981 was a positive step. As is expected, there was some resistance from the Construction Manager (Daniel) to this, especially on its timing. Edison management felt, and rightly so in our judgment, that it would be easier for the Edison start-up group to take over systems, completed and screened by Edison personnel (SCO was under Edison responsibility). Obviously, there was some tension developing between Daniel and Edison site people. Finally, the project was reaching a point where Daniel had to be phased out and Edison was to exercise the ownership role.

A more detailed evaluation of the creation and implementation of the SCO concept will come later. Other changes in 1981:

(a) Sizable increase in field engineering support.

(b) Site Manager Mr. Syl Noetzel was brought in to assist in day-to-day decision making. Daniel demanded this. DE also took over Project Controls function.

In 1981, the project also faced a financial dilemma. Edison's security case for financing construction in 1981-82 was approved by the Michigan Public Service Commission in August 1981. The Commission decision was challenged by the State Attorney General and other interest groups. A court stay order was placed on the Commission order. Edison could not proceed with financing plans until the matter was cleared up. Detroit Edison faced a serious financial bind if the case was decided against the Company. As a precautionary action, a freeze was placed on all hiring at the Fermi project, overtime was reduced and other budgetary limits were placed on the project. Funds from the Wolverine & Northern Michigan Cooperatives kept Fermi going. In November 1981, the Michigan Supreme Court decided in favor of the Company. At issue was the consideration of need for the project by the MPSC as part of the securities proceedings. Intervenors argued that need and economic benefits vs. cost must be determined before financial approval is granted by the MPSC. The Supreme Court ruled that while such a consideration is desirable, it must be done at the start of the project, not a continuous review during each security proceeding. Thus, the Supreme Court endorsed some form of "need for power" procedures--under consideration in Michigan for several years.

Once the financial uncertainty was lifted, project funding was increased at Fermi. Also, in 1982, a significant milestone was reported in successful completion of RPV hydro tests. Turnover of skilled personnel had also improved due to recession.

In September 1981, the Advisory Committee on Reactor Safety (ACRS) issued a letter to the NRC generally favorable to the Fermi project. It indicated no major problems affecting licensing. It, however, advised Fermi of the need to retain expert start-up personnel on the project even after fuel load.

In February 1981, Senior Management set up a task force to study construction options, e.g., delaying the projects, sale and retirement of power plants. The task force recommended continuation of work at Fermi and completion as planned.

During 1982, efforts were shifted towards system completion and start-up. In February, 1982, a full-scale exercise of radiological emergency response plan was completed. In May, the turbine was placed on turning gear for the first time and the first emergency diesel generator was run. Systems were rapidly being transferred to start-up for testing; 38% of CAIO and testing was reported complete, mostly in the non-safety systems however.

Work was completed on the Technical Support Center and Office Services building annex. Modifications to the radwaste system and the on-site storage building were in progress and completed in early 1983. By June, 1982, 91% project completion was reported.

In July, 1982, a major milestone was reached by successfully completing RPV hydrostatic testing after a delay of almost two years. For the first time, both cooling towers were run together at full flow. Significant torus modification work, started since 1978, was completed.

In July, the Fermi 2 estimate and schedule was revised. The new estimate was $2.35 billion with expected fuel load date of June 1983, C.O.D. of November 1983. Favorable responses were received from the NRC, Atomic Safety Licensing Board (ASLB) and the Atomic Safety Licensing Appeals Board (ASLAB).

A second major milestone was reached in December 1982 with the successful completion of Flow Induced Vibration Testing (FIVT).

Ninety-four percent physical completion was reported by the end of 1982.

Several new and unresolved problems continued to impact work progress and testing throughout 1982. Some of these included: drywell steel modifications, vibration in RHR pump, diesel generator wedge problems, slab-over torus, rattlespace and cable tray hangar installations.

All of these seriously impacted schedule. By July 1982, it had slipped by at least six months. Moreover, each individual activity was behind planned schedule. Once again, the schedule was revised (unofficially though) to December 1983 fuel load. By now, Edison was directly controlling major segments of the project through SCO, start-up and direct contract administration (Bechtel, Comstock, etc.).

In early 1983, Edison took a number of serious steps to meet the December 1983 fuel load and to bring the problems to a successful resolution. Mr. W. Holland was brought on site in November 1982, to supervise all construction, engineering and start-up activities. The size and authority of the start-up group was expanded to drive the project. Deficiencies in the start-up group were corrected by hiring a large number of outside start-up experts from S & W, Bechtel, GE and others.

In 1983, Senior Management significantly increased its attention and direct involvement in the day-to-day decisions and site activities. Plant walkdowns and management meetings increased in frequency. The Board of Directors were also taking more keen and individual interest in the project activities. One formal Board of Directors meeting was held at the site. All of this was designed to emphasize the seriousness and importance that Edison Management placed on Fermi 2 completion. The Staff gained first-hand knowledge of these actions as the investigation team was on site during this period.

Significant progress was made in 1983 to reduce the number of punch list items (23,000 to less than 5,000) and completion of instrument control work units. Edison also utilized the opportunity to perform IHSI treatment of critical welds and a few other post-commercial activities. Many contractors were being demobilized in anticipation of project completion by the end of the year.

An assistance audit by the Institute of Nuclear Power Operations (INPO), an industry self-evaluation group, pointed out several deficiencies in the operator training program. Edison took immediate and vigorous actions to beef up the program with very successful results.

In May, 1983, a new cost and schedule estimate was released, although these were well known to the project personnel. The revised official estimate was $2.7 billion with a December 1983 fuel load. Staff discussions with the NRC resident inspectors and NRC reports indicated less optimism. Their prediction was a probable fuel load date of June 1984. Edison Management, challenged the NRC position (Summary of Caseload Forecast Site Visit, June 7-9, 1983). The NRC, however, expressed general optimism and stated that the plant is essentially complete.

Good progress in testing, system completion and nuclear operations readiness brought significant optimism to the project during August and September of 1983. Although schedule slippage of two or three months was still possible, the project was beginning to see the "light at the end of the tunnel". The first batch of fuel was brought and stored on site on August 14, 1983. Successive batches were received over the next several weeks. IHSI treatment was successfully completed in less than budgeted time and money.

In April 1983, the Electric Cooperatives who owned a 20% share of Fermi 2 and were currently paying their share of project costs expressed serious concerns as to the project completion. Further, they were seeking a revision in the agreement to limit investment in the project.

In July, the Co-Op agreement was revised to incorporate the following:

1. The level of Co-Op's investment will be frozen when the project cost reaches $2.7 billion.
2. The Co-Op share will be correspondingly reduced if the project cost exceeds $2.7 billion.
3. The buy-back agreement was modified to extend over a period of 15 years.

The Co-Op's suggestion of a capacity factor incentive provision was rejected by Edison.

In October, 1983, the project received a setback in two critical path areas. The drywell steel modification which had been ongoing in several phases since 1982 was discovered to be far more extensive. Testing of several systems must wait while the modifications in the drywell are designed and installed. A large contingent of design engineers from S & L were brought on site to complete design work by December 1983. (Installation was to be complete by February 1984.)

A second persistent problem was the vibrations in the RHR pumps. Earlier, Edison and GE had failed to isolate the cause of vibrations--considered serious and unacceptable. Several "hit and miss" fixes were proposed and adopted including bypass valves and ordering a new check valve. Finally, problems were isolated in the pumps as the primary cause of vibrations. In December 1983, the pumps were being repaired in GE facilities in California and expected to be delivered back at the site in early 1984.

In November 1983, Edison announced the last, and hopefully final, estimate and schedule for Fermi 2. The revised cost estimate is $3.075 billion, fuel load of June 30, 1984 and commercial operation date of December 1984. The plant is assumed to be 98% complete.

By now, Edison had run out of reasons and excuses for any further delays. According to the Company pre s release announcing the revised schedule, the latest delay was not due to any regulations or outside factors but directly related to the equipment, testing and start-up procedures.

CHAPTER 3: PROJECT MANAGEMENT, DECISIONS, PERFORMANCE AND CONTROLS

A. General

In this chapter, all of the issues identified in earlier chapters are fully discussed in detail. During the course of the investigation, the Staff learned of many new issues which have impacted the project performance, cost and schedule. These have been identified and discussed.

As a general proposition, the Staff found three broad categories of issues:

a) Issues which were primarily decided by and within the control of the Edison Management. Principal examples of this are:

- Pre-construction decisions such as selection of the system configuration and the NSSS, major AE, vendors and contractors, and project organization.
- Financial and other resources employed on the project, including construction shutdown, Co-Op agreement, etc.
- Senior Management role, involvement, philosophy and overall commitment to the project.

b) Issues which developed during the course of the project primarily as a result of interaction of various events and decisions which were directly or indirectly influenced by Detroit Edison. Examples of this are:

- planning and scheduling functions
- engineering and design group performance
- worker productivity and performance

schedule and cost estimates, project delays, document control, procurement functions and performance.

c) The third category of issues are those which occurred basically due to outside events and which Edison could not control. Edison role was limited only to a proper and adequate response. Examples of this include:

- Regulatory changes: mandatory and suggested (including MPSC regulations).
- Three Mile Island and Browns Ferry accidents.
- Economic and financial conditions within the state and the nation.
- Availability of skilled resources necessary for successful completion of the task.

The three categories of issues are not mutually independent. On the contrary, one set of conditions, say inflation and interest rates, can strongly influence all other aspects of the project. It is useful, however, to bear in mind the three classes of issues so that a separate, but consistent, set of criteria is applied in evaluating different types of issues. For instance, when judging the performance of the engineering design group, factors such as experience, supervision and design control functions are the dominant evaluation criteria and not the financial restraints or availability of skilled trades.

In developing an issue, attempt has been made to present all facts and viewpoints known to us. For this reason, issues may suffer from extreme detail. In most cases, contrary positions have been discussed. The final Staff position on an issue is the judgement of the Staff based on consideration of all the factors. An effort has been made to cite documents or other evidence in support of the position. In some cases, personal opinions, observations, comments and recollections have formed the basis of Staff position--but only after the Staff is satisfied through independent verification that the position is reasonable.

One difficulty in analyzing a project of this nature is the fact that it has been going on for such a long duration. Many individuals have worked on the project over the years. Recollection of events and decisions is difficult and varies between individuals. Secondly, even though the project has generated massive documentation of key decisions, evaluations and discussions, many underlying factors, often the true reasons for a decision, may still be expressed through verbal communications. The Senior Management confirmed during our interviews that this was generally their style of involvement and decision making on Fermi 2.

Finally, in recommending disallowances when an issue is found imprudent, the Staff has exercised its best judgement to derive a reasonable relationship between the level of disallowance and the nature and degree of imprudency. In many cases, it has been impossible to identify the exact dollars associated with an issue. The Edison project people have acknowledged this inability. The Staff has, in many instances, taken the second best approach and estimated the costs associated with an issue. The Staff feels confident, however, of the reasonableness of its estimates.

B. Vendor/Contractor Selection and Performance

1. Pre-Construction Decisions, Engineering Committee

One of the most crucial phases in the nuclear project is the selection of major systems, equipment and the selection of vendors who can supply such equipment. Equipment must be selected on the basis of safety, compatibility, performance and cost-effectiveness between alternate choices. Similarly, criteria for vendor selection must be: experience with similar jobs in size and quality assurance, reliability of performance to deliver equipment on time, ability to accommodate design changes, ability to interpret and communicate with the owner, constructor and quality control personnel and, above all, the overall economic evaluation.

The choice of equipment and vendors for major systems was determined very early in the Fermi 2 project. The evaluation process started in 1966, two years prior to announcement of the project. Between 1968-70, most major equipment and vendors were selected and awarded. The evaluation of options was performed by the General Engineering Department of the Company. Their evaluations were then presented to the high-powered Management Engineering Committee. Decisions of this committee were subject to approval by Mr. Walker Cisler, then chairman of Detroit Edison. (See Engineering Committee minutes.)

Detroit Edison has the document "Enrico Fermi Project Procedures Manual". This manual details, among other things, the guidelines for project procurement procedures. A key element of this procedure is preparation of Purchase Analysis Review (PAR). This document must be prepared for every major contractor and vendor. It identifies the bid process, the quotes and evaluation of bids, and final recommendations.

The factors to be considered for bid analysis as listed on the PAR are:

Lowest price
Best quality
Past service
No competition
Replacement parts
Engineering preference
Delivery, and Management decision.

A detailed ranking order is developed for each vendor/contractor. In the case of major equipment, although all these factors were considered, generally the final decision was done at the management level.

The PAR is a contract document which contains the history of the contract, all change orders, budget provisions and actual expenditures.

To evaluate the equipment and vendor selection process, we reviewed reports of the Engineering Committee, presentations by the Generation Engineering Task Force on Fermi and the PARs. We also interviewed several persons who were associated with that phase of the project. In general, we were impressed with the knowledge of the technical details of the Edison personnel.

The evaluations for system and equipment selection were quite exhaustive and detailed, complete with charts and tables. Often discussions surrounded system optimization, economic effectiveness and life cycle costing. The pros and cons of various options were laid out clearly and thoroughly debated. (For examples of these, see Evaluation of Cycle Optimization and Reactor feed-pump selection.) The fact that senior Edison Management was engineering-oriented facilitated the communication and understanding of the technical details. Decisions could be made rather promptly. Frequent use was made of outside experts and consultants to independently evaluate the systems and equipment before their selection.

In our judgement, it was Edison philosophy to stay with the proven design with minimal deviations. This was a basic factor in choosing the containment and vessel, steel vs. concrete structure, radwaste system, feed water reheaters, demineralizers, etc. It should be recognized that actual design, construction and operating experience of the nuclear industry was still quite limited in the late sixties. The licensed suppliers of systems, equipment and installers were very few and offered a narrow range of options. The cost estimates assumed for any economic evaluation were not plant specific. Generally, the estimates on systems and subsystems were derived from experience at other jobs--prorated for size, scheduling, location, etc. At best, they were crude approximations.

Another guiding principle for design basis at Fermi 2 was that it was to be designed as a stand-alone unit with no regard for an additional unit. Fermi 3 was being conceived at the Fermi site, but not until 1980, if then. This was made clear in a memorandum from Mr. W. J. McCarthy to the project task force, dated November 10, 1969. It reads:

> "This is to confirm the conclusions reached at the Engineering Committee meeting of Nov. 8, 1969. These conclusions are largely based on the present system planning forecast which does not foresee a second light water cooled reactor at Fermi site until 1980, if then.
>
> These conclusions can be summarized as follows:
>
> 1. The capacities of equipment and systems provided for Fermi 2 unit shall be selected without regard for possible later addition of an adjacent light-water-cooled reactor which might be able to share some common equipment and systems with Fermi 2.

2. Design decisions on Fermi 2 shall be optimized on the basis of a single self-contained unit, subject to the proviso that no steps shall be taken in design of Fermi 2 unit which foreclose or make extremely awkward the possible later addition of, or efficient combined operation with, an adjacent light water cooled reactor."

The vendor selection was a broad based process. Bids were invited from vendors who had dealt with Edison in the past, recommended by consultants or had experience at other known jobs. Both domestic and foreign vendors were invited. In some cases, unsolicited bids were submitted and accepted, as in the case of turbine generator - Westinghouse and General Electric submitted such bids. In some cases, such as NSSS system, the choices were extremely limited.

The bid evaluation process was rather exhaustive, complete in detail and considered first cost and operating features. Weights were given to various factors and ranked. In our judgement, Edison Project Managers did a reasonably good job of vendor selection. In this section, we shall select a few major equipment and vendors and analyze their performance in-depth, evaluate the erection phase, design deficiencies and overall vendor performance, Project Management role, etc.

However, first, the following three examples which illustrate the reasons for our general satisfaction with equipment vendor selection and evaluation process. The examples are taken from the Engineering Committee minutes.

1. <u>Reactor Feed Pumps and Drives</u>

Edison Project Engineering developed the design parameters. From operating efficiency and reliability considerations, it was determined that two pumps will be required to meet full load plus margin (15%). Each pump must be capable of supplying 65% of the two pump design point (design graphs were presented and reviewed).

- Bids were requested of DeLaval, Byron-Jackson, Pacific and Ingersoll-Rand. KSB, a German firm, asked to be allowed to submit bids.
- Two alternate designs: diffuser design and double volute design were submitted. KSB and Byron-Jackson submitted the latter design.
- Edison preferred the diffuser type, as they generate and transmit lesser pressure pulsations to interconnector piping.
- Next, material and performance characteristics of each pump were compared for each bidder.
- The experience record of each bidder was evaluated.

  Byron-Jackson was the only bidder with pumps in actual operation--six units at AEC facility in Hanford. DE was unable to inspect these. B-J had 30 more units (5 tested) on order. DeLaval had 18 units (2 tested) on order.

  No other bidder had units in operation or on order.
- The cost comparisons, including allowance for fuel penalty, showed that B-J was $1600 lower than DeLaval. Performance-wise, DeLaval had the best efficiency.

The selection of reactor feed pump was deferred until the turbine drives were also evaluated.

The drive bids were obtained from GE & DeLaval. Westinghouse declined to bid, while English Electric submitted a preliminary bid; the detailed bid to be submitted by EE only if their offer looked competitive--it did not.

Essentially, therefore, only GE and DeLaval bids were evaluated in-depth.

Both offered acceptable material, with DeLaval having superior casing with 12% chrome, compared to carbon steel casing from GE. The double-flow exhaust design of DeLaval indicated better efficiency than GE's single-exhaust. GE had far greater experience in the non-military nuclear units, while DeLaval had large navy and marine experience. GE offered a 12-month warranty from initial operation; DeLaval offered 18 months from the commercial operation.

Price-wise, DeLaval was $198,000 cheaper than GE. Further, it offered a $21,000 discount if both feed pump and turbine were ordered from DeLaval. Therefore, it offered about a $219,000 advantage over the next bidder. Further, management determined that it was advantageous to have both pumps and drives from one supplier (better communication, inspection and responsibility). Thus, the decision was made in April 1970 to place an order for reactor pumps and drives with DeLaval, based on performance and cost-effectiveness (it is useful to emphasize here that differences of $100,000 or $200,000 appear rather minor when compared to current project costs running into billions. However, back then, in 1968-70, these amounts were significant when the total project estimate was $228 million).

2. Main Unit Transformers

Bids were solicited from 14 bidders; nine of which were foreign. All bidders were pre-screened and found acceptable. The bids prescribed three options:

- a full size, 3-phase, 1270 mva
- two half size, 3-phase, 635 mva, and
- four third size, 3-phase, 425 mva

Edison determined that the recent history of their transformer failures and failures at other utilities (in Ohio and Florida) suggested that a single main unit transformer for a unit of this size was unacceptable. The two half-size transformers were more attractive. The bids were, therefore, evaluated for this option.

- McGraw-Edison offered the lowest first cost bid; but when losses are taken into account, the bid from Ferranti, an English firm, appears to be the lowest. This firm had supplied 34 transformers in the U.S.A. of up to 400 mva range, and has repair shops in Toronto capable of all but major repairs. Five railroad cars are available in the U. S. for transporting transformers of 625 mva size.

  GE bids were 19% higher than Ferranti.

Ferranti was selected as transformer vendor. The committee members, Heidel and Meese, raised questions as to why Ferranti claimed smaller transformer losses when the overall weight and copper usage for two sources (Ferranti & McGraw-Edison) were the same. Their concerns were addressed.

3. Deaerating Feedwater Heaters

The following excerpt from the Engineering Committee minutes of Nov. 19, 1969 illustrates the discussion on this issue:

> B. Enrico Fermi No. 2
>
> 1. Award of Feedwater Heaters
>
> Mr. Sinnott introduced the subject by reminding the Committee that the feedwater cycle had been discussed in some detail at the last meeting and emphasized that the ability of the No. 5 heater to deaerate the drains was of critical importance. He asked Mr. Stanley to briefly review the approved cycle before leading into a discussion of the feedwater heater bids. Mr. Stanley

presented Exhibit 2 and Exhibit 2C showing the approved feedwater heater cycle with pumped forward drains and the location of the No. 5 heater in the cycle. He indicated the work duty in terms of oxygen removal imposed on the No. 5 heater. He presented Exhibit 3, an economic comparison of the offers submitted by Yuba, Sweco, Westinghouse, and Foster Wheeler. Yuba is the lowest bidder by some $94,291. Mr. Stanley presented Exhibit 4, a cross section of the Foster Wheeler No. 5 heater, and described its deaerating features. He next presented Exhibit 5 and described the method by which Sweco proposes to deaerate drains in the No. 5 heater and then discussed the design shortcomings in the method of oxygen removal that Yuba has proposed and is shown on Exhibit 6.

Mr. Stanley indicated that the method proposed by Yuba would be entirely acceptable in a conventional heater layout but in his opinion would not perform the duty required in the Fermi cycle. He next presented Exhibit 7, a summation of quality assurance, shop facilities, venting, ability to deliver, and oxygen removal guarantee and indicated that Yuba and Westinghouse could not be considered satisfactory suppliers for the No. 5 heater. The designs submitted by Foster Wheeler and Sweco are considered acceptable designs for this purpose by the engineering and operating departments. Mr. Anderson asked if any opportunity would occur in which a Yuba feedwater heater of the design proposed could be checked in order to determine its ability to remove oxygen. Mr. Stanley reported that there are none in service encountering the oxygen removal requirements required by Fermi. Mr. Meese asked if Detroit Edison has any other Yuba heaters in service and was told that we have Yuba heaters at Harbor Beach.

Mr. Meese asked if Sweco were large enough and had sufficient financial stability to be able to undertake the furnishing of the Fermi feedwater heaters and was told that they were capable of handling an order of this magnitude. In response to Mr. Meese's question, Mr. Stanley reported that P.E. Heidman, R. Gies, L. Schuerman, and J. Carey had recently inspected the facilities of both Yuba and Sweco. The opinion of the inspecting group was that Yuba was probably the lowest on the list of bidders as far as quality assurance and shop conditions were concerned. Mr. Drummond asked why Foster Wheeler was so much higher than the other bidders and was told that Foster Wheeler is primarily a high-pressure heater manufacturer and cannot be truly competitive in a low-pressure heater offering. Mr. Sinnott reported that the apparent reason that Sweco appeared to be far ahead of Westinghouse and Yuba in the design of a deaerating heater of this type was that they had been working closely with GE to provide heaters with high oxygen removal capability. Mr. Stanley recommended and the Committee agreed that the feedwater heater business should be placed with Sweco. Mr. Meese asked Mr. Anderson if he had any concern because the lower bidder had not been accepted. Mr. Anderson said the explanation as given by Mr. Stanley was entirely satisfactory and the Purchasing Department had no objection to placing the business with Sweco. Mr. Zavitz reported that the delivery of design information promised by Sweco appeared to be in good order. Mr. Anderson added that a drawing submittal requirement would become a part of the contract with Sweco. Appended to the minutes is a copy of R.E. Barry's memo of November 12, 1969 comparing contact time for various sizes and shapes of falling water from the standpoint of deaeration. This information was part of the discussion on deaeration and the memo was received subsequent to the meeting.

These are only three examples of numerous vendor awards that we examined. Based on this, the Staff is convinced that the process was:

- logical, technically sound and detailed;
- the economic evaluation of options--design, equipment and vendor bids, and assumptions was prudent and reasonable, given the cost estimates;
- the people making technical reviews were experienced, qualified and knowledgeable. Adequate outside expert assistance was obtained wherever needed (e.g., hired S & L, Dames & Moore, and GE for expert reviews);
- the senior management was sufficiently involved in making major decisions.

One does not conclude from the above that the decisions made turned out to be correct, only that the process was reasonable and prudent. Nor did we make an independent verification of the design criteria and parameters. Further, how effectively these decisions were implemented will be reviewed in this section for a few systems and equipment.

A final observation in this regard is that the equipment bids were issued in a relatively short period. By 1970, most major equipment or systems were on order. We conclude that there were at least four identifiable reasons for this:

a. As mentioned earlier, good technical communication between Project Engineers and the Management enabled prompt decisions on the issues. Further, general approach to stay with proven design helped expedite decisions.

b. General increase in nuclear power plants placed severe demands on vendors and contractors. Equipment must be ordered early to receive vendor priority. For example, NSSS suppliers did not build equipment specific to the unit. The vendor would build up to its capacity common equipment, which would be shipped to whoever was ready to receive it.

c. It seems Edison was adopting the so-called "fast track" approach. This was a relatively recent approach to large construction projects. Under this concept, procurement and construction start off early on "long-lead" time items, while design elements are still being developed. This incremental approach to construction allows an early construction start. A benefit of this concept is that, in theory, it reduces inflation effects and construction duration. However, it also reduces the overall job coordination and optimization. Further, this method does not lend itself to fixed price contracts, since work packages are not complete.

d. It appears that Edison had set a February 1974 completion date by edict. Every action was geared towards meeting this date.

Some say that this date was chosen for a purpose. Detroit Edison Management wanted Fermi to be a showpiece of nuclear power in preparation for the World Power Conference in May 1974, in Detroit.

As the project personnel realized, the schedule began slipping quite fast in 1969-70, and soon the 1974 deadine became totally unrealistic. Next, we shall analyze in some detail, procurement, award and performance of selected major systems.

2. General Electric as NSSS Supplier

Edison performed an early evaluation of the source and type of NSSS. In the years 1966-68, bids were requested from the four domestic NSSS suppliers: GE, Westinghouse, Combustion Engineering and Babcock-Wilcox for 800 MW units. The first one is a BWR supplier, while the others were PWR. GE and Westinghouse also submitted unsolicited bids for 1100 MW class systems. Later, Edison also requested formal bids from all four for 1100 MW class systems. Combustion-Engineering did not bid due to inadequate time.

Edison hired the design and construction firm of Sargent & Lundy (S & L) to evaluate the bids and provide an independent assessment of the NSSS systems and estimates. Economic evaluations showed that 1100 MW units have cost advantage over 800 MW units: $185/kw vs. $220/kw.

Edison decided to construct an 1100 MW-class BWR unit. With this decision, Edison was constrained to purchase the General Electric system since they were the only BWR suppliers. Edison also chose the containment and vessel design and configuration, then being offered and operational at other BWR's. Specifically, the configuration was a BWR 4 containment and Mark I vessel, with torus suppression chamber and light-bulb shaped drywell. Mark I is the earliest BWR design. A more advanced design called Mark II was being developed by GE at the time. As stated earlier, Detroit Edison chose to stay with the proven design.

In August 1968, Edison placed an order with GE for supply of NSSS System for Fermi 2 unit, with option to purchase a second same-size unit at a later date.

The value of the contract was $44.5 million, as follows:

NSSS:		$33.8 million
First Core Fab:		9.2 "
Radwaste System:		.9 "
Fuel Pool Cooling & Filtering System:		.16 "
Accident Calc. & Consulting Services:		.42 "
	Total	$44.5 million

The contract delivery date was September 1971.

Independent equipment evaluation by S & L for the GE bid was $33,875,000, excluding fuel.

The other two quotes were (NSSS only):

Westinghouse	$34,375,000
Babcock & Wilcox	46,000,000 (firm)

The GE contract award was a fixed price with provision for escalation adjustment for material (35%) and labor (55%). The remaining 10% was to remain fixed. Material escalation would use "Steel Mill Products Index", published monthly by the Bureau of Labor Statistics. Similarly, labor escalation adjustment used "Index of Average Hourly Earnings Rate in the Electrical Equipment and Supply Industry".

The GE, NSSS contract included supplying equipment, i.e., reactor pressure vessel, internals and auxiliary, plus supervision of erection, but not erection itself. All manufacturers of NSSS system declined to bid on erection at that time.

Subsequently, in October 1973, Edison signed a contract #1A-92100 with GE - I&SE (Gen. Elec. Installation and Service Engineering Dept.) for installation of RPV internals and control rod drives.

A second decision was the erection and structure of the containment. In 1968-69, S & L evaluated two alternates: a concrete structure vs. steel structure.

The estimates showed that the former would cost about $400,000 less than the steel structure. The main reason against it was that concrete structure had not been in operation or licensed at the time. (The Shoreham Unit had a concrete structure under construction in 1969. In 1970, P P & L ordered a Mark II concrete containment unit for Susquehana.) The AEC had raised upwards of 100 questions on the licensing of a concrete structure. Further, Chicago Bridge & Iron (C B & I), who was being considered to erect containment, had a complete design package ready for a light-bulb steel structure. The concrete structure, on the other hand, would require a re-design. Some cost advantages, therefore, could disappear due to the redesign work.

Prior to selection of the primary containment erector, Edison General Engineering developed detailed comparisons of cost estimates by C B & I at other jobs.

At its meeting of November 19, 1969, the Engineering Committee discussed at length the award of primary containment to C B & I. Although the decision had previously been made to select C B & I for the job, some of the design parameters and economic factors were being reviewed. Some of the issues included:

- C B & I is the only completely qualified supplier of primary containment structures in the country. They have the ability to design, construct and interface with the AEC on behalf of the client.
- Another group, Pittsburgh-DeMoines, was erecting primary containment but has no design capability.
- The EF2 containment will be designed at 62 psig, and 281°F., it will be tested at 1.25 design pressure.

- Peach Bottom unit of Philadelphia Electric was a comparable unit in size and time. Its estimate is $400,000 less than EF2 because Peach Bottom is a 2-unit package deal. Also, it was committed a year earlier.
- Costs were also compared with Georgia Power's Hatch #1 unit, scheduled in 1973, yet $400,000 lower than EF2. Engineering response was that it was an 800 MW unit and committed two years earlier.
- Tear drop vs. light bulb configurations were also evaluated. Light bulb/torus was selected as it would be $270,000 less and more conventional.

Staff Analysis

Based on review of Engineering Committee analysis and discussions, availability of alternatives, and limited number of suppliers, the Staff believes that:

1. Selection of General Electric as NSSS supplier was prudent and reasonable. This assessment is predicated on the assumption that Edison had decided to go for the BWR unit. We did not evaluate this decision of Edison's. The NSSS decision was largely dictated by their philosophy to stay with proven design--but optimized to the specific needs. There is persuasive evidence that Edison Engineers and Managers were competent, knowledgeable and performed necessary evaluation of all feasible alternatives. The tendency to stay with proven design and parameters is reasonable given the fact that this was their first venture into a commercial nuclear unit.

2. Edison obtained expert technical assistance from S & L before final decisions were made. The 1100 MW Unit had a price advantage over the 800 MW.

3. The terms of the contract were reasonable in that it provided only for adjustments in material and labor rates based on B.L.S. indices.

4. The delivery schedule of September 1971 established by Edison appeared reasonable, considering the commercial operation of the unit in February 1974.

Other Auxiliary Contractors for NSSS

In addition to the General Electric NSSS contract (agreement #1E-83800), Edison hired a number of other contractors to provide services and material. The General Contractor, Ralph M. Parsons, was overall in charge of contract administration.

1. Reliance Truck Company of Phoenix, Arizona (contract #1C-70092) "To provide unloading, transport and setting in of RPV".

This was a lump-sum contract for $645,000. The RPV was to be set in the reactor building between September and October 1972. As it turned out, due to delays and other reasons (see GE contract: RPV distortion and repairs), the vessel was installed around July 1974.

The final price for transportation, unloading and RPV set-in was $1.1 million. The main reasons for higher expenses were escalation due to delay in installation and changes in scope.

Contractors performance was satisfactory. No accident or damage occurred during this activity.

2. In October 1973, General Electric - Installation and Service Engineering Dept. was hired under separate contract (#1A-92100) to

"Erect Reactor Internals System and control rod drive system and all associated specified equipment, materials and systems".

"GE shall furnish all labor, tools, erection equipment, and all items necessary to accomplish the work".

The contract was for a lump-sum amount of $2.93 million. Other bidders were Reactor Controls and Foster-Wheeler. They were rejected on the basis of less experience.

A detailed review of contract agreement with GE-I & SE very much impressed us with Edison contracting skills. It had several positive features for Edison:

- A $30,000 incentive bonus if GE finished work on time or sooner.
- The contract was thorough and compensated Edison for delays and damages due to contractor errors, demurrage and other charges.
- $3,000/day compensation to Edison by GE if it fails to meet the May 1, 1976 deadline.
- Edison has the option to delay work if to its advantage, and suspend GE work. The completion dates may then be renegotiated.
- GE shall submit a detailed (CPM) schedule of erection.
- If Edison directs GE to expedite work, it will compensate GE for actual craft hours plus 20%.
- GE shall work under the direction of General Contractor.

- GE shall warranty all equipment, material and service to comply with applicable design, specifications and workmanship. This warranty shall expire one year after reactor operation at 50% or higher level.
- GE shall perform all repairs necessary under this scope of work.

It is interesting to note that in 1973, Edison was able to enter lump-sum contracts with favorable performance guarantees. The work began in July 1974 and was suspended in December 1974.

In 1976, GE - I & SE advised DE of their concern about extended shutdown, the technical changes and the change to Daniel as Construction Manager. GE requested a change to a cost reimbursible contract with incentive provision. GE expressed difficulty in identifying the balance of the work. Due to similar problems at other projects, GE was no longer accepting fixed price jobs.

The Edison negotiating team reviewed the GE offer and made the following recommendations:

(1) GE has informed DE that they will not complete the work under present contract.

(2) Continuation of work under GE is the only option for Edison to meet September 1980 C.O.D.

(3) Continuing with GE will allow maximum salvage of work already completed. GE had been paid $750,000, of which $300,000 will be lost. Additional termination charges of $200,000 may also be incurred.

(4) Changing to a cost reimbursible contract will provide added flexibility to incorporate technical changes and drywell engineering can be better handled by GE due to their experience.

(5) Verification at Philadelphia Electric showed that the GE renegotiated offer was reasonable.

(6) Daniel, the CM, was in agreement with the Edison recommendation to continue with GE.

In 1977, the cost plus agreement was accepted. Performance of GE I & SE work was less than satisfactory. In May 1979, (CO #25) a $100,000 penalty was assessed against GE because, as per contract, the manhours had overrun by 29,452 from the base estimates. The cost of this installation was increasing rapidly due to scope changes, rework and low productivity. GE exceeded their manpower target by a factor of three. They were demobilized in September 1979 after they had completed an estimated 60% of the work and expended 162,000 manhours vs. the target of 116,000 for 100% completion. Edison seemed unhappy with GE performance. They were paid $9.2 million. Reactor Controls, who had bid on the job in 1973 and again in 1976, was now called in to complete the installation of reactor internals and control rod drive system. The RCI bid for remaining work at $3.4 million in 1980. By December 1982, RCI had been committed more than $20 million and still was not done. More discussion of this later.

3. Inland Ryerson Construction Products Co. (#1M-92300) for "Detailing, Fabrication & Furnishing of Reactor Building Drywell Structural Steel".

Contract Price: $560,000 (firm)

Several revisions were made in this contract, principally due to the insufficient design definition by Edison at time of contract; changes in scope (see CO#1, 2, 3, 9).

The changes did not seem to impact schedule. Several back charges were initiated by Edison. Some were not collected, e.g., Back charge

J5044 for $2,719: Repaint job

J5149 for $125,317: Rework drywell steel

J5162 for $20,790: Loading, unloading DW steel

J6825 cancelled - piece scrapped Rework Pedestal Support

Generally, performance of this contractor was acceptable.

Performance of General Electric Contract for NSSS Supply (IE-83800)

GE was one of the first and the most critical contractor from the Fermi 2 standpoint. Their commitment was not only through supply of material and service for the construction phase, but beyond into fuel load and commercial operation. In our judgement, both GE and Edison recognized the need for an honest, fair and equitable relationship throughout the project. Mr. Charles M. Johnson has been the GE Project Manager for Fermi 2 since 1968. The Staff twice met with him.

As the project stretched out, scope and regulatory changes, redesign, and rework all brought frustrations to both parties.

Our interviews and document reviews indicate that both sides attempted to maintain a professional and cooperative relationship.

Between 1968 and 1982, there were at least 66 major contract revisions, some involving more than one change.

(a) Cost Increases

- NSSS cost increased from $35 million to about $92 million by December 1982. Although this is a 2.5-fold increase, it compares very favorably with overall 11-fold project cost increase.

- Most of the increases were due to a delay in the project.
- In 1977, GE asked for and got a time and material cost adjustment for the remaining project. Other significant changes include:

	Amount
11/74 CO-32: Warranty Extension to 7/79	$1.5 million
6/77 CO-50: Warranty Extension to 10/80	$3.98 million

This contract revision provided for delay claim, Home Office Service under T & M, site overheads, etc. Analysis by Edison auditors showed a $880,000 advantage for Edison, so the revision was accepted.

11/77 CO-52:	Edison asked to replace obsolete computer HS-4010 with HS-4400. Old equipment salvaged.	$1.14 million
4/78 CO-53:	GE tech. direction & start-up serv.	$2.00 million
11/78 CO-55:	Inst. repairmen to supplement Edison work force during pre-op. GE selected as they have better BWR experience, better mgt. control, GE personnel better qualified.	$1.50 million
12/80 CO-61:	Extend engg. & warranty to 12/83; home office; legal, QA and procurement, site direction; licensing design and installation support. T & M rate raised by 12%; start-up technicians ($9.9 million).	$18.00 million
3/82 CO-64:	ATWS work	$1.1 million

A review of individual change orders shows that they were generally reasonable; Edison performed independent estimates against the vendor quotes before acceptance. Investigation team is satisfied with GE cost escalations for NSSS.

(b) Schedule Performance:

GE seemed ready to deliver equipment on time. As is evidenced from revisions, most delay claims came from GE against DE. The only possible delay in the early stage was due to RPV repair problems mentioned elsewhere, the responsibility for which was under dispute.

The investigation team is satisfied with GE schedule performance.

(c) Back Charges:

In the long course of the project, hundreds of back charges were generated against GE. We found GE to be generally conciliatory in settling disputed items. A review of back charge report shows that Edison was able to collect some direct labor and equipment replacement from GE, though not overheads. GE seems to have a better record in this regard. Some others, principally English Electric (turbine vendor) and Schreiber Manufacturing, were not so cooperative (see Staff Request 116, 167 on Back Charges).

Although both General Electric and Detroit Edison have maintained good working relations, they have also acted in a businesslike manner to protect their respective interests.

- Edison was often in a weak negotiating position. General Electric was the sole licensed supplier of much of the safety equipment and spare parts. It had expertise on

BWR not available from other sources. Edison's own inexperience in nuclear design made it dependent on GE. There is no evidence that GE exploited this position, but they did protect their interest and were tough bargainers.

Early in 1973, during the construction of RPV (GE had subcontracted the RPV fabrication to Combustion Engineering at Chattanooga, Tennessee), a dispute developed due to damage to RPV.

(a) Cracklike reflectors in 5 nozzles were found during ultrasonic testing at C E shop.

(b) GE demanded that Edison issue a purchase order before repair work could proceed.

(c) DE issued a separate PO (IE-90227), under protest, to allow repair and fabrication to continue. Separate PO was to identify the rework costs. Estimated repair was $506,000.

(d) In Aug. 1973, during RPV-hydro testing, CE found that closure head would not properly fit on the vessel flange due to distortion. Again Edison, under protest, asked GE to proceed with the fix, which included refacing the flange, boring out holes and installing bushings in the holes. The total price for RPV repair was $902,000.

To settle the dispute, both parties entered a "favored nation" clause, whereby GE will make the same settlement as it may reach with Georgia Power at Hatch 1 unit on a similar issue.

The final settlement was offered by GE where DE will only pay the direct C E repair cost. GE will absorb its own costs. The settlement price--$769,000.

The Staff believes that this repair cost should not be borne by the rate payers. It is not evidence of imprudency of DE. If anything, it indicates an effort to recover the damage costs. Nevertheless, rate payers should not pay for costs resulting from faulty fabrication by the vendor.

The total disallowance after AFUDC (1974-82) is estimated at $770 x 1.20 x 1.73 = $1.6 million; where 1.20 is overhead multiplier and 1.73 is AFUDC multiplier.

- In 1975, GE filed a fuel fabrication delay claim. The claim for $6.5 million was based on underutilization of personnel and facilities. A second claim for $1.55 million was filed in October 1975 for fuel design and licensing work which will have to be redone due to new fuel design. GE refused to proceed with fuel fabrication until the claim was resolved. In September 1976, Edison made a $700,000 payment so that fuel work can continue during negotiations to "identify a mutually acceptable settlement". In November 1976, the dispute was settled for $4.0 million.

  A review of correspondence (see CO#2, 1A-75750) shows that both sides bargained hard to reach a resolution.
- To achieve increased fuel channel life, GE advised DE in September 1974 to increase from 80 mils to 100 mils. Edison issued a WCR under protest because they felt that the incremental cost should not be the Edison responsibility.

  Amount disputed: $458,000 ($335,000 in de-escalated 1968 dollars).
- Prior to shutdown in 1974, Edison requested GE to defer shipment of equipment scheduled to arrive during shutdown period.

GE, however, insisted on delivery and Edison received the equipment. Cash flow problems were important to both parties.

- During shutdown, Edison elected not to maintain lot of equipment which was already installed or stored with inadequate protection. For example, HPCI, RCIC turbines were ordered early and sitting in a reactor building, while craft people were climbing all over it, unprotected from dust, etc. After the construction resumed in 1977, GE insisted that in order to receive full protection of performance warranty, Edison must refurbish and perform continuous surveillance of the equipment. GE also advised that this should be undertaken soon so that Edison not get burned later. Refurbishment effort began in 1979, though seriously only in 1981-82.
- GE was often frustrated with the project schedule developed by Edison or its Construction Manager. GE found it unrealistic and not detailed. General Electric maintained a policy of non-interference in Edison's project management, selection of contractors, etc. In the early years, Edison often sought GE advice on contractor selection.
- Vibrations in RHR pump were a serious critical path item found during pre-op testing in 1981. (This issue is examined elsewhere in detail.)

  The dispute developed between Edison and GE because Edison blamed it on defective pump supplied by GE. GE felt no responsibility because they blamed it on the wrong valve selection by DE. The dispute is unresolved. A task force is performing an engineering analysis of the issue. GE has made several recommendations to solve the technical problem.

- Heat exchanger performance in RHR.

  GE admitted that one of its vendors was at fault. The restricted flow problem is solved by cutting out the last baffle. GE accepted picking up the cost of direct labor and material.

- CRD-HCU:

  An accumulator in the hydraulic control unit (HCU) was found corroded during the refurbishment. Upon inspection at a GE facility, water was found in the component. Edison claims it is a manufacturing defect. This dispute is not yet resolved. A 1/3:2/3 solution was being debated.

- A 1500-hp motor in the MG set which provides power for the recirculation system was found dried up on inspection. Each claimed the other party was responsible. A 50:50 solution was being discussed.

- Steam condensing mode deletion: Engineers at DE recommended deletion of this capability because they felt it was unnecessary and too complex to be safe. GE advised against it. The issue has been resolved (a detailed examination of this issue later).

- GE also has an unsolved claim on DE for $350,000 for services performed on regulatory issues.

Many of these issues and recommendations have been discussed in the section on "Pre-Op Testing and Start-Up".

3. Selection of Reactor Containment Vessel Design (Mark I) and Erection

The BWR's built in the early sixties have a Mark I containment design. This consisted of an inverted light bulb called drywell and a doughnut-shaped suppression chamber called torus.

During 1966-68, when Edison was developing the design parameter, the Mark I design was the only one available from GE. A slight variation in drywell known as teardrop design was available, but essentially with a Mark I design.

As mentioned previously, Edison generally held the philosophy to stick with the known and proven design. Another concern was that such design and construction was an "off-the-shelf" technology and, therefore, could be built sooner and cheaper. The 1974 deadline was a serious consideration to Edison.

Edison chose to stay, therefore, with the Mark I design. Some debate within the Engineering Committee centered on the teardrop design and the concrete containment, but these were not adopted. In 1970, an order was placed with Chicago Bridge & Iron to build a 68' diameter, light bulb type containment vessel.

In 1969, General Electric developed an advanced design containment vessel known as Mark II. Later, a Mark III design was developed by GE. The new design had several design advantages over the older design. The principal advantage being that the Mark II had more space inside the drywell and, therefore, was easier to construct. The newly adopted AEC regulations on pipe whip restraints required a large amount of piping, hangars and other equipment. The size of the containment was also an important factor in worker accessibilitv and maintainability. The Mark II design was slightly more expensive than Mark I. According to one

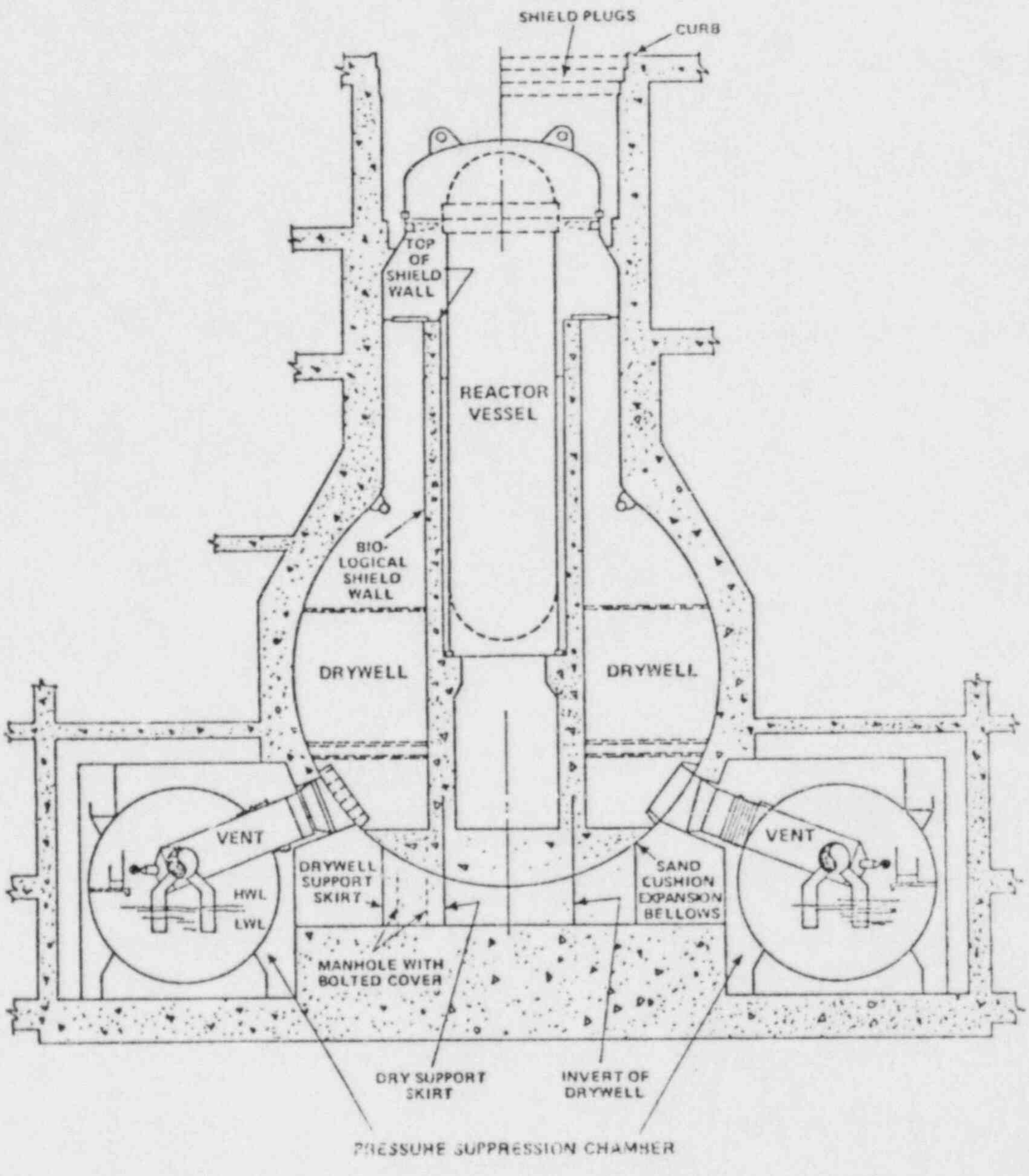

Fig. 1. BWR Light Bulb Torus Containment (Mark I)

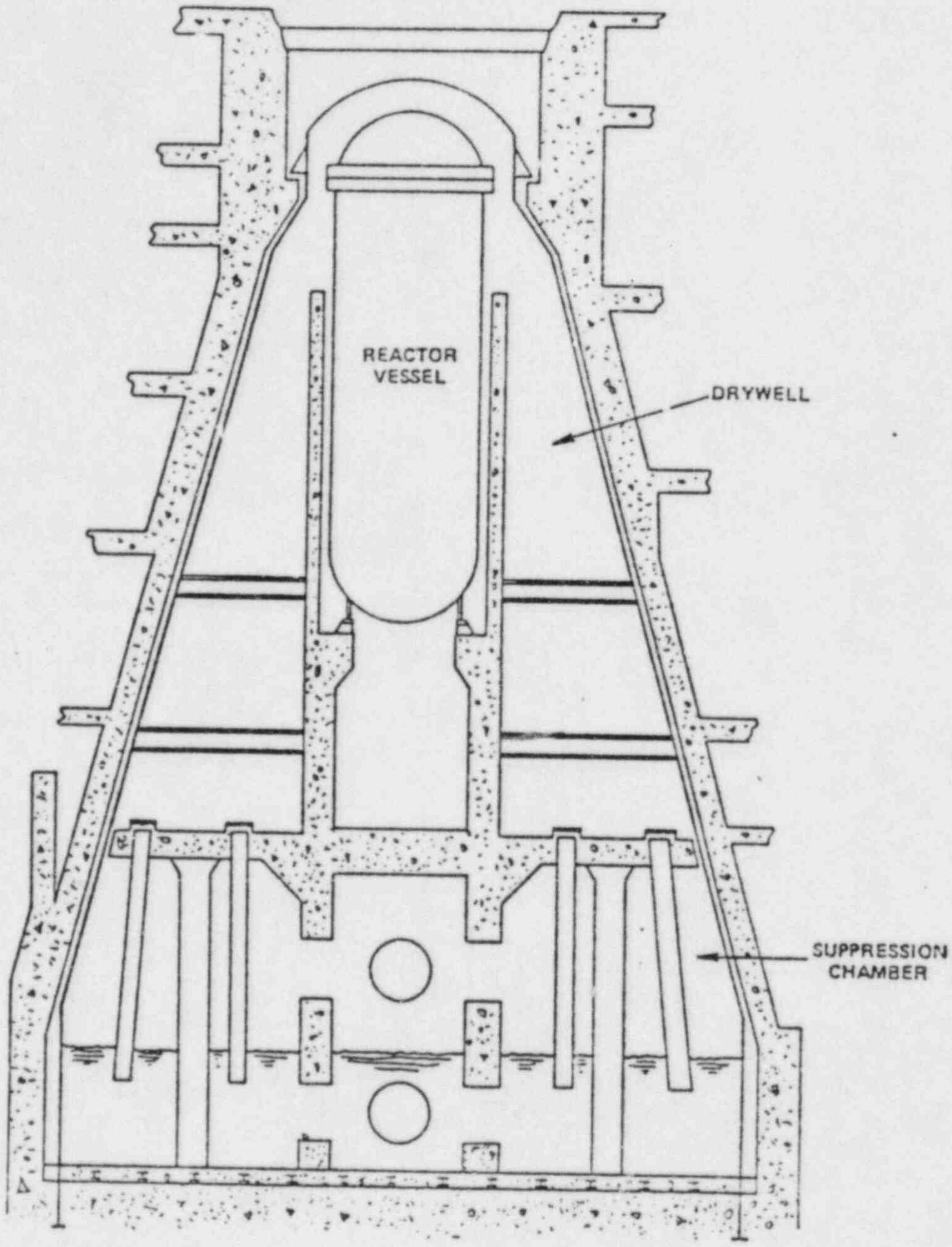

Fig. 2. BWR Mark II Containment

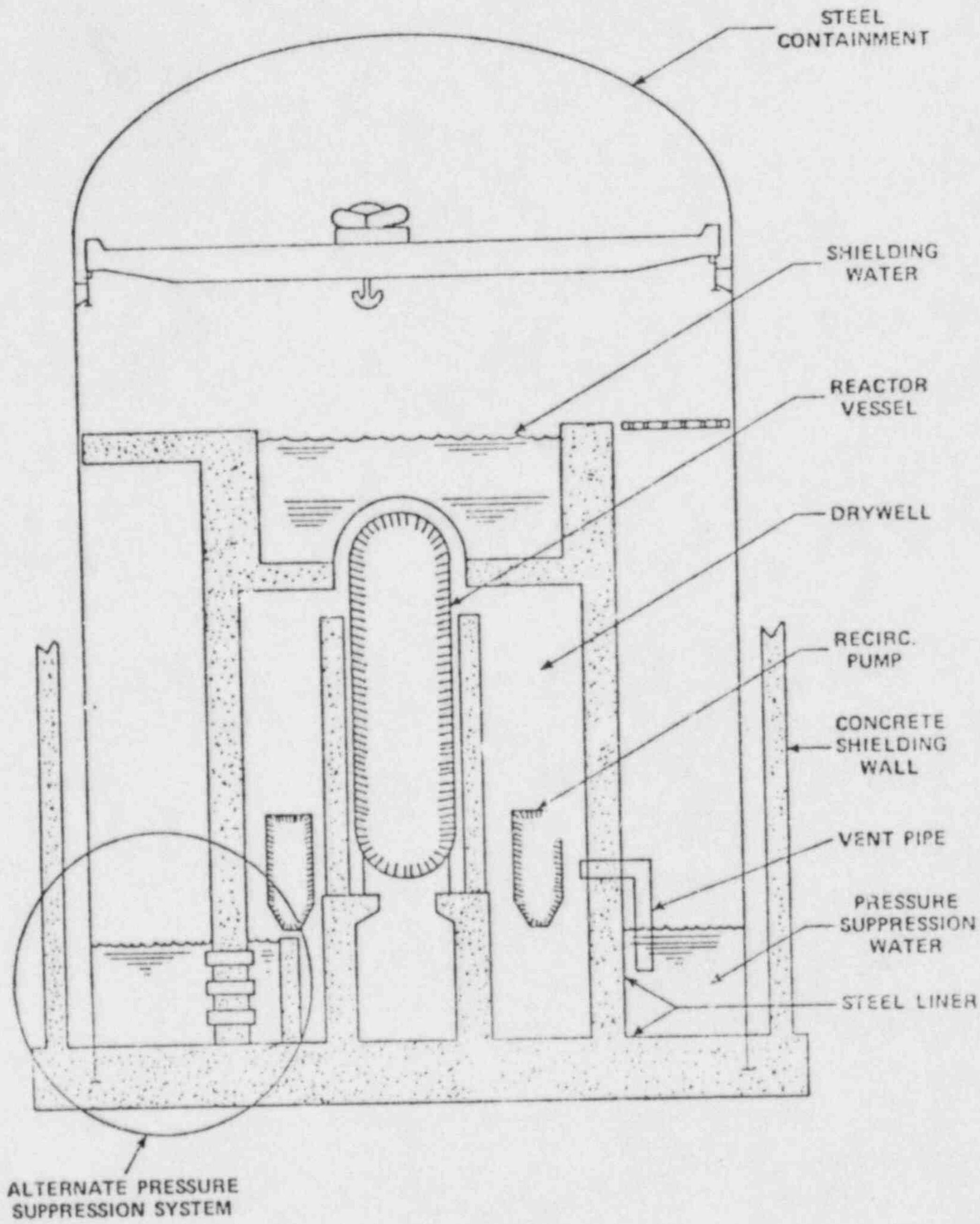

Fig. 3. BWR Mark III Containment

Edison Senior Project Engineer, by its design, Mark I requires more cooling than Mark II or III.

The prevailing consideration was purely economic. The smaller containment was to be accompanied with lower design pressures to satisfy the safety requirements.

In 1969, GE offered Edison the newer design[1]. However, Edison never seriously considered the GE offer and proceeded with the chosen design. (See fig. 1-3)

At the same time, other utilities who had ordered BWR's Mark I were reconsidering their option. Two of them were the Shoreham Unit of LILCO, and the Susquehanna Units of PP & L.

In 1967, Shoreham, like Fermi 2, had ordered a BWR-Mark I. When the new design was available by GE in 1969, LILCO decided to change over[2].

In April 1968, four months prior to the Fermi 2 order, Penn. Power & Light (PP & L) ordered an 1100-MW Class BWR with Mark I design from GE. In 1970, PP & L made a reassessment of their containment design performed by Bechtel. The Bechtel analysis showed that:

- A change to Mark II design would not adversely affect the Susquehanna application for a construction permit.
- Anchoring pipe whip restraints in the Mark II concrete containment presented design advantages over Mark I design.
- Mark II containment would be easier to construct, considering the need to incorporate the new AEC requirements.
- The estimated costs for the Mark II containment were about the same as the larger size (74 ft. diameter) Mark I.

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[1] Based on discussions with C.M. Johnson, GE Project Manager at EF2.

[2] Based on discussions with C.M. Johnson, GE Project Manager at EF2.

In January 1971, PP & L directed GE to change from a Mark I to a Mark II design for Susquehanna[1] (the Unit 1 was completed in 1982). Detroit Edison was aware of the congestion and accessibility problems with their chosen design. In 1971, at an Edison Board of Director's meeting, the subject was brought up by Edison Engineer, Dr. Bacher. The Fermi 3 design was originally a copy of EF2. When DE did their modeling of pipe whip and piping restraints, they knew that the Mark I would be too congested and difficult to build. So DE converted EF3 to Mark III in 1973 based on advice by Ebasco, a consulting firm. Ebasco was chosen as A/E for Fermi 3.

Industrywide, serious problems were raised with the design and size of the containment vessel.

A report by Harold Oslick, Chief Engineer at Ebasco Services Inc., described the problems with the older design as follows:

> "The reasons for the development of the different containment design concepts have, for the most part, been related to economics. The prevailing thought was the lower design pressure, the lower the evaluated plant cost would be. The same philosophy was applied to the containment size. As a result, we had everyone striving for the smallest containment with the lowest design pressure. The results in my opinion, were disastrous, as we begin to examine system-related problems and interfaces.
>
> With respect to the containment size, one need only walk through some of the smaller ones to admit a mistake. The problems associated with maintenance, accessibility and inservice inspection are a mechanic's nightmare. A good comparison in miniature would be found under the hood of your modern car. The effects of lower design pressure were more subtle and were not realized until the ECCS crisis. The development of more sophisticated computer codes showed us that the ECCS performance was enhanced with increased containment back pressures, this being more pronounced in PWR than BWR systems. System design

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1 "An Historical Assessment of the Susquehanna Nuclear Project" by Management Analysis Company, 1981.

considerations now have to balance reduced design pressure versus degraded ECCS performance in developing an optimal containment design."[1]

Undoubtedly, Mark II containment was not without problems. Serious hydrodynamic feedback load problems were found with all BWR designs under postulated loads during transient conditions. These problems were found to be far greater in the Mark II & III design, with the suppression chamber directly under the vessel. The torus design was structurally somewhat more flexible under transient conditions. Susquehanna and other Mark II owners spent several millions to resolve the issue to NRC satisfaction.

In 1975, Edison joined 16 other utilities owning BWR (Mark I containment) to fund a study by GE to analyze the suspected design deficiencies in:

1. Safety relief and blowdown systems
2. Hydrodynamic Pool Swell Phenomenon

An initial $120,000 was authorized for the phase I - short term program. Eventually, Edison contributed $3.7 million as its share of costs to resolve the problem.

Edison argued that it was in their best interest to join this common effort rather than embark on a separate effort to provide "fix". In recommending this course, Edison indicated (contract 1A-87661, CO#2, 6/16/76):

"The contract is a composite document to meet the needs of many different companies and while it might not be exactly the way Edison would write it if we worked directly with GE, our Legal Dept. review finds it adequate. Legal has advised Purchasing that this contract does not change Edison rights to recover these or any other costs for repairs to the torus, which might be contained in Edison

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[1] "Safety Aspects of Containment System Design"
Harold Oslick, Chief Engineer, Nuclear Licensing
Ebasco Services, Inc., New York, N.Y. 10006

contract with GE for NSSS. Edison right for recovery is a complex legal question which has not been fully researched and Legal Dept. cannot advise Purchasing that we can recover these costs at a future date, but only that if that right exists today this contract does not in any way change our rights.

If Edison does not become a signed member of owners group we would have to provide NRC a separate plan of action for appr val and a "fix" as a result of this study. It would be almost impossible to prove our fix in that we need a test facility. We would also have to fund a duplicate work which is being shared equally by the Owner's Group. This cost is estimated to be $10 - 14 million.

There is also a chance that we would be forced to provide a fix to code criteria instead of the interim criteria permitted for volunteer fixes. If enforced by NRC, it would be a very costly fix and from public relations standpoint could cause real problems for those companies who make a volunteered fix."

Besides the above-mentioned problem, numerous other modifications became necessary to the torus and drywell during the construction history at Fermi 2. These modifications required a significant increase in piping, hangars, snubbers and reinforcement of drywell loads. Access and congestion in the drywell were a critical problem. Severe manloading restraints have reduced productivity and undoubtedly delayed the project completion. Currently, Phase II Drywell Steel modification is underway in the drywell and is a critical path item to testing and fuel load. At least 27 safety systems are waiting to be tested in drywell. It is difficult to estimate to what extent the Mark II design would have reduced this access and congestion problem, but certainly it has been an important contributor to project delay and costs. In its annual 1981 presentation to the Board of Directors, the Fermi Project Management identified the containment size as an important factor, contributing to the project delays.

Construction of Reactor Containment Vessel

In November 1969, a contract was assigned to Chicago Bridge & Iron (C B & I) of Illinois to "design, develop, fabricate and deliver" the containment vessel in accordance with the specification developed by Sargent & Lundy.

The vessel design was to be a light-bulb type with the option to change to a teardrop design.

Total contract price was $3.86 million, of which the field construction component of $1.70 million was subject to escalation. The remaining $2.16 million was fixed component.

C B & I began below-grade work in 1970 in anticipation of a construction permit in early 1971. By December 1970, the NRC permit had been delayed by four months. Another four months delay was further anticipated. C B & I asked for and received a compensation for 8 months delay totaling $182,000.

In June 1972, C B & I was temporarily demobilized because all the below-grade work had been completed and the construction permit to continue work had not been received. A $54,100 demobilization expense was reimbursed. C B & I was to return after 5 months, by which time the construction license was expected.

C B & I resumed work in late 1972 after the permit was received in September 1972. The C B & I work was completed by 1978. The total final price was $5.0 million.

The only significant event in the C B & I performance was damage to the containment vessel during the application of concrete under pressure in the drywell. The damage consisted of an inward deformation about 7" high and 8' in diameter. C B & I proposed to repair the damage for

$25,000. Edison had estimated a much higher cost. The total cost of repair by all parties was estimated at $200,000. A 10CFR50.55(e) was filed with the AEC.

Staff Analysis

(a) Selection of Containment Vessel Design

In Staff judgement, Edison should have seriously considered the option to switch to the Mark II design. Serious problems were becoming apparent with the older, obsolete design, particularly in terms of constructability and accessability. Primary containment is the key system in a nuclear plant and the focus of all safety concerns. It is not uncommon in the industry that when an initial agreement is made, options are left open for future design changes.

Edison was given further opportunity when its construction license was delayed to make such a re-analysis. It was known that AEC licensing was under suspension for some time subsequent to Calvert Cliff. Edison failed to utilize this window. The start of below grade work pending construction permit was, in our judgement, an imprudent step. It closed all options for basic design improvement. This, in the Staff's view, may have been the primary reason for not reassessing the containment design.

Other possible reasons:

- Adherence to tested design.
- In general, Edison engineers were not experienced in nuclear design. They were even less comfortable with newer design.

- This decision was tied to their decision to do their own engineering.
- February 1974 completion date was sacred. Edison wanted no major deviations to upset this apple cart. Mr. Cisler controlled the early phase of all construction decisions. With permit delays this target became impossible to achieve.

  At EF2, Edison ended up with the earliest design BWR, a 1960's design, still being built in the 1980's. Today, EF2 is the only BWR under construction and in near-term license stage with the Mark I design, first developed by GE in 1960.

(b) Edison Involvement with BWROG on Hydrodynamic Load Problems.

- The Staff believes Edison took the correct approach by joining the utility pool and performing shared cost research to resolve this nagging problem.

  It reduced a potential exposure of $10-14 million to about $4.00 million.
- Further, Edison made a courageous and sincere effort to assert their right to recover costs of any torus fix from GE, the supplier of NSSS, although unsuccessfully. At this point, it warrants mention that generally the Staff found Edison taking an aggressive stand on recovering costs of a repair, rework or refurbishment resulting from vendor/contractor errors. We reviewed several back charge reports (Request #116 & 167), PAR's, etc. to analyze the back charge policies and collection history.

  Generally, we found hundreds of back charges initiated in the field by Daniel/Edison on vendors and contractors. The success rate in affecting these back charges, particularly on large items, was not very satisfactory. As one individual on PMO stated, "we often get 10¢ on a dollar, but we try". With the joo so complex, long, and involving multiple work groups, to pin down an error on a party is often difficult: to recover from him, even more so. Edison also must consider good relations important for safe and efficient job completion. Uncollected back charges is the "owners curse" on a large project.

(c) C B & I Performance

The Staff is generally satisfied with this contract. The difficulties in installation were largely due to delay in the construction permit. The final price was only 1/3 above the contract bid--an extremely good performance by comparison.

The only abnormal event was the damage to the vessel during the concrete application under the vessel at an estimated repair cost of $200,000. According to Edison, all but $50,000 was recovered from insurance. No disallowance is recommended.

4. <u>Turbine-Generator: Vendor (English Electric) and Installer (Aycock)</u>

(a) Vendor Selection

In 1968, Edison invited bids for 800 MW turbine-generator units. Four foreign and two domestic vendors submitted quotes. Subsequently, 1100 MW T-G bids were invited from only the four foreign manufacturers. GE and Westinghouse submitted unsolicited quotes for the 1100 MW T-G.

The quotes are summarized as follows:

		$ (000)
1.	General Electric	$27,985
2.	Westinghouse	$28,896
3.	English Electric	$16,548
4.	C.A. Parsons Ltd.	$16,900
5.	A.E.I. Ltd.	$21,580

On September 16, 1968, Detroit Edison awarded the contract to English Electric Ltd. of England. The installation schedule was for 1972. The turbine rated at 1154 MW, with 9,748 Btu heat rate; 14.16 million lb/hr., 965 psia, and 99.6% quality is guaranteed.

A principal rationale for selecting English Electric was the lowest quote. Another important reason, in our judgement, for choosing a foreign manufacturer was the Edison intention to expand the domain of T-G suppliers and competition from the four or five domestic ones. Down the road, Edison envisioned purchasing several large units for their system. Greater competition was advantageous to them in the long run. At one time, Edison considered Allis-Chalmer, another domestic supplier, but later withdrew from the market.

Offsetting these advantages were several disadvantages to purchasing the English Electric machine.

1. EF2 was the largest turbine unit to be built by English Electric at the time. Edison had made a detailed review of the design concepts, performance and parameters of the machine prior to order. Several Edison engineers had visited EE facilities and talked to technical personnel. Edison engineers, over the years, had designed and operated turbines, more recently at the Monroe Units. So they felt confident at the time about the EE turbine-generator. From time to time, during installation and testing, Edison did feel concerned about the equipment performance. For instance, this was one of the reasons for the extensive clean steam testing program planned by DE in 1978. Subsequently, San Onofre Units of Southern California Edison purchased similar units from GEC. Their performance has been found generally satisfactory. Some vibration problems developed at the San Onofre turbine during operations in 1983. Edison has been notified and a fix is planned prior to fuel load.

2. The logistics of communication, equipment, transport and shop supervision became quite difficult through the manufacture and erection phase. Edison hired VinCotte Associates, a Belgium consulting outfit, to inspect and supervise the manufacturing phase. Also, the English engineering firm of Merz and McLellan was hired to verify critical design features. Other agents were sent to perform the final inspection.

3. Edison was constantly exposed to currency fluctuations between the dollar and pound sterling. This factor was not considered by Edison in the initial review.

Payments for EE - Home Office Technical Services were based on pound sterling. In 1978 - 1979, Edison paid additional costs to EE of $69,000 to cover currency exchange (change order #54 dated April 24, 1980, contract 1E-83799). In June 1980, Edison also had to pay $160,000 for additional customs duty since the "Constructed Value" of equipment had increased from the original contract price.

In analyzing the bids, i.e., domestic vs. foreign, these incidental costs were not fully recognized by Edison.

4. As will be discussed later in detail, serious installation problems developed due to the inexperience with foreign equipment, lack of full understanding between Daniel, Aycock (turbine-generator), EE - Technical Team and Detroit Edison PMO. Many component parts had to be shipped back to England, e.g., rotor blades and generator welds, for modification. This held up erection, created liability claims and caused general frustration. A specialist who had erected a similar EE unit in Korea was hired to assist. EE equipment was built to different standards than normal GE/Westinghouse design. Edison did not fully evaluate these factors and their impact on cost, schedule and performance risks in selecting the turbine-generator supplier.

   In 1969, English Electric merged with AEI, another manufacturer of turbine-generators. The new company offered to supply an AEI design generator. The Edison Generation Engineers visited

English Electric, AEI and C.E.G.B. (Central Electricity Generating Board of England) facilities in England to inspect the AEI generators. Based on technical review, they recommended that Edison select AEI equipment over English Electric because:

1. AEI-EE prefer to manufacture AEI design as their design is nearly complete and shop is empty.
2. AEI has more experience. They have built 18 units of 100 MW of more, compared to only 3 by EE.
3. AEI is an advanced design with hydrogen-cooled rotor; the stator is simpler to erect. AEI design is more efficient.
4. Vibrations and cracking problems have been experienced with EE design rotors.
5. Consolidated Edison and C.E.G.B. have ordered AEI design generators. (Although C.E.G.B. units are used in HTGR nuclear units, their turbines are more like oil or gas turbines).
6. Experience gained from Con-Ed units will be useful.

After firm orders were placed with AEI-EE for supply of the turbine-generator, Edison was continuously reviewing the design.

- In October 1970, ratings on the turbine and generator were raised from 1100 MW to 1180 MW and 1203 MW, at a cost of $730,000. Another $250,000 was added for the increase in scope (see CO #4; 10/5/70). The rating was then lowered to 1154 MW when cooling towers were added.
- In June 1971, another scope of supplies was increased at a cost of $295,000 (see 8 items on CO #5).
- In November 1971, scope of supplies increased by 9 items (see CO #7 & 8) cost of $259,000.

- June 1972: 16 more items added or changed at a cost of $270,000.
- December 1972: 12 more items added or changed. Added cost amounted to $328,000.
- April 1973: 5 new items added; cost, $49,000.
- January 1974: 3 new items added; cost, $152,000.
- March 1974: 8 equipment modified; cost, $157,000.
- December 1974: Edison suspected problems in the stator coil end-winding. DE asked GEC to perform additional vibration tests, at a cost of $60,000. This was prompted by problems experienced in the U.S.A. on domestic and foreign generator designs. It was Edison thinking to take the "extra step" to ensure reliability and performance.
- In 1974, DE challenged the integrity of H.P. rotor forging. Tests performed by GEC confirmed that the rotor was entirely sound. In May 1975, Edison contracted Merz & McLellan Consultants to conduct an in-depth technical analysis of the rotor. M & M recommended that the rotor be accepted as is. Edison deferred approval of the rotor and hired another consultant, Dr. Allen, to review the data. He recommended that the rotor be accepted after a 100% ultrasonic inspection. Next, Edison hired a retired Westinghouse chief metallurgist who also recommended the 100% UT inspection. Finally, DE contracted the South West Research Institute (SWRI) to perform this ultrasonic examination. SWRI tests indicated that the rotor was fit for service. DE acknowledged to GEC that the rotor could be shipped. The dispute delayed the shipment by about 15 months. GEC billed DE $146,000, principally for storage of equipment and inspection assistance. The final

settlement was $101,000 (CO #29). Edison paid for all the inspection and consultation.

- In July 1977, modifications were made in the governor pressure control system. Cost: $136,000.
- In October 1977, major modifications were made in the electro-hydraulic governor to add redundant power units, load rejection relaying, time delaying and duplicate trip relays, etc. on H.P. valve controllers.

  According to Edison engineering (Memo EF2-38840, dated 10/31/77), this effort was caused by "the fact that adequate redundancy was not incorporated into the valve control modules and remained undiscovered until the final system acceptance tests were performed". Edison recommended the modification at a cost of $204,000.

- In January 1979, EE was authorized an additional payment of $1.4 million due to a 2 1/2 year delay in the erection of the turbine-generator (see note VPFP79-15 from Mr. H. Tauber to J. Hammond). By now, $4.8 million had been added to the EE T-G contract for equipment, design modifications and technical assistance for erection phase. The erection had just begun. As will be discussed, more problems developed in the erection phase which further added to direct EE contract costs. By October 1982, the contract price was $24,066,081, an increase of $7.5 million from the original price.

IMAGE EVALUATION TEST TARGET (MT-3)

150mm

6"

Staff Analysis:

The choice of English Electric was attractive for Edison due to the low bid compared to other domestic suppliers. It appears that Edison had made a prior decision to go with foreign manufacturers to create supplier competition. This is borne by the fact that domestic bids were not solicited on 1100 MW equipment. Edison may argue that based on an 800 MW bid, the foreign suppliers appear more competitive. Edison engineers also seem to have been impressed with the EE design. At any rate, the Staff agrees that these factors were important considerations for Edison. However, the other direct and indirect factors were not fully evaluated. For example, the relevant cost should be the total equipment and erection costs. This will be more important when large size equipment of untested design is ordered.

The performance risk was not adequately considered at the initial stages. Later on, Edison became overly concerned with performance and operability. This resulted in costly, multiple, independent tests of rotors mentioned earlier. In our judgement, these concerns were a direct result of a "foreign design". The rotor delay for this reason alone was about 15 months. Escalation and delay charges were building up rapidly.

It was not necessary for Edison to take upon itself to experiment on major equipment like a T-G for a critical, first nuclear unit in its system. Edison tied up experienced engineers who traveled frequently to Europe to supervise and resolve problems with T-G construction. All this could have been avoided with a domestic supplier. The desire to be "Industry Champions" should have been resisted.

Since Edison engineers were very knowledgeable in technical details of a T-G, oftentimes they proposed changes and modifications which appeared unnecessary and unimportant. At the same time, some signficant redundancy design considerations were ignored.

The Edison decision to opt for AEI generator appears to be reasonable and prudent based on analysis performed at the time.

Erection of Turbine Generator

In November 1977, Aycock, Inc. of Campbell, Pennsylvania was awarded the contract for the erection of the turbine-generator at a lump sum price of $4.92 million. Simultaneously, a cost reimbursible contract was also awarded to Aycock to complete the condensor installation. Much of the condensor erection had been performed earlier by Foster-Wheeler.

The Aycock selection was made after a detailed bid evaluation performed by Daniel, Edison and English Electric management personnel.

A principal consideration in the selection of the erector was his "understanding or awareness of the unique erection requirements of an English Electric turbine" (DIC 77-4303). Other factors included price and prior experience.

Bids were received from Aycock, Union Boiler, Townsend & Bottum, Power Systems Inc. and J.A. Jones Construction. Only the first three were given serious consideration based on bids. Individual meetings were held with these bidders.

Aycock was selected for the following reasons:

(1) Lowest bid;

(2) Satisfactory understanding of the complexities of the English Electric turbine;

(3) The contractor has limited nuclear experience but has performed heavy lifting at several nuclear sites, including RPV setting at Calvert Cliff, Zimmer, Cooper Stn; Pilgrim and some work at

Shoreham. Aycock was selected by Bechtel for bidding at Greenwood 1.

Edison/Daniel verified the financial, technical and resource ability to handle the job. Aycock was to sub-contract mechanical/piping work to a local company, Power Process Piping (PPP), which had performed several jobs for Edison.

The Aycock contract was a lump sum for turbine erection for $4.9 million, plus a cost reimbursible condensor installation (contract #1A84501). Daniel had the responsibility for monitoring the erection work. The English Electric Technical Director was at the site to assist with erection instructions and interpret technical specifications.

Erection Phase:

Erection began in August 1978 when turbine component parts were transported from the parking lot where they had been stored since 1976. At the suggestion of EE, Edison hired a materials engineer to inspect the condition of the stored equipment. Cost: $72,000.

Serious erection problems developed from the very beginning. The intial schedule was that erection would begin in 1979 and completed by March 1980. It took until the end of 1982. Aycock was demobilized by mid-1981; the system was turned over to start-up. Bechtel maintenance finally finished work by the end of 1982.

Some of the erection problems encountered are discussed below:

- Edison, Aycock and Daniel lacked experience with the EE-type turbine.
- EE required too much field fitting of bolts compared to domestic suppliers.

- Piping on the turbine was designed and shipped by EE. Designs were delayed.
- Erection instructions by EE were not properly sequenced and were incomplete; this caused scope changes and delays. (See, for example, CO #6; additional $239,250 expense.)
- Too many interferences resulted in the removal and refabrication of tubing, welds, etc. (See CO #7.)
- Interference and extra work to temporarily install equipment and perform early oil system flush. EE had to redesign, fabricate and install extra piping.
- Defective equipment returned to England for repair, e.g., L.P. blades, L.P. sole, dowel pins and posts. (See CO#2.)
- Serious problems with coupling bolts;

  British standards for tolerance were much more rigid. Controversy developed within Daniel, EE and DE as to tolerance standards. Arguments went on for three months as to need for fine grinding of coupling bolts. Finally, a local machinist from Toledo, Ohio was hired who had the expertise in fine grinding, and he completed 4 to 5 couplings with 20 bolts each in 6 weeks. This type of problem would not occur with domestic suppliers.
- There was evidence of conflicts between Aycock, Daniel and EE Technical Director. Daniel, it appears, was tightly controlling the work, which was resisted by both Aycock and EE. They felt Daniel was an unnecessary hindrance to progress. In February 1981 (CO #64), Edison decided to eliminate the need for directions from Daniel. "Technical direction was to be given by EE to Aycock".

- Lack of coordination, unfamiliarity with EE design, poor installation instructions and too many parties involved created confusion and misunderstanding and loss of work progress.
- As a result of erection delays, rework and extended technical directions, several escalation claims were filed and payments received by English Electric. Among them:

(a)	$1.4 million	January 1979
(b)	$116,000	April 1980
(c)	$278,000	September 1980 (CO # 62)
(d)	$222,000	March 1981 (CO # 65)
(e)	$129,000	March 1982 (CO # 77)

A separate $1.6 million contract was signed with English Electric for start-up engineering analysis. During erection, Edison generated hundreds of back charges on EE. The success rate was very poor.

- The erection contractor, Aycock, also received several adjustments for rework and delays due to no fault of the contractor. Among them:

(a) $249,000: C03; (4/79) authorized for future extra work

(b) $109,000: C04: construction based on superseded drawings

(c)	Rework of cold heat piping; Piping not built to specs; EE may pick up part of the cost.	$63,000	CO # 5
(d)	Inadequate erection instructions	$239,000	CO # 6
(e)	Turbine frame interference	$ 71,000	CO # 7
(f)	Cold flush system preparation	$100,000	CO # 8
(g)	Future funds for extra work (back charged to EE)	$249,000	CO # 9
(h)	NDE as per British standards	$ 52,600	CO #11

(i)	Extra work due to EE (back charged)	$100,000	CO #12
(j)	Cost overruns due to rework and fit up accessibility	$330,000	CO #15
(k)	Delete instrument piping & tubing from the contract because Aycock/PPP does not have the ability to design the piping as per specs	(65,000)	CO #16
(l)	Cost overruns	$494,000	CO #17
(m)	Delay adjustment	$390,000	CO #19
	Extra work	$600,000	
	Add. delay of 112 days @$98,235 per month	$412,000	CO #23
(n)	Extra work for turbine oil flush	$105,000	CO #25
	Delay	$575,000	CO #26

(o) Power Process Piping, a subcontractor for Aycock, filed a claim for $3 million against Edison in a civil action suit. Basis for PPP suit was:

(1) Handling and transportation problems. The lay-down and storage area was moved by 1000 yards. Additional costs were incurred in transporting material due to longer distance. Edison PMO recognized this problem.

(2) Interferences due to hangar supports were encountered during fitting, assembly, installation and alignment. Of the 329 interferences, Daniel recognized 295 as valid claims

(3) Design changes and various interferences. At least 42 claims were documented by PPP.

(4) Delays and indirects.
PPP claimed significant costs due to schedule delays resulting from "material deficiencies as well as

numerous extra work". Original completion date was September 30, 1979, but PPP was demobilized on January 16, 1981.

(5) PPP also claimed interest and legal fees.

The dispute could not be resolved by the parties. The major contention of DE/Daniel was that the claims had not been well documented rather than their validity.

An arbitration was conducted in January 1983. According to Edison, new facts were brought to light not known to them previously. Edison settled the dispute for $1.7 million.

Staff Analysis and Findings on Performance of Turbine-Generator Supplier and Erection

Based on its detailed review, the Staff concludes as follows:

1. Selection of English Electric as the turbine-generator supplier was not entirely justifiable. Even though it provided first price advantage, the installation, logistics of dealing with several overseas parties and lack of experience both at EE and DE/Daniel with new design all involved unwarranted risks.

2. Selection of Aycock as installer was thoroughly reviewed by Daniel/Detroit Edison. The choice of Aycock with PPP as the piping subcontractor was prudent and justifiable.

3. The erection of the turbine generator was poorly planned, badly coordinated and mismanaged. Principally, both Daniel and Detroit Edison must be faulted for this. The Staff is constrained to note that DE mismanaged an essentially non-QA,

conventional turbine system. One cannot blame regulation or any outside factor for it.

4. Many of the erection problems resulted from deficiencies in equipment design, lack of instructions and inadequate experience with the new design from a foreign supplier.

5. The delay and rework costs received by Aycock/PPP were reasonably justified due to severe problems encountered in the field. PPP had done several jobs for Edison previously and performed satisfactorily. The problems on this job were not their fault.

6. Both Edison and Daniel attempted to back charge English Electric for manufacturing deficiencies. Hundreds of claims were generated. A review of the back charge file indicated inadequate collection by DE.

Recommendation

The Staff recommends the following disallowances regarding the turbine-generator purchase and installation expenditures:

1. All expenditures in excess of the original contract for erection of the turbine-generator and condensor installation. The cost plus condensor contract should also be held to its initial estimate.

   The Staff believes that the principal reason for cost overruns on this job were poor coordination, lack of understanding, and poor management. Edison, therefore, should not be reimbursed for this cost overrun.

Calculation of Net Disallowance (based on December 31, 1982).
Contract #1A-84501

		(000)
(a)	Total Expenditures	$10,680
(b)	Orig.	$ 5,912
(c)	Cost overrun	$ 4,768
(d)	PPP Settlement	$ 1,700
(e)	Add. DE overhead plus Daniel Supervision @20% (includes legal fees, etc.)	$ 1,294
	Subtotal	$ 7,762
(f)	AFUDC (using mid-point of 1979-1982 & AFUDC rate)	$ 1,397
	Total Item (1) Disallowance	$ 9,159

2. The following English Electric charges should be disallowed:

a. Change Order #35-37: Modifications of governor press. control system

Direct Charges: $ 340,000

b. Change Order #43: Settlement due to erection delay

Direct Charges: $1,402,000

c. Change Order #54: Escalation for Tech. Services

Direct Charges: $ 116,000

d. Change Order #62: Site & HQ tech. direction

Direct Charges: $ 278,000

e. Change Order #63 & 65: Completion in TG erection delayed

Direct Charges: $ 250,000

f. Change Order #77 & 83: Additional services

Direct Charges $ 488,000

g.	Turbine start-up engg. services Contract 1A-84844	$ 900,000
	Subtotal Direct	$3,774,000
h.	Add. DE/Daniel overheads 20%	$ 755,000
	Subtotal	$4,529,000
i.	Add AFUDC (1979-82) @ 9% per year use mid pt.	$ 815,000
j.	Disallow unit upgrading to 1204 MW	$1,480,000
	Total Item (2) disallowances through December 1982	$6,824,000

5. Choice of Organizational Approach to Design and Construction

In today's nuclear environment, a utility must take overall responsibility for project management. The NRC requires that the owner must assume all responsibility for safety, construction and operation of a nuclear plant.

While regulatory conditions have changed over the years, the basic approaches to project management remain the same. Greater involvement and management by the owner provides better cost and schedule controls and better understanding of project parameters and problems.

Very few utilities, however, have the capability to design and construct the nuclear units entirely with in-house resources. For the most part, utilities with major construction programs provide in-house engineering and construction staff to closely monitor the design and construction work generally being performed by outside sources.

Further, when the engineering contractor is separated from the construction group, better results may be achieved because it provides a better opportunity for problems to surface and be brought to the owner's attention. A utility must assess its financial and technical resources to determine how much of the work should be contracted out. For this reason, every utility is unique in its organization of a major project. One can generalize these approaches in four basic categories. A utility generally uses a variation of an approach or a combination.

a. Engineering, Procurement and Construction - All In-House by the Owner

Only large utilities have the staff and resources to take on a major effort. The advantage of this approach is that it keeps the engineering and construction experience within the owner, a useful asset in a nuclear project. Also, the mark ups and contractor overheads are eliminated or minimized. Financially, this is the most cost-effective approach. Large utilities like Duke Power, AEP and Commonwealth Edison tend to take this approach.

Most utilities retain full responsibility for procurement of "engineered" items regardless of the design and construction organization.

b. Design, Procurement and Construction by a Single AE/Constructor Firm

This is different from the old turnkey projects. Here a single contractor performs all the functions, sometimes including start-up, on a cost reimbursible basis. Generally, the owner's role is considered minimal until towards the end. This approach was considered cost-effective because it reduced the need for multiple contractors, duplicate overheads by sub-contractors, etc. Historically, firms like Bechtel have touted this approach. Recently, effectiveness of this had been questioned. Examples of this approach are the Midland, Susquehanna Units & Edison's Belle River Coal Units.

c. Engineering by an Outside AE, Construction by a General Contractor or a Construction Manager

This has been the more common approach. Under this arrangement, there are two separate primary contractors--engineering and construction. The utility acts as an interface. It has a much larger involvement and better control and understanding of the project. Generally, the utility has major input in the cost and scheduling functions.

This concept, in theory, is designed to allow fixed price contracting of work packages. In practice, fixed price contracts have been ineffective and unenforceable due to a large number of design changes, delays and regulatory requirements. Generally, the more effective method is cost reimbursable with incentives for good performance. A strong construction manager acts as the utility's agent.

d. A fourth possible approach is where engineering is done by an outside AE, while construction is managed by the utility. Here a utility can control cost, scheduling, contract administration, labor relations and work progress. Through the scheduling function, it can put pressure on the engineering organization to meet construction deadlines.

In practice, a utility adopts a combination of these basic alternatives while maintaining one conceptual structure.

Detroit Edison, at the beginning of the project in 1969, chose to perform its own AE function augmented with assistance from Sargent & Lundy (S & L) who had extensive experience in design of BWR plants. Edison also determined that it would be in their best interest to employ a general contractor who would be the prime constructor and construction manager.

These two decisions were crucial because they had a profound impact on construction progress in the early years. The AE choice has impacted the project throughout its history. These decisions are further analyzed here.

1. Prudency of Edison Decision to Perform Its Own Engineering and Design

In making this decision, Edison considered several factors. According to the PSAR filed for Fermi 2, Edison justified its decision on the following basis:

- Edison's AE responsibilities will be augmented by the consulting firm of Sargent & Lundy. S & L will be responsible for the design of the reactor building and other areas of the plant where the firm's experience is especially appropriate. S & L has provided engineering services for 15% of the nation's electric generating capability. S & L has been actively engaged in the nuclear power plant field since its inception.

- The non-profit R & D organization of the Atomic Power Development Association (APDA) had been retained in a nuclear engineering consulting capacity. APDA has outstanding competence in basic nuclear engineering having designed the nuclear portion of the Fermi 1 power plant--an experimental breeder reactor. Many of the Edison engineers were involved in the Fermi 1 project. Eventually, APDA was dissolved and most of its technical people absorbed by Detroit Edison.

- Edison planned to hire specialty firms for design of specific jobs as and when necessary.

Edison strongly felt that their engineering resources and expertise were adequate to undertake the Fermi 2 design responsibility. Further, Edison argued that as its own AE, it will possess valuable knowledge about the design parameters and engineering details. These will be useful during the start-up and operation phase. Finally, since Edison was planning a major nuclear program for future needs, the design experience at Fermi 2 would allow them to design future plants in-house. Edison Managment placed high confidence in their engineering capabilities. This is not surprising in view of the fact that historically Edison has been an engineering oriented organization. Its senior management consisted entirely of engineering people until 1975.

STAFF ANALYSIS

Engineering and design is the most critical function in a nuclear project. It controls every phase of construction, start-up and operation.

Review of other similar projects in the same timeframe reveals that there is no single approach which guarantees effective and successful project organization. There are examples where the same approach has worked in one situation and backfired in another. Further, a project approach by itself does not guarantee effectiveness. It must be tempered with constant utility surveillance and good judgement. Therefore, in evaluating the Edison decision, we considered not so much the industry practice, but rather Edison's own motivation and capabilties and cost-effectiveness. Various elements are analyzed as follows:

(1) Prior experience:

Edison, in our judgement, did not possess adequate experience in a large commercial nuclear reactor design. Involvement of Edison and APDA in Fermi 1 was of a much lower dimension and insufficient for an 1100 MW BWR.

The nuclear inexperience of Edison engineers was one of the major concerns expressed by numerous reviews throughout the project history.

- In 1974, a Daniel project audit pointed out serious deficiencies in the engineering effort resulting in schedule slippage. Edison Management has acknowledged this fact and attributed it to nuclear inexperience, as evidenced from the project reports and correspondence.

- Major rework and modifications were directly attributable to the lack of detail design experience by Edison. Prime examples of these are modifications to the general service water and radwaste systems and fire protection systems.

(2) Cost-Effectiveness:

Design of a nuclear unit requires a major financial commitment. Edison had to maintain a large high-level technical staff on their payroll for the design work. In many ways, they were learning on the job. Unlike the consultant's firm who had worked on multiple jobs, Edison engineers were not familiar with the nuclear industry. Further, they could not be let go when their assignment was over. An outside AE provides greater flexibility. For example, during the 1974 shutdown, S & L was demobilized for one year to save cash. (Staff questions this decision, however.)

At the start of the project, Edison Management was confident of their capability to handle engineering design. Soon they realized (as early as 1971), that they had underestimated the task. The redesign, due to engineering errors and regulatory changes, was holding up procurement and construction. Piping and valve design was seriously impacting the schedule. Edison could not cope with the volume of design work and rework.

Edison started to contract out more and more design work. S & L was approached to take over the piping design. Stone & Webster was hired to do major work on pipe stress analysis and hangar support design, security system, engineering evaluation and inspection of pipe supports; lots of redesign work.

Because Edison did not choose a single AE responsible for the entire design, they had to hire multiple consultants. Sometimes these firms were unwilling to take on more jobs because of overwork in the industry. Lack of coordination between contractors and Edison Engineering reduced turnaround and efficiency. Also, consolidation of all engineering in one AE would have been more cost-effective due to single overhead, easier monitoring and audit functions.

Edison later tried to consolidate most outside engineering with the two firms, S & L and S & W, but dozens of other AE firms were employed. In our judgement, the Edison decision on AE was less cost-effective compared to the alternatives.

(3) Industry Practice:

The Edison decision to perform its own engineering was a deviation from industry norm at the time. Discussions with managers involved with Fermi 2, both DE and outside consultants, expressed the view that engineering was one of the most serious problems during the entire project. It demoralized the craft, caused procurement difficulties and had significantly impacted the project completion.

(4) Engineering Expenditures:

The initial project budget for design effort was estimated as a meager $5 million. We believe, and Edison soon admitted, that it was grossly underestimated even based on circumstances known in 1969. By 1973, this estimate had increased to $27 million (See EF2 detailed estimates). The engineering percentage completion was being constantly overestimated. Edison did not have a full grasp of engineering completion or balance to go throughout the project.

By June 1983, the engineering budget had exploded to $275,000,000, of which over $190 million was out-of-house. The current annual engineering budget is about $60 million. Over 9 million hours have been expended. The project is reported to be 98% complete.

All in all, the Staff believes that Edison grossly misjudged the engineering effort on Fermi 2; they stumbled a lot due to lack of experience, redesign and severe schedule impacts, and overall it was more costly than the alternatives. More detailed discussion of Engineering performance in later sections.

6. Parsons as General Contractor

In February 1969, Edison hired the Ralph M. Parsons Company to perform general administration of all the work making up the installation of the NSSS and the turbine-generator from the very beginning of site development through the turnover and operation of the unit (a separate quality assurance assistance contract was entered). Specifically, duties of Parsons were described in the PSAR as:

> "It is planned that Parsons will provide overall construction management from the early stages of design through plant start-up; field engineering and inspection, craft supervision, labor relations, cost & schedule control, material control and expediting...all as a field function under the direction of their project manager, who will be located on the plant site.
>
> As a general contractor in the nation's missile program, Parsons has developed in conjunction with the Armed Forces complete quality assurance programs tailored to each of the projects. The QA program at EF2 is based on the experience gained on the Minuteman, Titan II, III, NASA test facility and Nike-X programs. Parsons' quality assurance organization operates completely free from their engineering and construction and is staffed with engineers and technicians who have gained their experience on these projects and on other nuclear power projects".

Parsons, as General Contractor, was to receive a fixed fee of $865,000 plus all net costs. The fee was to cover up to the completion date of April 1974.

Beginning in February 1969, which was the official "Start of Project" date, Parsons performed all the pre-construction activity, including preparation of schedule on an advanced basis to the release of engineering information, developing system of project controls and management for items such as cost engineering and control, estimating and cost tradeoffs, purchase order status reporting, and progress vs. cost and schedule reporting system.

From a review of the contract and initial work performed by Parsons, it appeared that Edison had a great deal of confidence in Parsons. They were given a broad role in the project management and administration. Edison intended to continue with Parsons throughout the construction into the start-up phase. The bulk construction was assigned to Townsend & Bottum. Parsons and T & B seemed to form a good team to construct the project.

Parsons is one of the largest and reputable construction-engineering firms. It has vast experience in large construction projects, including missile programs, mining, shipyards and power plants. Although it lacked specific nuclear plant construction experience, it had, according to Edison, good quality assurance experience. During pre-WWII, Parsons had built several large engineering complexes and petroleum projects in conjunction with Bechtel (Bechtel, McCone, Parsons).

Based on Parsons' background and experience, it appears to the Staff that Edisons's choice was reasonable, at the time, in selecting Parsons. Further, the general contractor approach also seems to be reasonable. As stated earlier, no single formula guarantees success. Edison intended to closely monitor the project, yet minimize subcontracting and day-to-day administrative burdens. The key functions, however, i.e., procurement, vendor inspection of engineered materials, NSSS and turbine contracts were still Edison's responsibility. Edison employed some of their experienced individuals in the field to monitor cost estimates and oversee project progress.

Edison retained control of the quality assurance program. Parsons was to augment this program by furnishing quality control services. This covered inspection of construction work, surveillance, receiving inspection, vendor QC site representative coordination, administration of subcontracted QC services, perform NDE and radiography testing, and documentation control.

Given the scope of activities, job understanding and schedule, it appears that the Edison arrangement with Parsons was reasonable. The agreement with Parsons was formally signed in January 1971.

By 1973, a combination of factors was severely impacting the project progress. Among them:

- Delay in obtaining construction permit
- Engineering delays (to be described in detail elsewhere)
- Edison was busy preparing the PSAR for EF3
- Purchasing delays in nuclear piping, valves, pipe hangars, GE control panel, GE nozzle repairs, etc.
- Shortages of material, QC/QA manpower and overloaded engineering manpower

Edison expressed dissatisfaction with the degree of control Parsons was exercising on the job site. Parsons was also found lacking in developing integrated master project schedule and cost controls. Their labor management was also being questioned. Edison raised doubts about Parsons' ability to effectively manage the project. The most serious concern of Edison Management was the enforcement of a strong QC/QA program. About this time, the AEC was issuing numerous regulatory guides and prescribing tougher standards. Edison Management, led by Walter McCarthy, renewed its commitment to a strong safety and quality assurance program. Edison perceived yet tougher standards to be imposed on the nuclear industry in the years to come. Edison raised serious doubts regarding Parsons' ability to provide the necessary QA/QC service. Lack of prior nuclear construction experience and actual EF2 performance were the basis for this doubt.

From Parsons' standpoint, they appeared frustrated with the lack of engineering support, engineering delays, excessive redesign and procurement problems. All were impacting Parsons' ability to exercise project control. The project estimates had more than doubled and the scheduled completion date slipped to 1978. Parsons, as General Contractor, was taking a lot of the blame for it. Finally, in this period (post-oil embargo), Parsons' business was booming in the petroleum industry. They were taking large projects in the oil industry. Power industry was not their mainstay so they seem to have lost interest in the Fermi project.

By mid-1974, Edison Management had decided to terminate Parsons as General Contractor. The Daniel International Corporation, another large construction organization, was brought in, first to perform a project audit and to recommend changes. From all documents and evidence, it is apparent that Edison fully intended, in 1974, to replace Parsons with Daniel as Construction Manager. In July 1974, Daniel was appointed as Construction Manager. Parsons negotiated about $1 million in termination charges.

Staff Analysis

Official explanation from Senior Management is that Parsons was removed for the following reasons:

- Concern about their QA/QC abilities primarily due to lack of prior experience.
- DE wanted to switch to a Construction Manager concept as being more cost-effective. Parsons was unwilling to assume this reduced role.
- Some concerns about their weakness in the planning and scheduling. However, Parsons was strong in the piping installation

area. This was critical in the later years of the project.

- Project shutdown in 1974 provided opportunity to accomplish this transition.

The Staff noticed that dissatisfaction with Parsons was generally at the Edison Management level. The Project Management Organization and field personnel generally expressed satisfaction with Parsons' performance save in the planning and scheduling area. Reviews of project reports indicate some examples of deficient performance and inadequate documentation. In one case, 280 pipe supports had to be reworked due to inadequate QC inspections (K. Dempsey memo to W & B, March 1, 1979). But when measured against other rework/repair prior to and since Parsons' departure, the Staff does not find it as significant evidence of poor performance. Project review performed by Daniel pointed out several Parsons weaknesses. It should be recognized, however, that Daniel knew that they were about to replace Parsons. This must influence their judgement of Parsons.

In Staff view, separation of Parsons was mutually desirable. Edison was asserting its ownership role to demand better performance. Management used its prerogative to simply not extend the contract with Parsons which expired in April 1974.

Parsons, on their part, appeared to be frustrated because they could not control major elements of the project, e.g., engineering and procurement.

In our judgement, Edison acted reasonably in its Parsons decision. Continuation of agreement under strained relations would not benefit the Fermi p oject.

As for impact on this decision, we do not believe that it had a significant impact. The project was in a shutdown mode. Transition to

Daniel was carried out well. One possible effect of Parsons termination was that Daniel felt relatively secure in their job. Edison would not terminate the Construction Manager twice in the project.

Termination Charges

In our judgement, Edison was tough in negotiating termination charges.

- Parsons received contract fee only based on actual man-months spent on the job.
- relocation expense of $254,000.
- equipment lease cancellation: $12,000.
- the remaining portion of the $802,000 total termination expense was for the actual work performed.

The Staff recommends disallowance of $266,000 (in 1974 dollars) because this expense is extraneous to the project and should be borne by the utility.

The total disallowance for December 1982 level is:

$266,000 X 1.65 = 439,000

(AFUDC multiplier for 1975-1982 is 1.65.)

7. Daniel International as Construction Manager

Daniel International was hired in July 1974 to perform a project audit and to evaluate the cost estimates and status of the project.

At this point, Edison Management had already made a decision to terminate Parsons, switch from General Contractor to Construction Manager concept and to hire Daniel for this role.

We have already discussed the Parsons termination issue.

The second decision--to hire a CM--was largely prompted by the fact that Edison wanted a more direct involvement in the project. Especially in the areas of QA/QC, contract assignments, and project controls. About this time, NRC regulations and its enforcement demanded greater accountability from the owner--not from his proxy. Above all, it permitted a better opportunity to bring to the management's attention shortcomings in the contractor's performance. In the GC concept, contractors were employees of the GC, while the CM is a different organization than the contractors. The disadvantage of the CM-method is that it requires multiple administrative services (multiple-brassing)--each contractor brings his own non-manual personnel, services, facilities, etc. So there is a loss of efficiency in duplication efforts. Tools and consumable items are all separately maintained. Secondly, with a large number of different crew on site, work coordination, sequences and manloading become a serious problem. Perhaps the most important job of a CM is to coordinate craft activities, prioritize work and space use, sequencing, and resolution of conflicts between different groups. For this, he uses tools such as project scheduling at craft levels, provides a congenial work environment, establishes productivity improvement programs, and resolves conflicts.

The CM concept was new in the industry at the time. A CM is like a plant General Manager--he is not the owner but has authority as the owner's agent.

In our judgement, Edison action was reasonable to adopt the CM-concept. The experience with Parsons made this a logical change. Finally, with impending suspension, Edison fully intended to catch up and freeze engineering, prepare complete work packages and give out fixed price contracts. (See Edison response to Daniel review.)

Daniel, as stated earlier, is a large constructor--Daniel claims second only to Bechtel in the power industry. In 1974, Daniel was working on the Farley Nuclear Unit of Alabama Power. It had earned a good reputation for construction management and quality assurance. Other projects of Daniel include:

- Wolfe Creek Nuclear Unit for Kansas Power & Light
- Surrey Nuclear Units (steam gen. replacement)
- Callaway Nuclear Unit for Union Electric
- Itan 1 & 2 (fossil units)
- Crystall River 4 & 5 (fossil units), as CM
- 2 nuclear units for Carolina Power & Light
- 2 fossil units at Dayton Power & Light (CM)

At the time of selection, Daniel's nuclear experience was thin. Since then, several nuclear jobs have been awarded to Daniel. All other nuclear jobs are PWR's--Fermi 2 is the only BWR. This has posed some difficulty in Daniel understanding of Fermi 2 systems. Daniel attempted to overcome this deficiency by hiring individuals with BWR experience. Specifically, Don Ferguson was brought in as PM at Fermi 2. He had worked on several turnkey projects for General Electric.

To evaluate Daniel competency and performance at Fermi 2, we traced their history of involvement. Numerous documents, reports and evaluations were reviewed. We reviewed Daniel performance with several individuals at the site--both Edison and non-Edison. The Staff interviewed Daniel Project Manager, Jim Ard, on site several times. Finally, the Staff visited the Daniel Head Office in Greenville, South Carolina and interviewed Daniel Senior Management: President, Vice-President, Regional Manager and the Project Manager. We found Daniel Management very cooperative. The following pages describe our assessment of Daniel performance in various areas:

(a) Choice of Daniel as CM

As constructors, Daniel was developing a good industry reputation in the early 1970's. According to Daniel, the first contact between Daniel and Detroit Edison was through professional industry contacts between Walker Cisler and the then Chairman, Mr. Buckmickel, of Daniel. Mr. Cisler had suggested that Daniel assist Detroit Edison in its Fermi 2 project. In 1974, Edison formally invited Daniel to provide a project diagnostic and percentage completion status. Daniel review found serious deficiencies in every major project segment.

In particular, Daniel called attention to: engineering, construction practices, procurement, project staffing and organization, master project cost and schedule systems and quality assurance.

Daniel questioned the status of engineering and construction as being reported by Project Management. In their estimate, the project was about 40-42% complete compared to 60-65% being assumed by Edison.

The major difficulties, noted by Daniel in the engineering area, resulted from lack of coordination between various design groups, inadequate design document control, lack of planning and scheduling, interface between engineering and construction organization. Daniel, however, considered the design effort as technically excellent and commended the engineers for competency.

The procurement effort suffered from lack of coordination between General Contractors and Detroit Edison--the latter had the responsibility for procurement. The General Contractor had the warehousing and construction responsibility. The expediting function was weak according to Daniel. The contract administration was weak and ineffective.

As for construction practices--this was a strong Daniel suit--major Daniel concerns were: reduced craft productivity, inadequate planning and scheduling efforts, insufficient craft supervision, and insufficient generation of work efforts. Daniel also questioned the economics of renting vs. buying of heavy equipment. Daniel appeared impressed with the quality of construction.

Daniel found the DE project organization structure inefficient. The operational responsibilities were not clearly established and fostered lack of communication, duplicate effort and no clear-cut authority and decision-makers on site.

Daniel found project controls inadequate due to inadequate document control, a poor materials management system, and overall lack of control in the reporting system.

There was no Master Project Schedule which integrated engineering, procurement and construction activities. Each of these functions were guided by several individual subschedules.

Daniel found insufficient cost and budgetary controls, an inadequate cost reporting system and inefficient organization of cost group.

Finally, in the quality assurance area, major weaknesses were found in the organization make-up, inadequacy of QA audits, and lack of QA-document control.

Daniel findings were first presented to Detroit Edison Mangement in verbal form. Upon advice of Detroit Edison, these recommendations were then put in a written document. We had access to this document.

Daniel recommended a broad based shake-up in the organization structure and work procedures; strongly recommended a Master Project Schedule and suggested strengthening of every area. Although serious deficiencies were indicated in the engineering and design effort, Daniel did not provide a recommendation in this area. They were basically confined to construction.

The Project Management challenged some of Daniel's findings and strongly questioned the Daniel suggestions in many areas.

It is not uncommon with many large projects that engineering and construction groups are at odds with each other. Each blames the other for project problems. Edison was no exception. This issue will be further discussed elsewhere.

There was general agreement with the Daniel finding that lack of nuclear engineering experience by Detroit Edison had significantly contributed to the project delays and design problems. The project manager at the time felt that with impending shutdown, engineering would get breathing room and catch up on design delays without any drastic reorganization effort. Daniel challenged this assumption and warned that:

> "historically, when the construction delays occur, the engineering effort slows down also. As a matter of fact, because of construction delays, Edison should place renewed emphasis and top priority on engineering effort".

In retrospect, Daniel proved to be right. Daniel also stressed a strong need for a drastic reorganization of the project. More specifically, Daniel stated that:

> "The organizational change recommended by Daniel is the single underlying factor which will foster rapid improvement in the problem areas mentioned. The 'new face', the different organization, and the establishment of a strong central control should foster a more significant change in operations and eliminate any tendency to drift back to previous methods of operation".

Daniel promised that as Construction Managers and with their recommended changes and proper support, they would do a better job. In support of their conclusions, Daniel claimed to have 300 pages of work papers. Daniel appeared reluctant to share them with us. The Staff did not insist.

The comprehensive review performed by Daniel seems to have impressed Edison Management. They were also looking for a third party to provide a rationale for the removal of Parsons. The littany of problems recited by Daniel appealed to Edison's management. We have described Daniel's findings in order to assess their own performance in these specific areas in light of their promised improvements.

According to Edison, Daniel was well equipped to handle the CM job and provide the needed project leadership. Further, they were willing to assume the limited role as CM--as per Edison's terms. We were told that others were contacted but unwilling to accept the CM-job at Fermi--specifically, Bechtel was approached but declined. We did not verify this. However, our interviews with Daniel confirmed that they would have much preferred to assume a wider role as general contractors but were satisfied with the limited assignment.

Given the circumstances that Edison found itself in, in 1974, the Staff is satisfied that the choice of Daniel as Construction Manager was a reasonable decision on the part of Detroit Edison. The project was stagnating due to weak and relaxed controls. The construction and planning activities needed strong and dynamic management. Daniel appeared capable of filling this role. Their home office assured full project support. Experience at other jobs was to be applied in moving Fermi 2 forward.

It should be noted that Daniel was weak in some areas. Daniel is primarily a large constructor. They do not possess, nor do they assume to possess, engineering/design capability. Many other organizations such as Ebasco, Bechtel, and S & L generally have both design and construction organizations. The management of such organizations have a better understanding of engineering and design problems. This tends to supplement their construction efforts. Daniel lacked such a background. They were, therefore, unable to assist or evaluate the engineering errors and problems faced by Edison. In our discussions, Daniel was reluctant to comment on Edison system deficiencies and design problems.

By way of background, it is useful to mention that Daniel Management believed very early in the nuclear game that design and engineering was the "Achilles heel" of the nuclear industry. Engineering, in their judgement, as practiced in the nuclear industry, will be the ultimate downfall of the nuclear projects. Daniel, therefore, made a conscious decision not to develop an A/E organization and to restrict their role to constructors. The Senior Management at Daniel are engineers by training. Throughout its involvement, Daniel maintained a distance from Edison design and engineering activities.

Another concern about Daniel was their ability to manage predominatly unionized labor at the Fermi site. Prior to this, Daniel had dealt with essentially open shop craft in southern states. Edison had entered into a general project agreement with Michigan craft labor in which Daniel had not participated. Some difficulties were experienced during Parsons' time on labor relations. It was a concern as to how unions would respond to Daniel and whether Daniel would be able to obtain satisfactory performance.

As will be discussed later, Daniel stabilized the labor situation and maintained good labor relations at the job site throughout the project.

All in all, the Staff feels that the decision to hire Daniel was reasonable and based on sound judgement.

(b) Scope of Daniel Responsibilities and History of Involvement

At the time Daniel was hired as CM in August 1974, Edison was in the process of shutting down the project. Daniel activity was confined to assisting Edison in orderly demobilization of contractors, to get familiar with the project procedures, and to take over charge from Parsons. An interim contract (# 1A-95666) which defined Daniel scope of functions included:

- Preparation of QA manual and QA program covering Daniel responsibilities as CM
- Review project cost estimate performed by Parsons
- Participate in contract discussions with Edison and site contractors to handle equipment rental, reduction of work and delay
- Develop revisions to improve Project Procedures Manual
- Conduct an audit of physical material on site and orderly takeover of warehousing activities.

By October 1974, about 70 Daniel people were at the Fermi site, familiarizing with various site activities. George Crowder was the Daniel Site Manager in this period. In January 1976, Daniel started remobilizing and hired Don Seifert as the Project Manager. During this period, one of the major Daniel activities was to resolve the warehousing problems. Townsend & Bottum was running the warehouse when Daniel took over. As the construction activity shut down, material and equipment were still being delivered. Storage facilities were undersized even for normal warehousing. Material was being placed and boxed into space all over the place. Two cooling towers were being used as a storage area. Daniel recommended adding 20,000 square feet of additional storage. Lack of funds further aggravated the storage problem.

When the project remobilized in February 1977, Daniel brought in 200-300 people on site and assumed the full CM role with Don Seifert as the Project Manager. Bulk construction started in full swing when the project resumed. Responsibilities of Daniel included:

- Contractor bid evaluation
- Project controls and cost estimates
- Contract administration
- Preparation of work sequencing and work activities bi-weekly
- Warehousing and inventory control
- Verification of labor payroll and audit reports
- Project progress reports
- Preparation of quality assurance and monitoring of quality control procedures

The Daniel Project Manager attended weekly project meetings to evaluate problem areas, assess progress and recommend resolution of conflicts and restraints. At this time, the Edison Project Manager, and several major functions, e.g., purchasing, were conducted off-site from Detroit. Several prime contractors were hired such as piping (W & B), Aycock, and RCI in early 1977. Edison invited competitive bids which were independently evaluated by Daniel. Edison generally, but not always, followed Daniel recommendation.

In 1977-78, turnover problems were seriously affecting Daniel site organization. At the same time, Daniel was taking on several other jobs in the power construction industry. Complaints were heard of inadequate staffing and lack of qualified Daniel people on the job. It should be mentioned that the Daniel agreement absolved Daniel of any liability resulting from their mistakes.

Daniel was relatively strong in contract administration. As will be discussed later, they brought in tough construction managers on site who were very demanding--sometimes with adverse consequences. In the main, Daniel were constructors and took this responsiblity seriously.

In 1979, project progress had slowed down. Excessive tiers of organization within each contractor were creating inefficiencies and lack of work coordination. This was particularly so in the QC/QA organization. Each contractor had its own QA/QC activities. Daniel Management felt that they were assuming more responsibilities than their contractual obligations. The Management Analysis Company (MAC) was brought in in 1979 to perform project diagnostics. As a result, a major progress reorganization took place. The Daniel role in QA activities was reduced; Edison site organization was strengthened. Mr. Fahrner, the PM, began to operate from site. Similarly, purchasing, project controls, and field engineering all were beefed up. In 1981, project controls and planning and scheduling activities were assumed by Detroit Edison.

In late 1980, with the project reported 80% complete, it entered into the phase to switch from bulk construction to system completion. Daniel brought in Mr. Jim Ard as PM on site. There was a need for an individual who understood the transition problems from construction to system completion. We had several interviews with Jim Ard--in our judgement, he is competent, analytical, and understands the human factors on the project. His principal job was to demobilize various contractors and their subs. As is understandable, there is a tendency among contractors to drag out the work and latch onto the job as long as possible. The poor economic climate in Michigan in 1981-82 did not help the demobilization effort.

As has been stated elsewhere, Edison Mangement was getting restive to show completed systems which could be tested by start-up. In late 1981, a formal system completion organization was formed to receive and punch list the systems. Our discussions indicated that Daniel advised against the SCO formation on the grounds that it was premature by 3-4 months and could disrupt the construction underway. Further, that a premature takeover of systems would relieve the contractor of his construction responsibility too soon. Edison, however, moved ahead with their plans. To our knowledge, no ill feeling developed between Edison and Daniel on this account. Conflicts, however, were to be resolved as to how best to use resources available. As the SCO performed a check list of missing parts, equipment, and refurbishment, a large amount of equipment had to be procured. Many had large lead times. The completion and testing of systems could not be done while parts were on order. Therefore, Daniel insisted that the craft and other resources could be better utilized on systems in the construction phase. Staff discussion with MAC consultants also supported this view. As an aside, in our judgement, Edison's inventory levels on critical spare parts were inadequate which held up construction in many instances.

During 1982, Daniel's role was considerably reduced as various contractors were being phased out. Edison took over warehousing, contract administration, payroll and cost accounting systems from Daniel. However, many Daniel employees were utilized in various groups. They report to Edison supervisors but are on Daniel payroll. In 1983, Daniel was supervising W & B piping work, modifications in drywell (Mr. Don Hunt is the DW task sponsor, also known as DW-Czar). Daniel is also providing support services for transfer of responsibilities to Detroit Edison.

Daniel played no role in start-up activities, nuclear operations or maintenance activities. When Bechtel was hired to perform general maintenance services, radwaste modification, and on-site storage construction, Edison was their direct supervisor.

Staff Evaluation of Daniel Performance

We reviewed thousands of documents specific to Daniel performance year-by-year, discussed with many individuals, both Edison, non-Edison, craft and non-manual. As is expected, each perceived their role and performance somewhat differently. Comments on Daniel personnel, for example, ranged from "Bunch of clerks who didn't understand systems" to "very tough, very aggressive". Also, many complained that either they had too much authority or too little. In forming our judgements, we attempted to verify the personal comments through performance documents, actions, and advice that Daniel ultimately rendered Edison over the years.

It is best to evaluate Daniel performance by listing specific areas of their responsibilities and discussing their weaknesses and strengths.

1. Daniel Performance on Bid Evaluations and Estimates

After the project was remobilized in 1977, Daniel played a major role in providing an independent assessment of contract bids solicited by Edison.

We found Daniel's evaluation very detailed and comprehensive. Besides independently pricing the bid package, Daniel cost estimators also reviewed the bidder's terms such as markups, organizational capabilities, understanding of the work, and placed dollar values on such factors. Although we did not verify Daniel estimates for accuracy, the Fermi Project Directors commended Daniel cost estimating capabilities and found them very sound and methodical. Daniel also participated in hundreds of work change requests (WCR) where contractors asked for contract revisions or compensation due to delays, scope changes, rework, etc. These WCR cost claims and revisions were also independently evaluated by Daniel. They participated in disputes, arbitrations and other contract negotiations.

In general, Edison seems to have accepted Daniel recommendations. We found several instances where Daniel advised against an award but was ignored by Edison. It is our understanding, for example, that the major piping contractor, W & B, was not the preferred choice of Daniel. Daniel questioned the W & B experience and organizational size to meet the nuclear piping needs. W & B had performed at Diablo Canyon on limited piping weld work and quoted it as their nuclear experience. They obtained an N-Stamp after coming to the Fermi site. Also, Daniel felt that W & B was a marginal organization, too small in 1977 to handle the Fermi job.

We also found several other examples (see evaluation of Comstock) where Daniel evaluations indicated that a bidder's markups were too high and, therefore, must be rejected. For various reasons, they were ignored. One must realize, however, that Edison was the owner and had ownership prerogatives. It is not unreasonable to expect that it not accept Daniel's advice in all cases. At the same time, Daniel advice was not infallible. For instance, Daniel had recommended termination of GE - I & SE contract for CRD, RPV internals and associated work (1A-92100). Daniel also recommended hiring RCI to complete the job. Edison had concurred with this recommendation. As this issue is discussed elsewhere, Edison was dissatisfied with GE (I & SE) performance and was forced to go to RCI. (GE & RCI have performed 90% of the CRD, RPV internals work in the BWR industry).

Later, performance of RCI was also found to be very poor. It is alleged that RCI sent their B-team (eastern region) to Fermi 2, which is less experienced than the western region. RCI is headquartered in San Jose, California. Between 1981-83, the RCI costs escalated from $3 million to $26 million. Our discussions with project people suggest that both Edison and Daniel regret this decision. It may be helpful to shed some light on the RCI vs. GE (I & SE) issue.

By early-1980, both DE and Daniel were frustrated with poor General Electric (I & SE) labor utilization on the installation of RPV internals, CRD, HCU. Less than 60% work was completed with 3 times the targeted man hours and dollars spent. Daniel recommended and Edison decided to rebid on the remaining job. GE (I & SE) and RCI both bid on the job. The RCI bid was a lump sum of $2.9 million, GE $3.9 million, while Daniel independently estimated at $2.75 million. In view of dissatisfaction with GE, the contract was awarded to RCI. Later, RCI was also awarded CRD-hydraulic system design work completion for an additional $156,000.

While from cost and previous experience the RCI award seemed attractive, a number of difficulties arose with this decision.

Teledyne Engineering had been subcontracted by GE (I & SE) to perform seismic testing on reactor internals design work. (As an aside, it should be pointed out that CRD in a BWR comes from the bottom; on a PWR, it comes from the top. Some experts claim that this is preferable because if anything goes wrong in a PWR, the CRD's just fall and scram the reactor. Others challenge this position. High pressures in PWR are likely to cause CRDs to fly off.) RCI at first refused to work with Teledyne and wanted to take over all engineering work. This led to duplication, lost time, and conflicts. Daniel had to take over direct supervision of Teledyne. RCI received 12% markup on Teledyne subcontract.

Considerable time was lost between GE demobilization in November 1979 and restart of RCI work in January 1981. Thirdly, the GE (I & SE) contract was terminated after a long and bitter dispute. GE filed for demand arbitration against Daniel and Edison in April 1981. Daniel and Edison filed for dismissal and a counter demand for arbitration.

The settlement agreement released I & SE from any liability resulting from I & SE performance whatsoever. When RCI found fabrication and other mistakes as a result of I & SE work, they charged DE for corrective work. Had GE (I & SE) still been there, some of these costs could have been salvaged.

Finally, RCI's own performance was not entirely satisfactory. The cost overrun was of the order of 10 times in a period of two years. A firm price contract was soon changed to a cost-reimbursable plus fee. In retrospect, Daniel advice on I & SE was poor. In 1983, DE invited GE (I & SE) to perform IHSI treatment on pipes and welds. GE (I & SE) performance was commendable. It appears that GE is extremely good in highly skilled and technical work, not so good in craft management.

Going back to the issue of Daniel performance, we reviewed in detail numerous contracts for price revisions, escalation and delay cost renegotiations, and contract dispute settlements. One of the early contracts supervised by Daniel was the construction of RHR Complex by Utley-James. We describe this contract in detail to illustrate Daniel involvement.

In 1973, Edison decided to build a separate Residual Heat Removal Complex as a Class I structure. The AEC required at that time that after a reactor shutdown, residual heat must be removed from the system. The RHR system receives water from the reactor and dissipates this heat through mechanical draft cooling towers. The RHR Complex is a 225' X 120' concrete structure. It also houses the emergency diesel generators. The building is located west of the reactor building. The Complex was designed by S & L and they prepared the basic bidding documents. Parsons was the General Contractor on site. The Edison Project Management decided that the contract for this job be awarded to local contractors. One consideration was that the RHR Complex must be completed by May 1, 1975. Edison proposed to give incentive of $10,000 per day for early completion.

The five bidders on the job were:

1. Barton-Malon: $5.2 million
2. Darin & Armstrong: $5.3 million
3. Utley-James: $6.5 million
4. A. Bentley & Sons: $8.4 million
5. A.J. Etkin: $8.4 million

R.M. Parsons evaluated the job at $6.4 million.

Utley-James was selected on the following basis:

1. U-J had a better reputation and obvious desire to perform nuclear work.
2. U-J agreed to work with L.K. Comstock as the electrical contractor.
3. U-J proposed to use Handcraft Metals as the steel subcontractors. Others proposed Inland-Ryerson. Edison had previous problems with I-R.
4. QA manual submitted by U-J was acceptable for Class I nuclear work. Others were found to be deficient. Therefore, U-J did not require much "hand-holding" in QA areas.
5. Work sequencing activities better proposed by U-J.
6. D&A were obviously scared of nuclear work; B-M wanted to be insulated from Parsons; U-J would double-shift the work, etc.
7. U-J agreed to work on terms suggested by Edison: i.e., 7% markup + cost and additional 3% bonus if work as done on time. Contract guaranteed maximum of $6,580,253.

In April 1974, U-J was awarded the RHR contract work (# 1A-94984). Edison was in a hurry to get the job done by May 1, 1975 and was willing to pay a generous bonus for this.

In November 1974, U-J was demobilized and asked to remove all equipment from the site. U-J did not perform any work due to project shutdown. They were paid $39,000 to remove the trailer, dismantle and return tower crane, etc.

U-J resumed work in April 1977. By now, Daniel was on site to supervise U-J work. Daniel reviewed the U-J contract with revised terms. U-J asked for an additional $1.87 million. Daniel recommended retaining

U-J and settled for $1.5 million in addition to the original price. Some of the U-J contract revisions are detailed below:

a. Daniel obtained $15,000 credit for reduced steel installation.

b. Daniel inspected the stored material and asked U-J to remove rust and scale from it. U-J claimed it was outside the scope. Daniel/U-J settled for half the claimed labor costs.

c. In March 1978, Daniel requested U-J to accelerate the work. Daniel/U-J negotiated and reduced the fee escalation on additional work from 10.95% to 2.25%.--a savings of $38,000.

d. In mid-1977, the RHR basement was flooded several times, power outages, valve malfunctioning and other events created a need for major clean-up and dewatering efforts. U-J was directed by Daniel to perform clean-up and dewatering. Cost: $39,000. Daniel estimates were reasonable.

e. In June 1978, U-J received $49,000 to remove epoxy from the RHR concrete and reinforcing steel.

f. In December 1977, Daniel directed U-J to cease backfill operations around the RHR to facilitate electric duct work. Daniel demanded and received a credit of $24,000 from U-J.

g. In October 1978 (CO # 19), Daniel successfully negotiated installation and assembly of four fiberglass liners supplied by Marley, for $22,000 (contractor bid $29,000).

h. In December 1978 (CO # 20), Daniel directed U-J to perform a number of modifications in reinforcement steel, modify embedded plates and sleeves, and modify roofing. The price was negotiated by Daniel & U-J. Cost: $206,000.

i. In June 1979, a final contract adjustment was negotiated (CO # 22) by Daniel and U-J. Edison received full credit for work not performed, material not used, and clean-up operations. Daniel demanded and received a $47,000 credit for inaccurate location of embedded plates, pipe sleeves anchor bolts, and equipment foundation location.

The final price of U-J work was $9.5 million, a 50% increase from the original contract. About $1,000,000 was estimated to be added to the original contract when complete drawings were available from S & L. The contract was closed out with $210,000 left in the contract budget--something which rarely happened on other contracts.

From review of this and other contract reviews, (See Aycock, W & B) we are satisfied Daniel cost estimating and contract negotiating performance was generally good. Daniel made a reasonable effort to protect Edison's interest.

It is important to mention here that there was a fundmental difference between Edison and Daniel contracting approaches.

Prior to project shutdown, it was Edison's desire to award fixed price contracts. Edison firmly believed, in our judgement, that it was more cost-effective and practical to go this way. Edison, however, was finding it very difficult to enforce such agreements due to incomplete design, rework, and equipment delays, etc. For example, in the U-J contract, a $1,000,000 contingency allowance was made at the time of work assigment as a result of incomplete design package. Similar problems existed in contracts with Aycock, GE (I & SE) and others. Edison felt that some of the engineering and design issues would be sufficiently resolved during the project shutdown (1974-1977), and enable it to prepare relatively complete work packages, frozen designs and, therefore, fixed price contracts will be practical and enforceable.

When the project restarted, Edison, in its mistaken belief of engineering design capabilities, solicited, and indeed issued, several fixed cost contracts. A principal example of this was the piping contract. W & B underbid everyone and offered to complete the remaining piping work for $62 million.

In our judgement, Daniel understood the pitfalls of a fixed price contract in the nuclear industry--especially after the mid-1970's. Daniel advised Edison against fixed price awards for W & B; fire protection system and others. Within 9 months, the W & B contract was changed to cost reimbursable, as were many others.

The Staff believes that although attractive on the face, fixed price contracts generally are not cost-effective in the nuclear construction industry. Some of the reasons being:

- Regulatory uncertainties and attendant design and engineering changes;
- Too many interfaces between contractors; dependence on engineering and procurement provides a ready excuse to a constructor to demand compensation for interferences, delays, space limitations, etc. Generally, such a compensation is quite high (20% + added cost is not uncommon) and is on top of the built-in allowance in the fixed price.
- Owner/CM has more control over the contractor in a cost reimbursible case. He can be more easily removed from the job without expensive termination charges.
- Generally, a contractor would accept a fixed price job only to get a foot in the door. He is assured of full cost reimbursement as soon as the first revision is brought to him. It's a trap for the owner.

- A fixed price approach was particularly unworkable for Edison since their nuclear experience was inadequate, design work was fragmented (too many speciality AE's), and project schedule not well under control.

This is not to suggest that hard money contracts are totally unworkable. In areas where work can be well defined, design frozen and work conditions isolated, such arrangements are well suited to hard money jobs. Edison, for example, got successful results in cooling tower and on-site storage jobs using hard money contracts. But in the main, nuclear construction does not lend itself to hard money contracts.

The Staff believes that the Edison philosophy on contracting was a genuine effort to control project costs. In part, it was perhaps dictated by the responsibility to the rate payer and accountability to the regulatory commission. We found several memos expressing this concern. The Staff commends the Edison effort. Further, the Staff agrees with Edison decisions to convert several fixed price jobs or to award new jobs on a cost reimbursible basis. Also, the Staff notes that in many cases, contracts had other incentives and bonuses for target performances, productivity improvements, etc. Finally, it should be pointed out, the appointment of a Construction Manager was consistent with later contracting approaches.

2. Contract Administration

This was a primary Daniel responsibility. Organizationally, Daniel assigned a lead person in each major area, e.g., piping, electrical, who directly interfaced with the primary contractor organization. Further, supervisors were assigned by bulk area who would define and monitor work activities, reporting procedures, QC inspections, authorize staffing levels, and overtime, etc.

We selected two major contractors: W & B and L.K. Comstock to evaluate Daniel performance. Correspondence and documents were reviewed for each year 1977-1983.

It took Daniel quite some time to get familiar with project procedures, work rules and adequate staffing levels. Staffing levels were inadequate in several areas such as materials testing lab, field checks for daily face checks, accounts and payroll functions. Edison PMO issued several guidelines on invoicing, purchasing, accounts payable activities, and records management systems, assumed by Daniel. Concerns were expressed by PMO on work backlogs, understaffing and corrective actions to be taken by Daniel.

Incidentally, Edison Auditing found several discrepancies in Daniel's own home office and field invoicing for their expenses. Terse letters were issued by Edison to remind Daniel of the audit concerns (Staff request #136 and EF2-39988, dated 3/15/78). For example, Daniel was charging its management time as direct expense. The contract did not provide for that above the level of a manager.

Daniel had the responsibility to collect and verify the subcontractor weekly craft payrolls. Funds were transferred by Edison to the Daniel account. Daniel made direct payments to the contractors. In the case of W & B, Daniel did all the invoice checking. However, W & B would estimate their next weekly payroll, and Edison wired funds direct to the W & B account. There was a monthly reconciliation of W & B payroll and other expenses.

Prior to 1980, there was no on-site Edison staff to verify or monitor Daniel accounts payable activities, other than part of the normal internal audit function of the project.

After the 1980 project reorganization, financial controls were strengthened by bringing staff on site, supervised by Norm Miller. This staff performed a more detailed audit of the accounts payable. In October 1982, Edison took over the payroll system from Daniel along with other project control functions.

The Edison internal audit found several problems with the Daniel accounts payable functions, such as:

- Overbilling through payroll taxes, FICA, etc.
- Contract misinterpretation
- Michigan Single Business Taxes, etc.

Prior to 1980, Daniel also maintained the Cost Accounting & Reporting System (CARS). This was directly tied to project costs and general ledger system.

The Daniel payroll function improved considerably over the years. For example, on August 11, 1981, a complimentary memo was sent by the Edison Assistant Project Manager to Daniel, commending them for excellent performance, and rating the Daniel payroll department as a "9" on a scale of "0" to "10".

The Staff feels that the overall performance of Daniel in the financial controls area was about average and could have been improved. This is further elaborated in the Staff report on Internal Audits.

- In 1978, Daniel recommended the need for an automated records management system (ARMS), which was established on site.
- Daniel had considerable difficulty at first in controlling housekeeping activities sucn as monitoring early quits, late starts, face checking, and clean-up of site. A vigorous face checking program was instituted requiring 100% face verifications.

Craft people were let go for unaccounted absences, loafing, etc. Cost plus contractors were docked for lost time, early quits, etc.

In November 1978, a rather desperate letter was written by Don Seifert, the Daniel PM, to Edison PM (DIC8-7118). The memo outlined the Daniel difficulties in labor control, being one or more steps removed from the position of an employer. Some of the problems, causes, and corrective measures were listed as:

- Leaving site prior to quitting or authorized time. Names of such individuals were given to their contractors and 30 minutes of pay was deducted for each observed instance.
- A 100% head count of people brassed in is made. This assures that craft is present though not necessarily working.
- Assigned alleys and staggered opening time for various contractors.
- Some problems due to parking, egress and ingress. Staggered shifts were recommended and instituted.
- Utilization of manpower: all parties have observed that productive activity is less than normal. Contractors have been ineffective in correcting this situation. There is a general attitude that this management is unwilling or afraid to manage their people in this area.
- Part of the problem results from numerous changes in design, assignments and instructions as well as in delays due to information, material, inspector, or approval. This complicates coordination, demoralizes supervision and craft.
- Many site and contractor QA/QC and work procedures are cumbersome and overly restrictive. This often necessitates work

stoppage, reassigning craft with significant loss of productivity. A DIC/DE task force has been established to streamline the procedures.

- Daniel recommended a good work sampling program to identify the type of delays. This will be a useful tool to the supervision. One difficulty was that there were too many contractors on site.
- Daniel recommended that Edison participate in a comparative study at no cost. The study will identify relative craft performance and causes of delay, lost time, etc. (Edison did participate in that study, to be discussed elsewhere.)
- Memo surmised that due to critical shortage of skilled labor in piping and welding areas, outright firing was no solution. The replacements were no better.
- Daniel recommended that efforts be placed on minimizing delays in design, change, information, materials, inspection, and approval.

Daniel exhibited a considerable level of detailed control over the day-to-day activities of contractors. Daniel met with the contractor's managers at least 2 to 3 times a week. All manpower levels had to be approved by Daniel, including the specific individuals in the supervisory levels. Man-hours would be deducted for observed late arrivals and early quits. Many were fired for negligent work. Daniel showed a great deal of concern, for example, that contractor man-hours were properly assigned to rework vs. original scope work. A major disagreement arose between Daniel and Comstock on this issue. Daniel obtained authority from Edison to arbitrate the issue. Daniel asked LKC to document the history of cost code disputes on seismic tray hangars, seismic conduit hangars, wedge anchors, conduit ID, relay panel access holes, continuity testing, etc. Daniel only allowed 257,000 MHS for claimed 314,000; about 82%. Daniel stuck to its decision and prevailed. Between 1979-1982, there were at least six other cases of arbitration between Daniel and Comstock, which shows that Daniel was quite tough on Comstock.

- 1/8/79: Daniel writes memo to LKC with final decision on QC invoices and invites arbitration. Arbitration was dropped.
- 7/3/79: Daniel withheld LKC management fee and craft markup payments temporarily to spur performance on terminations. Later payment was made when work improved. Daniel demanded and obtained removal of LKC Site Manager.
- 4/8/80: Daniel wrote to LKC maintaining final decision on contested codes. It seems LKC was continuously miscoding the work to receive higher compensation.
- 11/12/81: Dispute over Michigan Single Business Tax. Daniel prevailed in the arbitration.
- 1981-82: Several arbitration cases over employee terminations.

Often Daniel disagreed with LKC work procedures and asked to find better method of performing work; for example, in retrofitting of 20,000 feet of power struts. Power struts supplied by vendor, Power Struts Corporation, were found to be unacceptable. A dispute arose between the vendor and Edison regarding defective material. The vendor claimed that this was due to Edison design specifications. This is a potential disallowance item.

Daniel also identified generic problems of excessive (50%) DDR's and asked LKC to re-evaluate acceptance criteria and to improve first line inspection. Daniel also enforced re-testing at LKC expense of wedge bolts which had been mis-tested before.

Daniel was equally tough on Comstock's quality control program. In 1978, Mr. Bolt, Daniel's QA Manager, assessed the LKC QC program and identified numerous defects in the installation practices. A memo was sent to LKC, indicating:

> "In view of above listed items, and corrective action not completed as committed, ..., please direct Comstock QA to assess all deficiencies and show cause to DE QA thru this office why this problem should not be reported as a possible reportable deficiency under 50(55)e for significant breakdown in QA program of L.K. Comstock".

LKC responded with promised corrective action although denied it as a significant breakdown of QA program. Daniel insisted that it have major input on training programs, and management reviews of LKC QC performance.

How tightly Daniel controlled manpower levels and their detailed involvement is illustrated by an excerpt from a response memo by LKC to Daniel, dated March 7, 1978:

> "Your letters authorizing the number of personnel and pay rates is contrary to your stated goals of 'getting the job done'.
>
> - LKC will, however, comply with your desires in recognition of your responsibilities as a 'manager'. However, our ability to respond to your scheduled needs and goals will be greatly impaired and we cannot accept the responsibility for future impact.
>
> - Your attempt at further tying our hands by requiring resumes and interviews prior to hiring additional personnel is totally unacceptable.
>
>   Further, your desire to interview and receive a copy of their resume is an involvement in proprietary information and in conflict with our contract, etc.
>
> - Your threat to withhold payment of all invoices is unjustified and not conducive to a working relationship".

Obviously, Comstock resented such tight and aggressive postures of Daniel.

Daniel also questioned, on numerous occasions, LKC interpretation of the contract agreement as to original scope. For example, in March 1978, Daniel insisted that installation of Thermo-couples by LKC was covered by the original scope and should be performed without charge.

Daniel challenged billings and fringe benefit claims by LKC on numerous occasions (see 1978 contract correspondence). Items dissallowed included: escalation of extended fees, overheads, markup fees for snow-days, relocation cost reimbursible personnel, overtime vs. straight hours, and shift differential for non-manual.

- Daniel demanded a three-month cash flow forecast of all its major contractors
- Daniel routinely computed ratios of supervisory personnel to the craft-personnel for each contractor. These were submitted to the contractors as part of the cost control program (see DIC8-4356).

Daniel was also quite adept in labor invoice control; as this memo of July 18, 1978 from Daniel to LKC suggests:

> "Your request to utilize the services of a labor broker to fill electrical engineering design positions is hereby approved.
>
> In order to clarify the matter of per diem, I suggest that a dummy invoice be solicited from each potential broker. Additionally, the use of sliding vs. fixed scale should be quoted by all suppliers".

In reviewing the Daniel contract administration of W & B, we found similar examples of aggressive and detailed involvement of Daniel supervisors in day-to-day activities. There were many examples of good cost controls and demanding performance from W & B. Daniel constantly reminded W & B of the understaffing in QA/QC area; welders shortage--Daniel implemented a welder training program at the site with GE assistance.

Daniel was constantly hassling W & B for QA deficiencies, performing work out of priorities and out of scope, lack of confidence in the inspection of first-line inspection leading to reinspections, e.g., continuous re-verification of welder's ID against a weld, serial number and heat numbers, and better utilization of QC personnel.

Daniel emphasized lack of document control at W & B shop and instructed more disciplined procedures to minimize DDR violations--a serious problem. Daniel also recognized specific instances of good performance at W & B and provided incentive awards--"Crew of the Month", etc.

Daniel very tightly controlled manpower craft levels. In the early years, W & B suffered from inadequate craft (1977-79); in 1983, the problem was how to reduce their size. DIC83-0108 informed W & B to reduce 10% craft, starting with persons who have poor work and absenteeism records. A 5% cut was ordered in December 1982. Reductions were ordered in specific areas throughout 1982.

Daniel often chided W & B for improper hiring practices (DIC82-2923), violations of Nuclear Quality Material Control (DIC82-2434), and delays in weld turnover for radiographic testing.

Daniel also closely monitored back charges and refunds that Edison was entitled to due to contractor errors, refunds, etc. For example:

- Daniel applied a 25% markup to all back charges due Edison from contractor errors. W & B contested this as excessive. Daniel made strong justifications for this policy.

- W & B received a Workman's Compensation premium dividend. Daniel insisted that this be turned over to Edison since the owner would have paid all premium charges. At first, W & B balked at this. Daniel threatened to credit an estimated $500,000 to the DE account (DIC80-5740). To our knowledge, W & B complied. Later, this amounted to over $900,000.
- There was a dispute on a 15% shift premium for non-manual personnel. Daniel refused to pay this until specifically approved by Edison. Daniel recommended against it (DIC8-5975).
- When Daniel found unauthorized W & B personnel on the site, they were challenged. In the case of one Mr. A. Levine, Daniel refused to reimburse him since he was on site without Daniel knowledge and approval. It so happened that the Edison PM had authorized his hiring on the site, without Daniel knowledge.
- Daniel asserted their role rather strongly. Often W & B tried to bypass Daniel and deal directly with Edison--hoping to get a better deal. Daniel reminded the contractors of the agreement provisions, such as:

  "All determinations and instructions of Daniel .... will be final";

  "If the contractor is taking directions directly from Detroit Edison as opposed to thru Daniel, as specified in the agreement, then it should request a contract modification....".

In one instance where W & B requested approval for an employee to attend a welders conference in Orlando, Florida, the Daniel Construction Manager politely responded:

"Homer, they say money is tight. So this was not approved".

Daniel performed annual evaluations of each contractor's performance on site. In our judgement, this was a good management tool. However, Edison PMO paid scant attention to these evaluations.

All in all, the Staff review of Daniel suggests that they performed extremely well in the area of contract administration.

3. Daniel Planning and Scheduling

One of the Daniel responsiblities as CM was to:

"Develop a coordinated engineering, construction and testing schedule. This schedule is to be updated monthly and completely evaluated quarterly". (II B (5)).

In their 1974 project review, Daniel had indicated lack of an Integrated Master Project Schedule as a major weakness at the time. One would expect, therefore, that Daniel would improve on this activity.

In our judgement, Daniel made several efforts to develop a Coordinated Master Schedule, but with little success. Daniel was quite effective in planning a short-term construction schedule--two-week to six-week activities. Daniel prepared CPM Models in order to prepare integrated manpower loadings by craft by area; prepare work sequencing and activity levels. The cost estimating process was not integrated in the work scheduling and planning functions.

Daniel, to some extent, acknowledge this lack of long-term planning during the project. Their assertion was that a key element in integrated planning--the engineering schedule--was outside their control. Further, procurement suffered from the same delays and uncertainties. Both these functions were outside Daniel responsibility. Therefore, no meaningful Master Integrated Plan could be feasibly developed under the circumstances.

Incidentally, the planning and scheduling functions improved considerably towards the end of the project in 1982-83. At this point, Edison had assumed control over this function. Detroit Edison implemented a highly sophisticated state-of-the-art computer model called PROJECT 2 (PCP). This model integrates cost, scheduling and control activities for all segments of the project.

Schedule and costs are two of the most important factors for a large project. To optimize effective project control, cost and scheduling must be integrated in one system. Also, such a system provides a more realistic assessment of the work that has been performed. Often, managers tend to be optimistic rather than realistic regarding completion of an activity. Subjective estimates often reflect this tendency. An integrated Cost/Schedule Model gives the ability to a project controller to have:

- Performance Measurement Baseline. Time-phased budget plan against which work performance is measured. Thus, performance is measured not based on dollars spent, but on value earned for physical/schedule completion.
- Variance Analysis. Those differences which require further review, analysis or actions can be identified. Reports such as negative weeks, and critical path items can be identified.
- Work Breakdown Structures. A WBS is a hierarchical division of work tasks which organizes, defines, and graphically displays the work to be done. It produces Level I, Level II-Level IV type activity scheduling.
- Identifiable Work Packages. These are short-span jobs, or material items, identifying work required to complete the project. A work package represents units of work where work can be performed; is clearly identifying from other packages and is

assignable to a single organization element. A work package has a scheduled start and completion date, and interim milestones, which represents physical accomplishment.

Implementation of Project 2 (PCP in late 1982), improved significantly Edison's ability to identify, analyze and control its broad planning activities. One reason, in our judgement, for emphasis on this integrated planning was the fact that in 1982-83, start-up activity was beginning to drive the project. Therefore, start-up created a push on all other phases of the project.

Finally, we must emphasize that sophisicated planning and scheduling is not widely practiced in the industry. Even very large and experienced constructors often shun CPM/PCP type tools. They often resort to the semi-automated trending analysis, etc. One reason for it is the human factor. No group or entity wants to be tied down to a schedule or deadline. Engineering groups are notorious for this.

Typically, construction groups bear the blame for this lack of accountability by engineering, procurement, and other non-construction groups. After all, the progress on the job is measured by the physical work done. No one looks at engineering/design as the culprit--unless one looks closely.

In summary, the Staff feeling is that Daniel was able to successfully plan short-term construction scheduling activities. But in the long-term planning, they were not so successful.

4. Did Daniel Employ its Best People at Fermi?

During our interviews, some concern was expressed that Daniel did not bring their best people to Fermi.

In our judgement, this allegation is not fair. In every organization there are weak areas and strong ones. Daniel was first and foremost a Construction Manager. In this role, we believe Daniel employed well-qualified and aggressive individuals.

As stated earlier, Daniel lacked BWR experience. To overcome it, Don Ferguson was hired. Mr. Ferguson had worked on several GE turnkey projects. At the managerial levels, we found Daniel people competent and experienced. Mr. Ralph Williams, Vice-President in charge of all nuclear projects, had worked on the Surrey Nuclear Unit of VEPCO and was in charge of all construction. Mr. Williams took an active role at Fermi 2, and attended all management meetings on site. He directed the Daniel Project Organization.

Similarly, Mr. H.W. McCall, the current President, had been in the construction organization of Ebasco for about 20 years. In our judgement, Daniel Management support was adequate. As has been indicated earlier, Daniel had favorable bias towards PWR.

At the project site, Daniel's area managers, and construction managers all appeared very aggressive individuals. In fact, many of the concerns expressed suggested that Daniel asserted its role too much, and sometimes developed bad relations with contractors.

There is some evidence of this on record. It is our understanding that Daniel removed several of its personnel from Fermi to improve working relationships. Mr. Don Siefert was found less effective than subsequent Daniel Project Managers.

One name that came up frequently was Mr. Mark Albertin. Our understanding is that he was a very dynamic individual, but extremely tough and demanding. Many resented and questioned his effectiveness.

He was taken off the job as Construction Manager. He later left Daniel. Working relations between contractors and Daniel improved considerably after Mr. Jim Ard, Jr. came as a Project Manager.

The Staff feels that although there were a few instances of overbearing managerial techniques, in the main, Daniel was exercising its authority and contractual obligation to get the job done efficiently and serve the interest of its client.

Overall, the Staff is pleased with Daniel performance.

Disallowances

1. The Staff recommends that Daniel expenditures incurred during the period of May 1974 to July 1974 should be disallowed. These expenditures were ostensibly for Daniel's project review activities. All evidence indicates that Detroit Edison fully intended to replace Parsons and hire Daniel prior to their review. In a 1975 memo, Edison requested Daniel to summarize their finds outlining the reasons for removal of Parsons, to which Daniel gladly complied.

   There is also the question of true independence of an outside reviewer if he is promised a large contract based on his findings. Detroit Edison may argue that the Daniel review was beneficial in Edison's understanding of Daniel capabilities, before committing them as CM. In that case, Edison should have done the opposite, i.e., hired a third party to review Daniel projects.

The Board of Directors' minutes of May 20, 1974 discusses that consideration is being given to removal of Parsons and turning over the project to another group (Daniel).

The Staff's estimated disallowance for this item is:

Base Cost	$100,000 (estimate)
AFUDC (1974-82) rate	1.73
Total Disallowance	$173,000

2. In July 1974, Edison and Daniel entered into an interim contract agreement (1A-95666). The purpose of this agreement was essentially to phase out Parsons, acquire familiarity with the project, and in general, perform project take-off activities.

In the Staff's opinion, these were duplicate activities resulting from Parsons' termination. Therefore, expenditures during this period, July 1974 through November 1974, should also be disallowed.

Estimated Dissallowances

a.	Base Cost (see 1A-95666; CO#5)	$ 575,000
b.	Edison Contingency Factor	.2
c.	Total Base Cost	$ 690,000
d.	AFUDC Factor (1975-1982)	1.651
e.	Total Disallowances in 1982	$1,140,000

8. Radwaste System Modifications

Background

The Radwaste System for collecting, processing and drumming of low-level waste at Fermi 2 was purchased from GE as part of the original NSSS option package. GE provided the concept design, while Detroit Edison Engineering performed the detail design. Construction and actual installation of the Radwaste System was done under R.M. Parsons during 1971-74 and was completed in 1979. Daniel International was the Construction Manager at this time. The direct costs of construction of the radwaste were recorded at $12 million. At the time it was purchased, similar GE radwaste systems had been installed at several other plants. Detroit Edison claims that it reflected the state-of-the-art in terms of installation, operability, maintaining, and processing capacity.

In mid-1979, however, only a few months after the original installation had been completed, Detroit Edison start-up engineers were raising serious doubts about the workability of the system as designed and installed. These doubts were based on experience at other plants with similar GE radwaste systems, walkdown by start-up people, and several experienced individuals who had seen the EF2 System.

In 1979, an independent task force was formed of Detroit Edison engineers (who were not involved in the original design) to review, in detail, problems with the just-completed radwaste system. On October 25, 1979, an internal memo prepared by Detroit Edison Project Engineers summarized the serious problems with the radwaste system found by the in-depth review team. The memo recommended appointment of an outside engineering consultant to do an independent, in-depth review of the operability of the system and to recommend fixes. An outside consultant was suggested to design the modifications as Detroit Edison felt that it lacked the special skills and manpower necessary to pursue the radwaste system any further.

In April 1980, the NUS Corporation, a large engineering firm with extensive radwaste experience, presented a "Report of Evaluations: ENRICO FERMI 2, Solid and Liquid Radwaste Systems". The report confirmed the problem list developed by the Detroit Edison engineers that the system as designed and installed was inoperable, inefficient, unsafe, and uneconomic. Serious design problems were found with almost every subsystem. The problems were identified by NUS in three general catagories:

Catagory A: There is a consensus that the item will not function as is and must be corrected before start-up.

Catagory B: Important. The item may function, but not well and not for long. There is little doubt that it eventually must be corrected (perhaps soon after commercial operation).

Catagory C: "Nice to have". These items will be corrected in the near future.

NUS evaluations, though utilizing experience at other BWR radwaste systems, focused on specific problems in the Fermi 2 radwaste system. NUS identified several problems common to many radwaste systems designed in the same general timeframe including:

- liquid inputs are regularly running at or above "maximum expected" levels depicted in the NSSS design documents.
- quality of water treated by waste collector and floor drain systems consistently contained high level of suspended particulates. A large amount of particulate matter does not come

from the reactor building or "balance of plant", but rather from the radwaste system itself. Thus, the radwaste process became the source of much of the suspended solids in the radwaste collector and floor drains.

- oil in the floor drain wastes and equipment drains is an important contributor to the problem.
- much greater than expected quantity of solids created need for more frequent drumming, higher quantity of radioactive material, frequent drumming results in faster depletion of equipment, more downtime, flooding, and breakdown of the system.

In general, NUS found that what was thought "to be a capacity-related problem was actually a process problem". NUS also found that EF-2 has a series of components for liquid-solid separation which can cause precisely the problems listed above. Fermi 2 tank capacities were marginal at best (inadequate for maximum floor drain inputs). There is serious doubt as to the radwaste system's functionability as far as sludge handling facilities. NUS review, however, went on to report a large number of other serious design deficiencies and installation problems at EF-2 which went beyond the generic design criteria. These problems were systematically identified by NUS and Detroit Edison engineers. Some of them are listed as follows:

A. Liquid Processing

1. Waste Collector Subsystem

a. Comparison of design input quantities shows that at a typical BWR, the experience's input quantities average 40,600 gpd compared to 18,500 gpd designed at EF-2.

While the maximum design of 61,000 gpd at EF-2 seems to fall within the standard of 49,600 gpd established by ANS-55.6.

b. The collector tank recirculation for mixing and sampling prior to processing, as designed will have serious adverse effect on the suspended solids loadings. Recirculation will only re-suspend the solids, which have already settled in the tank, thereby increasing the amount of suspended solids. Recirculation and sampling serve little purpose. If samples are desired, they out to be obtained further downstream. The recommended fix calls for a non-recirculating system.

c. Tankage: EF-2 tank size for waste collector is designed for 28,000 gallons. ANS-55.6 criterion is calculated at 20,000 to 30,000 gallons. NUS assessed that tank size, therefore, is inadequate.

d. The system as designed requires more frequent filter backwashes, which introduces large volumes of back-wash water into the radwaste system for processing, i.e., process creates more radwaste than it processes.

e. Carbon steel used in construction material has the potential for a conglomeration of the radioactive crud component and for corrosion oxides adhering to the walls. This will increase background radiation. Tanks are also made of carbon steel and unlined, and, therefore, have the potential for increased radiation. Waste collector tank and waste surge tanks should both be lined with plastic.

f. Operability: Serious problems due to:

- Placement of system block valves within the tank cubicles requires unnecessary entry into radiation or high radiation area. Limit switches with indicating lights on the control panel could have eliminated this problem.

- The installation at EF-2 is so arranged that it takes 51% longer to complete the manual functions necessary for precoat than at an average BWR.

- To improve operability, several modifications should be made, e.g., build platform or catwalk so that the operator does not have to raise container of dry precoat beyond safe dictates; place valves and switches within easy reaches of the above mentioned platform; place limit indicator lights on several manual valves to shorten the operator processing time.

- The demineralizers as installed and piped have several problems associated with operability.

- The method provided for initially filling the vessel resins is wholly inadequate. Forcing dry resins through a diaphram down a 30-foot long circuitous path is near impossible (defies gravity and friction laws).

- Manual valves located in hard-to-reach, hard-to-operate positions.

- Discharge of spent resins difficult due to circuitous routing of pipes.

- Diversion of product water to the receptor vessel is too manpower intensive; lack of limit switches on manned valves and indicator lights is a serious contributing factor.

g. Maintainability:

- Maintainability as designed will be quite difficult for same reasons as operability.

- High maintenance items are in less accessible locations, equipment should be selected with better maintenance records.

- No permanent platforms or catwalks to afford easy accessibility. Detroit Edison has planned on building temporary platforms for maintenance purposes only. But these are more expensive after commercial operation (harsh environment) and can increase costly downtime.

- Pumps will be serious maintenance items as currently installed. Gelatinous precipitates can plug the seals and rings causing lack of lubrication, overheating and shaft failures.

- ALARA: The manpower intensity of operation and maintence, described above, will cause personnel to be in close proximity to radiation components for long periods of time; carbon steel used in piping and tanks will further add to the background radiation. With proper design and operability improvements, the radiation levels can be reduced by 90%.

- Significant maintenance man-rem savings can be made by reducing general corrosion, by use of stainless steel and other equipment changes.

- For ALARA considerations, it can be shown that improving accessibility will alleviate these concerns.

h. Pipings arrangement: Based on field inspection and review of piping arrangement drawings, the NUS found serious deficiencies due to unneeded direction changes, close radius elbows (90° elbows), small pipe diameters, etc.

2. Floor Drain Collector Subsystem

a. Detroit Edison design assumed 8,700 gpd of inputs to the floor drain collector, compared to 16,000 gpd experienced at other BWR's.

b. The tank size of 23,000 is larger than at other plants by a factor of 1.8 to 2.7. However, only one floor drain sample tank is provided at EF-2. This could result in backing up of the floor drain if it becomes necessary to discharge the sample tank. A second sample tank must be installed. Also, evaporators should be used for floor drains.

c. Entire floor drain system is made of carbon steel and has the same problems as the waste collector system. Also, the tanks should be white-metal sand blasted and epoxy lined.

d. Operability: The system as designed imposes serious limitations on operability. The fifty-gallon per minute filter feeds a thirty-gallon per minute evaporator. A steady state operation requires 1600 gallons of evaporator feed; therefore, the filter rate cannot be backed down.

There is no surge tank in the evaporator feed.

Further operability suffers from same deficiencies as the waste collector system (24% more manual time needed than at an average plant).

- greater frequency of backwashing built into EF-2 makes it much more manpower intensive. The repetitive pre-coating of floor drain filter will create pipe "deadleg" to the filter.
- Maintenance of floor drain collector system will be extensive and difficult. It has the same shortcomings as the waste collector system. Also, there is only one pump for the floor drain. During pump failure, there is no possible route by which any other installed pump can supplement this unit. Therefore, this pump must be repaired in an extremely short time if a problem develops. The filter has the same problem. An alternate filter and an extra pump is strongly recommended.

- ALARA: Man-rem burden is mainly created due to poor design, material and operation and maintenance design.

- Piping system arrangment suffers from the same defects as the waste collector system.

3. Detergent Waste Subsystem

a. Design input capacity and tank size is adequate (3,000 - 4,000 gpd).

b. Two pumps are provided. However, with present piping arrangements, a given pump can only take suction from one of the two waste tanks. A cross connection should be made.

c. Operability: Serious problems. A simple operation of tank to pump to filter discharge has been encumbered with difficult, unneeded valves so that it takes 12½ minutes to begin evolution. Use of valve position indicator lights on radwaste control panel and better communication system will reduce the operating time to 27 seconds per cycle, a 95% savings.

- Maintenance: Detroit Edison has chosen pumps of entirely different type and design from the majority of other radwaste systems. This increases spare parts requirement, necessitates annual valve maintence cycles and adds 5 to 10% to the maintenance hours.

- ALARA: Increased manpower intensity built in the current system adds to the ALARA concerns. Further, the Detroit Edison Company should have looked at the drycleaning alternative vs. the current liquid laundry. Use of drycleaning at other systems shows it has definite financial advantage, less water to be processed and manpower and man-rem savings. Initial cost of units is only about $90,000.

Further, use of drycleaning system can eliminate the need for the entire detergent drain subsystem.

4. Chemical Waste Subsystem

   a. The size and capacity is adequate (500 gpd).

   b. Only one tank is provided. This creates problems during neutralization, mixing, and sampling process. Also, single pump as provided is undesirable.

   c. Operability of chemical waste system is unnecessarily increased by 40% due to lack of a dedicated radwaste communication system. Pump size is inadequate and will require use of in-line chemical neutralization with tighter operational controls.

   d. Maintainability: The outstanding deficiency of this system is the lack of properly chosen and properly located block valves for the waste pumps. Removal and repair of this pump will be difficult. Also, unique design of the pump will impose other serious problems, e.g., spare parts, downtime, etc.

   e. Piping Arrangement: Most serious problem here is the tortuous path of discharge piping. Also, poor location of valves, chemical waste pump, and filter will result in greater radiation exposure.

f. Valving: Weir-type diaphragm valves used in this chemical waste system have potential to become crud traps and localized radiation "hot spots". Frequent diaphragm changes are necessary for these valves and add to the maintenance time, cost and exposure.

5. Evaporator Subsystem

a. Poor location of pumps. Maintenance and operation checks on these pumps will expose personnel to high radiation fields.

b. Shield walls between pumps and shells should have been installed. Only one bottom transfer pump is provided which limit steady operation.

c. Pressure reducing valves poorly located.

d. Operability: Dry-run studies showed that the start-up of the evaporator system will take six manhours of attendance. This inordinate manpower intensive evolution is the result of poor equipment arrangement rather than due to the basic evaporator system. The valve station for the heating steam pressure adjustment is located in the evaporator cubicle. For each minor adjustment, the operator must enter the high radiation area as would be the case with the control of the condenser cooling water, alignment of blowdown valves, etc.

For safe operation of evaporators, there is no choice but to move to the steam pressure reducing system outside the evaporator cubicle. This will also address the ALARA concerns. Further building of a shield wall will reduce maintenance time 45% and exposure by 60%.

6. Sludge Handling

a. Although drumming capacity is adequate, the lack of redundancy in the phase "separator" pump is a serious concern. Sludge mixing and discharge cycle of 20 to 30 hours is too short to provide for maintenance of the pumps.

b. Field inspection of pump installation shows that the seal water supply is taken from the pump discharge. This can result in the plugging of seal water supply lines (installation deficiency).

c. Possible problem with level measurement provisions in all the tanks and phase separators, using air bubbler system.

d. As in many other subsystems, use of diaphragm valves throughout the slurry handling system has serious problems.

e. Much of the piping in the phase separator subsystem is poorly arranged, e.g., too many direction changes and short radius elbows, which could cause plugging.

f. Backing ring welds: Butt welds employing backings are undesirable in the radwaste system because they act as crud traps and increase local background radiation levels. This applies not just to the condensate phase separators, but to all piping systems.

g. Based on field inspection, sample lines connected to slurry piping appear to be too small.

h. Radwaste system at EF-2 has no accurate measure of solids-liquids interface. There is no provision to prevent unsettled material from being decanted. The slurry pumping system has many inherent features which will prove highly maintenance intensive, e.g.:

- Diaphragm valves must be changed annually.

- Lack of redundancy in slurry & decant pumps.

- Recirculating loop 4" gate valve being used as a flow restrictor to centrifuge will cause: accelerated seat & disc wear; right angle draw-off line will prove high plugging and high-wear area due to abrasive nature of pumped streams; and resonant frequencies can cause metal fatigue.

- The centrifuge feed lines have many close elbows and unnecessary changes of direction. There will be frequent plugging of this line, requiring section cut-out and cleaning or replacement. The line runs more than 20 feet above the floor and there are no catwalks or maintenance platforms.

- The modification of the phase separator system is of paramount importance if ALARA is to be addressed, because the subsystem as designed and installed is highly maintenance and manpower intensive.

7. Spent Resin Tank

a. Tank capacity is adequate but it will be limited due to the design of the overflow nozzle.

b. No provision for decanting of the spent resin.

c. Numerous modifications must be made to ensure reliable removal of resin. For example, flat bottom tanks should be replaced by cone bottom tanks, also the mixing provision as arranged will not maintain the resin suspension.

d. To improve operability and maintainability, the destination of spent resin should be altered, replace the educator and the centrifuge pump by a cavity pump. This will also reduce the amount of clean water processed through the radwaste system, more direct discharge will prevent plugging inherent in the existing system. This will also reduce the slurry concentration from 25% to the recommended 5%. Drumming required will be greatly reduced. Finally, as designed, the resin system is incapable of measuring and controlling the quality and the quantity of feed. The centrifuge system will not work without such control.

e. As with many other subsystems, slurry pipe is burdened with close elbows, excessive changes of direction and inordinately long runs. Calculated friction losses in this subsystem amount to 82 feet of head loss. The system cannot supply 22 gpm to the pump as designed, at sufficient velocity to prevent settling in the line.

f. Maintainability

- diaphragms must be changed yearly.
- pump is undersized and will cause excessive wear and early replacement.
- system as installed will require many manhours of maintenance time.

It is imperative that the spent resin tank be completely redesigned with fewer components, shorter and straighter pipe runs and more dependable equipment.

8. Water Sludge Tank

a. Tank size too small. Design cap is 65 lbs. compared to 104 lb./10 hr. estimated at other BWRs.

b. As designed and installed, the system will require more frequent backwashes. Settling time in the sludge tank will be reduced, leading to still higher filter loadings. Also, more backwashes will add more clean water to radwaste process. As designed, the system will have a daily processing deficiency of 13,000 gallons.

9. Centrifuges

Because the expected inputs to the system will be much higher than the design quantities, operating demands on the radwaste centrifuges will also increase. It is expected to operate for 4 to 5 hours every two to three days.

As designed, the system may not have the required uniformity and consistency in the feed necessary for centrifuge operation. Further, piping and valve stations contain too many direction changes, and short elbows. Also, weir type diaphragm valves must be replaced with plastic lined plug valves.

NUS recommends replacement of the entire feed piping system.

NUS also said that "Centrifuges have been operated since the turn of the century in the chemical, pharmaceutical, and refining industry". Lessons learned from there show that feed consistency in quality and quantity is of utmost importance.

10. Drum Loading and Capping

a. EF-2 currently has no means of removing drums after they are weighed on the strain gauge weigh station. Also, the station is unprotected from weather. A loadout facility must be built around the loading dock.

b. Improper alignment of locking band and improper air wrench operation.

Overall Assessment

Drumming facility should work as designed, but there is a possibility of massive air influx carrying abrasive dust in the area. Cement particles from drumming aisle can be extremely detrimental to roller bearings. The use of a mechanical conveyor increases the frequency of repair and thus, radiation dosage. An enclosed building with handling and monitoring of drums is recommended.

Determination of operability of the EF-2 radwaste system was conducted by an actual dry run and timing of various operation evolutions.

As currently designed, the system will require 32 persons using a 4-shift operation. If more shifts are used, personnel will escalate to up to 50 persons, although productivity will decline when persons are increased. At the same time, the total dosage will escalate considerably, thus extra manning will be counter-productive.

The design at EF-2 tends to utilize distance in lieu of shielding. Piping is installed 18 feet above the operating floor. However, there are a number of manual valves nested in these piping runs in hard-to-reach areas. The individuals are put in the industrially-hazardous situation of having to climb ladders resting against pipes, etc.

The shielding in the evaporator area is wholly inadequate. Pumps and valves underneath the evaporators pose a severe problem of personnel protection during normal operation and maintenance.

There are no work platforms or installed vertical ladders. After commercial operation, it will be much more costly to install these platforms.

Many valves are located in such close proximity to other equipment that removing them will present serious problems of access. There is not enough room to tie anchors for equipment removal. These conditions will subject maintenance personnel to unsafe lifts, falling objects, and improperly secured components.

The 557 foot level of the building is 26 feet underground. There is only one stairs and no other access to the radwaste lower level. This is a violation of 29 CFR 1910.36. Alternate means of egress and an elevator must be installed.

A double door must be cut in the east wall to meet fire and safety codes.

Many of these problems were found by the Detroit Edison Start-Up Engineers and summarized in a memo from the Project Engineer to the Project Manager on October 25, 1979.

By its own admission, Detroit Edison Engineers confirmed that the design and installation of the radwaste system had been very sloppy, careless, and with little consideration for operability, maintainability, and radiation exposure levels.

In April 1980, EG-2 management decided to completely modify and revamp the radwaste system. NUS, who did the review, was asked to take responsibility for designing and engineering detail drawings of the modifications. NUS submitted three alternatives:

Alternate A: Incorporate only those changes necessary to allow radwaste system to function properly upon start-up. Extraordinary attention to preventative and corrective maintenance, and careful radwaste management will be necessary to keep up with processing demands.

Alternate B: This includes changes and design modifications believed necessary to allow the radwaste system to function properly upon start-up and reliably thereafter, with reduced solidification loads.

While no new processing concepts are introduced, the functional role of many items of equipment is changed to improve performance of systems and components.

Alternate B-Prime:

This includes all changes under Alternate B, plus replacement of the present concrete solidification subsystem with an asphalt encapsulation volume subsystem.

Alternate C: Extensive process redesign, additional rip out, and addition of crystallizing evaporator system to the liquid processing concept.

Costs of Modifications

NUS estimated present worth costs of various alternatives which ranged from $106 million (Alternative A) to $32 million (Alternate B-Prime). Alternate C was higher than Alternate B-Prime by $4 million.

In April 1980, EF-2 Project Management decided to proceed with the modifications as recommended in Alternate B-Prime.

Bechtel was hired as constructor to rip out parts of the old radwaste and install the modification.

The radwaste system modification was completed in January 1983. The total cost of modification has been estimated by Detroit Edison at about $35 million.

Analysis of the Issues

The Staff has made an extensive review of the circumstances leading to the radwaste modification. It is undoubtedly the major modification of any system. The Staff reviewed numerous reports and analysis performed by Edison and outside consultants. Interviews were conducted with Project Engineers, Bechtel Project Managers, Edison Managers, and others to establish that when the system was purchased back in 1968, it reflected the state-of-the-art. GE was offering the same radwaste system for many other BWR users. It had demonstrated workability, and the system was adequate to handle the radwaste input quantities as was known at that time. Detroit Edison claims that the major reasons for the radwaste modification in 1980-82 were:

1. Increased difficulties in disposal of low-level waste dump, and transportation of waste through states hostile to the nuclear industry. This resulted in passage of National Low-Level Radioactive Waste Policy Act of 1980, requiring states to form regional burial site compacts.

   This concern, Detroit Edison claims, led the Company to institute a volume-reduction system, going from cement binder to an asphalt system.

2. Detroit Edison claims that they were afraid the Federal or State policies will get much more stringent on radiation exposure levels. Thus, the need for greater shielding.

3. Adoption of ALARA (As Low As Reasonably Achievable) standard adopted in 1977, put a burden for further radiation reduction, although Detroit Edison also claims that the original design would have met the ALARA.

4. The estimated input quantities of radwastes as assumed in design criteria turned out to be significantly lower than actually experienced at other similar BWRs (size adjusted).

5. Finally, Detroit Edison claims that analysis of the operating and maintenance requirements indicated that the new modifications will result in substantial ($8 milliion per year) savings in these costs over the life of the plant. Therefore, the modifications are cost-effective as well.

In our opinion, although the above-mentioned factors did contribute to the radwaste modifications, the factors themselves were, to a large extent, a result of insufficient design verification and poor installation of the original system which was the responsibility of Detroit Edison.

Firstly, there was no attempt by Detroit Edison to obtain an independent design concept verification to ensure operability of the GE-radwaste system. Given lack of experience, Detroit Edison should have hired in the beginning, as they did later on in 1980, someone like NUS.

Secondly, it is quite evident by Edison's own admission (see memo of October 25 from PE to PM) that the detailed design performed by Detroit Edison Engineers, iqnored numerous elementary design considerations and basic laws of physics. Some of them include extremely poor piping arrangements, locations of valves and motors, insufficient shielding, poor material selection; e.g., untested Wier-type valves, carbon steel, flat bottom tanks, lack of redundancy, disregard for radiation exposure levels, unnecessary and excessive manpower intensive operation, and maintenance requirements, etc.

These problems indicate not so much the defects in the concept design, but rather in the detailed engineering and installation.

- Edison's claim that experience at other operating plants show much higher actual input quantities than assumed in the EF-2 design, again reflects inadequate analysis of oparating radwaste systems prior to the design and constructin of the EF-2 system. It can also be argued that a sophisticated engineering subsystem should have independent mathematical calculations as its basis, and not merely the emperical data collected from other operating plants.

- There is evidence that some engineers had raised doubts regarding the operability of the radwaste even prior to its completion. However, Project Management seems to have ignored them and proceeded with the completion of the radwaste as originally designed. The construction was completed in 1979, the same year the decision to rip out and modify numerous subsystems was undertaken.

- Although construction of radwaste was underway prior to shutdown in 1974, Detroit Edison failed to make use of the shutdown period 1974-77 to review the radwaste design.

- Although volume reduction, dewatering and drumming needs became more important due to burial and transportation difficulties in the late 1970's and 1980's, the economics of the reduction in volumes and drumming should have been a consideration all along. Detroit Edison failed to evaluate the economic benefits and costs of alternate subsystems.

  Indeed, the alternates evaluated, including the Werner - pfleiderer asphalt system selected in 1980, were available and in extensive use in 1968.

- ALARA concerns were only heightened by poor operability and maintainability built into the design and further aggravated by poor installation, material selection, etc. As the NUS report pointed out, ALARA radiation burdens will be considerably reduced by the same factors that improve operability and maintainability.

- Edison made no serious efforts to improve the system performance, costs, and radiation doses. An example of this is the drycleaning option widely available in the early 1970's. Edison chose the wetcleaning detergent system which, besides being more time/space consuming, created much larger quantities of liquid wastes and drumming needs.

  Data gathered from other BWRs indicates that detergent waste from liquid laundry requires 4 operator hours, plus 2 health physics technicians daily. Filter cartridges must be changed daily after 3,000 gallon processing. About $2500 per month operating cost is incurred in the purchase and disposal of filters. Further, the laundry detergent system adds 20 to 24 drums of waste per year, which is more odious than the financial cost.

  The wet laundry facilities require 6 industrial washing machines and 6 to 9 dryers, at $60,000 per unit. Operations require 4 persons per shift at a minimum.

  The drycleaning option, on the other hand, will only need two drycleaners and one dryer at an initial cost of $90,000 per unit. The manpower need is reduced to one-half to two persons per shift. There is no liquid radwaste to be disposed of.

Further advantages of the drycleaning system include:

- longer garment life and reduced replacement cost due to gentler and shorter cycle

- proportionate reduction in dry active waste (DAW) to be shipped from the site
- more complete removal of radioisotopes reduces the garment contamination
- maintenance and warehousing costs are reduced due to less detergent, reduced garment inventory, etc.
- a closed system precludes the need for any ventilation and air handling system

DE did modify to install the drycleaning system.

A second example is the evaporator system. Currently, the evaporator system uses an auxiliary reboiler. Use of reactor steam would be economically preferable to the fuel oil burned in the auxiliary boiler. Edison failed to perform the economic analysis for this option.

All in all, these are examples of Detroit Edison not seeking the most efficient options in their initial design to obtain an efficient, economic and operable radwaste system.

Findings and Recommendations

Based on its review, the Staff finds:

a. There was inadequate design verification of the functionability of the initial GE radwaste system.

b. The detail design by EF-2 Project Engineering was poor and showed a marked lack of concern for operability, maintainability and efficiency.

c. There was a lack of on-going review of the workability of the system as it was being installed.

d. The selection of material, location of major components, and space arrangements ensured a non-functional system.

e. There was no attempt made to employ the upgraded systems, technology, logic, and control that became available during evolution of the project.

In its overall assessment, the Staff finds that the EF-2 project handling of the radwaste design and installation was not carried out in a reasonable and prudent manner. The Staff, however, finds that the EF-2 project decision to modify the system to improve efficiency and to ensure operability was the correct decision.

Recommendations

The Staff recommends that all expenditures incurred on the radwaste system prior to 1980, including all direct costs, engineering, overheads, and AFUDC be disallowed from the inclusion in the rate base for the Fermi 2 plant.

Although Detroit Edison will argue that much of the equipment in the initial system has remained intact, it is unarguable that the modifications to radwaste have been extensive including the rip out of large components, piping, and relocation of equipment, etc. As is often the case with construction, modifying systems costs much more than building anew. This is so for several reasons: space limitations and reduced working areas, reduced worker productivity due to congestion, working around equipment, reduced access for construction equipment, etc. The rip out of equipment, piping, etc., alone has been estimated to be over $3 million in labor costs. Much of the piping, cables, and controls had to be discarded after they were ripped out. Modifications were so extensive that GE removed the radwaste from its scope of systems supplied to Fermi 2.

It is, therefore, the Staff's opinion that the expenditures on modification were of the order of a new radwaste system. Senior Project Engineers at EF-2 concurred with our assessment. It should also be recognized that some of the system improvements could not be incorporated even in the modified system due to limiting factors of original design and installation. Therefore, inherent features of the original design will continue to inhibit efficient operation of the radwaste system.

Cost Estimate of Disallowances

The information obtained from the EF-2 Project Cost System (CARS) shows the direct construction expenditures on radwaste between 1971-1979 of $11,728,420. The total expenditures, including engineering, general overheads, AFUDC, and property taxes is $26,376,206. The AFUDC is only included up to December 1982, and must be updated for the commercial operations date. Details of computations are shown on the attached sheet. The estimates of engineering and overheads are based on ratios of total project to the total engineering, etc; these items may be further refined when the final project is complete.

At this point, the Staff recommends disallowance of $26,376,206 from the EF-2 rate base.

DETROIT EDISON COMPANY

ESTIMATED TOTAL COST OF RADWASTE SYSTEM BEFORE MAJOR MODIFICATION

AT DECEMBER 31, 1982

YEAR	Direct Charges (1)	Engineer. Overhead (2)	General Overheads (3)	Property Taxes (4)	Subtotal AFUDC Base (1-4) (5)	Cumm. AFUDC Rate % (6)	AFUDC (5 x 6) (7)	Total Cost (5 + 7) (8)
1971	2,540,474	498,949	211,622	73,420	3,324,465	95.66	3,180,184	6,504,650
1972	2,459,624	483,070	204,887	71,083	3,218,664	88.16	2,837,574	6,056,238
1973	1,518,358	298,206	126,479	43,881	1,986,924	80.66	1,602,653	3,589,578
1974	1,356,303	266,378	112,980	39,197	1,774,858	73.00	1,295,647	3,070,505
1975	261,067	51,274	21,747	7,545	341,633	65.08	222,335	563,968
1976	457,542	89,861	38,115	13,223	598,739	57.08	341,760	940,500
1977	288,274	56,617	24,013	8,331	377,235	49.08	185,147	562,382
1978	1,297,548	254,838	108,086	37,499	1,697,971	41.08	697,526	2,395,497
1979	1,549,225	304,268	129,050	44,773	2,027,316	32.83	665,567	2,692,884
TOTAL	11,728,420	2,303,461	976,977	338,952	15,347,810		11,028,396	26,376,206

Source:

Staff Request 266

Overhead Rates	19.64	8.33	2.89

9. Non-Nuclear Steam for Testing

As a part of Pre-Op testing, Edison was developing a program of testing steam systems by running clean steam through them. While there were no mandatory regulations, the tests were to be made to ensure satisfactory performance. One of the key issues in the design of the test program was the source of clean steam. The extent of the steam test program was primarily determined by the quantity and quality of the steam. Some of the key systems to be tested are:

> Main Turbine, Reactor feed pumps, turbine seal glands, condensor vacuum and the HPCI & RCIC turbines. The latter two being the Safety System. In addition, many steam pipes could be tested and cleaned under this program.

Early in the project (around 1972), Edison analyzed the use of auxiliary boilers for this steam source. Auxiliary boilers are used in the plant for plant heating and provide about 150,000 lbs/hr. steam at 120 PSI, 340°F. This source could accomplish only a limited testing of key systems such as HPIC, RCIC and reactor feed pumps. None of the major turbines, condensor vacuum, etc., could be steam tested with this source. The auxiliary boiler option was, therefore, rejected as inadequate.

A second source of clean steam, unique to EF2, was the boiler at Fermi 1. It is a considerably larger source providing up to 1.5 million lbs/hr. at 900 PSI and 544°F. The normal NSSS operation at EF2 will produce about 13 million lbs/hr. at 1020 PSI and 547° F.

Therefore, EF1 was considered as a viable source of clean steam and could accomplish a much more extensive test program. The 1972 project estimate provided $300,000 for engineering for this purpose. However, due to plant shutdown, and other delays, the clean steam testing program never received serious attention until 1977.

In 1977, Edison hired the S & W firm to perform a feasibility study of various steam sources. The S & W recommendation was that EF1 was the most feasible and cost-effective option. EF1 became a particularly attractive option because it was felt, at that time, that erection of the turbine-generator will be at least two years prior to the NSSS completion. Therefore, they had this two-year window which could be utilized to conduct an extensive steam testing program. Testing of the main turbine was also considered important since it was a relatively newer English Electric design of this size. In 1977, EF1 was a fully operating plant. A primary advantage of the EF1 alternative was that, with two years or so float in the schedule, it will afford early identification and correction of problems without impacting the commercial operation date. S & W estimated that based on probability analysis, this "problem avoidance" could save about 60 days in the final schedule. The EF1 steam source would afford the most extensive testing opportunity for numerous systems. The environmental permit was available for FERMI 1 to burn oil. unlike a new package boiler option. In 1978-79, Edison proceeded with engineering design to connect the steam system from Fermi 1 to Fermi 2. All the material necessary for the steam system was purchased and some installation was also made (e.g., concrete supports for pipe). To prevent the test system from backflowing into the reactor steam lines, special plugs were provided in the MSIV system. Approximate estimates are that between $2-3 million dollars were spent on the steam source.

By 1980-81, the turbine installation had run into installation problems. As will be discussed elsewhere, Edison was having serious difficulties in installing the turbine due to poor instructions, inexperience with English Electric equipment and material procurement, hangars, etc. Turbine erection, which in 1978 was expected to be done in 9 months to a year, actually took considerably longer--two to three years. The turbine erection was finally completed towards the end of 1982.

Edison, therefore, lost the two-year window expected in 1978-79. The extensive testing program contemplated in 1978 was no longer possible without impacting the schedule.

In June 1981, Edison did a reassessment of the clean steam test program. An in-house review group did the cost-benefit analysis of three options: (See SU-7156, June 4, 1981.)

Alternate A: Use Enrico Fermi 1 to supply 1-5x10^6 lbs/hr. steam at 825°F, with a temporary desuperheating to drop temperature to 544°F. Condensate is returned from EF2 to EF1 drain cooler line and back to condenser.

Alternate B: Bring in single package boiler, oil-fired to provide 500,000 lbs/hr. at 990 PSI, located adjacent to EF2 turbine building.

Alternate C: Use both EF2 auxiliary boilers to supply 100,000 lb/hr. at 120 PSI, with make-up water from condensate storage system.

A fourth alternative considered was to perform no clean steam test. However, this option was rejected on the grounds that a problem had developed in HPCI, RCIC at other units and so must be pre-tested. Further, that DE could run into problems with the NRC, since other owners were doing the testing.

The in-house assessment was essentially a re-evaluation of the options considered in 1977 and used much of the same data. However, the conditions had changed: (a) Due to oil prices, low peak demand, and to conserve cash, the EF1 Unit was de-activated in 1981. EF1 was kept in active mode in 1977-78 due to the clean steam test program. To bring back the steam line would require significant O & M expenditures and a 30-day restart period, (b) Edison had lost the schedule float between turbine erection and plant completion, so testing prior to fuel load could have severe schedule impact, and (c) significant investment had already been made in Alternate A. The in-house team recommended scrapping the EF1 option (Alternate A) on the grounds that it would be a serious drain on manpower resources of the start-up and operations groups; the time savings in pre-testing main turbine is questionable, based on experience at San Onofre; and that without the time savings, EF1 was not a cost beneficial option. The package boiler option (Alternative B) would permit more extensive testing than Alternate C, but not the main turbine testing. Costwise, it would be a satisfactory option and would simplify coordination. The major disadvantages of this option were: long delivery date of 80 weeks (too late in 1981); environmental restrictions, tie up many people from operations and start-up, and required more engineering support.

The review group, therefore, recommended and the project management adopted the Alternate C, i.e., use of existing auxiliary boilers. The test program was scaled down considerably. Only the RCIC, HPCI, and Reactor Feed Pumps are to be steam tested and only in limited modes (uncoupled). Further tests could not be performed in winter due to plant heating needs. Much of the material purchased and/or installed was scrapped. Practically the entire expenditure, including consultation (S & W), in-house engineering, material procurement, installation, and rip out was wasted.

Issue Analysis

The Staff believes that the existence of the Enrico Fermi 1 oil unit on the site provided a unique opportunity for pre-testing the systems with clean steam--something not available to other single-unit nuclear plants. The capacity, quality and other characteristics of EF1 were singularly suited to extensive testing at EF2. The relative inexperience with the English Electric turbine unit made it further desirable, if not necessary, to identify and resolve all the bugs out of the steam lines and systems.

In our judgement, Edison made the correct decision in 1977 to utilize the schedule float and take advantage of EF1 to plan for an extensive steam test program. Such a program would have given the project much-needed confidence and assurance.

As it turned out, schedule slippages in the turbine erection rendered the planned test program infeasible prior to fuel load. Edison decided to take a risk and essentially scrapped the program and performed only a limited testing. Even the option B., i.e., package boiler source --the second-best option--which seemed viable in 1977-78, became less so in 1981. Some additional arguments against Alternates A and B, by the review group, appear less convincing to us, such as: (a) interference in the start-up of EF2 activities due to start-up of EF1; and interference in other construction. (b) We also take issue with the key argument made by the review which states:

> "The key point to be made here is that the EF1 approach comes down to ......buying insurance. If, indeed, the economic well-being of this Company can be affected by a sixty (60) day delay in achieving commerical operation, then this alternative should be made available to prevent any pre-fuel load schedule impact. If another two (2) months won't make any difference, then maybe the price of insurance in this case is very high".

The statement then goes on to challenge the validity of the 60-day schedule impact assumed in the S & W report.

If the EF2 management decided to make this decision on the basis that a two-month schedule impact is not significant, then we question the mangement's judgement. Given the plant estimate of $2 billion in 1981, a two-month delay was equal to approximately $40 million in additional AFUDC cost--not insignificant by any standards. It was valid, however, for the review group to challenge the S & W impact estimates, but then they did not develop their own alternate estimates.

As it turned out, however, Edison underestimated the completion schedule for the main NSSS and auxiliaries. The 1981 estimate for December 1982 fuel load further slipped by at least 12 months, to December 1983. To a large extent, Edison was being optimistic in 1981, assuming a 1982 fuel load. Without such an optimistic assumption, the same options for a clean steam system were present in 1981 as in 1977. It was a series of cascading events and assumptions resulting in lost opportunity and expenditures with no concurrent reduction in risks.

Findings and Recommendations

The Staff finds that, based on its research of the issue:

- The early approach planned for clean steam testing was sound and reasonable.

- the construction organization did not fully embrace this option as they felt it to be an interference in their activities.

- the delays in turbine erection rendered the planned test program unachievable in the target schedule.

- the test program was still viable and desirable if Edison had made more reasonable assumptions in the fuel load date, in 1981.

The Staff recommends that as a minimum, all direct construction, material, design, and overhead expenses, including AFUDC associated with EF1 option and the original test program, be disallowed from the rate base. This is based no so much on the prudency of the decision, but rather on the fact that this expenditure was not used or useful.

The total costs are estimated to be $3 million, including AFUDC through 1983.

If the lack of pre-op testing results in schedule impact on the commercial operation, then the Staff recommends further review of this issue, and possible disallowance.

10. Wismer and Becker (Piping & Mechanical Equipment)

A. History

Prior to project shutdown, piping and mechanical equipment erection was performed by Parsons as general contractor, under a cost-reimbursible agreement. At the time of shutdown, much of the piping and mechanical installation remained to go.

In February 1977, a contract was entered (1A-84001) with Wismer & Becker for $62.2 million to perform the remaining work. About 65% of the contract was under a fixed-price agreement; the remaining $20 million was cost-reimbursible work. Other bidders for this job were:

J.A. Jones	$77.6 million
B.F. Shaw	$77.5 million

The award to W & B was based on low bid and ability to perform. According to PAR reports, Daniel evaluated the project. At the time, one of the highlights of the W & B contract was the fact that a major piping contract had been obtained on a hard-money basis, i.e., lump sum. By August 1977, serious problems were being faced by W & B to proceed with piping work under the agreement. Some of the stated problems were caused by:

1. Work performed by previous contractor (Parsons) must be completely reviewed by W & B, including all QA records, before restart of work.

2. Length of shutdown had caused greater than anticipated degradation of stored equipment. This had made it impossible for Edison to provide material to the contractor to meet the

schedule. More time had to be spent in reviewing material than in actual erection.

3. Regulatory changes had caused the engineering to undergo more changes than expected at the time of bidding. Engineering changes had caused disruption to both the flow of material and the release of system for erection.

4. Delays in restart by other contractors had impacted W & B ability to erect in an efficient construction sequence.

For these and other reasons, W & B sought a change in their contract to a cost-reimbursible one. In the meantime, W & B was performing more work under cost-plus component and less under fixed-price. In June 1978, the W & B contract was formally converted to fully cost-reimbursible basis. The change to the cost-reimbursible was based on proposed bids from three other contractors. Mark-up by W & B was on a sliding scale, ranging from 18% to 10.5%. The comparable fee for similar job was assumed to be 23% in the Detroit market. The W & B mark-up was later increased to 13% (CO #7).

B. Expenditure History

- By August 1979, more than $68 million had been committed to W & B, $10 million over the total original estimate; only a fraction of work had been performed.

- In September 1979, over $12 million was added to the W & B price.

- $27.3 million was added between December 1979 - May 1980 to a total W & B cost of $108.7 million. At this point, W & B requested and received an extension and increase in the mark-up fee to 13%. Also, the Incentive Compensation program was dropped as unworkable.

- By December 1981, $154 million, almost three times the original estimate, had been committed to the piping contractor, W & B.

- More than $30 million was added in 1982.

- In September 1982, Daniel/Edison estimated that the remaining work by W & B will cost $27.9 million and be completed by June 1983. Direct manhours estimated at 757,286 and indirects of 173,298 manhours, 10,152 non-manual. This last estimate included:

a)	Repair & Rework, DCR, DCN field routed tubing	$3.3 million
b)	Direct Work Scope	$4.5 million
c)	Scope Increase (DCP)*	$7.8 million
d)	Engineering	$4.1 million
e)	Unit Rate Adjustment (due to low productivity)	$5.8 million

(*Note: Some of the DCP's included radwaste mod., clean steam testing, gen. serv. water circ. syst. which have been dealt with and disallowed elsewhere.)

- By September 1983, W & B had received over $216 million, and an additional committment of $32 million, to a total of $248 million.

As of December 1983, W & B was still working on site; their total bill was likely to approach $300 million.

W & B was not the only contractor installing pipe and mechanical work. RCI, WACO, Bechtel, and T & B have also performed substantial piping work at EF-2.

To summarize the cost history, the W & B costs increased over four-fold from $62 million to $250 million between 1977-83. It is interesting to note that the W & B contract alone is larger than the total project cost estimated in 1968.

C. Discussion of Contractor Selection

1. W & B was selected on the basis of lowest bid and hard money. The Staff learned that Daniel had advised against W & B. Daniel's feeling was that W & B was too small and too inexperienced for the large scale nuclear job. Much of the piping experience of W & B was a small portion of the work at Diablo Canyon. W & B had done some work at Ludington Pumped Storage. W & B did not possess N-Stamp until after obtaining the Fermi 2 work. General Electric, we learned, had recommended W & B. Both GE and W & B are headquartered in California. In 1983, W & B was involved in a Class Action suit by several utilities, including WPSS for anti-trust activities. The suit, to our knowledge, covered W & B electrical work. Fermi 2 is not involved in the law suit.

2. Although Edison boasted of a hard-money contract and it represented a sincere effort on its part to control costs, the contract had inherent weaknesses. The contract had a cost-plus component, which left an opening for W & B for misuse. Further, this portion had a whopping 29% mark-up.

In our judgement, the piping work did not lend itself to the fixed price agreement. This was particularly so at Fermi 2 due to shutdown, change of general contractor, and uncertainties in the project in 1977.

Finally, we believe that W & B grossly underestimated the job (see letter of 6/77 from DIC to W & B).

D. W & B Work Performance

The piping work has been out of control at Fermi 2 since the project beginning. Further, the problems have been experienced in every phase of design, fabrication, installation, welding, QA/QC inspection, craft productivity, non-manual and indirects control, and foreman supervision. Piping contract management was a primary responsibility of Daniel. Since piping craft must work throughout the plant, interference, coordination, and work sequencing are significant factors in work progress. To properly assess W & B performance, we interviewed several W & B foremen, the manager and PE on site.

In our judgement, piping and hangar installation has been a critical and chronic problem at EF2. As has been discussed in several places, Edison never fully grasped the piping design and complexity at EF2. Excessive redesign and rework demoralized craft and affected their productivity.

Some of the factors contributing to W & B performance were:

- Lack of nuclear experience both by W & B and Edison.

- W & B hired local people as foremen and supervisors. While this was positive for Michigan and this region, W & B could not effectively control and communicate with their supervisors.

- W & B management was not aggressive to control craft or impact the work schedule. In our opinion, after receiving the cost-reimbursible contract revision, W & B took a more relaxed attitude at EF2.

- The 1979 University of Texas study showed that craft of W & B thought that their foremen were incompetent. The findings were shocking to DE management.

Assessment of construction by a team from Commonwealth Edison also noted that productivity and installation rates were below industry standards at Fermi 2 in the piping and hangar area. More specifically, the report noted:

- Piping spool installation rate at LaSalle is 800 spools/month; Fermi rate of 160 spools/month is not enough.

- General comment on productivity for electrical and piping is that it does not look good. It seems to be a supervision problem.

- Project should be on multiple 40-hour shifts rather than loading up on manhours or extensive overtime. LaSalle has 300 to 400 people in second shift.

- In some areas, productivity is better at night due to less confusion and interferences.

- To build welder manpower, CE has (a) training program for welders, (b) sends reps. around the country to test and recruit welders.

The April 1978 survey showed that 64% of large pipe and only 9% of SB piping had been completed at the time. SB piping design was too far behind and the current estimated quantities were ridiculously understated.

- Productivity measurement studies showed that W & B ranked lowest in productivity in all categories for contractors evaluated (see DIC/DECO/W & B management meeting 4/7/82).

- Daniel evaluations consistently showed that poor supervision and management of W & B was the root cause of all other problems. Early quits, wandering and loafing were chronic problems at W & B (see 1977 memo from D. Seifert to W. Fahrner)

- W & B QA/QC program was weak throughout the project.

- Welding was one of the most significant problem areas in the piping installation. W & B welders were ill-trained and inexperienced. The acute shortage of qualified welders existed throughout the project. To solve the problem, many steps were taken, such as: establish welder training program, hiring from Ontario, and paying headhunters, etc.

- Employee hiring practices became an embarrassing media issue when Bill Bonds and "20/20" programs reported violations and resume falsifications. Investigations confirmed some of these allegations. DE auditors expressed concerns that inadequate attention was paid to an employee's actual work once he was hired. Investigation indicated a strong probability of someone inside the project involved in it. Employees involved were all W & B hirees.

- Besides shortages, welder utilization was a serious problem. In one survey, only 50% of the welders on the site were drawing weldrods. It was not known what the remaining welders were doing.

- The quality of welds, heat number control, have been questioned by the NRC. Recent NRC SALP report raised some new questions as to the integrity of welds and qualifications of welders.

  Throughout the project, Edison has made efforts to improve quality of work in this area through retraining, recertification and tougher supervision.

- Another major problem at W & B was too many indirects and non-manuals associated with the craft. At the same time, W & B was short on design engineers. Reductions in indirects were ordered from time to time (see July 1982 mgt. meeting).

- W & B made inadequate use of second shift. For example, in one study, 64 welders were assigned to the first shift, only 4 to the second (see August 1982 minutes).

- Poor welder performance also created costly delays in the Radiographic Testing program.

- QC inspection delays by W & B created hold points to proceed with the job and efficiently utilize the craft. (See DIC 8-2970, dated 4/19/78.) This memo from Daniel to W & B complains of work delays because W & B QC personnel are not adequately responding to their job requirements. Several specific examples are given where work is held up because QC inspectors were scheduled but didn't show up. Memo summarizes as follows:

  > "In the interest of job progress, Daniel is forced to spend an inordinate amount of time and resources to compensate for lack of planning and follow-up on part of W & B. Despite this, craft manhours are being wasted while items such as above (QC inspection delays) are resolved. Costs and delays due to items such as above will be closely reviewed and W & B held accountable".

As has been discussed under Daniel performance, W & B was under constant pressure from Daniel to meet the contract agreement and performance. In July 1977, W & B demanded time extension under General Condition 15 of the original agreement. W & B, in effect, wanted release from the fixed-price agreement. Daniel blamed delays on inadequate staffing by W & B. DIC7-2112 from Daniel to W & B :

"Since W & B is entirely responsible for adequately staffing the job, W & B has no basis for claims for extension of time for unit price or cost-reimbursible work contained in the value of the contract. The only cases in which extension of time will be considered by Daniel is when 1) a significant amount of additional work is added to the original value of contract and a time extension is properly authorized and shown by contract modification, or 2) W & B is delayed in the prosecution of its contract work by some cause which would not have been reasonably foreseen and guarded against and a time extension is properly authorized and shown by a contract modification".

This Daniel memo further warned W & B:

"Should you not agree with above and continue to .... submit estimates (based on time extensions) then we must assume that W & B does not intend to perform its contract work and has, therefore, shown cause for default as defined in General Condition 14 of the Contract".

General dissatisfaction with W & B was expressed as early as July 1977. As this memo from Daniel to W & B (DIC7-2411) states:

-"Your attendance is requested at a management conference meeting on July 1977 ....

-At this meeting W & B is requested to submit a work plan at management summary level. The plan should include quantities of hangars, spools, welds and mechanical equipment to be installed by system. This is in addition to normal planning and scheduling reports

-All work plans should be thoroughly researched and realistic. W & B performance will be judged against the project quantities shown in this plan

-Further, W & B should provide detailed breakdown of production rates, manpower projection of qualified welders, presented in a graphical form

-Daniel is not satisified with the performance of W & B. W & B has been on the job site for five months and has installed and accepted seven hangars. Four spool pieces in DW are temporarily hung. The only significant mechanical equipment work done to date is the modification to the reactor building crane auxiliary hoist. At this rate, the project cannot be completed on schedule and we must have a definitive statement from W & B as to how this situation will be rectified".

In May 1977, Daniel informed W & B that staffing under "Small Bore Engineering" as estimated by W & B would be insufficient (DIC7-1923).

"We are concerned that W & B has greatly understated the magnitude of this work. Daniel estimates that approx. 100,000 ft. of SB wall pipe to be designed, engineered and installed; 235,000 ft. of instrument tubing to be designed, engineered and installed. In addition there are hangars for all of the above".

During its early contract, W & B attempted to recruit temporary employees to meet the cost-reimbursible portion of the agreement. Daniel objected to this (DIC7-1732).

"Daniel/Edison would prefer that W & B provide permanent employees rather than temporary personnel which may have tendency to be transient. These people should definitely not fill lead positions. We agree to the limited use of these personnel with the following guidelines:

1. There is no need for draftspersons or pipefitters with more than eight years experience. We see no need for mech. engineers with more than 12 years experience.

2. Salaries are acceptable if all inclusive. A 15% markup will be allowed.

3. Personnel in this category would never be used for hard-money work, unless specifically approved by Daniel".

The above examples are provided to demonstrate that:

a) W & B was inadequately prepared and understaffed to meet the Fermi 2 needs;

b) W & B engineering and welding were the two most significant weaknesses (also see May 1980 Internal Audit Report);

c) W & B material and warehouse control was poor. Material was being drawn by Bechtel, T & B and others on W & B account;

d) W & B had no intention of working under tne "fixed price" for duration of the project;

e) In our judgement, W & B realized that they had the N-Stamp and that they were here to stay, and, in essence, they had the key to the Edison safe. W & B set its own work pace.

Staff reviews show that the burden was entirely on Edison and Daniel to extract performance. While Daniel exercised tough controls, Edison was caught in the owner's dilemma. Repeated concessions were made to keep W & B on the job and yet obtain satisfactory work. The first major concession was to convert to all cost-reimbursible work in early 1978. This opened up a "floodgate" of money for W & B.

Edison was also unable to recover any significant back charges from hundreds of instances of defective work performed by W & B.

In one major instance, the Staff found significant weld repair work and made the following request (Request #371) of Edison:

> "The February 5, 1983 PMO minutes refer to a significant weld repair problem involving W & B which could cost $1 to $2 million and 4 to 5 month delay. Please describe scope of the problem, systems involved, and resolution of the problem and direct costs. Was this backcharged to W & B? If not, why?".

The Staff received the following incomplete and unintelligible response:

> "Question #371
> An independent review of the ASME III type welds by a third party was a commitment made to the NRC. The scope of review covered 26 systems and approximately 1867 welds. Of the total, 272 repairs and 371 blends were required. This action was reviewed and it was determined that there was not gross negligence but that it was an in-process situation, so therefore a backcharge was not prepared against the cost-reimbursible contract. No separate accounting of this scope was established. Correction action was the training of welders and weld inspectors".

Unclear about the response (in-process situation?), the Staff followed up by a discussion with Mr. Fahrner (meeting on December 1, 1983). He confirmed that problem was a result of a) W & B QC inspectors not qualified to read the radiographs; b) similar problems had been experienced at other jobs, specifically at Zimmer; and c) the problem appears to be inherent in the process. Therefore, no backcharge was initiated. The Staff is not satisified with the Edison response.

On December 21, 1983, the Staff again met with Mr. Fahrner to discuss the September 1983 SALP report regarding questionable W & B QA performance. According to Mr. Fahrner, some problems have been indicated in:

a) Control of calibrated tools by W & B, losing tools, torque wrenches, etc.;

b) May have to reverify some torques;

c) W & B didn't offer good training to foremen;

d) Qualifications of QA auditors.

According to Mr. Fahrner, the end product was generally acceptable. Some of the NRC concerns were due to increased attention on EF2, being in NTOL stage.

In another case involving back charges, problems were found in grouting on penetration X-43. Daniel was asked to determine the commercial responsibility and to determine if the procedures are in place to prevent recurrence.

The January 29, 1982 meeting stated that:

> "-Daniel believes that W & B is solely responsible and should pay for problem on penetration X-43.
>
> -W & B believes that the man acted responsibly.
>
> -Detroit Edison (S.H.N.) believes that there was some neglect and indicated that there should be some good faith payback from W & B. If W & B disagrees, they should come back in writing".

To our knowledge, no back charge was recovered.

It should be mentioned that throughout, Edison and Daniel took steps to monitor and improve W & B performance. Examples of this include:

- establish a welder training program with the assistance of GE;

- establish welder rod control program. Ensure that all welders on site are welding. To improve welder productivity, determine number of inches of welds deposited per day; number of weld rods drawn per day, etc.;

- establish a side welder pool. Establish list of all welders and their qualifications. Match welders listed in the pool with job welding requirements, transfer welders between contractors.

  One finding in 1982 was that there were adequate number of welders on site. One Dr. Rich Nelson was hired to review personnel needs;

- Daniel/Edison implemented craft incentive programs;

- instituted management tours to improve productivity.

It is unfair to conclude that W & B is entirely responsible for poor performance in piping and mechanical installation.

The 1974-77 shut down had made it difficult to estimate the project needs. Parsons' termination necessitated re-evaluating QA/QC records, work status, etc. Much of the stored piping material had to be upgraded and recertified. Engg. and design delays, new regulations, TMI all impacted W & B performance. W & B, after all, did not control the project. A large number of temporary piping and hangars were installed to meet other construction and hydro testing. As the following conclusion of May 1980 Edison investigation shows, late drawing approvals were seriously affecting work progress:

- Most hangars are installed on a temporary basis prior to final approval. This is seriously impacting progress; example: 75% of 1" SS tubing in drywell has to be installed with temporary hangars.

- Urgently need final design for the "Excess Flow Check Valve" to support outside drywell.

- Lack of coordination between hangar requirement and pipe design; example: E11-5079, 12 hangars needed, none have been designed.

- Small bore designers were not visible in the plant taking field measurements.

As has been mentioned repeatedly, a massive amount of rework and repair has taken place in the piping and hangar area. Equipment installed one day may be scrapped the next. While this may have been good for W & B management, it demoralized craft. Further, work grew complex, and congested work areas and paperwork became overwhelming. Many groups were making conflicting demands on W & B, as illustrated in the following discussion between Daniel, Edison and W & B dated April 1982:

"5. Discussion of the effective use of craft manpower and how it can be improved.

The discussion on the subject was started by J. Stewart (W & B) who indicated that he is currently receiving criticism from one area of the project, and "pats on the back" from another. He indicated that the work they are currently doing is very complex and it is a full-time job for his supervision to resolve problems with Engineering.

A. Godoshian (DE) indicated that paperwork cannot keep up with the field. J. Ard indicated that one group, SCO, is results-oriented and as such, when W & B completes a job, they will get 'pats on the back', and another group is concerned with effective use of manpower--the productivity-- and as such, will inform W & B when productivity is below that which is required. S. Noetzel indicated that relative to last productivity measurement just completed, W & B was the lowest in all categories for the contractors evaluated."

As a result of all the above factors, installation rates and work completion in piping and hangar area had significant project impact. The following illustrates the situation in December 1979:

	Quantity to Go	Present rate/wk	Required rate/wk
1. LB pipe (Lf)	15,267	18	954
2. LB welds (ea)	1,164	19	58
3. LB supports (ea)	3,648	11	152
4. SB pipe (Lf)	19,732	192	822

This poor progress, despite a letter in February 1979 from Mr. Fahrner to D. Seifert (DIC) re: weekly W & B progress report, which asked why productivity is 50% less in January than October for LB? Why productivity is 60% less in January than October for SB? Why 15% rework in SB pipe? Why has productivity gone down from 5.6 mhs/Lf in November 1978 to 12.1 mhs/Lf in January 1979?

Although W & B generally maintained good relations with Edison and Daniel (especially after 1981 when J. Ard came as Daniel Project Manager), they attributed major construction problems to the following:

1. Lots of redesign and rework;

2. Shortage of qualified welders;

3. Material shortages;

4. Serious paperwork problems, e.g., foreman will come 30 min. early to organize work crew, but he is not qualified to review design. More strict procedures at EF2 than at any other nuclear plant. Overdoing safety, e.g., more attention to pipe support than pipe;

5. Waiting too long for QC inspectors. By law, you cannot "bad mouth" QC inspector;

6. Inadequate field support. All W & B engg. must be approved by Troy. Example: need to put a LB hangar, no room, talk to field engineer, write a DCR, goes to Troy, goes to S & W, return to Troy, to field to W & B;

7. Interference with other crews from WACO, Bechtel, RCI.

In 1981-82, W & B performance improved considerably. Hangar work assigned to RCI was turned over to W & B. W & B performed some rework to correct RCI installation errors. Also, work planned for Bechtel was reassigned to W & B. In our judgement, W & B learned on the job the hard way through constant prodding by Edison and Daniel.

It should be realized, further, that welders and pipe fitters work in a very stressful environment in a nuclear project. Working conditions are particularly difficult towards the end when welding or working in difficult-to-reach areas, and many other activities are going on simultaneously.

Staff Findings and Disallowances

In general, the Staff finds that piping and mechanical equipment installation work was inefficiently managed. The craft productivity was low, rework excessive, and rate of installation poor. The basic reasons for this relatively poor performance have been cited throughout this discussion. Both contractors and Edison contributed to the problems in the piping area. As a result, excessive project costs and some delays were incurred. The W & B expenditures exploded from $62 million estimated in 1977 to $250 million by September 1983.

The Staff identified several specific items of rework and repair, productivity adjustments and other disallowable items. Examples of these are:

a) Illegal hiring through Quan-tech and poor supervision resulting therefrom (Bill Bonds; "20/20" reports).

b) Red Head Anchor Test and replacement (WCR 22).

c) Rework and repair (WCR 29) approx. $3.3 million.

d) Unit rate adjustment (WCR 29) approx. $5.8 million.

e) Reinspection and rework of 238 welds as discussed with Mr. Fahrner (est. $1 to $2 million and potential 4 to 5 month delay).

f) Too high indirects and non-manual by W & B. At least 10% was recognized by PMO.

As indicated in response to Staff request #371, Edison does not separate the individual item costs for repairs, rework, etc. The LCSR's for W & B do not classify rework properly. The contract change orders and work change requests carry only the amounts added to the contract without detailing the reasons. This is particularly so after the change to the cost-reimbursable mode.

The Staff believes that the disallowance can only be made from judgement and estimated at best.

The following disallowance is, therefore, recommended:

a) 5% of W & B expenditures for low productivity.

b) 5% of W & B expenditures for rework and repair.

c) 5% for poor supervision and management by all parties.

Total of 15% of W & B contract is disallowed.

Calculations of Disallowance

1.	W & B expense committed through 1983	$ 248 million
2.	15% Disallowance	$37.2 million
3.	20% adjustment for Edison overheads	$44.6 million
4.	AFUDC (1981-83) @ 30.12%	$13.43 million
5.	Total disallowance thru 1983	$58.03 million

11. L.K. Comstock (Electrical)

Contract History

In August 1972, Edison awarded L.K. Comstock electrical work for an estimated $10 million. The basis of the award was excellent QA experience, local craft use, good incentive fee structure, good nuclear experience, etc. LKC was selected from among 5 bidders.

In 1972, direct electrical work was estimated at $10 million, i.e., about 2% of the total project cost of $451 million.

There were several major revisions in the LKC contract.

In May 1980, the original contract was renegotiated. The incentive fee structure in the initial contract was unworkable due to a large number of engineering delays, NRC related changes, seismic hangar tray requirements, Browns Ferry accident related revisions (Appendix R), and many other factors.

By January 1983, the LKC contract climbed to $113 million. This is an 11-fold increase, compared to a 6-fold increase in the total project since the 1972 estimate of $451 million. Some of the major change orders are shown in the table on the following page:

TABLE 1

Change Orders Exceeding $1 Million

CO#	Date	$ Million	Description
6	4/77	16.8	$1.3 m for shut down delay; $15.5 m for increased man-hr estimate from .5 m to 1.0 m
7	1/78	1.2	Take over QC from Parsons
9	5/78	3.1	Escalate labor rates 1974-1977
22	5/79	18.1	Update for new cost forecast
26	5/80	1.2	Retention refund and bonus per original contract ($1.0 m); out-of-scope work ($0.2 m); change to cost/plus contract
28	8/80	13.2	Extend to 6/81 for projected costs
31	5/81	15.2	Extend to 12/81 for projected costs
35	4/82	5.0	Extend to 12/82 for projected costs including 1) modifications to 1100 cable tray hangars, 2) repairing 20k ft. power strut
36	9/82	15.8	Extend to 3/83 for cable tray hangar modifications (7/82 design release)
40	1/83	7.1	Extend to 6/83 for cable tray hangar modifications (11/82 design release)

A review of the Labor Cost Status Reports (LCSR: weekly printouts of man-hrs. broken down by location, e.g., reactor building, turbine building, etc.) show that total electrical manhours increased from 490,000 to 3,170,000 between 1973 and January 1983. Further, the analysis suggests that the rework, and modifications as coded in the LCSR are distributed as:

		Total mhrs
Engineering (Code E)	14%	440,000
Rework (R)	1%	40,000
Voucher (V)	9%	270,000
Suspense (S)	11%	340,000

(Since January 1983, major modifications have been performed by Bechtel in the electrical area to complete the Appendix R requirements.)

By definition, Code E is all the rework due to Edison design changes and errors. Codes R and V are rework codes due to Comstock errors. The Suspense Code S is the rework not assignable to any particular category.

As stated earlier, Daniel had challenged Comstock's code allocation procedures. Also, Daniel had attempted to back charge LKC for rework resulting from their errors.

To make an independent assessment of rework, the Staff analyzed a sample of 100 DDR's (Deviation Disposition Requests). The principal causes of DDR's were in the following categories:

- Violation of Separation Criteria, i.e., cable trays not separated as per Appendix R

- Male-Female connections reversed
- Miscalibrated torque wrenches
- Battery damage in storage
- Tray hangar deviations

Based on this sample, the causes for DDR's were attributed as:

DECO	10%
LKC	36%
NRC	16%
Unknown	38%

This analysis by no means gives comprehensive assessment of rework problems.

In 1979, complaints of inadequate cable pulling and termination procedures led Edison to appoint an internal audit team to investigate. Several serious flaws were found in Comstock work habits. In some cases, however, audit findings were challenged by the PMO. For example, audit suggested using plastic softeners to sharpen the edges. However, NRC rules wouldn't permit them.

In 1982-83, major modifications were made to tray hangars (CO# 35, 36, and 40). Some of these repairs relate to 20,000 feet of hangars purchased from Power Strut Inc., with welds that had separated. There is a major dispute as to who should pay. The vendor claims that Edison design specifications were at fault.

This item, if not recovered from the vendor, should be disallowed. WCR#47 estimates direct cost for this rework as $2.3 million.

In general, LKC productivity was poor on the job. As a result of rework, suspense items and engineering changes, the unit rates affected were as follows:

Activity	Estimated U/R	Experienced U/R	Δ %
Conduit	.85	1.12	32
Cable	.05	.07	40
Termination	.41	.67	61

(It is appropriate to point out that Edison unit rates in these categories compare favorably with industry averages: See Susquehana Report P 174.)

A 1978 in-house review (assignment #264) identified electrical progress as a major restraint on fuel load (then scheduled for January 1980).

This study suggested that as of April 1978:

- Various electrical systems were not fully defined as to their scope.

- Conduit was 19% behind schedule; the completion rate should be 4.2% per month, compared to current rate of 2.5%.

- Cable pulling was 42% behind and required about 6% monthly rate. Cable termination was even worse.

- Inadequate use of second and third shifts. Often productivity is better at night in electrical construction (assessment of Commonwealth Edison).

- Bechtel assessment was that wire and cable delays would add at least 11 months to the scheduled fuel load date.

The study recommended, among other things, that:

- Material status be integrated into schedule.
- Detailed CPM in critical areas.
- Cable pulling charts be integrated with overall CPM.
- Assurance that qualified/experienced personnel are in the leadership role.
- Review of electrical superintendent who is now on the job.

In 1982, QC conduit inspection had a severe backlog causing restraint to project schedule. It seriously impacted completion of FIVT, ILRT and turnover of many systems. Many QC inspectors were hired, and a training program established, but with little success (see LKC mgt. meeting notes December 1982 - February 1983, Request #204). Installation quantities were significantly below what was required to support project schedule. As an example, during the period of December 1982, LKC reported the following results:

Activity	% Completed vs. Required
Conduit	33%
Cable	60%
Terminations	20%
P/L Cards	50%

In November 1982, Edison took over LKC contract administration from Daniel. Bill Wilson of Edison performed a strong supervision of Comstock and work improved considerably in early 1983. Mr. Wilson was assistant to the Project Manager. He also supervised fire protection. Bill Wilson was taken off the project in October 1983.

Overall, LKC performance was also affected by the following factors:

- Electric is one of Edison's weak areas. They never showed a sense of urgency. A 1978 comparison study of Fermi and a similar unit showed that Fermi conduit installation was 44% compared to 89% and cable installation was only 4% compared to 45% at another comparable unit.

- Material shortage and late delivery significantly impacted electrical progress. At one point in 1978, 1.6 million linear feet of cable was on hold for defective insulation. In response to our formal request, we were told that the defective cable was acceptable. However, it is being closely watched by Edison for performance. We question the veracity of this response.

  In another case, several thousand feet of cable could not be found at the site. (See: Project Schedule Analysis November 1982.)

  In response to our follow-up inquiry (Request #444) on the missing cable, the Staff received the following response:

  > "The project purchased the stated footage for use in the High Range Radiation Monitoring System (non-QA cable). The footage that was reported missing was utilized in miscellaneous locations in the turbine building. Administrative controls that exist on the project did not allow this cable to be utilized in safety related areas".

- DE design of bin radius was conservative and later found to violate bin radius requirements.

- DE had established their own standard on cable routing. All cables must come from the top. This, we learned, was due to flooding in one of Edison's power plants, but this standard made electric work more costly.

- As a corporate policy, Edison decided to use QA Level 1 Cable for all parts of the plant. This was to minimize safety problems of mixing Q from non-Q cables. Nevertheless, this decision was quite costly and time-consuming. QA Level 1 Cables cost a lot more. Further, recordkeeping and storage requirements are far more stringent.

- Daniel Construction Manager, Mark Albertin, whom we mentioned earlier, had electrical background. We found evidence of his nitpicking on LKC. In November 1982, Edison took direct control of the electrical contractor. Relations between LKC and Daniel were strained for the most part.

In our judgement, LKC performance and productivity were also significantly affected by outside factors: project delays, redesign, regulatory changes, fire, and seismic criteria. This gave Comstock an opportunity to place blame on these factors for their shortcomings, principally in the QA/QC area. Comstock demanded, and generally received, very high mark ups on their work (See DIC7-1431, and DIC7-1865).

Given the circumstances, we consider LKC performance satisfactory, but not outstanding.

FERMI II NUCLEAR PROJECT

3.P1

[DETR]OIT EDISON

DANIEL CONSTRUCTION COMPANY
CONSTRUCTION MANAGEMENT
P. O. BOX 1096
MONROE, MICHIGAN 48161

TO: W. Everett
Project Superintendent

DATE: May 5, 1977
DIC7-1431

FROM: D. E. Seifert
Project Manager

SUBJECT: DANIEL PROJECT NO. 210-7163
L. K. Comstock's Proposals To Furnish Additional Engineering & QC Personnel

REF: 1. Comstock's Letter Of April 11, 1977 -- Engineering Work
2. Comstock's Letter of April 11, 1977 -- QC Inspection Personnel

Daniel recommends that Edison reject L. K. Comstock's proposal to furnish additional Engineering Personnel. We further recommend that Edison counter Comstock's offer to furnish QC Personnel with a more cost effective proposal.

In a meeting held April 29, 1977 attended by interested Edison and Daniel personnel, both of the subject Comstock's proposals were discussed. The conclusion of the meeting and Daniel's recommendation was to reject Comstock's proposal to furnish Engineering Personnel. Edison's needs for additional drafting support are most cost effectively met by hiring job shop personnel under Edison supervision.

L. K. Comstock's proposal requesting reimbursement for QC Inspectors is contractually justified. However, the rates of pay proposed by Comstock are unreasonably high. We recommend that a counter-offer be made allowing payment at hourly rates commensurate to the rates quoted and Comstock's Control No. 77-2-19 dated February 18, 1977, plus a markup of 23% for employee costs and fringe benefits and an 8% profit. Adopting this recommendation effectively reduces Comstock's profit on the subject QC individuals from a 30% average to 8%, resulting in a substantial savings.

Please forward this recommendation to appropriate Edison Personnel for their consideration and action.

D E Seifert

D. E. Seifert
Project Manager DS

Written by: A. L. Lambart
Asst. Contract Administrator

/dlk

File: 2-ZZ-10.067

3.1

D.067

FERMI II NUCLEAR PROJECT

DETROIT EDISON

DANIEL CONSTRUCTION COMPANY
CONSTRUCTION MANAGEMENT
P. O. BOX 1096
MONROE, MICHIGAN 48161

TO: W. Everett
Project Superintendent

DATE: June 2, 1977
DIC7-1865

FROM: D. E. Seifert
Project Manager

SUBJECT: DANIEL PROJECT NO. 210-7163
Contract No. 1C70112
Comstock Proposal to Furnish QC Personnel

Based on additional information received concerning L. K. Comstock's Employee Bid Package, Daniel is revising their recommendation originally submitted on May 5, in DIC7-1431.

Subsequent to issuing our recommendation concerning L. K. Comstock's proposal to furnish QC personnel, Daniel received from Tom Hill a copy of L. K. Comstock's alleged indirect costs. These costs indicate a mark-up of 37 percent over and above bare hourly rates. Daniel recommends that Edison audit the mark-up rates quoted by L, K. Comstock for their indirect costs. If the audit verifies L. K. Comstock's costs, these rates should be accepted. If in fact the rates are as quoted, L. K. Comstock's profit would be reduced to approximately 16.6 percent, from an average of 30 percent profit as stated in our earlier recommendations.

Unless the audit referenced is performed, Daniel can not verify the rates quoted by Comstock. But we do question the cost of Comstock's guaranteed wage plan. In addition, an allowance of 16.6 percent for profit is excessive. Daniel still maintains that an eight percent pure profit should be the maximum allowed on a cost-plus contract.

Please forward this recommendation to appropriate Edison personnel for their consideration and action.

D. E. Seifert
Project Manager

Written by: A. L. Lambart
Asst. Contract Administrator

/tjr

File: 2-ZZ-10.067

Disallowances

Based on its analysis, the Staff recommends that, as a conservative estimate, at least 10% of work performed in the electrical area was imprudent and preventable. In large part, this imprudence was a result of inadequate attention, excessive rework and redesign by Edison. For example, separation criteria for fire protection had been in effect since 1977 (after the Browns Ferry accident in 1975). Some criteria were revised in 1981. Yet, we found hundreds of examples where Appendix R provisions have been violated as late as October 1983. Indeed, at present (December 1983), one of the critical path items is to put hangars and insulation wrap around the cable trays which do not meet the 20' Div 1/Div 2 separation criteria. Conceivably, this could impact the fuel load at this late stage.

- As stated earlier, at least 14% of rework has been identified as a result of engineering errors and redesign at one time.

- By Edison's own estimates, the unit rates (manhrs/unit) for cables, conduit and terminations increased by 30% to 60%.

- Cable inventory has been in disarray. For example, project estimates that at least 8 million feet of cable is installed in the plant compared to gross purchases of an estimated 10.7 million feet. This is all Q Level 1 expensive cables and wire. Edison claims that their inventory levels fully account for unused cables. We doubt the Edison contention, given massive rework. (Initial estimate from the Purchasing Department was that 20 million feet of cable has been purchased.)

- Material shortages and defective material contributed substantially to the delays, waste, and loss of productivity.

- it is impossible to identify and quantify each item of rework, redesign, and errors. As an example, the Staff identified at least following cost changes in electrical construction area, due to low productivity, scope changes, modifications, delays, interferences, and miscellaneous reasons:

1978 (EF2-41933)	\$ 6.0 million
1979 (EF2-45755)	\$13.5 million
1980 (Forecast 1, B-45)	\$ 8.8 million

(not all, however, are attributed to errors/deficiencies)

As a minimum, the Staff recommends the following disallowances in the electrical area:

1. 10% of expenditures on direct electrical construction.

		Disallowance
(a)	As of September 1983 LKC was paid \$124 million	\$12.40 million
(b)	Misc. overhead/mark up @ 20%	2.48 million
(c)	AFUDC (mid-point 1973 -1983) use 1978-83 factor - .516	7.68 million
	Subtotal Item (1)	\$22.56 million

(Note: DE policy was to charge 25% mark-up on back charges from contractors.)

2. Defective Material

(a)	At least 1.6 million feet of cable w/defective insulation @ $1/1ft.*	$ 1.60 million
(b)	Power struts (20,000 feet of cable tray)	2.30 million
	Subtotal Item (2)	$ 3.90 million
3.	Total Disallowance	$26.46 million

* Unit cable costs range from .15 per foot to $12.00.

12. IHSI and Fuel Corrosion - Problems and Resolutions

The phenomenon called Intergranular Stress Corrosion Cracking (IGSCC) has been found in many BWR stainless steel piping welds. Normal residual stresses in these welded areas are in tension, and when combined with reactor recirculation water conditions can lead to pipe cracking. The problem has been of major concern in BWR units for many years.

One solution found effective to prevent IGSC cracking is the heat treatment method known as IHSI (Induction Heating Stress Improvement). The treatment involves simultaneous heating of pipe on the outside, while cold water is circulated on the inside to create a thermocouple effect. The result is a creation of compressive stresses which mitigates probability of IGSCC in the sensitized metal zones.

In March 1981, Edison performed phase I evaluation of the IGSCC problem at Fermi 2. At least 57 welds were identified which could benefit from the IHSI treatment. Edison assessed that all of the interferences in the drywell would have to be removed. Further coil design contours, thicknesses and other measurements were recorded. The program cost was estimated as $2.1 million.

In October 1982, phase II (actual treatment) of IHSI was approved by Edison's Change Control Board. In January 1983, GE was contracted to perform the work.

One restraint on IHSI treatment is that there are only two equipments in the country to perform the treatment - while many BWR plants have been performing the treatment.

Therefore, Edison had to be scheduled after Shoreham and Peach Bottom. Fermi 2 was scheduled in July 1983.

Performance of IHSI Treatment

- Edison began planning and scheduling in March 1983.
- Training, preparation and site mobilization began in April and continued through June.
- All equipment arrived in June 1983, including thermocouples and the first shipment of coils.
- Verified that all interferences in drywell had been removed; access to DW restricted.
- IHSI treatment began at 6:00 PM July 12, 1983.
- Initial 10-day schedule was extended by 2 days because six more welds were added to a total of 79.
- Work was completed 6 hours prior to 12-day schedule. Eleven nonconformities were generated and resolved through FDDR's.
- The overall program was finished two weeks ahead of schedule. Eight days of full manloading were saved with an estimated cost saving of $460,000.

Problems Encountered

Major problems encountered were:

A. Cable shortage due to strike at the manufacturing plant.

B. Equipment failure. Leaks were found in many coils; over-current trips and modifications were required in power supply equipment; computer failure during treatment resulted in many lost hours. Failure of communication system caused some delay.

C. An additional six welds were found needing treatment. In March 1983, Edison had found that some welds at Zimmer were identified by GE as not being "solutioned annealed". DE requested GE to verify that welds at Fermi were actually "solution annealed". This was confirmed by GE to be so.

In June 1983, GE informed DE that their earlier response was incorrect. At the last minute, therefore, Edison decided to give IHSI treatment to six of these welds - the remaining such welds could not be treated.

Cost Performance

The final cost, after scope revision, for 79 weld treatments was estimated at $2.9 million.

The actual cost of the program was $2.45 million. The interferences on other work were minimal.

This is an example of excellent planning, coordination and successful completion of an important IHSI program.

The Staff feels that DE did a commendable job in this instance.

Independent Staff Verification of IHSI

The Staff verified the prudency and necessity of Edison's decision to perform IHSI treatment.

As stated earlier, IGSCC is a major concern in a BWR affecting many utilities. Numerous R & D studies have been done to study solutions and possible alternatives. EPRI has been a leader in resolving the IGSCC issue. Staff reviewed several of these studies. IHSI has been an accepted cost-effective method.

In December 1982, EPRI conducted a decision analysis type study for coping with IGSCC alternatives. Staff requested the results of this study for review (EPRI NP-2758; Project 1542-2: Decision Analysis Applied to Intergranular Stress Corrosion Cracking).

The study evaluates the cost benefits of three strategies on the IGSCC problem:

(a) Replace all piping susceptible to IGSCC

(b) Mitigate tendency to IGSCC by IHSI treatment

(c) Do nothing

A fourth strategy of increased inspection was also evaluated.

The principal conclusion of the analysis is that the IHSI option is the best prevention strategy. Other conclusions:

- IHSI yields $22 million savings relative to no prevention option.
- IHSI yields $239 million savings compared to replacement option.
- A potential savings of $320 million with IHSI when replacement power cost during repair outages is considered.
- There is only a 15% chance of regretting the IHSI decision.
- The IHSI alternate dominates the others so strongly that the value of perfect information regarding key uncertainties directed towards improving the basis of decision is essentially zero.
- Finally, the EPRI estimate for a typical IHSI treatment is $3.5 million. Edison performed with $1 million less expense.

Based on this independent review, the Staff reiterates its belief that on this program Edison acted prudently, in a timely and cost-effective manner. Edison contributed $900,000 to the EPRI research.

Fuel Corrosion

Early in 1983, some other BWR's were found to have developed corrosion problems in GE-fabricated fuel. The cladding causes reduced conductivity at high fission levels. Edison discussed the problem with GE. In March, Edison tentatively decided to refurbish the fuel. The fuel delivery was to be rescheduled. Later in the year, Edison studied the fuel corrosion problem at Hatch 1 unit of Georgia Power, which has the same GE-fabricated fuel. Edison was satisfied that based on Hatch experience, Fermi 2's first fuel assembly would perform satisfactorily. It is Edison's assessment that:

- The levels of fission during first load will not be high enough to cause the corrosion problem.

- The fuel corrosion problems have been usually experienced with reload assemblies. Edison's reload fuel will use the improved fabrication process and eliminate corrosion problems.

- Edison, therefore, decided not to refurbish the fuel assembly.

Fuel has been delivered at Fermi 2 in 25 batches, starting on August 14, 1983. Most of the fuel is now on site.

The Staff does not offer any comment on the technical problems associated with fuel corrosion. In our opinion, refurbishment could have potentially impacted the fuel load date as it was then known. In March 1983, F/L was estimated by June 1983. In May, it was revised to December 1983. Edison's decision not to refurbish fuel appears justifiable.

13. Cooling Towers

One of the early design considerations in a nuclear unit is the circulating water system for condenser cooling. The turbine back pressures, condenser capacity and unit outputs are all affected by the type and size of the circulating water system.

In 1969, when plant design parameters were being developed, Edison General Engineering developed three alternate cooling modes:

(1) Cooling towers using closed loop system

(2) Spray Cooling Ponds, and

(3) Lake Erie intake and discharge using once-thru cooling. In this last case, two options were reviewed (a) $18^\circ\Delta$ and (b) $10^\circ\Delta$.

These options were examined in some detail from an economic and technical standpoint.

Some of the major concerns with the once-thru using lake discharge were:

(a) Lake levels. Concern here was that Lake Erie is relatively shallow, especially towards the western shore. One must go 4,000 to 5,000 feet to obtain satisfactory depths for lake discharge. Edison hired consultants, Dames & Moore, to calculate the historic lake conditions. The lake attains elevation 564' once in 10 years, and elevation 558.8' was calculated to be lower than ever recorded and must occur when coupled with strong sustained off-shore winds plus a seiche. In their PSAR, Edison used 558.8' as the lowest possible elevation for Lake Erie. The level elevation at 564.0' was assumed for design basis in reviewing the once-thru cooling option.

(b) Thermal and radiation effects. Edison seemed concerned that intake water for the City of Monroe is obtained from the same general area as the intake/discharge position for the recirculating water. This, and general concern for radiation and thermal pollution, were discussed by the Engineering Committee. It was agreed that the Water Resources Commission would be amenable to the intake pipe structure if they were provided sufficient guarantees. The Fermi plant would have to be shut down if radioactive wastes were indicated in City of Monroe intakes. Edison was reasonably confident, at that time, that the AEC would not pose any serious objection to lake discharge/intake. Similar systems had been approved for the Pallisades Unit of Consumers Power and Cook Units of AEP. Finally, icing problems in the lake were also recognized and had to be resolved.

The spray pond option was a relatively newer approach. It consisted of 700 self-contained aqualator spray pumps, each driven by a 20-hp motor. Water would be sprayed about 20 feet in the air, and the system requires 150-acres of impoundment. The pond would also serve, it was felt at that time, to meet RHR requirements. A major drawback with the spray pond method was that it would take all the remaining acreage at the Fermi site and leave no room for a third unit.

The cooling tower option would involve three towers, 300-feet high and 400-feet in diameter. Make-up water would be syphoned from an intake pipe similar to option (3), but smaller.

Two choices were evaluated for the cooling tower options: an 18° rise and a 28° rise.

The detailed economic evaluation indicated that the once-thru lake intake discharge using an 18°Δ was the cheapest option and cost half as much ($12.6 million) as the CT option ($25.3 million). A key item against the CT was the large pumping load ($2 million) and the capacity penalty ($31 million). The spray option was also rejected on the basis of economics. A summary of cost evaluation is attached as an exhibit.

At its August 4, 1969 Engineering Committee meeting, Edison decided that "Plan B2 (Lake intake/discharge) be undertaken as our design at an 18° rise and that the plan provide for a possible future installation of cooling towers, should this become a necessity. Plan B2 will be designed using lake elevation 564.0 as the design level. Mr. Heidel asked that Plan B2 be optimized on the basis that the recirculating line might serve as an intake line during summer months, thus decreasing the size and cost of normal intake line".

Edison began design preparations for the intake piping system. Bids were analyzed for both cement and steel pipe options. The pipe was to be fabricated on site.

In thermal generation, the cooling mode and parameters must be synchronized with the design parameters and sizing of the turbine and condenser systems. For example, the cooling capacity (energy loss) is a function of temperature rise (Δ) and the volume of flow. With large volume intake flow possible, an 18°FΔ was efficient. Once this Δ is fixed, however, the condensor and turbine design must be matched to obtain the lowest back pressure and optimal efficiency. The turbine was optimally designed to 1½" back pressure.

Thus in 1969-70, Edison firmed up their decision to proceed with the lake intake/discharge as the circulating water cooling system, although some door was left open for possible future cooling towers. Similarly, although the spray pond option was considered uneconomic and unworkable for Fermi 2, there was some experimental testing of this system performed at this site during 1970-72. Our understanding is that it was an R & D program being conducted for possible use at the Greenwood Unit.

The Staff recommends that the consideration of the spray pond option was reasonable as an alternative, even though it was later rejected. However, all expenditures associated with design, installation and operation of this spray system do not belong to Fermi 2 and, therefore, must be deleted from the Fermi 2 project.

In 1970, after passage of the Environmental Policy Act, Detroit Edison became concerned that the growing momentum in environmental activity would have a serious impact on the licensing of nuclear plants. Of particular concern were the objections to the lake discharge effects on marine life and thermal and radioactive pollution on Lake Erie. Edison was afraid that they may be subjected to costly retrofits and delays.

In November 1970, the decision was made to reverse the earlier decision, scrap the once-thru lake intake system and go to the closed-loop cooling towers. The PSAR was revised to incorporate the new circulating water system.

Since the turbine/condenser were designed in syn. with the once-thru cooling system, the cooling towers and pumps had to be designed around them. The cooling towers were designed for 94° temp. max. inlet compared to 70-75°F achievable from the lake inlet.

The resultant system, though optimal given the fixed design of the turbine and condenser, reduced the system efficiency and output. The two cooling towers, each with 450,000 gpm capacity, were the most efficient choice given design constraints. If the system had been originally designed with cooling towers, only one cooling tower would have been adequate. Perhaps the most significant effect was that the system output had to be derated from 1200 MW to 1139 MW, a 60 MW derating--in summer.

Therefore, the change in decision had a significant cost impact on the project.

The Staff discussed the cooling tower issue with Edison Project Engineering and obtained written information on the decisions leading to the installation of natural draft cooling towers and their impact on plant output rating. Their response is summarized as follows:

1. One of the major design modifications made to the plant shortly after its inception was the addition of the cooling tower in place of once-thru cooling as described in the original PSAR.

2. Although no State or Federal laws limiting thermal discharge had been written, Edison decided, in view of environmental concerns, to voluntarily switch to closed-cycle cooling. Problems with the depths of Lake Erie, long intake pipe, and the large size of the plant all contributed to this decision.

3. In 1969, many research studies were in process to study other closed-cycle cooling options--such as spray ponds, cooling ponds and cooling towers.

4. By the end of 1969, it was determined that the cooling tower options were the most feasible. The spray pond option would take all of the remaining land and not leave room for a third unit. Fogging and icing would also be a problem.

5. In February 1970, after a meeting of the Water Resources Commission, Edison was left with the impression that lake discharge at a site close to Monroe would be seriously opposed. In November, the decision was made to install cooling towers. A study by Doxiadis Associates also recommended this option.

6. At the time, only limited experience was available in the U.S. for cooling towers of this size, although they had been used extensively in Europe.

7. A 1970 study by Gibb & Hill Inc. concluded that (PIII-1):

   a) Mech-draft cooling towers are significantly more economical than natural draft towers in capital and operating costs.

   b) Optimum design approach for the mech-draft towers is 15°F, while it is 18°F for natural draft.

   c) While it is difficult to predict with precision the frequency of occurrence of CT plume effects in the vicinity of EF2, the order of magnitude of expected grounding of plumes is likely to be 10 to 20% higher with mechanical than with natural draft towers.

   d) The overall construction period for natural draft towers is 25 months, compared to 4 to 5 months for mechanical draft towers (note: mech. draft towers are a series of 15 or so smaller towers operating with mechanical pumps).

Therefore, based on the above environmental concerns (plume and icing), Edison decided to construct two large hyperbolic natural draft towers.

The Staff also reviewed the question of plant rating as a result of the switch from once-thru to closed-cycle. An analysis performed by Edison shows that average derating of only 1% (about 12 MW) is expected to occur as a result of the CT decision. The mechanical draft would have improved it by 1MW. Further, that the largest derating (up to 5%) may occur only on the 3 hottest days in summer when the back pressures may increase to 31/2 inches.

Finally, the plant efficiency will decrease by an average of 105 Btu/kWh as a result of CT, with the largest losses experienced in the summer, of up to 200 Btu.

The Staff is generally satisfied with the plant heat rate and derating conclusions. No further disallowance is recommended for these items.

Issue Analysis

There are at least three issues raised by this Edison decision:

(1) Were the cooling towers necessary? Did Edison overreact to the environmental fears?

(2) Were the cooling towers oversized due to design constraints or other reasons?

(3) Should the expenditures on the intake system be disallowed as imprudent, not used and useful?

1. In our judgement, Edison took the line of least resistance with environmentalists, the AEC, and other regulatory groups. This has been generally the Edison philosophy. While concern about possible later problems was legitimate, Edison had no mandatory obligation to switch to

to cooling towers. As Edison pointed out in its Fermi cost history, it was not until 1975 that EPA mandated cooling towers. Even so, exemptions were granted to units under construction, such as the 2-unit, 1050 MW each, Cook plant, completed in 1977-78 in Michigan. Edison claims that it won the appreciation of the Sierra Club due to the CT decision.

It should be noted that Edison's was one of the earliest cooling towers in the nuclear industry, although it became fairly prevalent later on.

Our opinion is that Edison should have stood firm on their decision once the once-thru system was designed. Although less desirable than CT, there was no serious challenge to it. Further, if challenged, they should have seriously resisted. It is possible that, in the end, Edison had to give in. The erection cost of the cooling towers would not have changed materially in 1975 as compared to 1973-74, when AFUDC is included, nor would it impact the schedule or interfere with other construction.

The owner of a nuclear plant is sufficiently subjected to mandatory regulations and it is not prudent to volunteer compliance when costs are an important concern. A second related question is that if Edison was reconsidering the cooling system in mid-1970, why did it not take a serious look at this option in August 1969--it left the door open for a possible CT, but went forward with the lake intake route. No major events had occurred to alter the situation. NEPA was under consideration in 1969; the Calvert Cliff decision did not come until April 1971.

Our conclusion is that while the cooling tower decision per se is not imprudent, the indecisive manner in which it was finally arrived at was inefficient. The result was that Edison ended up with the most expensive option, lots of duplication and a significant adverse effect on system output and efficiency.

In the nuclear business, it is dangerous to equivocate.

2. As indicated earlier, the cooling tower design became subject to the constraints of the design parameters of the condensor and turbine, which were already underway. The unit had to be derated due to higher back pressure and lower heat rate efficiency. In 1971, Edison was planning a second nuclear unit at Fermi of the same size, which called for only one CT of 650,000 gpm capacity, i.e., somewhat larger than the ones built for Fermi 2 (450,000 gpm each). This was to be accomplished through a larger Δ and corresponding sizing of turbine and condensors.

We believe, therefore, that the current cooling tower is overbuilt compared to one designed and built ab initio. Therefore, expenditures prorated for only one CT should be allowed, recognizing that there are savings in design and construction of two towers compared to one.

3. Although no major installation work was done on the lake discharge mode, some engineering and bid analysis process was underway. Since Edison changed their decision rather soon, and in view of the discussion in (1) above, we believe that Edison not recover expenditures associated with the lake intake design work and any installation preparation work.

However, in view of the recommendation in (2), we believe disallowance of 50% of entire cost of the cooling tower expenditure would adequately cover item (3) , and no further adjustment is necessary.

Computation of Disallowances

Based on cost information provided from the Edison CAPS system, year-to-year direct expenditures were developed. The engineering and overheads were assigned using the proportionate ratios for these items for the entire project. The AFUDC was assigned using the actual rates to the total annual expenditures.

The total expenditure on the cooling towers, including AFUDC, up to 1982, is $31.7 million.

The Staff, therefore, recommends disallowance of $15.84 million (50%).

Cooling Tower Construction

The Staff also reviewed the design and erection of the two cooling towers.

In February 1971, Edison Engineers developed the concept design of the natural draft cooling towers--each about 400 feet high and 450 feet in base diameter.

Three well-known firms were selected to bid on tower design and construction: Flour Corp., Marley Co., and Research-Cottrell. Of these, Flour had no experience in the construction of natural draft cooling towers; the other two had about 20 towers each under construction or completed.

Bids were submitted on the basis of labor, material and erection. Alternate bids were also submitted where Edison will supply the concrete. All three offered non-combustible materials in accordance with specifications. Use of PVC instead of asbestos as fill material was reviewed to meet new regulations. The Marley and Flour design incorporated cross-flow type design while Research-Cottrell was a counter-flow type.

The failure of cooling towers at C.E.G.B. (England) was recognized, and the thickness of the Fermi design was increased from 5" to 8" with double rows of re-steel instead of the single row used at C.E.G.B. The design and erection of towers at Beaver Valley was also reviewed.

A rather exhaustive economic and design evaluation was performed by Edison Engineering, including operating efficiencies, pumping power penalty, lighting, aviation safety, etc.

Edison Engineering recommended, and the Engineering Committee approved, award of the cooling tower contract to Marley Co. Edison was to provide the concrete. The recommendation was based on the following factors:

1. lowest cost
2. satisfactory design
3. satisfactory past performance, and
4. experience

The Marley contract was a fixed price. Marley subcontracted construction to Ragnor-Benson.

The erection work began in early 1972. To facilitate construction, separate access was provided to transport material, labor and equipment. It was one of the few work activities which was independent and non-interfering.

The cooling towers were completed by February 1974. Thus, the towers have been standing for almost ten years awaiting completion of the rest of the plant.

During the intervening years, there have been a few modifications in the cooling towers. The most significant was to resolve the icing problems, first discovered at the Beaver Valley Unit in Pennsylvania. The location of control panels was modified to prevent icing.

Issue Analysis

We believe that Edison Engineering did a good job of concept design on the cooling towers. The bid evaluation was thorough and complete. The selection of Marley as the erector was the right decision. The actual construction work was carried out reasonably well and within the schedule time frame. Edison provided adequate support to this activity.

One question, however, lingers in our mind. With the rest of the schedule slipping (the C.O.D. had been revised to 1975/1976), it appears that the cooling tower construction was undertaken too soon. This activity could have waited at least 1 to 2 years without a significant impact on the plant cost or schedule.

CHART No 5
COST EVALUATION - $ x 10^3

	FLUOR		MARLEY				RESEARCH-COTTRELL			
	BASE BID		BASE BID		ALT. BID*		BASE BID		ALT. BID*	
	1	2	1	2	1	2	1	2	1	2
LABOR & MATERIAL	13,145	12,480	12,874	12,301	8,215	7,643	16,823	16,104	7,321	6,601
EDISON CONCRETE	—	655	—	525	—	525	—	768	—	768
EDISON LABOR	—	—	—	—	4,868	4,868	—	—	5,780	5,780
INVESTMENT COST	13,145	13,135	12,874	12,827	13,083	13,036	16,823	16,872	13,101	13,149
DIFFERENCE	318	308	47	BASE	256	209	3,996	4,044	274	322
PUMPING POWER PENALTY	229	229	186	186	186	186	—	—	—	—
INLET PIPING PENALTY	21	21	—	—	—	—	53	53	53	53
EVALUATED COST	13,395	13,385	13,060	13,013	13,269	13,222	16,876	16,925	13,154	13,202
DIFFERENCE	382	372	47	BASE	256	109	3,863	3,912	141	189

BASED ON NON-FIRM LABOR ESTIMATE

*TARGET ON-SITE LABOR MANHOURS
FLUOR - DID NOT BID ALTERNATE
MARLEY - 384,000 MANHOURS - FIRM
R-C - 451,460 MANHOURS - ESTIMATE ONLY

ALL ESTIMATES $ x 10^3	PLAN "B-2" SINGLE INTAKE WITH RECIRC. 18° ΔT	PLAN "C-2" SINGLE INTAKE WITH RECIRC. 10° ΔT	PLAN "D" 3-COOLING TOWERS 18° ΔT	PLAN E SPRAY POND 18° ΔT
PIPE DIA. & LENGTH	19/10 - 3,800'	29/12 - 3,800'	3,800'	3,800'
WATER INTAKE	6,800	7,500	900	900
SCREEN HOUSE AND FOREBAY	2,950	4,896	466	466
SCREEN WELL EQUIP.	207	344	25	25
MAKE-UP PUMP	-	-	150	255
CIRC. WATER PIPING	2,050	3,000	3,830	2,500
POND AND PUMP HSE. FOR RHR.	325	325	325	625
ADD. SITE FILL	-	-	1,400	-
COOLING TOWERS OR AQUA-LATORS	-	-	11,000	7,000
ADD. COND. COST	-	600	150	-
PUMP HOUSE AND FOREBAY	-	-	1,700	1,100
TOTAL INVESTMENT	12,332	16,665	19,946	12,871
PUMP POWER	268	216	2,000	2,000
HEAT RATE AND CAPACITY PENALTY	-	-	3,150	2,875
MAINTENANCE ALLOWANCE	-	-	275	200
TOTAL EVALUATED	12,600	16,881	25,371	17,946

DETROIT EDISON COMPANY

ESTIMATED TOTAL COST OF FERMI 2 COOLING TOWERS

DECEMBER 1982

Year	1 Direct Costs	2 Engineering Overheads	3 General Overheads	4 Property Taxes	5 Subtotal AFUDC BASE (1 - 4)	6 Cumulative AFUDC Rate	7 AFUDC	8 Total
1969								
1970	3,570,836	701,312	297,451	103,197	4,672,796	103.41	4,832,139	9,504,935
1971	495,102	97,238	41,242	14,308	647,890	95.66	619,772	1,267,662
1972	5,566,568	1,093,274	463,695	160,874	7,284,411	88.16	6,421,937	13,706,348
1973	3,124,242	613,601	260,249	90,291	4,088,383	80.66	3,297,690	7,386,073
1974	2,013,375	395,427	167,714	58,187	2,634,703	73.00	1,923,334	4,558,037
1975	207,297	40,713	17,268	5,991	271,269	65.08	176,542	447,811
1976	67,769	13,310	5,645	1,959	88,683	57.08	50,620	139,303
1977	8,972	1,762	747	259	11,740	49.08	5,762	17,502
1978	189	37	16	5	247	41.08	102	349
1979	5,050	992	421	146	6,609	32.83	2,170	8,779
1980	52,770	10,364	4,396	1,525	69,055	24.03	16,594	85,649
1981	2,002	393	167	58	2,620	14.71	38,548	41,168
1982	87,168	17,120	7,261	2,519	114,068	4.97	5,669	119,737
TOTAL	15,201,344	2,985,543	1,266,272	439,319	19,892,478		17,390,879	37,283,357
Engg. & Design included in Marley Contract							Less	5,596,000
								31,687,357
Ratios		19.64%	8.33%	2.89%				

A total of $156,000 was added to the project, of which Teledyne's share was $100,000.

c) WCR#5:

To meet the schedule, overtime was approved at the rate of 1.45 and 1.85 times, e.g., consulting engineers OT rate was now $92.50/hr.

d) WCR#7:

Cost-plus portion of contract (SCR) was increased by $500,00 as the previous contingency had been exhausted.

e) WCR#9 & 10:

In March 1982, RCI estimated an additional $7.5 million to complete the work. This included:

- $2.6 million for Teledyne subcontract
- $4.25 million SCR work
- Delay and other claims: $712,000
- Misc: HQ support, escalation ($230,000)

The lump-sum portion of the contract was reduced by $455,000. The CRDHS installation was deleted from the lump-sum contract. RCI claimed, in effect, that it could not adhere to the original lump-sum contract due to:

- Changed criteria and increased seismic loadings resulting in, essentially, redesign of these systems and supports.
- Systems were redesigned due to too much electrical interference.
- Changes in flushing of systems different than originally planned.

14. Reactor Controls, Inc.

As previously mentioned, dissatisfaction with performance on the installation of reactor internals and CRD System led DE to terminate the GE (I & SE) contract.

In May 1980, a contract was entered with RCI (contract #1A-84803) to complete the work on reactor internals and CRD hydraulic systems. RCI had previously bid on the project but was declined. The RCI contract had two parts: (a) lump-sum $2.9 million, and (b) extra work at cost-plus for an estimated $500,000--called sub-contract release.

We have commented earlier that, in retrospect, this decision of Edison's was a mistake and very costly.

Problems developed with RCI from the start. The following pages summarize the problems.

a) RCI (Internals) work was delayed due to delay in receiving approved procedures from Edison. In September 1980, Daniel informed RCI to defer work on internals until 1981 due to (1) work not needed and (2) cash limitations. The original work was to start in June 1980.

   RCI filed a delay claim of $85,111 and received a settlement of $68,000.

b) After much negotiation, RCI agreed to continue subcontracting design work to Teledyne Engineering (GE had done so prior to RCI).

   RCI demanded a 12% mark up on Teledyne work plus their direct expenses, e.g., $50/hour for their Construction Manager, QA Manager, etc.

- The subcontract release, i.e., the cost-plus portion of the original contract is now the main contract.

- Teledyne review of design for CRDHS has resulted in a complete redesign of vent valve platform, scram system, cross-around piping, master control area, and pipe supports both inside and outside the containment. The cost of this re-analysis and redesign added $2.5 million to the Teledyne subcontract.

- RCI submitted a claim of $841,000 for 1981. This covered manual lost hours. Of the 46,250 manhours expended by RCI on the lump-sum contract, only 13,296 hours were spent productively. The reasons for lost hours:
  (1) Extremely high turnover and mobilization problems due to numerous delays.
  (2) Excessive FDI and FDDRs incorporated by RCI, and work stoppages ordered by Edison due to DDR all led to lost time (FDI, FDDR's are related to GE (I & SE) defective performance).
  (3) Equipment problems with refueling bridge, master control piping, cross-around piping, reroutings, etc.
  (4) Insert withdrawal piping put on hold by DIC.
  (5) Many other reasons cited by RCI.

f) In October 1982, an additional $6.2 million was added to the contract (WCR#12).

- $2.05 million increase in Teledyne due to extensive redesign resulting from interference problems in the field;

- $3.1 million increase due to extra work, increased overtime (50% compared to the anticipated 10%), extensive design changes as mentioned above.
- $568,000 increase due to unanticipated delay charges.
- $107,000 escalation costs.
- The lump-sum contract was virtually eliminated due to unforeseen problems such as: steam dryer lugs too short, shroud head alignment lugs out of alignment, feed water sprayer behind schedule, rescheduling of milestones, and lack of support from maintenance, etc.

This rather large increase was anticipated to go still higher.

g) In November 1982, $2.8 million was added to the contract (WCR#13).

h) In April 1983, another $6.2 million was increased. This was supposed to cover all remaining work.

The contract now had an estimated cost of $27 million. As of September 1983, about $25 million had actually been paid to RCI.

Discussion

RCI performance was frustrating to Edison and Daniel from the start. The RCI contract was a result of dissatisfaction with GE (I & SE). In our judgement, RCI recognized Edison's weak position and exploited it to the fullest. As has been previously mentioned, the RCI team came from the eastern region--called RCI (North Eastern Services, Inc.) and not from the headquarters in San Jose, California. RCI provided little home office support to its Fermi 2 project team (Edison complained and got some attention from the RCI home office). The schedules were rarely met.

At the same time, delays or interferences caused by Edison were exploited to the hilt by RCI. The RCI proposal was a typical "Sucker bid". It promised a lump-sum contract for $2.9 million and left an opening with a supplemental cost-reimbursable contract called subcontract release (SCR) with an initial estimate of $500,000. As should have been expected, RCI directed all work into this supplemental contract and ignored the lump-sum work. Later, the contract was revised to accommodate this.

Given Edison's vast experience in dealing with contractors, the Staff fails to understand why Edison was not more careful with the RCI agreement. Edison had another major contract with RCI for torus modifications work (1A-84054) since September 1977. To our knowledge, RCI performance on that job had also been poor. RCI was unable to control the labor, quality of work, and scheduling. That contract had many similar features. Cost escalated from $2.8 million to $25.5 million; initially a lump-sum, was changed to a cost-plus fee, although a significant scope change took place. In all, RCI has been paid over $53 million by Edison. This fact surprised even the Edison Project Manager when we pointed it out. It is not clear why this was not taken into account in the second contract. RCI work was complicated due to the unfinished job by GE (I & SE) (generated excessive FDDR & FDI), design subcontract with Teledyne Engineering, delays in initial mobilization and interferences. In our judgement, Edison was unable to effectively administer this contract. The cost escalated 8-fold in three years. The Teledyne subcontract escalated from $156,000 estimated initially to over $6 million. Teledyne almost completely redesigned the CRD hydraulic system. RCI generously benefited from this due to a 12% mark-up provision.

It is interesting that while RCI received several generous delay claims, it also performed excessive overtime (often 50%) to meet schedules. RCI was judged by Edison Construction Managers as one of the poorest performers at the Fermi site. The NRC also criticized RCI performance in the 1982 SALP report.

Based on its extensive review (PAR, WCR and discussions), the Staff concludes the following:

1. The decision to award CRD/internals work to RCI was ill advised. DE was in a weak position having terminated the GE (I & SE) contract.

2. DE failed to make the proper estimate of remaining work to go and greatly underestimated it.

3. By terminating the contract, it freed GE of any liability for poor and defective workmanship.

4. The CRD/Internals System was essentially redesigned by Teledyne and reinstated by RCI.

5. Work performance of RCI was poor, scheduling inadequate, and there was little home office support.

6. The agreement between RCI and DE was more to the RCI advantage. Further, RCI took full advantage of DE's weak position.

7. The RCI work was marred by excessive delays, interference, and enormous redesign and rework. A detailed review of tasks performed by RCI shows that a great majority of their work was redesign, repair or rework.

Recommended Disallowances

The Staff recommends the following disallowances as a minimum:

1. All delay claims, escalations and miscellaneous claims paid to RCI.
2. All RCI home office, field supervision and non-manual expenses.
3. All mark-up paid to RCI for Teledyne sub-contract.
4. Edison overhead expenses.
5. AFUDC (1980-82).

Computation of Disallowances

1. Delay Claims

WCR#1	$ 68,000
WCR#9-10	
delay	$ 712,000
escalation	$ 230,000
WCR#12	$ 675,000
Subtotal	$1,685,000

2. Home office, field supervision and non-manual

This is estimated to be 10% of the total payments to RCI and Teledyne based on Edison's own estimates of non-manual vs. total costs for RCI which range between 10% (WCR#6) to 14% (WCR#9-10). Teledyne assumed 20% project management costs.

As a minimum, a 10% disallowance of the total $27 million is recommended to be $2,700,000.

3. Total Teledyne Engineering (est.)	$6,000,000
12% RCI mark-up	720,000

4.	Total base cost disallowed (1+2+3)	$5,105,000
5.	Add 20% Edison overhead	$6,126,000
6.	AFUDC (1980-82) factor	1.2403
7.	Total Disallowance for this contract	$7.598 million

15. TenneComp

In December 1978, Edison awarded TenneComp Systems Inc. the contract for supply of the station security system. The system had been designed by Stone & Webster Engineering.

According to the Edison PAR, TenneComp was selected on the following basis (1A-84579):

(a) Six other bidders were invited to submit proposals, but declined to bid. Among them: Honeywell, Johnson Controls, V-T Technologies, and Diamond Electronics. The main reason for that was the inability to make delivery date specified by Edison. Also, Edison specifications were beyond in-house programs of the bidders.

(b) The TenneComp bid was in line with other plant security systems. Specifically, Arkansas Power and Light and Pennsylvania Power and Light were reviewed. TenneComp had been selected by the two utilities due to its superior design and conformance to 10 CFR 73.55 and NUREG-0220 and system life-cycle cost. (Note: We are not sure if Edison had access to bids received by other utilities.)

(c) TenneComp promised to meet Edison specifications and the delivery dates.

- The original contract price was $1,291,880.
- TenneComp is a subsidiary of Foster-Wheeler.

By October 1979, the contract was revised upwards to $1,572,000, of which $1,030,000 had been paid to TenneComp.

Edison was having considerable difficulty in receiving material promised by TenneComp, which in turn blamed it on computer material shipments from Digital Equipment Corp.

The actual payment made by Edison to TenneComp was far greater than the value of the material received. Edison and TenneComp negotiated a revised schedule of payments to match the material equipment.

Sometime in 1980, TenneComp declared bankruptcy. Edison filed a claim of $1,640,000, mainly to compensate Edison for replacement of the security system contract with Johnson Controls, Inc. In February 1982, Edison received a settlement check for $134,150. Edison directly lost $1,030,000 in payments to TenneComp and received little equipment against it. Our understanding is that Edison acted aggressively to recover whatever material it could--drove a truck to the TenneComp shop in Tennessee and picked up whatever material was there. Much of the expenses were in unfinished software programming efforts which couldn't be retrieved.

Edison lost considerable time in security system installation.

The replacement cost of the security system estimated by Edison and filed in its claim is $1,639,979. Of this, the recovered amount is $134,150, a net loss, therefore, of $1.5 million. In January 1981, Johnson Controls (1A-53114) agreed to install the security system for a lump-sum price of $1.7 million.

Although Edison should have been suspicious of the TenneComp bid when all other potential suppliers refused to meet Edison specifications and deadline, it seems Edison was caught in a bad situation.

The Staff feels that this loss was not a result of Edison negligence. On the contrary, Edison made an aggressive effort to recover its assets. Nevertheless, this expense should not be borne by the ratepayers on the basis of "Used and Useful" test. In retrospect, the Staff fails to see why advance payments were made to TenneComp in excess of the value received.

The Staff recommends the following disallowance:

a)	Direct Cost	$1.5 million
b)	Edison Supervision/overheads at 20%	$ .3 million
c)	AFUDC 1979-82 @ 1.3283 (since most expense incurred in 1979)	$ .591 million
d)	Total Disallowance in 1982 dollars	$2.391 million

C. Project Third-Party Reviews

During the long history of Fermi 2, numerous evaluations, assessments and project status reviews have been performed. Some of them were done by Edison in-house groups, e.g., Internal Audits, Generation Construction Department, etc. Many other reviews have been performed by outside third parties. Reviews include both technical as well as project management. In this section, we shall summarize the findings, recommendations and Edison follow-ups on some of the major reviews.

At the outset, the Staff believes that Edison Management should be commended for conducting several fact-finding reviews. It is a measure of good management, that Edison was willing to learn about the project weaknesses, deficiencies, and frank assessment from inside and outside experts. Management did not "bury its head in the sand". In many instances, Management took vigorous actions to remedy the deficiencies, restructure organization, and address specific issues. It should be recognized also that expert reviews are often focused on narrow issues. Their recommendations may not always fit into the overall project objectives. For instance, in general, recommendations often call for greater resource commitment in the specific area. Yet is is the Company management which must determine the best allocation of their resources. Moreover, the expert evaluations are not necessarily unbiased. For example, whether construction or engineering receives greater attention may depend on who is making the review. Biases can also exist within the management. Some of these will be discussed in the section on Management Decision Process.

1. Daniel

Daniel Project Status Review and Audit (1974).

This review has been previously discussed at some length. Daniel found serious deficiencies in engineering schedule delays, procurement, and project organization. Their recommendations formed the basis for removal of Parsons and hiring of Daniel as Construction Manager.

2. Project Services Section

DE Generation Construction Department (April 1978).

This review was requested by Dr. W. Jens, then Manager of Construction and Engineering. The objective of the review was to assess the probability of meeting the January 1980 fuel load date, and to answer the questions:

a) What is the % of completion?

b) Based on present production and critical path, when will we load fuel?

c) What can be done to improve F/L and when can we get there?

The study consisted of three separate, independent evaluations.

a) Project Services Section

Findings of this group were that:

- Detailed construction network was not prepared.

- Interfaces between construction/start-up not fully defined; start-up leadership not clear.

- Job site communication is weak.

- Non-manual to manual ratio too high.

- Shortages of qualified welders, pipe fitters and field supervisors.

- Contracting of 16 contracts behind. Some may affect fuel load, e.g., fire protection, security system, etc.

- Engineering status: Project is behind on small bore piping design. Estimated quantities are too low compared to other jobs (review had compared Fermi 2 quantities installed and to go with several other jobs with similar status, e.g., LaSalle 1 & 2, Susquehanna, Grand Gulf, and WPSS).

- The comparable engineering status on Fermi was also behind w.r.t. the fuel load.

Name	Net Cap.	Type	F/L Date	% Completion Engg.	Const.
Fermi 2	1139	BWR	1/80	50	45
Grand Gulf	1250	"	10/80	77	42
WPSS #2	1080	"	3/80	88	40
LaSalle 1	1048	"	3/79	82	51
LaSalle 2	1048	"	3/80	65	41
Susquehanna 1	1050	"	5/80	62	40
Susquehanna 2	1050	"	11/81	62	27

Source: Exhibit A (ii): Evaluation of EF2 Schedule).

- Material status was found behind and impacting fuel load, for L.B. pipes (1000 spools not delivered), L.B. valves (200 pieces), 2000 hangars not yet delivered, 400 B.I.W.

cables to be delivered, and 1.6 million feet cable on hold due to possible defective insulation.

- Review found 5 months' construction slippage between February 1977 (re-start) and February 1978. An additional 7½-month delay was expected based on experienced bulk installation rates.
- Start-up was behind in issuing final plan of sequences and activity duration for acceptance.
- Inadequate scoping of system boundaries, only 43/147 boundaries defined.
- Understaffing of start-up group.
- 50% probability of 12-month delay due to start-up, so 6-month expected F/L impact.
- Project status: 53-55% complete.

Recommendations of this group were:

- Emphasize proper planning and implement rigorously.
- Identify specific impact items.
- Manage by objective and assign direct responsibility.
- Allocate additional resources wherever needed.
- Implement productivity improvement effort.
- Have a hard look at current orgnizational structure to eliminate overlaps and waste.

b) Bechtel Power Corp.

Bechtel Power Corp. used project schedule analysis to evaluate the range of possible F/L dates.

Their assessment was that F/L could be delayed 9 to 12 months, i.e., probable F/L is between October 1980 and January 1981. The reasons for delay were primarily the time needed to install the remaining quantities of large and small piping, wire, and cables based on installation rates of other projects. Bechtel estimated the following specific delays impacting F/L:

Wire and Cable	11 month delay in F/L
Small pipe*	10 month delay in F/L
Connections (terminations)	9 month delay in F/L
Large pipe	5 month delay in F/L
Cable tray	0 month delay in F/L

* (Staff specifically confronted Daniel with the low rate of small pipe installation. Their contention is that purposely the major focus was on large pipe installation due to greater interference likelihood. Once L.B. pipe is sufficiently installed, S.B. pipe is relatively easier and the rate can be improved at will.)

c) Commonwealth Edison

Construction experts from Commonwealth Edison Company were called on site to make the project assessment. Their comments:

- Piping spool installation rates at LaSalle were 800/month; at EF2 it is 160/month; not enough.

- Productivity for electrical and piping does not look generally good. It appears to be supervision or area problem.

- Project should be on multiple 40-hours shifts rather than loading up the manpower. In some areas, productivity is better at night, especially in cable pulling.

- LaSalle has welder training program (later EF2 started the same program).

- If production continues at this rate, the F/L date is optimistic. Productivity must be greatly increased to achieve F/L.

- Number of supervisory people at Fermi appears to be too high. "With 70 Edison on site, why do you need Daniel?".

- Slab-over torus design (at LaSalle) is more difficult than Fermi 2.

- Marginal thickness of torus could give problems later.

Other comments on the project were:

- Some quantities, e.g., small piping, were grossly underestimated by Edison (by a factor of 2).

- Extra work required for Clean Steam could add 3 months to the schedule.

- Bechtel also noted that start-up would take longer due to lack of Edison crew experience in BWR start-up (early warning).

- DE should send out headhunters to recruit pipe fitters, and welders to meet project manpower needs.

The Staff feels that the above evaluation was comprehensive, candid, and essential. It provided early warning of some pitfalls. The study, however, concentrated on construction issues and not on engineering status.

3. T M I Impact Review

After the Three Mile Island (TMI) accident, Edison appropriately anticipated major NRC impact on all nuclear units, particularly those under O/L review. In April 1979, the TMI-Safety Review Task Force, consisting of Edison nuclear engineering and Stone & Webster consultants, was formed to identify impact items for Fermi. The group identified 284 action items which could possibly affect Fermi 2. Over 100 of these were adopted. The S & W report provided cost and schedule impact of TMI-action items.

The task force recommendations were intended to make, in the words of Detroit Edison, "An already safe plant even safer, and essentially all of them were adopted along with a number of other plant modifications required by the NRC". A special group called "New Issues Program Office" (NIPO) was set up to ensure that task force recommendations were implemented without delay. The principal changes included:

- Extensive control room modifications to provide operators with fail-safe indications of relief valves status, unequivocal core levels, and other safety related parameters.

- Installed computer to process and analyze accident data.

- To avoid possibility of excessive hydrogen collection during an accident (as happened at TMI), a containment inerting system is installed, existing hydrogren detection and recombiner system is upgraded.

  (The Staff feels that on this item DE went through several gyrations and, in the end, seems to have overreacted.)

- Backup to the emergency Core Cooling System improved by adding a standby feed water system. (This is not a TMI-specific, NRC requirement.)

- To improve fire protection, additional fire walls were added; electric cable trays fireproofed and more sprinkler systems installed (on the face of it, these do not appear to be TMI-related items, but simply to add yet one more layer of safety).

- Fermi 2 Simulator was ordered with a program to provide operators more on-line information to resolve major problems, malfunctioning data, core damage accident conditions, etc.

- Several new facilities were added: Technical Support Center, Emergency Operating Facility, and the Nuclear Operating Center which houses the Simulator.

- DE joined several utility-sponsored efforts to improve plant operability and problem detection programs such as:

  a) Disturbance Analysis and Surveillance System (DASS). This is a pre-analyzed accident sequence program. In the event of operating problems, the sequence of actual events is compared to the pre-analyzed sequence. The matching of sequences will identify the problem and instruct the operator into corrective and accident-prevention action.

  b) Nuclear Analysis Safety Center, staffed with specialists to analyze the safety design and incidents at operating plants.

  c) Institute of Nuclear Operations (INPO). This is an industry-owners group to perform self-evaluation and advise owners of operating deficiencies. The formation of this group was a direct response to the TMI accident and was intended to forestall further NRC regulations in the operating room.

The PSC Staff performed its own analysis of NRC requirements on utilities as a result of TMI. "TMI and its Impact on Nuclear Plant Operation and Design" - by George [illegible]. The report coincides with the Edison task force findings in several areas. Most TMI impact was in the area of operations.

In the Staff's judgement, Edison overstressed the TMI-impact. TMI undoubtedly had a major impact on all nuclear units. It appears to us that Edison's response was bordering on panic. Many costly fixes performed by DE were not fully justified and non-TMI related. Edison's attitude was one of submission to the NRC. Edison's TMI response had a significant impact on project cost (at least $200 million by Edison estimate).

4. MAC

Project progress deteriorated severely in 1979. Fuel load date was further slipping. The project appeared out of control.

The consulting firm of Management Analysis Corporation (MAC) was brought in to perform project diagnostics. The findings and recommendations of this review have been discussed in other sections.

MAC is an organization with experienced individuals who have managerial experience at GE/Westinghouse and at nuclear units. MAC has performed similar reviews at several other nuclear projects. In our opinion, MAC findings in the 1979 review essentially echoed those made by earlier reviews by Daniel, the Generation Department, and others. The common problems were: inadequate planning, lack of communication, and more direct involvement of Edison Management. The Fermi 2 project was reorganized as a result of this review: Edison took direct QA control, field staff was strengthened, field engineering, procurement, and project controls were brought at the site.

Subsequent to the 1979 review, MAC performed two other reviews: January 1981; Team Building at Fermi 2, and August 1982; Fermi 2 Project Evaluation. In 1983, Edison hired several MAC individuals to act as project advisors, and assist in start-up and system completion activities.

5. <u>University of Texas/D.O.E. Study</u>

In 1979, Edison participated in a productivity measurement study conducted by a team from the University of Texas and sponsored by the Department of Energy.

Five nuclear construction sites were audited; two in the Midwest, one in the South, and one in the North Central area. Fermi 2 was one of them. The study was performed primarily by interviewing craft at the site to assess the causes of delay. Six causes were outlined and measured for lost time in each category. They are:

1) Material availability
2) Tool availability
3) Work redone
4) Delay as a result of interference with other crew
5) Overcrowded work areas
6) Inspection delays

The lost manhours per 40-hour week per craft was estimated in each category. The results were as follows:

Causes	A	B	C	D*	E
1	8.40	6.7	7.54	6.4	6.85
2	4.98	4.23	4.58	3.41	5.08
3	4.92	5.47	5.92	7.73	7.03
4	4.66	3.49	4.36	2.63	3.54
5	4.55	4.36	4.56	4.42	5.93
6	2.31	2.57	2.06	2.89	3.60
Total	29.82	26.82	29.02	27.48	32.03

* (Project D is assumed to be EF2.)

Overall, Fermi 2 lost manhours per week fall within the range observed--in fact, somewhat below the average of 29.03 hours. Fermi showed superior performance in four categories: material availability, tool availability, work areas, and work interference (it is not clear to the Staff how these last two categories could be separately identified in the study).

The two weak areas in the case of EF2 were found to be: inspection delays and work redone. Edison was the worst in the group in these categories. In our opinion, the Texas Study appears to have a great deal of validity insofar as it applies to Fermi 2. Evidence from other Staff reviews tends to confirm that rework and inspection delays had significant impact on the crew's completion of their assigned activities. Tool availability, crowded work areas (except in the drywell area), have not been a major problem, in our assessment. Results on material availability were somewhat surprising. We felt that it had impacted the progress significantly. There may be two possible explanations for this apparent discrepancy: (a) Perhaps the material unavailability is not noticed by the crew because the activity is not scheduled unless material is available on site. The crew is only concerned with short-term, smaller work activities. Material unavailability affects higher levels of schedule and the Master Schedule; (b) It is possible that material availability is a far greater problem at other nuclear jobs.

Finally, the study makes an important point. At a typical nuclear project, productive work occurs only about 30-35% of the time.

The Staff is pleased with Edison's participation in the University of Texas study.

Edison also instituted comprehensive work sampling studies, a foreman delay program, and equipment utilization measurements as a part of the Productivity Improvement programs. These will be discussed elsewhere.

Follow-up to D.O.E./University of Texas Study

The original report issued in May 1979 was extended to 12 projects.

The results of the revised study applicable to Fermi 2 were surprisingly consistent with work sampling studies. Craft interviews conducted in the D.O.E. study gave Edison high marks for some housekeeping activities, e.g.: clear work areas, lunchrooms with tables, well-maintained parking lots and snow removal.

The major problem areas which caused lost manhours as seen by craft at Fermi, in the order of importance, were:

1) Material availability
2) Re-doing work
3) Tool availability
4) Inspection delays
5) Overcrowded work areas
6) Foreman incompetence (very high in pipefitters)
7) Craft turnover
8) Craft absenteeism

As a follow-up to this review, Edison instituted formation of a Labor-Management Committee. Such a committee would look into the root causes of problem areas which lead to non-productive work. Edison was particularly concerned about the incompetency of supervision in the piping area.

It is the Staff's opinion that supervision was an inherent weakness of the W & B contractor. As stated elsewhere, one reason was their lack of experience in handling such a large job. The other was the fact that W & B tended to hire local foremen and supervisors with whom W & B had not worked before.

The problem of poor supervision in W & B came to a head when allegations were made on the "20/20" program that resumes of contract workers at the Fermi site had been falsified; that these workers were not qualified for lead jobs that they were assigned. The Edison investigation of May 1980 audited on-site job shoppers: Butler Services Group, Quantum Technology and Flour Pioneer. All were personnel suppliers to W & B. A total of 139 resumes were reviewed. Their findings:

1. Quantum-Tech

   a) Thirty of the fifty-six resumes did not meet contractual experience requirements. Seven of these had submitted accurate resumes, but were still accepted.

   b) Twenty-five resumes were falsified by Quantum-Tech. Eight were falsified by the employees.

   c) Estimated overbilling to Edison due to over-classification was $144,000 plus $23,000 in W & B mark up. (This does not include rework/redesign due to poor quality or defective work.)

2. Flour-Pioneer

   a) Six of thirty-seven resumes did not meet the minimum job qualifications.

   b) Sixteen resumes were falsified by Flour, five by the employees.

3. Butler Services Group

No major discrepancies were found. Butler submitted resumes to Edison for review but received no response. Butler later learned that the employee was hired through Quantum-Tech.

Edison cancelled the Quantum-Tech contract. Later, it found that a sister company of Quantum-Tech, C.E.S., was still supplying manpower at Fermi.

The investigation recommended to: sever relations with Flour-Pioneer and Quantum-Tech, but keep Butler. A major concern of the audit team was that many of these contract employees were placed in work leader and supervision positions at W & B. It also suggested the possibility of inside involvement in the placement of unqualified employees.

6. Edison Internal Audit

In 1978-1979, Edison's Internal Audit Department performed a number of project reviews in selected areas. These were apart from their normal project financial/contract audit functions. These reviews included:

- Investigation of excessive hangar and piping rejection rates.

- Problems of QA/QC in electrical installation.

- Evaluation of warehouse functions.

- Investigation of allegations made on "20/20" and the Bills Bond's program regarding: illegal hiring practicies (discussed above), doctoring of DDR documents, and inadequate verification of piping material to satisfy QC standards. The NRC also investigated some of these allegations and found them baseless.

- Serious deficiencies in QA/QC document control functions.

Generally, the audit investigations were useful in bringing to the Senior Management attention specific areas of concern. Audit groups had direct access to top management and operated independently of the project organization. As is understandable, PMO did not always concur with the audit group findings. Talking to concerned people revealed some tension between the two groups. There is, however, a full-time audit staff at the site.

7. INPO Assistance Audit

In 1982-1983, INPO, the newly-formed industry group, performed an assistance audit of operating practices at the EF2 site. Their findings were somewhat shocking to Edison. INPO noted serious defects in the operator training program, major weaknesses in radiation protection areas, inadequate staffing and sloppy procedures in Rad-Chem and testing labs; and inadequate, incorrect labeling of lab reagents, etc. INPO cited instances of very sloppy and inefficient testing, which they observed in person.

Edison took vigorous action to revamp and strengthen their operator training program. INPO noted that operators were failing open-book tests after several weeks of classroom instructions. The reinforced training program was quite successful. In June 1983, 22 out of 23 trainees passed the NRC operator's examination. Moreover, the successful candidates had performed with very high ranking. A second group also performed quite well.

INPO conducted follow-up assistance visits to EF2 in September through October 1983.

The Staff believes that the INPO review was helpful to Edison in drawing attention to serious inadequacies in the operator training program and other housekeeping activities. Timely action by DE has prevented a potential licensing issue.

Since TMI, the NRC has been very sensitive to operator training, competency, and experience at all nuclear plants. Just recently, the NRC questioned a Shoreham Plant Superintendent's qualifications because he did not possess actual BWR operating experience. There is an industry scramble for qualified operators. Utilities are resorting to piracy with attractive offers. Operator training is quite expensive. Edison spends about $250,000 per operator to train and qualify him.

It should be noted here that it is Edison's policy not to pirate qualified operators from other plants. Unfortunately, not all utilities have this policy. Edison runs the risk of losing licensed operators and other nuclear experts after they have been trained at great cost.

An earlier INPO inspection at Fermi had pointed out serious lack of craft productivity. The project must get a handle on productivity immediately (Proj. meeting notes, 10/21/82).

8. <u>Cygna Independent Design Verification</u>

Design safety concerns at Diablo Canyon in 1982 prompted Edison to conduct an independent design verification of selected safety systems at Fermi. The consulting firm, Cygna Corp., was hired to perform IDV. It was a technical review of the "as-built" conditions. A vertical and sectional cut of the selected systems is analyzed. The review was performed between December 1982 and April 1983.

The scope of the review focused on detailed analysis of two cooling flow loops involving portions of RHR and emergency core cooling systems. There were 95 design observations made and compared to an established set of criteria.

As a result, 10 Potential Findings Reports (PFR) were filed for deviations from Cygna criteria. Upon further review and satisfactory response from the Edison design group, all deviations were cleared showing no Definite Finding Report (DFR) of anything that would affect plant safety. Of these ten deviations, six were cleared by Cygna as a result of "Management Directive" for improved procedures in the future.

D. Productivity Improvement Programs

The Staff team investigated the Productivity Improvement programs "in place" at Fermi. The purpose was to evaluate the types and extent of Edison efforts at improving craft utilization for productive work. As has been mentioned, worker productivity is a serious issue at complex nuclear projects. A 30-35% work productivity is treated as satisfactory on a typical project. Factors affecting productivity are many, such as work environment, crowded work areas, interferences, worker motivational factors, rework, work incentives (both monetary and psychological), scheduling, materials and tool availability, supervision, and scores of other factors.

The objective of the Staff review was two-fold:

(a) To determine if the project had methods and procedures in place to measure worker productivity. Further, whether the methods could identify specific causes of delays, lost work, and hold points;

(b) Did the Project Management take corrective measures to eliminate restraints, improve procedures, and increase productivity?

At the outset, it must be said that the Project Management expressed constant concern for improving worker productivity. The project correspondence, PMO notes, and memos are full of expressions of such concern. Discussion with project people indicates to us that real concern was shown not so much through written correspondence, but rather through countless verbal communications between PMO, Daniel, and contractors -- almost on a daily basis.

Here we discuss some of the specific programs implemented and their effectiveness at the Fermi site:

1. Rework, Waste Identifiction and Lost Time

   The Labor Cost Status Reports (LCSR) yield weekly computerized printouts of each contractor's actual manhours. Theoretically, the work is classified into codes by the contractors as:

   C= Construction
   E= Engineering (change to engg. errors)
   V= Vendor (rework caused by vendor or another contractor)
   S- Suspense (rework not yet classified)
   R= Rework (caused by subject contractor)

   These codes are entered by the contractor performing the work. No serious effort is made by Edison or Daniel to verify the correctness of distribution. In some cases, such as L.K. Comstock, their rework codes were closely verified in the early phase because their incentive bonus was based on "target manhours". These were to be adjusted for rework caused by others. Serious disputes developed between Daniel and Comstock on this issue.

   In June 1980, the LKC contract was changed to a cost-reimbursible. Since then, Edison or Daniel verification has stopped, even though LKC still provides this distribution.

   The Project Management admitted that rework codes for most contractors are suspect. Edison uses these codes for estimating purposes only. Occasionally, LCSR reports are used for verbal interaction between construction area managers and the contractors. In general, the LCSR was not used as an effective tool for productivity measurement.

2. <u>Work Sampling and Foreman Delay Program</u>

Prior to 1979, Fermi did not have a meaningful formal PIP program. The 1978 project review by the Generation Engineering Department and the Texas study seem to have brought their attention to such a program.

In November 1978, Edison established a company-wide work sampling program (DECO has earned nation-wide attention for their productivity measurement studies). The work sampling studies developed at Fermi 2 in 3 phases:

Phase I: January 1979 through November 1981

- Program Development
- Data Collection by Edison site inspectors

Phase II: November 1981 through September 1982

- Daniel performed foreman delay surveys
- A WSS for non-manual

Phase III: January 1983 to present

- Edison Audit Department took over the Daniel WSS; revised it into 7-element WSS; Edison dropped the non-manual study.

Based on review of documents, it is our opinion that a lot of planning, coordination, and orientation effort has been put into developing and implementing the WSS program by the Edison Internal Audit Group..

In the foreman delay surveys, a foreman is asked to fill out a form at the end of each shift. He identifies the causes of delay, such as waiting for instructions, travelling, inspection delays, interferences, etc. The results were tabluated and discussed with Edison, Daniel and contractors. Efforts were made to remove barriers. Daniel served as interface for "barrier removal". Information gained in the RHR building was used in other areas if identified as a generic problem, e.g., scaffolding stored near usage areas, and change of warehousing methods.

The results of the foreman delay surveys in RHR showed that the major causes of delays were:

- Waiting for scaffoldings (1.8%: 1st survey 11/9-11/13/81)
- Waiting for QC inspection (1.9%)
- T & B warehouse delays (1.9%)
- Waiting for T & B field engg. (1.0%)

The delays were an average of 8 to 10% of the time. The FDS program became a problem because foremen were hesitant to fill out daily sheets. Work sampling studies are performed by an actual walk down by Industrial Engineering (I.E.) personnel, and observing the individual workers. Separate hat colors and tags are required for craft identification. Seven WSS elements of first survey and their results are:

	Results
- Working	63.5%
- Waiting	8.8
- Idle	2.9
- Receiving instructions	3.2
- Travelling	10.9
- Non-productive	.2
- Personal	4.4
- Unobserved	5.6

The WSS results were compatible with the foreman delay surveys. At one point, the annual cost of delays to the project was estimated (for all contractors) as:

Total travel	$10,473,750/yr.
Total misc. delay	11,291,250
Total personal activities	6,665,000
Total Cost	$28,430,000/yr.

This shows the enormous cost impact during the life of the project resulting from lack of productivity control.

The WSS/FDS results were regularly discussed by Daniel and Edison and formed a basis of discussions with contractors. Overall, the program was beneficial and useful. Some obvious advantages of the program:

- The fact that they were being observed improved worker awareness and improved performance.

- The recycle WSS studies showed some improvement.

- To remove fear of WSS, Daniel/Edison conducted climate surveys. Individuals were interviewed to get their concerns. Some of them were:

1. Job layout
2. Safety
3. Job conditions
4. Tools & equipment
5. Supervision
6. Job security
7. Rework
8. Policies and procedures
9. Discipline

- Edison WSS was used as a basis for dispute settlements. For instance, the fire protection system contractor, Phoenix, filed a claim for $725,000 citing delays and lack of support activities specific to the Fermi 2 site. Using their WSS results, Edison was able to prove that Phoenix was able to perform at better than industry average (32%), although less than Fermi 2 average (41%). (Unofficially, we were told that Phoenix had a good case. They were just not able to document it and were buffaloed by DE.)

Overall, WSS/FDS have been moderately successful as PIP programs. WSS is a relatively new industry technique for measuring productive work. A WSS does not tell us how effectively the work is being performed, but merely whether the worker is busy or not. We should point out that Edison's effort at WSS or a comparable program was implemented late in the project when much of the bulk quantities had been installed. However, Edison put considerable and serious effort into their PIP program. Our investigative staff joined in one of the WSS surveys and observed the program firsthand.

3. <u>Overtime</u>

The Staff examined the overtime approval procedure by year and by contractor.

The overall craft overtime at Fermi has been 6.58% of all manual hours. Prior to 1981, overtime work was less than 4%. It increased considerably in 1981 (8.62%) and 1982 (14.93%). As the project nears completion, more overtime is expected.

The Staff concludes that EF2 overtime was one of the lowest compared to other typical jobs; 10% is normal.

Overtime approval process was very tightly controlled. It must be pre-approved by Daniel and later by the Edison Project Manager. OT requests must be submitted by Friday of the previous week.

Some contractor employees were unhappy about insufficient overtime at Fermi. Some non-manual, e.g., DE design engineering, did not particularly favor OT work.

4. Theft, Vandalism, Lost Tools

We reviewed Incident Reports of Fermi 2 plant security. In our judgement, there were few recorded instances of theft/vandalism. These had minimal impact on the project. Some of the typical incidents were:

- quite a bit of small tool theft, mostly crew vs. crew, or shift vs. shift
- parking lot damage, slashed tires
- once a nearby resident was found target-practicing in the direction of DE security.

Incidents of sabotage and mischief:

1983: - Two incidents involving damage to telephone wires, probably in protest to PMO decision to install craft phones outside brass alleys to cut down personal time. The decision was reversed.

- Some wooden blocks and scrap steel pieces found inside pipes long after they had been hydro tested.

- There was a bomb threat in March 1983. Later declared a hoax.

1982: - Destruction to piping by grinding wheel. Force used and not accidental. Probably set back construction one week. We discussed this incident with a W & B foreman. A worker upset over a late paycheck.

- A laid-off employee erased a portion of computer tape. Probable cost to restore: $3,000

1981: - Small amount of piping damaged.

- Intercom system damaged.

All in all, the acts of theft, vandalism, and sabotage were considerably less than what is expected on a normal job site of this size. No further investigation was warranted.

5. Ratio of Manual to Non-Manual

Frequent comments were found in PMO notes, project correspondence, and third-party reviews that Fermi 2 had an excessive number of non-manual personnel in relation to craft and compared to other similar jobs.

The Staff analyzed manpower levels for all areas by shift for the period of 1978-82. These are summarized in the attached tables.

The Staff is of the opinion that Fermi 2 indeed had excessive non-manual in relation to manual. In the earlier years, the typical ratio was .4 to .5; but after 1981, it was 1.0 to 1.3 (these include all in-house and out-of-house manpower levels). Our discussions with knowledgeable people suggest that these ratios are too high. We are unable, however, to make a detailed quantitative comparison with other jobs. No reliable data is available. At our request, Daniel provided their computation of manual/non-manual ratios. They are shown here (Request #142).

In our judgement, such a characteristic is inherent in the organization of the Fermi 2 project, for the following reasons:

1. Although Daniel was the Construction Manager, Edison had significant day-to-day involvement in the project. There was an influx of Edison people in 1981 (so much so, that congestions in the cafeteria were discussed to be a problem--see PMO notes 1981). One probable reason is that Edison had many regular employees freed from other jobs: EF3, GW1, GW2 and GW3. They were absorbed at EF2. In 1978, with only about 70 DE people at the site, the C.E. Co. reviewers commented "With so many DE people, why do you need Daniel?". In 1982, there were 550 DE people.

2. The multiple contractor approach created duplicate administrative and support functions and multiple layers of supervision.

3. The same was true in the design/engineering function. There were too many specialty A/Es, their contacts.

4. Budget cutbacks and freezes generally affected direct construction activities, resulting in further deterioration of non-manual/manual ratio.

5. Edison emphasis on QA/QC and safety also impacted non-manual manpower levels.

Manpower reports also suggest that Edison made insufficient use of second and third shift during much of the project. It is true that non-manual activities, e.g., QC inspections, and field engineering are less easily available in the night shifts. At the same time, optimal manloading and craft levelization can be better achieved by proper use of three shifts. Many activities, e.g., maintenance, and electrical installation yield better productivity during the nighttime. Congestion and work interferences can be reduced by judicious use of second and third shifts.

In our judgement, all these factors negatively impacted the Fermi 2 project cost and schedule.

FERMI 2

Work Force Summary

6-1-78 - 6-1-83

	6-1-78 Thursday	12-1-78 Friday	6-1-79 Friday	12-3-79 Monday	6-2-80 Monday	12-1-80 Monday	6-2-81 Tuesday	12-1-81 Tuesday	6-1-82 Tuesday	12-1-82 Wednesday	6-1-83 Wednesday
MANUAL (by Contractor)											
1st Shift	1893	1645	1293	1342	1131	1102	1224	1466	1420[1]	2219	1704
2nd Shift	272	212	150	3	-0-		82	187	120	465	454
3rd Shift			2	3	-0-		4			27	19
MANUAL	2165	1857	1445	1348	1131	1102	1310	1653	1540	2711	2177
NON-MANUAL (by Contractor)											
1st Shift	872	962	907	890	919	945	1048	1344	2204[1]	2889	2926
2nd Shift	38	47	37	11	9	7	22	50	23	71	61
3rd Shift	7	16	7	17	17	12	21	18	9	14	9
NON-MANUAL	917	1025	1059	918	945	964	1091	1412	2236	2974	2896
TOTAL	3082	2882	2504	2266	2076	2066	2401	3065	3776	5685	5073
RATIO Non-Manual/Manual	.42	.55	.73	.68	.84	.87	.83	.85	1.45	1.09	1.33

[1]Bechtel count added

FERMI 2 MANPOWER COUNT

(UNofficial Report)(Prepared by Site Fin. Adm. for the Ast. controller in Detroit)

	10-29-82	11-30-82	12-30-82	1-31-83	2-28-83	3-31-83	4-29-83	5-31-83	6-30-83	7-31-83
Site gate log total	5379	5610	5744	6177	6177	5895	5688	5130	4769	4495
Engineering Manpower Reports	618	634	675	760	769	769	752	834	876	789
Total People	5997	6244	6419	6937	6946	6664	6440	5964	5645	5284
Contract Manual Labor										
Bechtel	793	852	862	911	887	933	1006	901	917	939
Daniel	24	24	25	24	24	22	21	17	16	13
Sub Contractor	1763	1835	1865	2077	2027	1743	1495	1216	1037	866
Total Contractor MANUAL	2580	2711	2752	3012	2938	2698	2522	2134	1970	1818
Contractor Non Manual Labor										
Bechtel	243	249	257	280	302	299	303	307	308	314
Daniel	368	359	353	365	345	338	332	308	295	272
Sub Contractor	474	516	511	558	653	638	553	454	368	300
Total Contractor NON MANUAL	1085	1124	1121	1203	1300	1275	1188	1069	971	886
Contract Non Manual Support Includes: Manpower, Giffels, Global, Benchmark, etc.	753	800	891	929	875	893	944	770	715	826
EDISON NON MANUAL										
NueOps NueOps Staff	424	424	424	425	450	450	456	456	460	468
Other Depts. Reporting to NueOps	167	167	168	169	152	142	141	144	136	117
DECo Security	50	38	40	48	41	31	41	68	70	75
Wackenhut Security	in line 16 -	-	-	-	-	-	-	166	170	173
Total EDISON NON MANUAL	641	629	632	642	643	623	638	834	836	833
Construction Assigned to Site Casual Visitors deleted for our purposes	147	147	114	195	198	200	204	207	203	132
ENGINEERING										
DECo Troy	86	103	102	135	129	129	120	145	131	142
Contract Troy	50	61	60	80	72	72	81	98	109	101
DECo Site	24	23	27	25	25	25	37	43	42	43
Contract Site	123	122	126	130	130	130	148	191	228	183
Contract Out of House	335	325	360	390	413	413	366	357	366	320
Total Engineering	618	634	675	760	769	769	752	834	876	789
TOTAL (excluding casual visitors)	5824	6045	6185	6741	6723	6458	6248	5848	5571	5284

NUCLEAR POWER PLANTS

MANPOWER COMPARISON *

(At Other Daniel Projects)

DATE	PROJECT	PERCENT PROJECT COMPLETE	NON-MANUAL SALARIED OVERHEAD HOURLY OVER LEVEL	MANUAL	TOTAL MEN	NON-MANUAL SCOPE
12/31/77	Farley I	80	N/A	150	150	1 2 3 4 5 7 8
7/80	Farley II	80	505	1110	1615	1 2 3 4 5 7 8
11/78	V.C. Summer	80	850	1870	2720	1 2 3 4A 7 8
7/29/82	Wolf Creek	80	1034	1793	2907	1 2 3 4 5 7 8
11/82	Callaway	80	1340	2128	3468	1 2 3 4 5 7 8
4/20/83	Shearon Harris	78	420	2462	2882	1 3 6 8

*Client and subcontractor personnel not included.
Data supplied by Daniel International

Non-Manual Scopes of Work

1. Construction
2. Engineering
3. Services
4. Quality Control
4A. Quality (Partial Staff)
5. Quality Assurance
6. Control Partial Staff
7. Controls Full Staff
8. Other

E. Overall Assessment of Construction Management

Worker motivation and productivity were a serious problem at Fermi 2. Edison claims they were able to achieve 35-40% productivity. We believe that effective utilization rate averaged 20-25%. Many factors were responsible for this. Some were outside Edison control, others were inherent in the project structure. We review some of the factors here.

- General economic conditions and unemployment in this region were disincentives for contractors to complete work on schedule.

- Excessive design changes, whether regulatory related or otherwise, demoralized craft. Work done one day was scrapped the following day. Design changes or new work will be issued suddenly without coordinating with construction at the craft foreman level.

- Piping and hangar design and installation were the most inefficient. They seriously impacted other schedules. Typically, the engineered material (valves, pumps, and motors) delivery is matched with the piping installation schedule. No such coordination was possible at Fermi 2.

- Workers/Foremen often commented that management gave preferential treatment to Edison employees. Some commented that Fermi 2 was primarily for the benefit of Edison employees, and that work environment discriminated against non-Edison people. The "General President's Project Maintenance Agreement" favored management too much; that there was effectively no union at Fermi. Workers also resented inadequate parking and lunch facilities, etc. These factors had a demoralizing effect.

Regrettably, the Staff shares this feeling. Edison employees enjoyed liberal fringe benefits and facilities, which besides costly, demotivated non-Edison employees. For example, Edison provided a subsidized cafeteria service to its employees. A cup of coffee in this cafeteria was 25¢; a few yards away at a "Daniel gut bucket", it was 35¢. Obviously, workers resented this. In spite of this frustration, the craft performance and labor relations were generally very good. One reason is the state of the economy, especially after the restart of the project.

- Management of procurement and parts inventory management has been poor. Edison maintained insufficient levels of small parts inventory.

On the positive side, we believe that:

- Quality of construction appears to be good, based on many independent reviews.

- Craft performance, despite adverse conditions, has been quite good.

- Construction managers (Edison and Daniel) made the best effort to spur productivity and uplift worker morale.

- Record of worker safety has been very good. The Staff reviewed citations, fines, and penalty reports. There have been scores of citations from MIOSHA for unsafe work conditions--but none too serious to result in work shutdown. The fines have been levied for about $4,000 over the years. In response to Staff request for a list of fines, citations, etc., Edison responded that there were absolutely no citations or penalties. Staff, however, followed up on this because it had seen a number of citations posted on the bulletin board. Upon follow-up, DE responded with over 50 cases of fines, citations, etc.

- In relation to other major activities (engineering, start-up, and procurement), construction has better performance both in cost and schedule.

The Staff offers the following observations which, in our judgement, could have improved construction performance. One may dismiss these as "hindsight", but we believe they are a logical response to the then prevailing conditions:

1. More centralized control of planning and scheduling function by Edison from the start of the project. For the most part, planning/scheduling was fragmented; each group preparing its own. By taking direct responsibility for this function, Edison would have greatly increased their control over both construction and engineering activities as far as scheduling. Typically, on a large project, the construction schedule is used to exert pressure on the design group. As the project moves from bulk construction to system mode, the start-up takes the lead position. It sets the schedule for engineering and construction organizations. Only very recently, start-up has begun to assert their role. In the final stage, Nuclear Operation ought to drive the project. No evidence of this was found at Fermi.

2. The Project Manager should have been changed at Fermi sometime in 1981. This does not in any way reflect on the competency of the present Project Manager, Mr. Fahrner. Indeed, throughout we heard extremely good comments about Mr. Fahrner's competency, aggressiveness and human understanding of the project. He was placed in a difficult role and he performed remarkably well. However, in our opinion, the project had reached a different phase in 1981 where construction's role was to be de-emphasized. The project needed a different orientation. Site personnel felt that the project was stagnant. They needed renewed motivation and a "new face". In fact, the Staff feels that new managers in engineering and procurement organization would also have helped bring new momentum.

3. In the later stages of the project (1980 forward), some form of a direct incentive program should have been implemented. Edison attempted a few incentive bonus programs, but these were largely directed at the contractors--such as "targeted hours". What is needed is an incentive program targeted at craft, SCO, and start-up personnel--both Edison and non-Edison. Any reasonable and properly structured incentive program would be cost-effective. The incentives could be in the form of cash bonus and/or guaranteed job for a certain length of time. The simple arithmetic shows that one month's advance in F/L is equivalent to annual wage bill of approximately 1000 employees. The benefits of schedule compression are enormous. (In 1983, Mr. Holland hinted at some form of incentive program, but it went nowhere--Staff Request 178.)

4. Edison Corporate Policy on fringe benefits had built-in disincentives.

Edison employees at the Fermi 2 site were assigned "temporary" status. A "temporary" can opt to receive a per diem allowance for staying near the project, or receive a commutation allowance for time and mileage. The latter is computed as straight mileage (roughly $.20/mile) plus 1.5 minutes per mile. The mileage is based on the difference in distances between the employee's residence to Fermi and from his residence to his normal place of work (Troy or downtown). A typical Edison employee living in the northern suburbs may commute 80 miles to work at Fermi and receive about $60 per day commuting allowance. Employees have worked several years under this "temporary" status. Many of them chose to commute rather than relocate. The current "temporary" allowance expense is over $1.5 million per year.

Besides being costly, this benefit policy is a disincentive for two reasons: 1) this rather generous provision may encourage some employees to stretch out their work, and 2) productivity may suffer when an employee reaches work after hours of driving in poor traffic and weather conditions. We hasten to add that we have no direct evidence of this attitude. Many employees expressed frustration after years at Fermi and appeared anxious to return to normal duty.

Edison had difficulty in permanently locating its employees in the Fermi area. This was confirmed by a survey performed by MAC in August 1982.

In our judgement, relocation of Edison personnel during the long duration of the Fermi project would have been more cost-effective.

F. Financial Management and Controls

Project financial administration is one of the most important functions in a large construction project. Responsibility for expenditures of millions of dollars is vested in the hands of individuals who make strategic and day-to-day decisions. The financial administration covers a variety of functions, such as:

- Project accounting
- Budgeting and forecasting
- Authorizing work change requests, contract change orders
- Project financial reporting
- Project auditing

The Fermi 2 project Procedures Manual describes these activities, procedures, authority levels, auditing responsibilities, etc.

The Staff audit team reviewed these functions to evaluate the overall financial administration, control, and management of the project.

The nature and complexity of the project makes it prohibitive to review each and every aspect of the financial administration. Further, it would be impossible to perform an in-depth audit of the entire project cost over the long history of Fermi 2.

The General Audit group of Edison has the responsibility for financial audits at Fermi 2. We reviewed the performance of the Fermi Internal Audit program. Independently, we also reviewed the accounts payable, CARS, general overheads and AFUDC systems. Our findings are discussed here.

1. Internal Audits

Question 1

Background of Internal Audit Organization, scope, authority, and procedures as they apply to Fermi. Include staff levels and backgrounds, independence from the Project Management Organization, and ability to convey and discuss issues with Senior Management.

Answer

The Internal Audit Department at the Detroit Edison Company has been in existence since the early 1950's. Before that time, all internal auditing was conducted by the Audit Division of the General Accounting Department. Detroit Edison has had internal auditors on the Enrico Fermi Project since about 1968, the beginning of the project.

The goals of the Internal Auditing Department are purposely not clear cut, but maintain a conceptual flexibility that enables the Department to perform a range of services for the company. The Internal Auditing Department performs advisory functions for the Board Chairman and Corporate President; they also assist in decision making and contract letting for the Company, as well as performing the more traditional financial audit of the Company's operations.

The Internal Auditing Department derives its authority directly from the Chairman of the Board. The General Auditor, as a corporate officer, reports directly to the Chairman, bypassing the normal chain of authority. Regular meetings with the Chairman are held once a month to discuss the operation of the Internal Auditing Department. The General Auditor also meets monthly with the Audit Committee of the Board of Directors, without other corporate officers present, and regularly with Price-Waterhouse, the Company's independent accountants. Support from the Chairman and the Audit Committee and the unique corporate reporting arrangements lends a high degree of independence from other corporate influences.

The on-site audit staff is composed of the principal auditor, Bernard Bugnaski; a work leader, Jenny Wilson; and two site auditors, Dave Greer and Larry Wignicki. More auditors are available when necessary. The grade levels of the staff are officially comparable to other degreed employees with comparable experience. Some of the audit staff do feel that the grade levels are not as high as they should be for the work performed.

Mr. Bugnaski has a B.S. in Business. He had been employed by the Detroit Edison Company for approximately 38 years, 17 of which have been with Internal Auditing, 15 of those in construction auditing.

Ms. Wilson has been at the Fermi site for 10 years. Originally employed on site by Townsend and Bottums for approximately 4 years.

Dave Greer is a contract employee, hired for Edison through Daniel. He has a BBA degree in accounting and has been at the site for three years. He was previously employed as an internal auditor for the Chyrsler Corporation.

Larry Wignicki was a contract employee, hired for Edison through Daniel. He has been directly employed by Edison for one year. Mr. Wignicki has an M.S. degree in accounting.

Clark Wootin has a B.S. degree in business. He has worked for Detroit Edison for 35 years, most of which have been in inventory auditing. He is supposed to be joining the staff shortly.

The Internal Auditing Department has proposed hiring three more people for a temporary one-year assignment.

Financial audit procedures of internal auditing can be classified into three catagories: preliminary, field work, and reporting. These procedures appear to be professionally sound. These procedures remain essentially the same regardless of the type of audit conducted. Preliminary procedures involve a review of all apparent information in existence at Detroit Edison and Daniel relating to the vendor. This would include the contract, correspondence, prior audits, Articles of Incorporation, Dunn and Bradstreet report, and/or other pertinent information.

Field work procedures are the investigative sampling techniques used to formulate an opinion. This phase would include random sampling of invoices, calculation of labor and overhead rates, and any other audit tests considered necessary by the auditor.

Reporting procedures involve assembling the auditors' results and recommendations into a transmittal memo to L.W. Coombe, Assistant General Auditor, and an audit-finding memo from Mr. Coombe to W.J. Fahrner, Project Manager.

Internal auditing assignments can initiate from the Chairman of the Board, from the Internal Auditing Department through the General Auditor, or the site auditor.

Each year, the site auditor, Bernie Bugnaski; the General Auditor, Arnold Benes; and the Assistant General Auditor, Lloyd Coombe; meet to discuss the audit strategy for Fermi 2 for the year. A list of proposed audits is assembled. The list is reviewed by the Audit Committee of the Board of Directors and Price-Waterhouse for their input. The audits are prioritized on a need-to-resolve issue and have unlimited scope and authority within the confines of the vendor's contract.

The prioritizing system is based on a need-to-know or a need-to-resolve a problem. Currently at the Fermi 2 site, close-out audits have priority since there is a need to know what the final amount due to the vendors is before they leave the construction site. The Bill Bonds and "20/20" allegations were a priority because of a need to resolve an issue which was receiving substantial publicity.

The scope and confines of an audit are dictated by the terms of the contract. A fixed-price contract would not be subject to audit, while a cost-plus contract would be subject to audit, since the dollar amount of the contract is not controllable and subject to abuse.

Question 2

Indicate the nature of Internal Audits, how intensive or extensive; whether areas covered include contract administration, contractor performance, close-out audits, etc.

Answer

There are three types of internal audits. They are contract-compliance audits, follow-up audits, and close-out audits. The majority of the site audits are contract-compliance audits. Very few follow-up audits have been performed. There is, though, an on-going review of Daniel pertaining to their involvement in a particular vendor contract when the vendor is being audited. Only about eight close-out audits have been completed.

The close-out audits are:

Vendor Name	Contract Number
Phoenix	1A-84884
Reactor Controls Incorporated (RCI)	1A-84054 & 1A-84803
Comstock	1C-70112
Teledyne (subcontractor of RCI)	1A-84803

Vendor Name	Contract Number
Metalweld	1A-84811
Nisco (Nuclear Installation Services Company)	1A-75712
Aycock-Power Process Piping	1A-84501
Townsend and Bottums	1A-84599

Close-out audits will become more frequent as the project nears its completion.

Compliance audits check for compliance to contract terms and include both contract performance and contract administration. Contracts are administered through Daniel on all construction contracts or through DE on engineering contracts, Bechtel contracts, and administrative contracts. Areas covered in a compliance audit always include an examination of the invoiced amounts-materials, labor, and overheads, and can include an examination of subcontractors, employee qualifications, security, brassing in, field checks, or any function that Internal Auditing believes needs to be scrutinized.

Follow-up audits are conducted to determine whether prior audit recommendations have been implemented. According to Internal Auditing, approximately 13 follow-up audits have been conducted out of approximately 140 audits listed in the Audit Report Index for 1977 through 1982 (keep in mind that some of the 140 audits may not require a follow-up audit).

The follow-up audits conducted are:

1. Daniel non-manual hours
2. Robert Irsay
3. Wismer & Becker

4. Daniel site labor billings
5. GE-NSSS
6. GE-NSSS
7. Monroe Plumbing and Heating
8. NUS Corporation
9. Reactor Controls
10. Townsend and Bottums
11. Walbridge, Aldinger Company
12. Phoenix Contractors, Inc.
13. Home office of Phoenix Contractors, Inc.

Before 1980, Internal Auditing made very little attempt to institute their audit recommendations. A memo was sent to PMO concerning the Internal Audit recommendations. No attempt was made by Internal Auditing to insure that their recommendations were implemented until the next audit of the vendor was conducted. If the next audit was a close-out audit, no follow-up was done. In 1980, Internal Auditing became more active in implementing their audit recommendations. The procedures developed were:

1. Internal audit submits audit recommendations to PMO.
2. PMO is required to respond to Internal Audit (oral or written).
3. Discussions are held to implement the appropriate procedures.
4. If problems develop between Internal Auditing and the PMO, the General Auditor discusses the problem with the Chairman.

The rationale for not conducting a follow-up audit appears to be that time and manpower constraints prohibit it, and a close-out audit will be conducted at a future time that will settle all problems that have occurred.

This explanation is marginal, since we do not know that close-out audits will be conducted on all vendors. With the limited staff available in the Internal Audit Department, the possibility exists that some vendors might fall through the crack.

At times, PMO and Internal Auditing do not agree. Internal Auditing, therefore, has to convince the PMO that the recommendations are important. As of June 1983, this situation exists for three of the vendors audited. They are:

1. NUS Corporation
2. Bechtel Tool Procurement & Control
3. GE-NSSS

When this problem occurs the Company Chairman is informed. This normally occurs in the course of the monthly meetings conducted between Internal Auditing and the Chairman. It appears to be done diplomatically so as not to damage working relations, and is intended to keep the Chairman informed.

Close-out audits determine the final dollar amount due on the contract and resolve all financial issues between the Company and the vendor. Only one close-out audit was examined. The vendor was Aycock, Inc. This audit was very extensive because the initial audit sampling indicated many errors in the billings to Edison. The Internal Audit Staff had to compute all rates and all invoices for the entire contract period, approximately 21/2 years.

No follow-up audits were examined. Several compliance audits were examined. The extent of each of these audits depended on the findings in the initial sampling, prior known facts, and/or purpose of the audit. The audit can cover any subject from a specialized topic (such as telephone usage, Edison tools, or brassing) to an extensive evaluation of the plant security system--involving a midnight walkthrough of the plant, to an extensive vendor close-out audit where the auditor has to determine whether the contractual obligations of the contract have been complied with.

Question 3

Discuss specific findings by auditors, whether in formal reports or in back-up and informal material, which raises issues of inefficient contract management, overpayments, settlements, etc. Please be specific and critical and list issues.

Answer

A random sample of the internal audits conducted from 1977 to 1982 were taken, based on a review of all the internal audits conducted during that time. The internal audits selected for review were:

Vendor Name	Contract Numbers	Type	Approximate $ Committed
Power Process Piping (PPP)	1A-84501	Mechanical	10,832,200
L.K. Comstock	1C-70112	Electrical	
Townsend and Bottums	1A-845-9	Piping/Mech.	15,950,000
Aycock, Inc.	1A-84501	Mechanical	10,332,200
Utley James	1A-94984	Civil	9,279,000
Wismer and Becker	1A-84001	Piping	186,293,000
Security EF2	None	-	-
Pipe Whip Restraints	None	Mechanical	1,014,000
Daniel Site Labor	1A-85700	Cons.Mgmt.	82,008,000
Benchmark Technology	1A-84891	Engineering	966,000
A G & Associates	1A-84887	Engineering	1,623,000

The audit of Benchmark Technology specifically recommended the need for a contract administrator. (Each contract is supposed to have a contract administrator.) Several of the audit memos from 1977 to 1980 mentioned such a need. It is the opinion of Internal Auditing that Daniel does a poor job administrating the contracts under its jurisdiction based on the volume of errors found in procedures and dollar amounts when auditing vendors.

To verify this statement, the Staff reviewed the Internal Audit reports on a test basis and came to the same conclusion. To document this conclusion, the Staff selected 1982 as a test year and listed all the Internal Auditing recommendations and probable dollar impacts. From this, (copy attached) it is evident that the opinion of the Internal Auditing Staff is valid and that contract administration should have performed many of these tasks, yet failed to do so.

PMO would be made aware of Internal Auditing's position through the written audit reports from L. Coombe to W. Fahrner and/or oral discussions. PMO must respond to all written audit reports and work with Internal Auditing to resolve the issues. We understand that Internal Auditing usually wins. Internal Auditing indicated that the Company has had a Contract Administration Committee for about seven years that oversees all aspects of contract administration. Recently, financial responsibility has been emphasized. Many of the Internal Audit reports recommended refunds or credits to amounts due for a variety of reasons. A list of amounts recovered, based on vendor overcharges discovered during internal audit, is in Exhibit 1. One prevalent example of overcharges made by the vendors was in Workman's Compensation and Unemployment Insurance. The vendors paying Workman's Compensation insurance premiums would frequently receive discounts or rebates from the insurance carrier. These discounts were based on a good safety record on site, or based on a good financial year for the carrier. The vendors did not pass these discounts on to Detroit Edison. It is estimated that the credit due Edison as of December 1981 is approximately $1 million for the Wismer and Becker contract alone.

Since Internal Auditing is now aware of this situation, there is no need for any type of blanket disallowance. Few close-out audits have been completed. Edison will hopefully target this item on each vendor close-out audit, if applicable, and issue the appropriate adjustments.

The major items found in reviewing the Internal Auditing work-papers were:

1. Lack of adequate plant security before 1979. The total amount spent on plant security is $649,000 to 1979.

2. Resume hyping by Flour-Pioneer and Quantum-Tech.

3. Poor contract administration.

4. DE renting instead of purchasing equipment. (This issue was never resolved by the Company and is now a moot issue since the plant is scheduled for completion soon.)

5. Overbilling Workman's Compensation by vendors.

1979-1980 is a pivotal year for the Fermi Internal Audit group. Part of the reason for this could be due to the MAC report. Other reasons could be:

1. As the project became more complex, both in physical size and dollar size, it became more important to monitor progress.

2. The dollar benefits derived from Internal Auditing made the cost justifiable.

3. Management began to realize the importance of internal auditing. Before 1980, the plant had one internal auditor on site, no financial management organization on site, and a project controller that was there part-time. The Internal Auditing workpapers were of average to minimal quality. In 1980, Internal Audit hired three additional people; quality improved, a financial management organization was established on site, and internal auditing became a more important corporate tool. It is curious to note that Price-Waterhouse began reviewing the Internal Audit workpapers at about the same time (1980).

Question 4

Describe the follow-up procedures; management response, and implementation of the audit findings. Again, provide specific examples and issues which shall form the basis of your evaluation.

Answer

The Audit Department presents its recommendations in memo form to the PMO. Prior to 1980, Internal Auditing did nothing else and relied on the PMO to implement the audit findings. In 1980, the Internal Auditing Department role changed. After the recommendation memo was submitted, the PMO was required to reply. Internal Auditing and the PMO then settled on the appropriate way to implement the audit recommendations. If Internal Auditing is not satisfied, then the General Auditor discusses the issue with the Chairman at the monthly meeting and the problem is resolved.

The audit recommendations made by Internal Auditing then become part of the audit program for any future audit of that same vendor. If the audit recommendations are monetary, they are traced to the appropriate invoice when implemented. If the recommendations are procedural, no further verification is done until the next audit of the vendor. If the next audit is a close-out audit, no procedural verifiction is necessary, since the only objective in a close-out audit is to determine how much money is owed. The Wismer & Becker audit was selected in order to verify that dollar amount recommendations are implemented.

At times, the vendors and/or DE Management may not be convinced that the Internal Audit recommendations should be implemented. Internal Audit has to, therefore, convince all parties that their position is correct and in the best interests of the Company. All issues are resolved before final payments are made to the vendor. According to Internal Auditing, their success rate is very high: approximately 90%. A current example of such a situation is with Reactor Controls Inc. (RCI), where subcontractors are being billed to Edison at RCI rates when, in effect, they should be billed to Edison at substantially lower subcontract rates. RCI, Edison's Legal Department, and the PMO are currently resolving this issue.

Question 5

Describe your assessment of the Fermi management related to the areas covered by the audit reports. Indicate your review and plans for further verification and investigation of the audit reports.

Answer

The Staff assessment of the Auditing Staff, including Management, is that they are experienced and knowledgeable and have the desire to get the job done correctly. Since 1980, they appear to have authority and a voice within the company that is heard. Mr. Bugnaski indicated that the Fermi site auditors, in 1980, were able to recoup for the Company enough money to pay for the entire Auditing Department plus 100%.

There is a problem, however, with the Internal Auditing Department before 1980. Since 1974, the Company has had significant cost overruns at the Fermi project. Edison's audit function during this time consisted of one site auditor who was only able to handle "brush fires" as they occurred. In 1979-1980, the Auditing Department hired additional personnel to handle the workload, and Price-Waterhouse later started reviewing Internal Auditing workpapers. At about this same time, the MAC report was issued and the PMO was reorganized.

Consequently, 1979-1980 was a pivotal time for the Internal Auditing Department. Management must have finally realized the importance of internal auditing and the contribution it could make to cost control and monitoring. The question remaining is, where was Internal Auditing before 1979?

Question 6

Provide suggestions, and recommendations for further investigation by the team of specific areas, issues, contracts, decisions, etc.

Answer

Several areas exist for possible further examination. They are:

1. Why was Daniel such an inefficient contract administrator? If so, should the ratepayer pay for this?

2. Why was Internal Auditing not a vital part of the Fermi organization before 1980?

3. What brought about the tremendous interest in internal auditing in 1980--did something go wrong?

4. Since the only audit recommendations that merit follow-up by Internal Auditing are those involving dollar amounts, why make procedural recommendations?

DETROIT EDISON COMPANY

Amounts Recovered from Audited Vendors

1981

Report Date	Contractor	Contract No.	Total	Status
	ENRICO FERMI			
4/01/81	Wismer & Becker	1A-84002	$ 992,000	Credit Received
4/01/81	Stone & Webster Eng.	1A-84002	24,189	Credit Received
5/28/81	Sargent & Lundy	1C-80002	4,400	Forthcoming
		1C-70077		
7/27/81	Townsend & Bottum, Inc.	1A-84599	235	Credit Received
9/04/81	Daniel International Corp.	1A-85700		
	Worker's Compensation		Undetermined	Forthcoming
	Labor		1,733	Credit Received
9/09/81	National Studies Institute	1A-84806	13,163	Credit Received
11/02/81	Bechtel Power Corporation	1A-84600	6,093	Forthcoming
	TOTAL		$1,041,813	

EXHIBIT 1

Summary

1. The Internal Auditing Group is a strong, dedicated team at Detroit Edison.

2. Although late in starting, the group has done a valuable job, not only in conventional internal auditing, but in many other special assignments. Some of them:

   - Investigation of piping design problems.

   - Investigation of electrical construction practices.

   - Special investigations of allegations of hiring practices, inspection deficiencies and document tampering, document control, etc.

   - An extensive involvement in the development and implementation of Work Sampling and Productivity Improvement programs.

The Staff investigation team was concerned about the incidents of criminal conduct, payolla, and other similar practices at the Fermi project. We believe that it is not within our scope to assume the role of a criminal investigation. Based on allegations, rumors, and some factual information, we discussed this issue in detail with the Internal Audit Department. Some specific instances were also discussed. We are convinced that the audit group is well aware of the problem and has taken adequate action.

The Internal Audit Department has enjoyed good support of the Senior Management and has been called upon to investigate many special issues.

We feel, however, that the group was insufficiently staffed considering the size, complexity, and potential for abuse at Fermi 2. At any rate, the Staff was very pleased with the audit programs at Fermi 2.

More recently, the Internal Audit group has undertaken a major task to ensure that all open items resulting from various reviews have been satisfactorily closed out. Many of these could affect licensing, e.g., document control. The CYGNA review, mentioned elsewhere, expressed approval of adequate design control based on the promised close-out actions proposed by Internal Audit and promised by PMO.

2. Accounts Payable System

Background

The Detroit Edison Company has a Fermi 2 accounts payable function on site and at the General office. The objective of the site accounts payable function is to process the invoices for payment on time, and in accordance with contract terms. This would include verifying invoiced amounts, terms of payment, footing and extensions and assembling all appropriate approvals and routings. The General Office accounts payable function carries the responsibility through the general ledger reporting system.

Fermi 2 accounts payable have been handled by the General Contractor, Parsons (1968-1974), then by the Construction Manager, Daniel (1976-October 1982) and finally by Detroit Edison (1982-present). Each organization maintained A/P files on site.

Under the Parsons system, vendor bills were submitted by Parsons to Edison's General Office. Edison would then pay the vendors directly.

Under the Daniel system, Daniel would submit an invoice to the Edison General Office for payment, which would incorporate all the other vendor invoices chargeable to the project. Detroit Edison, after review, would pay Daniel, and Daniel would then pay the other contractors.

In October 1982, Detroit Edison assumed responsibility for the Fermi 2 on-site accounts payable function. All vendors, including Daniel, now submitted invoices to the Edison site accounts payable. Site Accounts Payable reviews and veriries the invoices. The invoices are then sent downtown for payment. Fermi 2 site accounts payable has no checkwriting capability.

The official explanation for Detroit Edison assuming control over the site accounts payable is that the project is nearing completion. When complete, Edison would have to perform the site accounts payable duties, since Daniel will no longer be on site. So, in order to facilitate an orderly transition, control of accounts payable was assumed in October 1982. It is important to remember, however, that financial contract administration has been very inefficient and not reliable (see report to H. Bhatia on internal auditing). In order to insure proper payments to vendors before they leave the site, Detroit Edison would have to be in control of the payable function. This, of course, was accomplished in October 1982, before the major vendors were off the site.

Audit Procedure

The strategy behind selecting a sample of the accounts payable files to examine begins with establishing a reliable universe of vendors from which a sample can be extracted. It is then necessary to select invoices from the accounts payable files of the vendors selected. The selection of the vendors was based on two sources: .

1. Fermi 2 contracts with commitment over $1 million as of December 31, 1982.

2. Fermi 2 Internal Audit Report Index.

The vendor sample selection was intended to include large and small contracts and provide a representative sample of the entire contract history. Six vendors were originally selected. They are:

Vendor	Contract Number	Contract Amount[1]
Wismer and Becker	1A-84001	$203,902,655
Robert Irsay	1A-84023	2,251,206
Aycock, Inc.	1A-84501	10,679,421
L.K. Comstock	1C-70112	120,772,227
Monroe Plumbing & Heating	1D-78864	4,825,821
KTA Tator	1A-84833	429,019
Kuhlman Concrete Co.	1A-84016	1,738,883
Nuclear Piping Systems	1A-79990	1,863,134

The selection of the accounts payable files was based on the vendor logbooks. These books provide an index of all the entries in the accounts payable files. The logbooks also keep a running total of dollars spent. To insure that the vendor logbooks were complete, the Staff traced the total dollar amount to date, as of the most recent entry made in the vendor log, to the C.A.R.S. report (by P.O. number). No major discrepancies were found.

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1 As of Accounts Payable information received June 21, 1983.

A random sample was then taken, based on the amount of the entry in the logbook and the explanation accompanying the entry, if any. Complicating this procedure would be the attempt to make the sample representative of the entire contract history.

Results

Based on the Staff's examination, the system now in place since Detroit Edison assumed control of the accounts payable function appears to be orderly, efficient, and workable. Approximately 2500 invoices are manually processed each month by a crew of approximately nine employees. This, of course, will change as the project nears completion.

The task appears to be a formidable one, but the current accounts payable staff has it under control. They are able to retrieve invoices filed by them, assemble data for input into the computer, and handle problems that develop on a day-to-day basis. They are able to detect errors as they occur and make the necessary adjustments; at times, with the assistance of Internal Auditing.

The only drawback to the system is that invoice information in the accounts payable files pre-dating the current Edison system is in a shambles. There are approximately 96 filing cabinets. The files are poorly organized. The logbooks are not consistent or complete from year to year. In many cases, it is very difficult to locate invoices that were not filed by the current site accounts payable staff. This situation is very evident with the Wismer and Becker files, which comprise 11 of the filing cabinets.

In the Wismer and Becker example, the Staff spent one unsuccessful hour trying to locate any invoice listed on a particular log sheet. The Staff then asked the accounts payable staff person to locate any invoice on the log sheet. It took approximately one-half hour to locate four invoices. Wismer and Becker had a contract valued at over $200 million.

Not all vendor files are in as bad shape as the Wismer and Becker files, but not all vendor contracts are as substantial as Wismer and Becker. Many of the smaller vendor files are logically organized and easier to use. It is reasonable to assume that some deterioration of the files can occur over time. Even so, the Staff would expect more continuity than observed, especially since Internal Auditing relies on these files in conducting vendor close-out audits. Consolation can be taken, though, in the fact that property records are not based on the information stored in the accounts payable files. Property records are based on a C.A.R.S. cost analysis and reporting system. This system is not dependent on the accounts payable files, but on the invoices as they are processed for payment.

Recommendations

As a result of the examination of the site accounts payable function, the Staff recommends that:

1. The staff should review close-out audit procedures and workpaper if site accounts payable files are relied on.

2. The staff should possibly extend the examination of account payable functions to insure that such files are a reasonable basis for close-out audits.

3. This follow-up audit verification should be undertaken after the plant has been completed.

3. Cost Analysis and Reporting System (C.A.R.S.)

CARS was designed as the principal cost reporting and monitoring system at Fermi. Its various functions were defined in the users manual as:

1. To track project quantity and cost data, e.g.;
   a) Original budgeted quantities, manhours, cost per Universal Code of Accounts (UNICODE).
   b) Actual installed quantities, cumulative, by month, etc.
   c) Expended manhours - per month, cumulative, etc.
   d) Purchase orders, Work Change Requests (WCR), purchase order changes, invoices, etc.
2. Provide a means for calculating current budgeted quantities, manhours, costs, etc.
3. Provide a means to estimate future quantities, manhours, cost, etc.
4. Generates various reports, information for management, and project reviews.

Our understanding is that CARS was jointly developed by GE and Parsons in 1971-72.

Although CARS was initially designed to be the principal project data base (dollars, quantities, manhours), it was never fully utilized for this purpose.

In the early years, manhours were accumulated in the CARS for cost-plus contracts. But it was never used for quantity tracking, unit rate, estimating, etc. The manhour data was not properly maintained in CARS. Currently, manhours are recorded, but not used for any purpose due to gap and inaccuracy in data.

Presently, the only use of CARS is as the principal data base which shows paid invoices by CARS code of accounts. It is essentially a detailed property records system. It is, however, not an accounts payable system. The General Ledger is the principal accounts payable system. The two are totally independent.

There is a periodic (monthly) reconciliation done between the General Ledger and the CARS system. Our verification showed a good matching of dollars between the two systems. The Staff sampled several months of reconciliations.

No centralized source data system has been maintained for most of the project duration. As a result, the quantities being reported for the project are totally unreliable. When Daniel started reconstructing the quantity files, they essentially discarded all the previous records. The data was reconstructed by taking plant walk-downs and using take-off drawings. Another problem with the way Edison maintains the quantity files is that after the rework, scrapped material is purged from the quantity records. Given the amount of rework at EF2, it is impossible to tell how much total material has been used in the plant.

To our knowledge, Edison does not maintain a material balance system. Such a system could show the gross material (e.g., cable) purchased, scrapped, in-plant and in-warehouse. This type of material accounting has been absent at Fermi 2. In our judgement, Edison's management of salvaged material has been extremely poor at Fermi 2. Although recorded cases of theft and vandalism have been few, we heard reports of numerous instances where personnel walk off with usable lumber and other material without proper check. The location of scrap areas have been amenable to such unauthorized removal of material. In one case, a responsible member of the PMO was allegedly blamed for permitting a local contractor to remove several hundred dollars worth of piping without payment. Although good salvage procedures are in place, they are rarely followed. More recently, management has become more aware of the situation and has adopted stricter procedures.

4. Project Capital Overheads

Overheads are allocated to the Fermi 2 project based on corporate policy on capital overheads. Our review of policy and procedures shows that DE has a sound and reasonable overheads allocation system.

Annually, the director of Plant Accounting requests that all officers, managers, and department heads submit, as a part of budget surveys, monthly and bi-weekly labor and associated expenses which are applicable to the construction project. The surveys are verified by an overhead analyst in Plant Accounting for reasonableness and accuracy. The overheads department then develops the summary ratios by a responsibility work order for monthly roll allocations and into labor transfers for the weekly, bi-weekly allocations. Normally, the ratios developed are good for the entire year, but can be altered if organization changes or field conditions warrant.

Overheads allocation criteria requires that:

(a) The compensation for personal services should be based on time records or upon periodic surveys of the employee activities. Such studies should be performed at least once a year and reflect a proportion of time which is includable in the construction account.

(b) For non-personnel expenditures, it must be shown that it has reasonable relationship to the construction activity and that a reasonable basis has been evolved for determining the amount or proportion properly capitalizable. No class of expenditure can be assigned to construction without first having established the relationship of the expenditure in question to the construction work. Such relationship must be properly documented. As a follow-up, the Staff verified a sample of actual detail sheets and the workpapers for the purchasing department's 1982 overheads allocated to Fermi 2. No exceptions were noted.

In general, the Staff is satisifed that Edison's corporate policy and actual allocation procedures for Fermi 2 overheads are proper and reasonable.

Edison overheads and all engineering design expenditures are being held in a clearing account. At the end of the project, they will be allocated to the proper FERC code.

5. Allowance for Funds Used During Construction (AFUDC)

The AFUDC rate represents the rate at which direct construction and overheads expenditures are to be capitalized. Since the Michigan Commission uses AFUDC as the income offset in the ratemaking process, it is important to ensure that the AFUDC rate used for ratemaking over the project history is consistent with the AFUDC rate used by the Company as interest charges for the project.

Prior to 1981, the Commission did not prescribe a particular AFUDC rate, but required it to be reasonable. The FERC had a prescribed upper limit for the AFUDC rate. The DE AFUDC rate is approved by the Board of Directors. Since March 1980 (Case U-5281), the MPSC has ruled that the AFUDC rate must be set equal to the overall rate of return authorized in the prior rate order. Further, the AFUDC rate should not be compounded.

Staff verification involved the AFUDC actually applied by Edison for the Fermi project. This includes the AFUDC rate and the base amount to which it is applied.

The Edison plant accounting provided an Apple computer recreation of the AFUDC capitalized to date at Fermi 2.

The Staff finds that the AFUDC rate used on the project is accurate and consistent with ratemaking and authorized formula. For more recent periods, the AFUDC rate has been derived after adjusting the Belle River project financing effects.

The year-to-year AFUDC rates and recorded amounts for 1968-1982 appear on the following table:

YEAR	ANNUALIZED RATE	RECORDED AMOUNT ($000)
1968	6.75%	0
1969	6.75%	59
1970	8.0 %	1,041
1971	7.5 %	3,573
1972	7.5 %	7,392
1973	7.5 %	11,966
1974	7.83%(1)	18,513
1975	8.0 %	23,281
1976	8.0 %	25,230
1977	8.0 %	23,060
1978	8.0 %	28,659
1979	8.5 %	41,187
1980	9.10%(2)	55,676
1981	9.54%(3)	55,676
1982	9.94%	105,387
		$419,417

(1) 1974 (10 mos. @ 7.5% & 2 mos. @ 8.0%)

(2) 1980 (1 mo. @ 8.5% & 4 mos. @ 9.0% & 7 mos. @ 9.25%)

(3) 1981 (7 mos. @ 9.25% & 5 mos. @ 9.94%)

The Staff verified the base amounts to which the AFUDC rate is applicable and found them reasonable. Less than .2% variation was found-all due to rounding. DE does not compound AFUDC.

The Staff reviewed the DE Controller's policy statement on AFUDC (Policy No. 6), formula computation, and exemptions. For example, AFUDC is not applied to property taxes not paid, accrued employee vacations, unbilled liabilities, contract retentions, and pollution control facilities for fossil plants.

The Staff is satisfied that the AFUDC accumulated for Fermi 2 is proper in amount and procedures.

It should be pointed out that the AFUDC is only accrued for the Detroit Edison's portion of the CWIP. The CWIP related to Cooperative's share is excluded from AFUDC computation. Further, the AFUDC associated with 20% of the CWIP prior to sale agreement with the Co-Ops has also been excluded from the DE AFUDC. This latter amount was collected from the Co-Ops pursuant to the 1977 agreement.

The project estimated cost of $3.075 billion reported by DE reflects all costs excluding the Co-Op's capitalization charges since the agreement.

Here, it should be mentioned that the Staff computed a table of cumulative AFUDC rates for each year until 1982, using half the rate for the first year. This cumulative rate is used for computing AFUDC associated with disallowance of an expenditure for a given year.

In passing, it should be stated that Edison has done a good job of keeping the Fermi 2 property tax bill at a minimum. We reviewed the property tax valuation for Fermi 2 with the Manager of Taxes at DE. To our knowledge, about $300 million of Fermi 2 has been successfully classified as pollution control, in part due to the cooling tower installation.

DETROIT EDISON COMPANY
Cumulative AFUDC Rates
For the 15 years ended December 31, 1982

Source: James A Mendenhall

Year/year	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1968	3.38(1)														
1969	6.75	3.38(1)													
1970	8.00	8.00	4.00(1)												
1971	7.5	7.50	7.50	3.75(1)											
1972	7.5	7.50	7.5	7.5	3.75(1)										
1973	7.5	7.50	7.5	7.5	7.5	3.75(1)									
1974	7.83	7.83	7.83	7.83	7.83	7.83	3.92(1)								
1975	8.	8.	8.0	8.0	8.0	8.0	8.0	4.0(1)							
1976	8.	8.	8.0	8.0	8.0	8.0	8.0	8.0	4.0(1)						
1977	8.	8.	8.0	8.0	8.0	8.0	8.0	8.0	8.0	4.0(1)					
1978	8.	8.	8.0	8.0	8.	8.0	8.0	8.0	8.0	8.0	4.0(1)				
1979	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	4.25(1)			
1980	9.10	9.10	9.10	9.10	9.10	9.10	9.10	9.10	9.10	9.10	9.10	9.10	4.55(1)		
1981	9.54	9.54	9.54	9.54	9.54	9.54	9.54	9.54	9.54	9.54	9.54	9.54	9.54	4.77(1)	
1982	9.94	9.94	9.94	9.94	9.94	9.94	9.94	9.94	9.94	9.94	9.94	9.94	9.94	9.94	4.97(1)
Total AFUDC Rate	117.54%	110.79%	103.41%	95.66%	88.16%	80.66%	73.00%	65.08%	57.08%	49.08%	41.08%	32.83%	24.03%	14.71%	4.97%

(1) 1/2 of the first year AFUDC rate

6. Summary Findings of Financial Administration and Controls

1. DE cost accounting and bookkeeping procedures were sound and reasonable.

2. The accounting procedures and policies were consistent with MPSC, FERC system of accounts and with ratemaking treatment.

3. The project cost data reflected in Fermi 2 accounts fairly reflects the costs actually incurred on the project. A final financial audit, however, must be performed by PSC Staff at the end of the project.

4. DE devoted less than adequate effort, however, on verification of labor payroll and accounts payable invoicing. Prior to 1980, virtually no financial management existed on site. It was considerably strengthened in 1980. A project the size of Fermi 2 demanded much larger financial management effort on site. Even after 1980, only three full-time staff persons were assigned--some of them Daniel contract people. In our opinion, DE should have assigned a larger staff comprising DE employees at the site.

5. There appears to be inadequate involvement of the corporate financial staff in the Fermi 2 project.

6. Internal Auditing was a strong group and had support of the Senior Management. This group performed a valuable service by pointing out project weaknesses.

7. Until 1982, the project lacked a data base for tracking and monitoring non-cost project data. Planning and estimating efforts suffered as a result of this deficiency.

G. Evaluation of Senior Management Role and Decisions Related to Enrico Fermi 2

In this section, we shall discuss and assess the involvement and decision making at the Senior Management level associated with Fermi 2. Specifically, we shall address questions such as:

a) Was Edison Senior Management sufficiently informed and involved in the project?

b) Did the Senior Management provide adequate technical, financial, and manpower resources?

c) Did the Senior Management provide for an efficient organization structure both at the Corporate and Project Management levels to ensure adequate line and level of authority, communication, reporting and problem resolution, and integration of various project activities?

d) How did Senior Management ensure that cost controls, contract management, and budgetary control functions were clearly defined and adequately applied?

e) What specific actions, if any, were taken by management to minimize delays, cost overruns and generally ensure efficient project management?

f) Was there a continuous assessment of project alternatives, strategic planning, and other corporate support activities integrated in Fermi 2 decisions?

g) Communication of project progress, problems and major decisions to the Board of Directors.

To answer these questions, the Staff interviewed Senior Management personnel, including:

Mr. Walter McCarthy, Chairman of the Board
Mr. Charles Heidel, President
Mr. Ernie L. Grove, Vice-Chairman and Chief Financial Officer
Mr. Harry Tauber, Group Vice-President
Mr. Burke Schneider, Group Vice-President
Mr. Wayne Jens, Vice-President (Nuclear Production)
Mr. J. Johnson, Vice-President (Finance)

Two former employees of Detroit Edison were also interviewed:

Mr. Robert Hartwell, Senior Vice-President (Finance)
Mr. Robert Wagner, Controller

Finally, the Staff had several interviews with Mr. Arnold Benes, who is the General Auditor for Detroit Edison.

The Staff also reviewed the minutes of board meetings, and numerous management reports and documents.

1. Organizational Structure (PMO Concept)

Detroit Edison has a well-defined Management Policy document called Major Generation Project. It describes mandatory minimum requirements for management of major generation projects. It defines the roles of the Project Management Organization and its various activities.

The Project Management Organization (PMO) concept was adopted very early at EF2. This concept includes designation of an individual as Project Manager, delegation of specific authorities, and responsibilities over a wide range of functions necessary to manage the project.

The PM is appointed by the Executive Vice-President. Edison General Orders 238 and 196 describe the authorities of the PM and the corporate approval level responsibilities.

Each major project has a charter that defines the project scope and parameters.

The Project Manager reports to the Manager (Engineering & Construction), who in turn reports to the Senior Management. More recently, the Manager (E & C) has been changed to the Vice-President (E & C).

In our opinion, the PMO approach for the Fermi 2 project organization was a good management decision. Further, the basic structure of the PMO appears to be a sound one. The PMO concept is now widely used in the industry. Edison was one of the early practitioners of it. More recently, there has been a trend in the industry to assign a senior officer of the VP rank to oversee nuclear construction projects, on site. This need is felt because of the large number of day-to-day decisions requiring higher authority levels and a higher degree of discipline and performance, presumably achievable by a senior level person.

In our opinion, effectivess of a Project Manager is more a functio.. of the individual personality and the level of authority vested in him, rather than the rank. Mr. Fahrner, who has been PM at EF2 since 1976 is an aggressive, capable individual and has enjoyed good management support. Mr. Fahrner is a member of the Edison Management Committee.

In November 1982, Edison did assign Vice-President Mr. Holland as overall in charge of the project. In our opinion, this was a correct decision, but only because the project was in a transitional mode from construction to operations. To some extent, this decision was recognition of internal conflicts within the management. As we were told by a Senior Officer, appointment of a VP (E & C) was to balance the Nuclear Production Group, who had a Vice-President, Dr. Jens, at the site.

In our judgement, the PMO structure was weak in at least three areas:

a) Much of the PMO functions were conducted from off-site until 1980. Key functions, such as project controls, project purchasing, project engineering and Quality Assurance, were not performed from the project site. This considerably hampered efficient communication, turn-around, and oversight by the PMO. The PM himself was located off-site. Prior to 1980, Edison had an armchair management style.

   The crucial field engineering function was virtually absent at the site until later in 1980. After an exhaustive project review in 1979-80, many of the functions were brought on site.

   Logistics was a particularly difficult problem as far as engineering. This function must be well coordinated with the field activities. The Fermi engineering was maintained in Troy, some 70 miles away from the project site. The difficult logistics, turn-around, and frequency of engineering and scope changes all made the function very inefficient. Field engineering was strengthened considerably in 1981-1982.

b) The Project Manager did not have a strong Site Manager until 1981. Given the complexity of negotiating with so many contractors, vendors, and others, it is imperative that a project of this size ought to have a competitive, strong Site Manager. In our opinion, the PM did not have such a capable person to oversee day-to-day construction and deal with the contractors, CM, etc.

   In 1981, Mr. Syl Noetzel was assigned as Assistant Project Manager and the Site Manager. This was a good move, though somewhat late. In their 1982 SALP report, the NRC applauded this move.

   Mr. Noetzel is a competent, strong manager with construction background. He was also PM at GW1. In our opinion, the performance of the construction groups improved considerably because of closer day-to-day supervision by the Site Manager. Daniel, Bechtel, and SCO all report to him.

c) Project engineering functions were not fully controlled by the Project Manager.

   Functionally, the project engineering group reported to the PM, through the Asst. Project Manager-Engineering. In essence, however, engineering decisions, schedules, and priorities were established independent of the remaining project. In our opinion, the PM did not exercise effective control on engineering and design functions. This was a result of several factors:

1) Logistics due to the location of the project engineering organization in Troy, far away from the site.

2) Edison traditionally has a strong engineering organization which tends to resist controls from non-engineering organizations. Remote location is itself an evidence of this attitude.

3) Decision to act as their AE gave a strong influence to the engineering group over the Project Management, outside of the PM's umbrella.

In our assessment, considerable conflicts developed between the PM and the engineering organization. As an example, the Project Manager was unable to make design groups work necessary overtime when construction priorities demanded.

2. Role of Senior Management

From the start, Edison's top management has taken a deep interest and involvement in Fermi 2. Prior to 1974, it was Mr. Walker Cisler who made every major decision personally, although with advice from other management members. Mr. McCarthy was the first Project Manager of EF2, now the Chairman of the Board. He has taken strong personal interest in the project until this day, although his corporate responsibilities have limited his project role. Mr. Heidel, the President, has been involved since February 1977, when he became Executive Vice-President. Prior to this, his Fermi role was limited to economic evaluations, purchasing decisions, etc. Mr. Heidel is involved with all aspects of the project and monitors progress, reviews major decisions, and resolves high level conflicts.

Mr. E.L. Grove, Vice-Chairman, oversees the project funding, cash flow and other resource needs. He critically reviews the budget revisions, project forecasts, and assumptions used to develop estimates. These are independently evaluated for reasonableness based on recent trends, other comparable project data, etc.

Mr. Grove is the only Senior Management person with experience and background in financial management. All others are engineers by profession. Prior to 1975, the chief financial officer was Mr. R. Hartwell, who was also an engineer. Senior Management lacked a balanced mix of backgrounds in the top management. The financial crisis of 1974 emphasized the need for a professional financial manager. This was, to our knowledge, one reason for Mr. Grove's appointment as Vice-Chairman. Mr. Grove has impressive credentials as a financial manager in the utility industry.

The person with the most personal involvement with the Fermi 2 project is Mr. Harry Tauber, first as manager of engineering and construction in charge of Fermi, and later as Group Vice-President. We had several meetings with Mr. Tauber to discuss the project history. He appears to be a competent, articulate, and strong manager. He has had major input in the decisions throughout the project history (for a brief period he was away from EF2, as manager of fuel supplies). Mr. Tauber makes presentations to the Board on projections and schedule forecasts. It is fair to say that Mr. Tauber has directed the project for most of its duration. He deserves credit for many courageous decisions at various project stages. Conversely, he must share some responsibility for errors.

Among the most positive accomplishments for which Edison Management; in general, and Mr. Tauber in particular, should be commended is the relationship with the NRC. It is a delicate and most important relationship in a nuclear project. Thus far, Edison has managed it well.

It is our judgement that collectively, Edison's top management has taken serious and deep involvement in the project. All of the executives, however, expressed the feeling that the Project Manager and the PMO were given the widest authority for project conduct. Management claimed a "hands off" policy.

We believe that even though Management had a good grasp of the project, it has, in the large part, been docile. Management, in our opinion, has also allowed outside forces and events to dictate the project. Vendors and contractors took advantage of the Edison Management approach.

Senior Management receives monthly project progress reports and visits the project site every month to receive briefings from the PMO. Informally, there are daily and weekly meetings within the management to resolve problems, and assess options and strategies. The Fermi project has not suffered from lack of management attention. Much of the communication between Senior Management and the PMO was verbal.

3. <u>Management Philosophy</u>

a) Although engineering and technical knowledge of the Edison Management enabled it to play a dominant role in technical decisions, it was not without its side effects. The watchwords throughout the project were: safety, public health, environmental concerns, and NRC compliance. Edison's own version of project history is replete with phrases such as, "defense in-depth"; "to make an already safe plant safer"; etc. Edison Management expressed near-obsessive concern for these issues. In turn, these have permeated through all major technical decisions. Within two weeks of the TMI accident, Edison instituted a task force to take a comprehensive look at safety issues at Fermi. In principle, safety, public health, and environment are all noble causes and should be protected. In reality, how safe is safe must be determined with a rational decision process. One can quickly get into diminishing returns when striving to achieve incremental safety.

Edison Management took the general approach to err on the side of safety. As the Chairman of the Board expressed it:

> "As an engineer, I view myself with a different perspective on safety".

As the President of the Company admitted, the QA organization has been allowed to drive the project:

> "I have let QA have a free hand, because I have faith in them".

In terms of NRC compliance, the Management has, in general, taken a non-adverserial approach: "better to switch than fight". Of course, this approach, coupled with good relations, has paid off thus far.

It is impossible for us to evaluate the cost-benefit effects of NRC compliance. Admittedly, one can attribute enormous benefits in light of difficulties at Zimmer, D· lo Canyon, and the Midland projects.

We simply surmise that additional costs have been incurred to improve licensability, safety, public concerns, and concomitant benefits derived therefrom.

b) Looking at the technical decisions, one is tempted to observe that it appears to be the Management policy to insulate Fermi 2 from outside forces to the extent possible; in other words, make Fermi a self-contained complex.

Examples supporting this observation are:

- Cooling towers vs. lake discharge
- On-site storage to reduce dependence on low-level waste transportation
- Separate, enclosed RHR Complex vs. an open pond
- Elaborate security system
- Shore protection barrier
- Four emergency diesel generators where two were needed at the time

Many of these were voluntary actions at the time they were taken, and are at variance from industry norms. It should be noted here that Edison took little advantage of the Fermi 2 location near Lake Erie.

4. Corporate Financial Support, Budgetary Controls, and Surveillance

Fermi 2 is the largest single project undertaken by Detroit Edison. Since the project restarted in February 1977, it has been the top priority project for Edison. It has also been the largest cash drain. Review of annual budgets and expenditures indicates that overall financial support has been adequate for Fermi 2. There have been periods of budget cuts and freezes throughout the project. However, these were in proportion to financial restraints Company-wide. Outside of the shutdown phase 1974-77, which we shall soon discuss, and the freeze in November 1981 prompted by the Supreme Court Case on Securities, the project has received the necessary overall funding.

The annual expenditures steadily increased since 1975 at Fermi. In most years, the actual expenditures exceeded the budget. From time to time, restrictions were imposed on field expenditures. But these, in our judgement, were normal management maneuvers to control field expenses, adjust to revised schedules, etc. For example, as a typical case, the budget for the year 1980 was proposed as $226 million based on requests from each group early in 1979 (before TMI). After the normal management review, and reassessment of TMI effects on schedule date, a $199 million budget was proposed to the Board. This was approved in June 1979. No budget restrictions were imposed.

Actual expenditures for 1980 totalled $211 million, 5% over budget.

In our judgement, it is part of a prudent management to periodically remind the PMO of the budget restraints. The 1980 PMO notes are ful' of such references. During discussions with us, outside AEs and contractors often commented that Fermi was financially starved. In our judgement, these are self-serving remarks. We believe that Fermi 2 financial support was adequate for its needs.

Two factors impacted the Fermi 2 project in a significant way. One was the 20% cost sharing by the Cooperatives. The initial cash payment of more than $87 million helped Edison restart the project in 1977. It is not certain if, and when, Fermi would have restarted without the Co-Op's contribution. Thus far, the Cooperatives have contributed more than $500 million--a rather significant financial boost to Fermi 2. At times, e.g., 1981, the Co-Ops have paid advance money to keep the project going.

Another factor which, in our judgement, has adversely impacted Fermi 2 is the simultaneous construction of one or more other large generation projects throughout the Fermi 2 duration. Greenwood 1 was started and completed (1971-1979) with more than $300 million cost. The two Belle River units, although financed outside the normal process, have strained the Edison financial capacity. Moreover, commitment of technical and in-house manpower resources to other projects have impacted Fermi 2 resource support.

As far as we can see, corporate financial managers played a limited role in the Fermi 2 activities. Confined only to budget revisions, financial impact analysis and cursory review of estimates developed outside their area of influence. To a large extent this is inherent in the Project Management Organization concept. The PMO acts somewhat as an autonomous entity, establishing its own priorities, needs, and controls. Secondly, by all accounts, since restart in February 1977, Fermi 2 occupied a top priority status, and financial concerns were often subordinate to the safety and regulatory concerns.

The Staff saw little evidence where the financial managers seriously challenged the project assumptions, decisions, budget overruns, or performance. Much of the project control was self-monitored.

The Management Policy on Major Generation Projects assigns financial administration and cost control responsibility to the PMO. A Project Controller is assigned by the Corporate Controller who is responsible through the Project Manager for "coordinating" financial administration and cost control plans (see General Order 238 and 1.2.2 of Financial Policy for Major Construction Projects). Specifically, the role of the Project Controller is described as follows:

- Assist PM on matters relating to financial aspects to ensure that adequate control systems are operative, and serve as a liaison between the project and several corporate financial departments

- Ascertain that adequate financial controls are in existence and monitored

- Assume that there are documented statements of responsibility for each PMO member

- Monitor activities pertaining to fiscal aspects of the project

- Establish procedures for securing authorizations for all required authorizations

- Ensure that DE and contractor's financial procedures and systems satisfy financial controls and reporting needs of the Corporation

- Review the project financial forecasts prior to submission for inclusion in DE financial planning schedule. This includes budget, and rate of expenditures. Update the project budget, ensure audit trails to support cost changes, etc.

Other responsibilities include:

- MPSC reports, environmental cost reports, financial statements, SEC reports, reconciliation of costs between CM and DE plant work orders, distribution of cost to proper plant classification and generally assist the Project Manager in preparing financial performance and status reports to the Edison Management.

The above list of items suggests that, on paper, the project controller had a wide role in the project fiscal and budgetary controls. In fact, however, his role was much smaller--essentially to ensure property records management, and later, accounts payable verification, etc.

The site financial administration staff consisted for 3 or 4 people. Prior to 1980, there were none at the site.

Edison's financial controls at Fermi have also been criticized by their public accounting firm. In one instance, for example, Edison was criticized for approving payments over the authorized budget levels without first receiving corporate approval.

5. Evaluation of Alternate Strategies

From time to time, studies have been performed at the behest of Edison Management to evaluate alternate strategies and capital expenditure planning.

One such major study was performed in 1981. Concerned with an extremely large concentration of capital expenditures--up to $4 billion between 1981-85--a task force was appointed to review options of shifting some of these to 1986-1990, a period of relatively modest expenditures. A 10% shift was targeted. Among the options: delaying construction, speeding up construction, selling generating units, and retirement of old units. In the case of Fermi 2, the study evaluated delays (COD in 1987) and abandonment options. It showed that it would not be economic to abandon the plant and cover the lost generation from other sources. The calculations showed a $965 million write-off after the tax effects. Also, present worth analysis showed that without EF2, the alternatives will cost more to the ratepayer after 1990 (1996 if write-off not recovered).

Similarly, it showed that any delay in commerical operation is not economic on a total cost basis. Therefore, it was concluded that it was more economic to maintain the current schedule. Results for Belle River units were also the same. As it has turned out, however, delays in EF2 have indeed occurred for other reasons and cost estimates revised several times since the 1981 study.

As a result of the study, agreements have been reached with Municipal Utilities to sell 37% of the Belle River units, GPU transaction and several unit retirement decisions.

In the Staff judgement, it is prudent management to continuously review options on the on-going and planned capital programs. In the case of Fermi 2, any further postponement would have been unwise and with disastrous consequences. Delays in 1974-77 are a prime evidence of this. We therefore agree with the Edison Management decisions in this respect.

6. Communication with the Board

The Staff reviewed the interaction between Management and the Board of Directors. Also, we reviewed the minutes of the Board meetings.

The Board receives a summary of the status, expenditure levels, and milestones on the Fermi 2 at regular meetings. Project budget revisions are presented to the Board in some detail. Mr. Harry Tauber generally makes this presentation on Fermi 2 and Belle River. (The most recent, in November 1983, was made by Mr. Holland.) To our knowledge, comprehensive discussions and questions are held at these meetings.

All budgets and revisions must be approved by the Board, as also the total capital expenditure levels, AFUDC rates, issuance of securities, etc. The Board members also visit the Fermi 2 site and inspect facilities.

In our opinion, the Edison Board of Directors is kept well informed about the Fermi 2 project. As is generally the case, the decision-making responsibility rests with the Edison Management, not the Board.

7. Management Decision to Shutdown Construction in 1974

In mid-1974, Edison reported a severe financial crisis in the Company. The financial crisis was attributed by the Company to the following factors:

a) After-effects of the October 1973 oil embargo resulting in high inflation, lower sales levels and high interest costs. In the years 1973-75, Company sales were 35,194; 33,412, and 33,419 million kWh, respectively.

b) Inability of Detroit Edison to sell long-term securities for its construction program. Further, both short-term and long-term capital markets were adversely impacted by economic conditions resulting in higher interest costs, and reduced availability of funds.

   The curtailment of quarterly dividend in April 1974 by Consolidated Edison further shocked the investment community as to financial viability of the utility industry. Up to now, utilities were considered safe income-providing investments.

According to the Detroit Edison Management (see response from Mr. J. Johnson):

The Company had difficulty in offering common stock securities. At the advice of their underwriters (Morgan Stanley, Lehman Brothers & Blyth, Eastman, and Dillan), the offering size was reduced; drop in share prices yielded less than the book value. The share prices dropped from more than $20 to $10. Similar difficulties were faced in issuing long-term mortgage bonds. Both Standard and Poor and Moody's downgraded the Edison bond ratings from AA/Aa to BBB/Baa between January 1974 and September 1974. The Company's Commercial Paper was similarly downgraded.

The Company, according to Edison, was foreclosed from the Commercial Paper market. In 1974, Edison had a $176 million line of credit (expanded in December 1975 to $200 million). Borrowings against this were about $156 million.

c) Edison Senior Management came before the MPSC, representing the serious financial situation and complained of inadequate rate relief (see highlights of testimony by the Detroit Edison Company before MPSC, September 4, 1974).

d) Edison expressed an acute cash shortage and inability to pay their bills as a result of inadequate earnings. Earnings had dropped from $2.13 in Feburary 1973 to $1.52 in May 1974. The high fuel bill resulting from the energy crisis had seriously impacted cash position.

According to Edison, investment analysts considered Edison in poor financial health. In 1974, Edison took drastic steps to meet the financial crisis:

a) Severe cutback on construction projects. Fermi 2 was completely shut down in November 1974. All site contractors were indefinitely terminated. Outside engineering firm (S & L) was demobilized. Only a skeleton staff in systems engineering and site construction was retained. The equipment on schedule was mostly delivered and stored at the site.

b) Payments to vendors and pre-payments to employee retirement funds were deferred.

c) Sold and leased-back equipment, e.g., coal, unit trains, trucks, etc.

d) In December 1974, enriched uranium owned by Edison was sold to two German utilities, net realized expected proceeds of $30 million ($5 million profit). Actually, Edison received only $17 million. This sale was necessary to improve cash; and due to the postponement of Fermi 2.

e) Edison did institute an early retirement program, but no lay offs. No evidence was found of wage freeze or hiring freeze.

To our knowledge, the Fermi 2 shutdown was resisted by the Project Manager and the PMO. The decision was finally made by the Executive

Vice-President, Finance (Bob Hartwell) and the Chairman (Meese) to shut down all major construction jobs.

The project was in an essential shutdown mode throughout 1975 and later extended to 1976.

Since early 1974, Edison had been negotiating with two Michigan electric Cooperatives (Wolverine and Northern Michigan) for sale of a portion of Fermi 2. Actually, the Co-Ops were insisting, while Edison was resisting such a sharing of the project. Ostensibly, Edison cited its internal power needs at the time. In fact, however, it was a general industry attitude at the time to avoid such a project sharing; in part arising from monopolistic nature of the electric industry. At any rate, the Edison attitude softened after the 1974 financial crunch. In 1975, negotiations with the Cooperatives were resumed. At this point, Edison had a new chief financial officer, Mr. Grove. Mr. Hartwell had left the Company taking an early retirement.

In January 1977, the agreement was completed. Edison received a cash payment of $87.4 million from the Cooperatives. It was a boost to the project. One of the conditions of the Co-Op agreement was that the Fermi 2 project should be resumed as soon as possible. By this time, economic conditions had stablized. The MPSC granted two rate increases in 1975 and 1976. Sales increased 9% in 1976 over 1975.

Construction at Fermi 2 resumed in February 1977.

Staff Discussion

Unquestionably, construction shutdown was the most critical management decision impacting Fermi 2. By one estimate, at least $200 million was added to the project due to the shutdown. In 1975, project estimates were revised from $510 million to over $900 million; the operation date was moved to September 1980.

Staff discussion shall address the questions:

a) Circumstances leading to shutdown and whether the financial problems were a result of poor financial management.

b) Was abrupt shutoff a prudent decision and were all the consequences fully analyzed prior to the decision?

c) Was the shutdown mode well managed?

a) Staff research indicates that financial problems at Detroit Edison were brewing up since 1971-1972 and were not suddenly discovered in November 1974. Examples supporting this contention are:

- December 1971 PMO notes: Reduce 1972 EF2 expenditures by $10 million to $81 million. The General Contractor, Parsons, was recommending a $29 million increase to meet the schedule. The 1972 annual report indicates that 1973 construction was being reduced by $81 million to $450 million. Yet new project were being announced.

- In 1972, Edison was asking its EF2 contractors to accept deferred payments with interest. For instance, the cooling towers contractor, Marley, was offered this plan. In 1972, Edison received a $47 million rate increase.

- At the June 1973 Board of Directors meeting, "President Meese cautioned that it may be necessary to curtail construction if there is no improvement in the Company's financial situation". In the same meeting, however, "the Board unanimously approved the recommendation of the Energy Resources Committee to proceed with plans to construct two coal-fired units (Belle River 1 & 2) on a site adjacent to the St. Clair Power Plant".

- In 1973, there was discussion within the Company whether to increase the dividend and by how much. The Edison dividend had remained $1.40 since 1966. A 5¢ increase was approved in the first quarter of 1973. (The Staff finds this action to be prudent.)

b) Edison had too many major projects going on at the same time and bringing in too much capacity. Edison had just completed several major projects.

Monroe - (4 units completed 1972-1974)	3200 MW
Pumped Storage - brought in 1972-1973	900 MW
Fermi 2 - announced in 1968	1150 MW
Greenwood 1 - announced in 1971	800 MW
Fermi 3 - announced in 1973	1150 MW
Belle River 1 & 2 - announced in 1973	1300 MW

Proposed: two 1200 MW nuclear units GW1 & 2 - 1980-1981. Other projects: major T & D expansion, Superior Coal Dock, and sizable environmental control projects. In all, by 1974, Edison had planned an outlay for more than $5 billion over the next 10 years. In 1973 and 1974, Edison's actual capital expenditures were $400-500 million per year. This was a dramatic increase in their capital budgets from about $100 million or so per year in the years prior to 1971. In our judgement, Edison was financially overextended. The revenue base of $675 million in 1972 (increased to $1 billion in 1975) was inadequate to support such a large construction program. A disproportionate share of this program had to be financed externally. Thus, when the electric industry ran into financial difficulties, triggered in part by the Consolidated Edison decision, Detroit Edison, which was a marginal case, dropped off the investors' list.

c) Edison's decision to build three units at Greenwood Energy Center had adverse effect on EF2 financing. In 1974, actual expenditure on GW1 oil unit was $63 million. Another $12 million on GW 2 & 3. Total actual expenditure on GW1 between 1972-74 was $103.7 million as compared to $325 million incurred on Fermi 2 since 1968. Indeed, in 1975, (see B of D notes February 1975) two years after the oil embargo, the order of priority of Edison generation projects was:

GW1
EF2
BR 1 & 2
EF3
GW2 & 3

(EF3 was cancelled later in 1975; GW2 & 3 were cancelled in 1979).

In the year 1975, when all construction was supposedly shut down, actual expenditure for GW1 was $27 million, exactly half that on EF2. Another $26 million was spent on Superior Coal Dock in 1975. In 1975, Edison agreed to loan up to $50 million to Midwest Energy Resources Company (MERC). About $35 million was actually loaned out. The annual levelized requirements for Fermi 2 were estimated at $100 million. (In 1975, the operation date for Fermi 2 had been pushed to 1980 at an estimated total cost of $900 million. Of this, about $375 million had been already spent.)

d) The financial community was rightfully skeptic of the Edison Management's ability to put its financial house in order and to act frugally. The greatly expanded construction program, and absence of a forceful voice to counsel fiscal prudency were perceived by security analysts as negative factors for Edison. Analysts also perceived Michigan's regulatory climate unfavorable for a quick Edison recovery.

Based on these discussions, the Staff believes that:

a) Edison was indeed in a severe financial and cash crisis in the middle of 1974.

b) The crisis was largely due to a weak financial position since 1972 as a result of large commitments for the generation projects in comparison to the revenue base.

c) The 1973 oil embargo and 1974 industry crisis severely impaired Edison's ability to raise funds.

d) To respond to the crisis, Edison needed a drastic reduction in capital expenditures.

e) Edison, however, failed to establish an orderly, prioritized procedure for an expenditure curtailment program. It seemed to Edison that EF2 had picked up some momentum by 1974 (estimated 43% completion, $325 million of the estimated $510 million expended). Further, much of the major equipment such as RPV, turbine generators, pumps, and diesel generators were all on scheduled delivery. By design, however, Edison Management placed reduced emphasis on Fermi 2 in mid-1974. Other projects such as Greenwood 1 oil unit and Superior Coal Dock received higher priorities. It is conceivable that this decision was also influenced by the Fuel Adjustment Clauses in effect in 1974 for all customer classes. In any case, Edison took the obvious approach, i.e., "shut down all projects", rather than a more prudent, measured case-by-case approach. As observed earlier, Edison had adequate resources in 1975 to continue with Fermi 2 construction, had it remained the top priority project.

However, in the Staff's judgement, the decision to slow down Fermi 2 construction and assign top priority to GW1 appears justifiable from the overall planning perspective.

The Daniel assessment of May 1974 made it abundantly clear that Fermi 2 completion was much farther behind than had been generally assumed by Edison. A serious lag in the engineering progress and admitted lack of nuclear experience and manpower would impact engineering completion. This led to the correct assessment, in our opinion, that the completion schedule of 1978 (or even September 1980 as Daniel estimated) was unachievable. A regrouping and rearranging of Fermi 2 was in order. The construction slowdown, if not a shutdown, was therefore, a logical step while focus was shifted to design work.

At the same time, Edison perceived a continued growth in electric demand at near historic rates after a temporary setback in 1974-75 (in 1976 demand increased 9% over 1975). These assumptions were supported by Staff reviews of Michigan energy needs, performed in 1974. Edison's conclusion, therefore, was that GW1 be advanced in priority over EF2 to meet the expected demand.

Given these assumptions, Edison's decisions to slow down construction at EF2 and to emphasize GW1 appear to be reasonable. The Staff still challenges the manner in which the slowdown was brought about--a complete and abrupt shutdown with little attention to equipment protection and maintenance. In hindsight, completion of GW1 was not cost-effective when the electric demand decreased and oil prices jumped in the years 1979-1982. As stated elsewhere, the goal of engineering catch up also fell off the mark.

f) Edison also failed to tap other potential sources to finance Fermi 2. No serious discussions were entertained with the Co-Ops who were offering to buy a portion of Fermi 2. Finally, a deal was consummated in January 1977 which led to the restart of the construction.

Also, in our judgement, Edison did not fully tap the short-term borrowing ability. If they seriously wished to keep the project running, an expanded line of credit, albeit at a somewhat higher cost, was potentially available.

g) Finally, to summarize it, we believe that Edison acted imprudently by not analyzing the consequences of its decisions based on "replacement cost". The Fermi 2 shutdown had the most severe consequences in large part due to growing nuclear regulatory requirements. Edison Management was fully knowledgeable of this, yet made little effort to save the project. Although unexpected, nuclear accidents at Browns Ferry and TMI had further significant cost impacts.

In the Staff's opinion, at this point, Edison should have reassessed the Fermi 2 options; either continue the project and devote all available resources, or seriously consider cancellation.

The economic conditions in 1979-1982, record high inflation, and interest rates all added to the schedule and costs at Fermi 2.

Due to its abruptness, the Edison PMO was unprepared to handle the shutdown mode. Vendors of major equipment declined to reschedule delivery, leading to serious warehouse problems. Despite best efforts, no adequate maintenance program was developed. A conscious decision was made not to extend warranties on major engineered material. Uncertainty as to restart date complicated this further.

As has been stated elsewhere, by this time (mid-1974), serious deficiences had been identified in various facets of the project such as engineering, cost estimates, planning, etc. A positive aspect of shutdown was that it provided an opportunity to rectify these deficiencies. A new Project Manager, new construction management, and catch up on design completion--all these actions were designed to restart the project more efficiently. As we have learned, Edison was only mildly successful. Engineering delays, inadequate planning and scheduling, and excessive rework plagued the project throughout.

Disallowances Resulting from Project Shutdown

During the shutdown, November 1974 through February 1977, overheads and indirect costs were incurred which did not directly benefit the project. These included demobilizing contractors, dismantling some facilities in 1974, site protection, and remobilizing in 1977. Some justifiable overheads were, however, incurred in warehousing, maintenance, equipment, etc. It is the Staff's recommendation that 50% of the indirects and general overheads incurred between November 1974 and December 1976 be disallowed. The disallowance is computed, using monthly project reports for the period, as follows:

		(000)
1.	Total indirects/overheads as of November 1974	$ 72,054
2.	Total indirects/overheads as of December 1976	91,415
3.	Total indirects/overheads during shutdown	19,361
4.	Disallowance for the period (50% of line 3)	9,680
5.	Add AFUDC (1976-1982) at 57%	5,518
6.	Total Disallowance including AFUDC	15,198

It should be noted that Edison estimate of costs to demobilze construction and to reactivate the project is $5.75 million (Staff request #182).

H. Quality Assurance and Federal Regulation

1. Introduction

The construction of a nuclear power plant in the United States today mandates utility involvement in a complex Federal regulatory process that is unparalleled in the utility industry. The utility, as owner of a nuclear power plant, acts as licensee in regulatory matters before the Nuclear Regulatory Commission (NRC). The NRC and its predecessor, the Atomic Energy Commission (AEC), are empowered by law to act as the licenser for commercial activities involving nuclear power. The paramount objective of the NRC in the commercial generation of nuclear power is the safe design, construction, and operation of nuclear facilities. The achievement of this objective requires the development and strict adherence to quality assurance beginning early in conceptual design and continuing through the end of a plants commercial operating life. The application of an adequate quality assurance program does not come without cost however. The administrative costs of implementing a program are substantial. Secondarily, a utilities relationship with the NRC in the regulatory arena can greatly affect project costs and completion.

The constructing utility must strike a delicate balance between the obvious need to design, construct, and operate a plant safely and cost required to do so.

2. Background

The Atomic Energy Act of 1954, as amended, and Title II of the Energy Reorganization Act of 1974 provide the NRC with licensing authority for nuclear production and utilization facilities. As owner of the facility, the utility acts as licensee. All actions or transactions involving the facility are the responsibility of the utility during the design, construction, and operation, even though the utility may delegate certain project responsibilities to third party contractors, consultants, and architect engineers. A utility wishing to build a nuclear plant must file an application for a construction permit with the NRC. The application must be accompanied by a Preliminary Safety Analysis Report (PSAR) which contains a safety assessment of the site, a summary description of the facility, the preliminary design of the facility, the design bases and the relation of the design bases to principal design criteria, information relative to materials of construction, general arrangement and approximate dimensions, and a preliminary analysis of the facility, with the objective of assessing risk to public health and safety resulting from operation of the facility.

The PSAR should also include a description of the Quality Assurance Program to be applied to the design, fabrication, construction, and testing of the structures, systems, and components of the facility. Appendix B of 10 CFR 50, "Quality Assurance Criteria For Nuclear Power Plants and Fuel Reprocessing Plants", sets forth the requirements for quality assurance programs for nuclear power plants. The description of the Quality Assurance Program for a nuclear power plant in the PSAR should also include a discussion of how the applicable requirements of Appendix B will be satisfied.[1] The application for a construction permit also requires submission of an Environmental Report and corporate anti-trust data.

After submission, the Staff of the NRC conducts an extensive review of the filing resulting in issuance of a Safety Evaluation Report.

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[1] Title 10 Code of Federal Regulations, Part 50.34

This report summarizes the Staff's review and evaluation with respect to the proposed facility's anticipated effects on public safety. It also delineates any outstanding issues that need to be resolved prior to plant construction and operation.

The application is next reviewed by the Advisory Committee on Reactor Safeguards (ACRS), an independent statutory committee established to provide advice to the NRC on reactor safety. This committee reviews every application for a construction permit or an operating license for commercial nuclear power plants. When the ACRS has completed its review, it reports via public letter to the chairman of the NRC. Any questions raised by the ACRS are addressed by the staff in a supplemental SER. After completion of the safety evaluation and a similar environmental review, the NRC dockets the application for public hearing. Intervenors can participate in the process on a limited basis by submitting written statements or giving direct statements, or they may participate directly by petitioning to intervene as a full party in the proceeding. The hearing is conducted as an adversary proceeding before the three-member Atomic Safety and Licensing Board (ASLB). The ASLB considers all evidence on safety and environment, including the aforementioned reports, and any new issues developed during the hearing. A favorable ruling results in issuance to Applicant of a construction permit. The ruling is, however, appealable to the Atomic Safety and Licensing Appeal Board (ASLAB). The decision may be further appealed to the courts. Once a utility receives a construction permit, it may begin construction in earnest. A utility may perform limited site preparation work, excavations, installation of temporary support facilities, and construction not subject to QA requirements prior to issuance of a construction permit. This can be performed by authorization of the NRC under a Limited Work Authorization. It is issued after the hearing board finds that a site meets all the environmental requirements for issuance of a construction permit.

During construction, the NRC employs two basic inspection and enforcement (I&E) mechanisms to ensure that safe design and construction is accomplished. Each licensee or holder of a construction permit agrees to allow inspection by duly authorized representatives of the Commission of its records, premises, activities, and of licensed materials in possession or use, related to the license or construction permit.[1] The inspection activity usually involves periodic scheduled or special visits by technical experts from the NRC regional office. In recent years the NRC has also stationed Resident Inspectors onsite. The second I&E mechanism is a self-policing action imposed on construction permit holders by 10 CFR 50.55(e):

> "...the holder of the (construction) permit shall notify the Commission of each deficiency found in design and construction, which, were it to have remained uncorrected, could have adversely affected the safety of operations of the nuclear power plant at any time throughout the expected lifetime of the plant and which represents
>
> (i) A significant breakdown in any portion of the Quality Assurance Program conducted in accordance with the requirements of Appendix B.
>
> (ii) A significant deficiency in final design as approved and released for construction such that the design does not conform to the "criteria A" bases stated in the safety analysis report or construction permit.
>
> (iii) A significant deficiency in construction of, or significant damage to, a structure system or

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[1] Title 10 Code of Federal Regulations, Part 50.70

component which will require extensive evaluation, extensive redesign, or extensive repair to meet the criteria and bases stated in the safety analysis report or construction permit, or to otherwise establish the adequacy of the structure, system or component to perform its intended function.

(iv) A significant deviation from performance specifications which will require extensive evaluation, extensive redesign or extensive repair to establish the adequacy of a structure, system, or component to meet the criteria and bases stated in the safety analysis report or construction permit or to otherwise establish the adequacy of the structure, system, or component to perform its related safety function".

The citation of a utility for specific noncompliance by an NRC inspector or the reporting of a 50.55(e) event by the utility triggers a sometimes lengthy documentation process. All deviations and noncompliances are noted in formal reports. A utility must respond to the NRC in writing within 30 days following oral notification of a 50:55(e) item. The report must include a description of the deficiency, an analysis of safety implications, and the corrective action taken. Items of noncompliance discovered by NRC inspectors require written description of corrective actions and are kept open until corrective actions are implemented. In addition, all NRC inspections are routinely followed by issuance of an inspection report.

When the construction of a facility has progressed to the point where final design and operational plans are known, the Applicant submits his Final Safety Analysis Report (FSAR) as basic support of an application for an operating license. The FSAR contains specifics of final plant design, intended operating procedures, waste handling procedures, and emergency procedures. Upon receipt of the FSAR, the NRC staff again prepares a Safety Evaluation Report, which is again followed by an independent review by the Advisory Committee, on Reactor Safeguards. A second hearing is not required unless a concerned interest successfully petitions the NRC to hold a hearing.

An operating license is issued only after all issues are resolved and the licensee has demonstrated satisfactory completion of design, construction, and pre-operational testing. The license is usually issued for a period of forty years and contains several technical requirements and specifications for operating the plant. The level of reactor output is usually one specification. The NRC monitors compliance with licensing requirements through the operating life of a plant. This necessitates adherence to the strict QA philosophy by the licensee that was developed during design and construction.

The licensee, therefore, is responsible for development, implementation, and documentation of an adequate QA program. Appendix B of 10 CFR set forth eighteen criteria for establishing a QA program that will continue through operation. Quality Assurance as defined in Appendix B;

> ....comprises all those planned and systematic actions necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily in service. Quality Assurance includes Quality Control (QC), which comprises those quality assurance actions related to the physical characteristics of material, structure, component, or system, which provide a means to control the quality of the material, structure, component, or system to predetermined requirements.

The first of the eighteen Appendix B criteria establishes the ground rules for a QA program:

> The Applicant shall be responsible for the establishment and execution of the Quality Assurance Program. The Applicant may delegate to others, such as contractors, agents, or consultants, the work of establishing and executing the Quality Assurance Program, or any part thereof, but shall retain responsibility therefor. The authorization and duties of persons and organizations performing activities affecting the safety related functions of structures, systems, and components shall be clearly established and delineated in writing.

These activities include both the performing functions of attaining quality objectives and the quality assurance functions. The quality assurance functions are those of (a) assuring that an appropriate quality assurance program is established and effectively executed, and (b) verifying, such as by checking, auditing and inspection, that activities affecting the safety-related functions have been correctly performed. The persons and organizations performing quality assurance functions shall have sufficient authority and organizational freedom to identify quality problems; to initiate, recommend, or provide solutions; and to verify implementation of slutions. Such persons and organizations performing quality assurance functions shall report to a management level such that this required authority and organizational freedom, including sufficient independence from cost and schedule when opposed to safety considerations, are provided . . . .

The Quality Assurance Program, therefore, continues to be the responsibility of the licensee regardless of who actually performs the function. In addition, the QA program must be independent of design and construction interferences; especially those that affect cost and schedule. The quality assurance responsibility is only one requirement imposed by the licensing process but represents the most visible evidence of the regulatory process onsite. Even though QA is, by law, independent of cost and schedule pressures, quality assurance requirements and NRC interactions have a substantial impact on project cost and completion.

3. Staff Approach

The MPSC Staff reviewed the quality assurance area to develop a better understanding of the interface between the NRC and Detroit Edison. The Staff was cognizant of a relatively quiet regulatory relationship between the two parties. Third-party intervention in the licensing process was less active and vocal than in other, more visable projects. The NRC, at the time of the Staff review, had not levied any fines on the licensee, nor had they officially ordered suspension of any phases of the project, although project Quality Assurance, in specific instances, issued stop-work orders until corrective actions could be implemented. The review was conducted to better understand the interactions between Detroit Edison and the NRC, and the effect that this relationship had on the project. Secondly, the inspection and enforcement process provided a wealth of well-documented inspection and 50.55(e) reports containing information on historical problems involving major safety related equipment. Thirdly, a review of the DE-NRC interface would provide an understanding of the impact of regulation changes on the Enrico Fermi 2 project. It is DE's contention that the vast majority of cost increases for the EF2 project can be directly attibuted to changes in project scope due to evolution and growth of regulations.

The Staff review consisted of interviews with selected senior project staff and all senior utility management. The interviews were not restricted solely to questions pertaining to quality assurance and the NRC. The Staff also interviewed the DE Quality Assurance Director and the NRC Resident Inspector, specifically with respect to QA. The Staff conducted an extensive document review including all 94 50.55(e) reports, all NRC inspection reports through August 1983, the EF2 FSAR, the EF2 PSAR, and Title 10, Part 50 of the Code of Federal Regulations. The Advance Planning Section of the Operational Development Division within the MPSC Staff provided assistance in understanding and evaluating NRC policies and procedures impacting the EF2 project.

4. Organizational History

The Quality Assurance and Quality Control functional responsibilities for the EF2 project have changed over the life of the project.

Organizational structure and application differed over their distinct periods of the project. The organizational concepts and responsibilities can be categorized to coincide with three distinct eras of the project. The first era, which the Staff shall refer to as the Parsons' era, encompassed the period from project inception until the October 1974 project shutdown. The second era, the Daniel era, covers the period from project restart in January 1977 through the project reorganization in January 1980. The third era, the DE era, spans the period from the project reorganization to the present. DE, throughout the project's history, has maintained administrative control over QA activities; however, the degree of DE involvement in QC functions has varied significantly during each era.

The EF2 project was authorized by the DE Board of Directors in August 1968. In February 1969, the R.M. Parsons Company (RMPCO) was named general project contractor. A major factor influencing the decision to use RMPCO as constructor was their strong experience with quality assurance in the Defense Industry. This was followed by filing of the PSAR and application for the construction permit in April 1969. The first project manager for the EF2 project was Walter J. McCarthy, Detroit Edison's current Chief Executive Officer and Chairman of the Board. Mr. McCarthy's experience at the time included eight years as point contact with the Atomic Energy Commission on issues dealing with the Enrico Fermi 1 project. DE, at the time, felt that their experience gained on EF1, and the relationship fostered with the AEC, were positive factors in leading to the decision to construct EF2. Senior Management, placing significant weight on DE's engineering experience in powerplant design and Quality Assurance, made the decision for DE to act as the prime architect-engineer for the EF2 project and to assume all QA/QC responsibilities. Project responsibilities were summarized in the EF2 PSAR and subsequent amendments. The following excerpt from the EF2 PSAR highlights DE's reasoning, at the time, for assuming A/E and QA responsibilities:

The Detroit Edison Company

The Detroit Edison Company is the sole owner of the facility and, as such, is responsible for the design, construction and operation of EF-2. DECo will act as architect-engineer for the plant. This practice has been followed in the past during the construction of the following DECo fossil-fuel power plants.

Plant Name	Capacity - MWe	No. Units
Delray	420	6
Conners Creek	635	9
Marysville	335	7
Trenton Channel	1110	9
St. Clair	1850	7
River Rouge	859	3
Enrico Fermi	162	1

Four units totaling 3200 MWe are presently under construction at the Monroe Power Plant.

A single unit 115 MWe capacity at the Harbor Beach Plant was supplied on a turn-key basis.

DE employs an engineering, design, and construction supervision staff numbering approximately 130 persons. As such, it is one of the relatively few electric power companies in the United States which has the experience and personnel to carry out the responsibilities of architect-engineer on major power plant projects. Many of the key engineering personnel have had previous nuclear experience, primarily on the design, construction and operation of the fast breeder reactor Unit No. 1 at the Enrico Fermi Atomic Power Plant.

In order to assure competence in areas of the plant design where DE has not had prior direct experience, the consulting engineering firm of Sargent and Lundy has been retained.

The General Electric Company will engineer, design and supply the nuclear steam supply system.

The Ralph M. Parsons Company will act as general contractor for the construction of the plant.[1]

DE also felt well qualified to assume project QA responsibilities, given their organizational concern for QA on recently completed and on-going system fossil projects. The decision was made to retain all direct control for QA/QC. The EF2 PSAR and amendments, per the requirements of 10CRF 50.34, contained a description of the quality assurance program to be applied. The corporate policy of DE with respect to quality assurance at EF2 is as follows:

> Is is DE's policy to assure the highest feasible degree of functional integrity and reliability for those structures, systems, and components of its nuclear plant facilities that contribute to the prevention or mitigation of the consequences of accidents. Such structures, systems, and components shall be identified and then designed, fabricated, and erected to quality standards that reflect the importance of the safety functions to be performed. These standards of quality will be maintained throughout the life of the plant. It is further the policy of DE to assure that as high a degree of functional integrity and reliability is achieved for the remainder of the plant as is necessary to meet its plant availability objectives.[2]

The PSAR also contained a description of the quality assurance organization to be used at Fermi 2. The proposed structure delineated the high degree of DE's involvement in QA in the early stages of the project. The responsibilities of the major parties are summarized from excerpts of the PSAR as follows:

> DE and its major contractors have within their organizations groups that are assigned the responsibility for implementing an

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[1] Enrico Fermi Atomic Power Plant - Unit 2, Preliminary Safety Analysis Report

[2] Enrico Fermi Atomic Power Plant - Unit 2, Preliminary Safety Analysis Report, Appendix D

approved quality assurance program. While DE has the ultimate responsibility for the overall quality aspects of the project, some of this responsibility is delegated to the contractors in their areas of activity. In each case, DE maintains an auditing function to assure compliance with planned quality assurance and control procedures.

Within DE, there has been established a QA organization responsible for the planning, implementing, and auditing of an overall QA program for the project. Ultimate responsibility for QA rests with the Executive Vice President for Production. Overall responsibility for QA, as well as other aspects of the project, rests with the Project Manager. The QA coordinator has direct responsibility for the establishment and implementation of the QA program. He is assigned full time to this function.[1]

The QA Coordinator reports directly to the Project Manager and is assisted by a staff of QA Engineers. The QA Engineers have QA responsibilities for assigned plant systems. Their responsibilities begin with design and extend through to the testing of the system.[2]

The QC Specialists are drawn from various Company Departments to provide the necessary expertise in performing the surveillance, auditing, and inspecting functions required in implementing the QA program or to provide the technical expertise required in evaluating or establishing QC procedures, reviewing specifications, etc. Personnel from the following departments will be called upon for their services: Construction and Maintenance, Electrical System, Engineering Design and Services, Engineering Research, General Engineering, Production, and Purchasing.[3]

DE originally intended to staff 70 plus QA positions entirely with DE personnel. However, it became necessary in 1970 to expand Parsons' role in the project to that of QA consultant when DE encountered difficulty in staffing the positions. The additional Parsons' responsibility is summarized as follows:

Quality Assurance Consultants

DE has engaged the Ralph M. Parsons Company as Quality Assurance Consultants. Parsons has assigned a full-time Project

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1 Enrico Fermi Atomic Power Plant - Unit 2, Preliminary Safety Analysis Report, Appendix D

2 Ibid.

3 Ibid.

Quality Assurance Manager is supported, as necessary, by a resident staff of technical specialists, and via the home office by the Power Division; and Systems Engineering Division Quality Assurance. Consultants advise the Quality Assurance Director on the formulation and implementation of the Quality Assurance program. In additiona, they are responsible for auditing the effectiveness of the Quality Assurance program as implemented; and submitting periodic reports of their findings to the Edison Executive Vice-President for Production; Manager of Engineering-Nuclear; Quality Assurance Director; and Project Manager. The Ralph M. Parsons Company Project Quality Assurance Manager and his staff report to a Senior Vice-President of the Ralph M. Parsons Company and are completely independent of the Parsons General Contractorship personnel.[1]

General Electric and Sargent & Lundy also retained specific QA responsibilities in their area of specialties. Their responsibilities are summarized as follows:

General Electric

GE is responsible for the design and manufacture of the nuclear steam supply system and first fuel loading and for implementing its QA program within its scope of supply. The delegated QA activities will be audited by DE and appropriate documentation will be provided by GE and its suppliers as evidence of the implementation of GE approved procedures.[2]

Sargent & Lundy

S & L's responsibilities include performing the engineering and design work required for the construction of the reactor building and its substructures. S & L is also preparing specifications and design drawings necessary for the electrical work, piping thermal stress analysis, seismic analysis, reactor building shielding, and the primary containment vessel. S & L will review and evaluate bids, check contractors' design calculations for the containment vessel, review and approve structural contractors' drawings, and review structural test reports.

S & L is required to implement a system of quality assurance including design control which satisfies the intent of DE's QA program. Their quality assurance system will be documented and approved by DE and will include requirements for the performance

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[1] Enrico Fermi Atomic Power Plant - Unit 2, Preliminary Safety Analysis Report, Appendix D

[2] Ibid.

and documentation of internal audits. DE QA in conjunction with Project Engineering, will audit S & L's compliance with their approved procedures.[1]

The QA organizational concept in the Parsons era, therefore, saw DE exhibiting direct control over most major areas of the EF2 Quality Assurance effort. DE Senior Management was involved in the QA process and separation was maintained between the construction and quality assurance functions which were desires of the AEC at that time. This organizational concept stayed largely intact until the fall of 1974 when the project was suspended for financial reasons and Parsons was removed as general contractor.

The DE corporate strategy for matters involving the AEC/NEC also emerged in this era. Largely at the direction of W. J. McCarthy, it was DE's philosophy to avoid damaging adversary confrontations with the AEC/NRC. This philosophy was consistently maintained throughout the life of the project. DE would engage in selected debate with AEC/NRC staff on design or safety issues in which the Company felt the AEC/NRC position or requirement adversely affected safe plant operation. The Company, however, was always cognizant of the impact of the final licensing authority that the NRC held.

One major project delay occured during the Parsons' era. The Company submitted the Enrico Fermi 2 PSAR and an application for a construction permit to the AEC in April 1969. Site preparations began shortly thereafter under a limited work authorization issued by the AEC in October 1970. Although prepared in a timely manner, the PSAR did not

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1 Enrico Fermi Atomic Power Plant - Unit 2, Preliminary Safety Analysis Report, Amendment 11

fully address the mode of plant cooling, i.e., closed-cycle vs. open-cycle, and the method of RHR cooling. Both these issues were still under evaluation by the Company. Processing of the construction permit by the AEC was slower than would have been if all design bases had been finalized originally. In July 1971, the U.S. Court of Appeals issued a decision involving Baltimore Gas and Electric's Calver Cliffs Plant. The ruling, in effect, said the AEC was required to evaluate both radiological factors and non-radiological factors resulting from passage of the National Environmental Protection Act (NEPA). The Fermi 2 construction permit fell victim to this ruling, as the AEC and Detroit Edison were required to renew the process and evaluate the requirements of NEPA relative to Fermi 2. The project's construction permit was issued in September 1972, some 42 months after the original application.

The financial shutdown, from July 1974 through February 1977, imposed major philosophical changes in the project organization. Parsons was replaced by the Daniel International Corporation (DIC). The hiring of DIC was a conscious shift by DE away from the Parsons general contractor/force account approach to use of DIC as a construction manager overseeing extensive use of subcontractors. The shift from the use of a relatively few major contractors to the use of several specialty subcontractors under the direction of a construction manager, changed the scope of DE's involvement in Quality Assurance. In addition, DE lost most of the QA/QC momentum and experience it had acquired over the course of the shutdown. DIC was engaged to act as the QA/QC agent for DE after the project restart. DE maintained an umbrella responsibility for QA but was, by now, down to less than ten people in the QA area. The contract[1] between between DIC and DE called for DIC to:

1. Provide QA/QC programs and procedures for the construction phase in cooperation with Edison's QA organization.
2. Perform QA/QC functions at the construction site, and in vendor shops.

DIC, as DE's QA agent, was responsible for administering site and vendor QA/QC activities including preparation, evaluation, and approval of vendor/contractor QA/QC programs, and inspection and approval of construction activities. DE's involvement was limited essentially to audit activities.

In the fall of 1979, DE senior management, Daniel and the Management Analysis Corporation (MAC) conducted an organizational review of the Enrico Fermi 2 Project. The review summarized several points of concern and ultimately led to reorganization of the project in January 1980. This reorganization ultimately ended the Daniel era with respect to quality assurance. Daniel had always been a proponent of strong utility involvement in quality assurance. It was DIC's philosophy that the utility, as licensee, be administratively in charge of QA, and have a high degree of management. Secondly, DIC recognized areas within the project where they had assumed support service without being contractually obligated to do so. All three principals in the review recognized instances where the then current organizational structure yielded layered and duplicated coverage in quality assurance and quality control.

A recommendation of the review was the integration of all quality assurance and quality control functions into the Project Quality

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[1] Contract 1A-95700, The Detroit Edison Company/Daniel International Corporation, November 20, 1974

Assurance Program under DE's direction. In January 1980, the Company became responsible for site administration of QA/QC, as well as their previous licensee responsibilities. The reorganization assimilated most of the DIC and contractor QA/QC personnel into the DE organization. Most key positions were staffed by personnel that had similar responsibilities although the organization was now a DE entity. The majority of QA and QC activities were now directed by DE with DIC supplying staff in a body shop capacity. The reorganization was carried out for several reasons. First, the NRC was continually pushing for more licensee control and involvement in quality assurance. Problems had occurred that were QA related, such as those uncovered in an internal audit of L.K. Comstock electrical activities and NRC Inspection Report 79-25. The Management Analysis Corporation, considered a leader in QA organizational evaluation, also urged strong utility involvement. In addition, duplication of effort was becoming a problem with the project having trouble distinguishing between DIC and DE QA responsibilities. The NRC was also emphasizing serious QA deficiencies at other plants in Region III.

As a result of the reorganization, DE assumed project responsibility for directing the QC activities of subcontractors on site. Most of the subcontractors working on Level I structures and equipment had internal QC programs that were previously directed by DIC. During this era, two contractors maintained QA and QC programs under DE. Certain contractors without QC programs were covered by DE QC. The organization structure of DE, the EF2 project, and DIC's QA organization at EF2 is illustrated in Appendix A of this chapter. The current organization, like its predecessors, is designed to comply with the requirements of Appendix B of 10 CFR 50. A discussion of EF2's compliance with the 18 criteria of Appendix B is contained in Chapter 17.1 of the EF2 FSAR.

The strict adherence to Quality Assurance on a nuclear project imposes significant administrative requirements and reductions in construction productivity that are not present at conventional construction projects. Engineering reviews, documentation requirements, inspection hold points, and QA-related work suspensions are a fact of life in present-day nuclear construction. Manpower levels in nuclear construction appear heavy in the non-manual area relative to conventional construction. For example, in fossil construction, each non-manual employee engaged in administration, procurement, design, inspection, and documentation typically supports two to three manual employees in the field. In nuclear construction, the reverse is often true where a multiple level of non-manuals support manual construction in the field. The difference is almost entirely the result of the added emphasis on quality assurance in nuclear construction. Given the mere existence of these ratios, resulting interface difficulties, and built-in checkpoints, construction productivity on a nuclear project is always lower relative to fossil projects.

In the first quarter of 1983, staffing levels for PQA and contractor QA/QC approached 450 people. Of this total, approximately 30 positions within PQA were filled by DE personnel. Each position represents an additional non-manual manpower requirement that is usually non-existent at fossil construction sites.

The current QA program at EF2, recognizing today's requirements, is designed to assure that:

a. Applicable regulatory criteria, codes, standards, and design bases are correctly translated into drawings, specifications, procedures, and instructions.

b. Systems, components, and materials fabricated or tested in a manufacturer's facility conform to drawings, specifications, procedures, and instructions.

c. Structures, systems, and components constructed and tested at the Fermi site conform to drawings, specifications, and procedures, and instructions.

d. Provisions are made for documenting and retaining information on quality-related activities performed on those structures, systems, and components whose satisfactory performance is necessary to meet plant safety and availabili*y objectives.

Given these objectives and the requirements of Appendix B, DE has established written procedures and policies within the project's QA manual that have been implemented during the design, procurement, manufacturing, installation, construction, inspection, and testing phases of the project to delineate:

a. The structure, responsibilities, and functions of the corporate organization relative to QA

b. The Project Management Organization established by Edison for effective management of the project

c. The project personnel responsible for certain QA functions, and to define the responsibilities, duties, and authorities of persons and organizations performing QA functions

d. The responsibilities and methods to assure that plant design is appropriately controlled in process and that its adequacy is verified and documented

e. The responsibilities and methods for evaluation and dispositioning of changes, deviations, and incidents affecting the plant configurations as defined in the approved design documents; in order to assure that such changes, deviations, and incidents are adequately controlled and do not compromise the design intent

f. The responsibilities and methods for receiving, identifying, filing, distributing, maintaining, and reporting status of project documents to assure that such documents are adequately controlled

g. The control of procurement documents to assure that requirements referenced or included therein for material, equipment, and services procured by Edison, or by its vendors and contractors, conform to the requirements of the procurement documents

h. The identification and control of material, parts, and components to assure the use or installation of only correct and accepted items

i. That the activities affecting quality be prescribed by appropriate written instructions, procedures, or drawings and are accomplished in accordance with these documents

j. That special processes are performed in accordance with qualified procedures and only by qualified personnel

k. That a program for inspection of activities affecting quality is established and executed to verify conformance to the documented instructions, procedures, and drawings prescribing a given activity

l. That a documented test program is established and implemented to demonstrate that structures, systems, and components perform satisfactorily in service

m. The control, calibration, and periodic adjustment of tools, gauges, instruments, and other measuring and test equipment used to verify conformance to established requirements

n. Controls for the handling, storage, shipping, cleaning, packaging, and preservation of material and equipment to assure the maintenance of quality from source through installation or use

o. Requirements, methods, and responsibilities for indicating inspection, test, and operating status of the plant structures, systems, and components

p. Methods of controlling items, services, or activities which do not conform to requirements

q. Methods to assure that appropriate and prompt corrective action is taken when conditions adverse to quality are identified

r. That sufficient records are provided and maintained to furnish documentary evidence of the quality of items and of those activities affecting quality

s. That a comprehensive system of planned and documented audits is carried out to verify compliance with all aspects of the QA program, and to assess the effectiveness of the program; and further, to require that management review the audit results and take necessary action to correct deficiencies.

This in a nutshell defines the responsibilities of the EF2 QA Program. The NRC being programmatic, requires that a system be designed, implemented, and consistently applied to assure compliance with Appendix B. Not only must the program be independent of construction, schedule, and economic pressures but senior management of the licensee must be directly involved as well.

5. Regulation Growth

Any project of long duration is naturally subject to events that occur over its construction life. The EF2 project is certainly no exception. The plant that DE conceptualized in 1969 is far different than the plant that exists today. Project evolution, to a degree, is a function of the stability of standards and guidelines and the translation of these standards into the physical plant. The AEC/NRC was certainly instrumental in regulation formulation, interpretation and implementation. The Staff, recognizing the timeframe of the EF2 project, undertook a review of regulation growth to identify areas where growth affected the project. The Staff did not, however, attempt to evaluate each and every regulation enacted for applicability to EF2 and its resulting economic and time impact. The Staff generally separates regulations into areas that are QA related and into areas that technically affect the physical configuration, design, and operation of the plant.

From the inception of the Atomic Energy Commission in 1954 until 1970, quality assurance requirements and the resultant plant programs were simple and informal. The AEC was content to leave construction of nuclear power plants to the utilities. What standards existed were prepared within the industry by the supplier of the system being installed.

The standards generally consisted of guidelines, specifications, and installation instructions rather than codes or standards. In 1967, problems arose during the construction of Jersey Central Power and Light Company's Oyster Creek Plant. An AEC investigation of the QA program revealed widespread problems in program organization, bookkeeping, and inspector qualifications. This, and the fact that several utilities had complained that they were being examined in the absence of any regulations, caused the AEC to finally issue QA regulations. These took the form of an appendix (Appendix B) to 10 CFR Part 50, issued on June 27, 1970. Appendix B was general in nature rather than detailing complex, specific criteria. It has been amended twice (1971 and 1975), but has changed little in substance.

From 1971 through 1977, the American National Standards Institute (ANSI) published a series of procedures or standards for compliance with the AEC's general requirements. ANSI is a standards-writing organization with formal committees for writing procedures for technical groups. For several years, these ANSI standards were accepted and applied for the industry and the AEC without formal endorsement by the AEC.

The Energy Reorganization Act of 1974 separated the research, development and promotion of peaceful uses of nuclear fission from the regulation of the private use of fissionable materials, certification, and monitoring of nuclear power plants.

The Nuclear Regulatory Commission (NRC) was established to assume the AEC's nuclear plant regulation. In 1974 and 1976, the NRC published guidance books which essentially endorsed the ANSI standards for QA during design and construction of nuclear plants. These books were respectively: Guidance on Quality Assurance Requirements During the Design and Procurement Phase of Nuclear Power Plants, the "Gray Book", and Guidance on Quality Assurance Requirements During the Construction Phase of Nuclear Power Plants, the "Green Book". This provided the NRC with enforceable regulations. Citations of non-compliance were still made against 10 CFR 50 Appendix B, but they were not made in terms of violation of the endorsed standards. Enforcement criteria were published by the AEC in 1972 and revised by the NRC in 1975, 1980, and 1982.

Prior to 1974, the AEC and NRC policy had allowed (as provided for in Appendix B) the utilities to delegate their QA responsibility to other parties, such as their general contractor; although still retaining ultimate responsibility for the proper construction and safe operation of the plants. In 1974, without any change in the regulations, the NRC began pressuring the utilities to split the QA operations from the field engineering department. The NRC reasoned that the QA departments had to have equal and independent powers relative to the design and construction departments. The QA departments could still be retained within the contractor's office, but with separate quality assurance and construction personnel.

In 1974, the NRC Regulatory Guides formalized design change procedures. Prior to this, field engineering could make changes during construction and mark such changes directly on the affected blueprints. With the formalized procedure, the field engineer could originate a design change, but prior to construction the design engineer had to approve the changes, and the drawings had to be revised to reflect the changes.

During the mid to late 1970's, the NRC found itself increasingly in the public eye. Interventions in the licensing process by various special interest groups and individuals became more common. This increased visibility brought on a stronger surveillance attitude by the NRC in its dealings with utilities. A significant increase in NRC inspection activity and resultant non-compliance citations corresponded with the 1979 initiation of the resident inspector program. Resident inspectors not only reviewed quality assurance documentation, as was the past practice, but also examined field construction, system installation, construction techniques, and construction standards.

On June 30, 1980, Public Law 96-295 amended Section 234 of the Atomic Energy Act to raise the maximum civil penalty from $5,000 to $100,000 and eliminated a provision which limited the total civil penalty payable in any 30-day period to $25,000.

This action followed a poor public perception of the NRC following the Three Mile Island event, and noticeable problems with construction at Zimmer, Nine-Mile Point and Midland.

In 1980, the NRC also began to emphasize increased involvement of licensee management in plant construction programs. No change in regulation occurred, but, particularly at sites which had recurring problems, the NRC was convinced that problems were arising because utility management was not accepting its ultimate responsibility for the plant. The NRC also pushed utility management to finally separate the QA programs from the engineering contractor, as well as assuming the QA function as part of their ultimate responsibility for plants.

In January 1983, Congress enacted Public Law 97-415; the NRC Authorization Act. Section 13 of this Act is known as the Ford Amendment. The Ford Amendment directs the NRC to study existing and alternative programs for improving the quality of construction at nuclear power plants. It also calls for a pilot program to test selected approaches.

The NRC is to report the results of its studies and recommendations for further action to Congress in April 1984.

The NRC has conducted studies of quality assurance programs for Marble Hill and Diablo Canyon. One remaining study is to be done at the South Texas Project. Also, the study of alternative plans is underway. The result of the completed study is the reorganization of the regional quality assurance functions into single offices within the region. This is similar to the NRC central office organization.

Further, the Construction Appraisal Team (CAT) inspections and Integrated Design Inspections (IDI) were developed and are now being tested. The CAT and IDI were developed to audit the industry, as well as the NRC process, to improve confidence in the quality construction and design of nuclear power plants.

The Ford Amendment also mandated the independent third-party audit concept. This program is proceeding.

Finally, within the Ford Amendment related studies, the NRC has implemented a special series of audits for plants in Near-Term Operating License status. These audits involve self-analysis by the utility, evaluation by the NRC regional office and independent design review by a consultant.

As can be seen from the discussion above, the regulations covering quality assurance aspects of nuclear power plants were not continually modified. What appeared to take place was the establishment of basic rules which remained relatively unchanged for almost 30 years followed by an increasing degree of enforcement of the regulations. The NRC changed from a passive, let-the-industry-work-out-the-details posture, to one which had the agency taking an active role in administering the regulations.

The evolution of technical standards and requirements affecting design and operation of the plant are totally dynamic. The Staff identified several instances of regulation evolution that occured during the construction of EF2. The new regulations took the form of regulatory guides, letters, bulletins, NRC orders, and appendices. These documents did not always represent new regulations; but, in some cases, more strict interpretations of existing regulations. Several of the appendices to 10 CFR 50 deal with design criteria for nuclear plants. Many of these criteria evolved over EF2's construction life. Appendix A of the EF2 FSAR lists regulatory guides applicable to EF2, their date of implementation by revision, and the EF2 method of compliance. Many new requirements spun off from Three Mile Island. The requirements and modifications at EF2 are discussed in other sections of this report. As stated earlier, the Staff did not attempt to evaluate each regulation for applicability to EF2. In most cases, the applicability question and method of compliance initiated a subjective technical debate between NRC Staff and DE Engineering. This is one instance where DE's general philosophy of non-adversary approach with the NRC came into play. In instances where DE was convinced that the proposed change improved plant safety, the Company utilized a "safety first" policy and generally complied without exception. However, in situations where DE was of the opinion that safety may be compromised, they employed a policy of selective resistance. This policy recognized the licensability of the plant when considering the effects of the change, including cost and plant operability. As a result, DE generally complied with NRC Staff interpretations and, in some cases, going beyond NRC intent while saving their fights for issues that, in their opinion, compromised safety or significantly reduced plant operability. Even in these instances, though, DE was always cognizant of the ultimate licensing authority of the NRC.

The Staff admits that this approach added to the project cost if one assumes that a strict adversary approach had an equal probability of yielding a licensable plant. However, when considering the problems of other plants of like vintage, the Staff concludes that DE's policy appears prudent given their relatively quiet enforcement and licensing history.

6. Staff Discussion

The Staff documentation review for Quality Assurance included review of 97 50.55(e) reports on 175 NRC inspection reports covering the period from the initiation of construction and continuing through September 1983. The review of these reports and subsequent DE and NRC responses was performed primarily to uncover "major" project problems in quality-related areas. Secondarily, the Staff developed a basic understanding of the NRC I & E process and how it is applied to, and affects the EF2 project. The successful application of a quality assurance program to a project of the scope of EF2 is extremely difficult, especially when the subjective determination of the program's adequacy is the responsibility of an external entity like the NRC. Nonetheless, the Staff identified areas where construction problems involving quality-related equipment and structures adversely impacted project cost. In addition, instances of programmatic and administrative difficulties with QA application necessitated re-performance of construction, inspection, and documentation activities.

As discussed earlier, the strict application of a Quality Assurance program results in loss of construction productivity relative to conventional projects. The need for engineering review, documentation preparation, and construction inspection hold points all negatively affect construction progress. The Staff recognizes the NRC position of separation of Quality Assurance from schedule and cost pressures, and thus concludes that related productivity losses are a fact of life in the nuclear construction industry. The imposition of a QA program, without a doubt, extends a project's duration. The delays incurred were not unusual in the Staff's opinion, and therefore, are not subject to disallowance.

The review of EF2 inspection and enforcement history did reveal several specific instances where construction and design problems occurred. These items, in chronological order, are summarized as follows:

1. Cracks in Reactor Building Base SLAB
   4/17/72 50.55(3) #1

   DE observed radial and circumferential cracks in the reactor base slab. The cracks required evaluation as to the effects on structural integrity and a subsequent grouting repair. The cracks did result in increased ground water seepage into containment of upwards of 8 gallons per minute. Collection and treatment through the floor drains imposed an additional treatment requirement on the plants radwaste system.

2. Buckling of the Drywell Vessel Shell
   6/13/72 50.55(e) #2

   On June 8, 1972, site contractors were making concrete placements external to the drywell vessel shell. An apparent over-pressurization of liquid concrete buckled the drywell shell. The incident required removal and replacement of the affected section of the shell.

3. Reactor Pressure Vessel Flange Distortion
8/27/73 50.55(e) #3

During ultrasonic examination of the EF2 RPV at Combustion Engineering's fabrication shop, technicians detected indications of cracking in the inlet and outlet nozzles of the vessel. The indications were subsequently removed and repaired. Following the repair, during the preparation for hydrostatic testing of the vessel, it was discovered that all the stud holes in the vessel flange did not align concentrically with the mating holes in the closure head. The distortion of the vessel flange was successfully corrected by installation of threaded stud-hole bushings on a corrected bolt circle. The distortion was apparently caused by the original repair of the nozzle indications.

4. RHR Heat Exchanger Relief Valve Deficiency
2/5/79 50.55(e) #14

On February 5, 1979 DE informed the NRC of an apparent design deficiency on two relief valves of the RHR heat exchangers. The current design did not conform to the requirements and bases of a related ASME code. The valves were designed for a relief capacity of 21,000 lb/hr when, in fact, should have been designed for a relief capacity of 150,000 - 200,000 lb/hr. The recommended fix involved the replacement of 3 valves and associated piping.

5. Wismer-Becker Quality Assurance Special Inspection
NRC Inspection Report 79-25

On December 18-21, 1979, NRC inspectors conducted a special inspection of the Wismer-Becker (W & B) Quality Assurance Program. W&B is the piping contractor for the EF2 project. The inspection uncovered several concerns about the EF2 QA program, including bypassing of inspection hold points. The NRC inspector voiced concern over the degree of management support for QA at EF2 and indicated that the "Quality Assurance Program at Fermi, as presently conducted, provides a situation for more and more allegations and will make it difficult to deal with intervenors at the licensing hearing." This report, and previous NRC investigation into allegations were partially responsible for DE's creation of the Project Quality Assurance Department in January 1980.

6. Non-Seismic HVAC Ductwork Over Safety Related Equipment
1/18/80 50.55(e) #26

On January 18, 1980, DE notified the NRC of an engineering review of Non-Seismic I items over safety related equipment. Failure of such ductwork during a seismic event could endanger operation of the safety related equipment. The ductwork in question was located in the reactor and auxiliary buildings. The fix required seismic supports for ductwork located over safety equipment or verification that the non-seismic equipment was not in close proximity to safety related equipment.

7. Audit of Electrical Testing in Startup
6/27/80 50.55(e) #20

On June 27, 1980, DE notified the NRC of significant problems in quality-related electrical testing during startup activities. The problems were uncovered by startup during a self-imposed audit. The fix required rewriting of test procedures, recalibration of test equipment, and retesting of previously completed tests. Although this event resulted in additional cost, it represents an example where the self-policing actions of project QA were performed as required.

8. CRD Penetrations Between Biological Shield and Primary Containment
5/28/81 50.55(e) #44

On May 28, 1981, DE notified Region III of questionable clearances for thermal growth with respect to Control Rod Drive penetrations in the biological shield. Reactor Controls Incorporated was involved in completing installation of the CRD lines when they noted instances where specified slopes of the CRD lines were exceeded. The fix involved removal of the existing core sleeves and refilling of the core before final installation of the CRD lines.

9. Snubber Reduction Program
5/27/82 50.55(e) #69

The requirement of seismically qualified piping and associated restraints have been an ongoing problem at EF2. The problems of non-seismic equipment over seismic equipment (50.55(e) #26), inadequate pipe clearances (50.55(e) #35), pipe support snubber design deficiencies (50.55(e) #69), and questionable QC acceptance of pipe hanger installations (50.55(e) #82) are typical of the problems encountered with piping duct, and restraints. Many of the problems are compounded by the relatively compact area within the drywell. In the instant situation an NRC Region III inspector raised concern regarding snubber installation near rigid restraints on large bore piping. It was doubtful whether adequate pipe movement could be generated during a dynamic loading event sufficient to activate the snubbers. The surrounding restraints therefore may become overloaded during such an event. the inspector also questioned the existence of certain snubbers for piping having small thermal movements. These concerns resulted in the formation of a "Snubber Reduction Program" by DE. The objective of the program was to minimize the number of snubbers used on EF2 and consequently reduce radiation exposure to maintenance personnel. The program involved computer analysis of large and small bore piping systems, identification of unnecessary snubbers, and removal and replacement of same with rigid restraints.

10. Drywell Structural Steel Load Carrying Deficiencies
8/29/82 50.55(e) #78

On August 24, 1982, DE notified NRC Region III of potential deficiencies involving the load carrying capability of certain drywell structural steel. The design in question was completed in the early 1970's. As new sources of load were defined, it became clear that re-analysis of the steel's load capability would be required. The analysis was impacted by the absence of final loading availability during the latter stages of drywell activity. The fix involved two phases of drywell steel analysis and reinforcement.

11. Control Rod Drive - Hydraulic Control Units
11/17/82 50.55(e) #80
This item is discussed in the "Preoperational Testing and Startup" chapter of this report.

12. Control of Design Change Notices
3/14/83 50.55(e) #90
Inspection Report 83-07 3/13/83

The control and documentation of changes in the construction of a nuclear plant requires a process that ensures all changes to safety related items are noted, evaluated, documented, distributed to the field, incorporated into the plant, inspected, and recognized in drafting and execution of test procedures. Failure to perform the above does not provide satisfactory assurance that the plant was designed, built, and tested within specifications. The EF2 project, beginning in 1979, experienced documentation problems in the change area. Various degrees of fixes were applied to the problem. A discussion of the historical problems and DE's commitments is contained in the above-referenced NRC report. The existence of incomplete and outdated field documentation is one factor that adversely impacted timely completion of preoperational testing and startup.

13. RHR Heat Exchanger Deficiency
4/6/83 50.55(e) #93

This item is discussed in the "Preoperational Testing "Startup" chapter of the report under E11-00 Residual Heat Removal System.

14. Emergency Diesel Generators Loose Pole Wedges
4/26/83 50.55(e) #94

This item is also discussed in the "Preoperational Testing and Startup" chapter of the report under Emergency Diesel Generators.

7. Staff Conclusions

1. The regulatory relationship between the EF2 project and the NRC has been relatively quiet, and in the Staff's opinion, positive. DE corporately advocates a non-adversary approach with the NRC and has taken an aggressive posture with the NRC only on select issues. Given the licensing and enforcement difficulties at other like-vintage plants, this policy, in the Staff's opinion, appears prudent.

2. Regulation growth in the Quality Assurance area was fairly stable. Most changes reflect escalation of enforcement philosophy by the NRC and not regulation growth.

3. Regulation growth in the technical area has been substantial and is ongoing. The Staff did not attempt to evaluate each NRC regulatory guide for specific application to Enrico Fermi 2. Detroit Edison maintains that the cost spiral at EF2 was generated by increased Federal requirements. The Staff identified the existence of these requirements. Questions still remain with respect to certain items whether DE was required to comply or did so by corporate choice. The evaluation of each guide and standard with respect to application to EF2 requires resources beyond those available to the Staff.

4. The Staff did not attempt to evaluate the effectiveness of DE's Quality Assurance Program in constructing a "safe" plant, since this is beyond the jurisdiction of the MPSC.

5. Quality Assurance imposes visible financial and administrative burdens on a project like Enrico Fermi 2. The Staff recognizes

that construction productivity is adversely impacted by QA/QC, but considers this a fact of life given the requirements of 10 CFR 50 Appendix B, and the requirements by the NRC for separation of QA/QC from cost and schedule pressures.

6. The specific items of imprudent rework, refurbishment, or re-inspection uncovered during the Quality Assurance review are combined and listed in Attachment A to the "Start-Up and Pre-Operational Testing" chapter of this report.

I. Preoperational Testing and Start-Up

1. Introduction

Preoperational testing and startup is the period in a project life when the successes and failures of other accumulated project functions come to the forefront. It is the point in time when the project management can begin verifying that all the efforts poured into design, construction, and quality assurance result in a successfully operating plant. It is also the time when problems with the same become painfully obvious. As a project function, it bridges the gap between construction and plant operation by, ideally, providing a smooth transition.

The function of startup is best summarized from the first paragraph of NRC Regulatory Guide 1.68, Initial Test Programs for Water Cooled Reactor Power Plants, which states:

> "The applicant for a construction permit or operating license is responsible for ensuring that a suitable initial (preoperational and startup) test program will be conducted for the facility. The primary objectives of a suitable program are (1) to provide additional assurance that the facility has been adequately designed and, to the extent practicable, to validate the analytical models used for predicting plant responses to anticipated transients and postulated accidents; (2) to provide assurance that construction and installation of equipment in the facility have been accomplished properly and in accordance with design; (3) to thoroughly familiarize the plant operating and technical staff with the operation of the facility; and (4) to verify, by trial use, that the facility operating and emergency procedures are adequate. Initial test programs satisfying these objectives should provide the necessary assurance that the facility can be operated in accordance with design requirements and in a manner that will not endanger the health and safety of the public."

This regulatory guide, in essence, requires that the Applicant demonstrate that his integrated efforts in designing, constructing and quality assurance were successful. Where unsuccessful, additional work involving engineering, construction, refurbishment, and testing is necessary.

Within the EF2 project, direct start-up responsibilities are assigned to the Nuclear Operations Department (NUC OPS). Detroit Edison, as the plant licensee, has elected to assume all responsibility for start-up. This position is neither unusual nor unique in the industry. At fuel load, the licensee assumes all responsibility for plant operation. The fact that few utilities now act as their own constructor necessitates a functional hands-off between construction and nuclear operations. The question becomes at what point in time does a utility assume direct project control for completing and operating a plant. The transition can vary in concept from a turn-key operation where the A/E--constructor completes construction and start-up and then transfers the plant to the utility at or near fuel load, to one in which the utility assumes responsibility for construction completion and start-up in the final stages of construction. Detroit Edison has chosen to employ the latter method for two reasons. First, valuable operating experience can be gained by having the people who will operate the plant be responsible for start-up. It provides a basic understanding of systems operation, maintenance requirements, and actual operator experience. Secondly, a point in the project is reached where it is necessary to phase out all, or most third-party corporate interests. As a project nears completion, it is often difficult for people to admit their function is complete and thereby excuse themselves. The assumption of tail-end construction activities in addition to start-up is a mechanism that aids this process.

The Staff review in this area focused on the functional transition process to gain knowledge on the interplay between major parties on the EF2 project. Secondly, the Staff's efforts were directed at identifying specific construction and design problems which must be resolved during start-up before plant operation can be achieved. The problems involve instances of rework, reconstruction, and redesign of areas of the project administration that resulted in direct additional expenditures or indirect project delay.

2. Detroit Edison Start-Up Process

The Detroit Edison Project Management Organization (PMO) has jurisdictional responsibility for systems prior to their release for acceptance by the Detroit Edison Nuclear Operations Department. (During construction, jurisdictional responsibility for a specific system resides with the assigned contractors under the direction of Daniel International Corporation (DIC), or in specific instances, the Detroit Edison Company (DE). DIC interfaces directly with the PMO through DE's Assistant Project Manager-Site Manager. Construction is a function that most people can readily identify with on any major project. Although it is not the intent of this section to detail the construction organization under DIC, it is necessary to highlight basic differences in functional responsibilities between construction and start-up.

Under the direction of the DE Site Manager, project construction is responsible for all construction activities on site, including, but not limited to, coordination of all on-site contractors, contract administration, safety administration of support services, productivity, implementation of QA/QC requirements, and project procedures preparation.[1] Also reporting to the DE Site Manager is the Bechtel Power Corporation (BPC), which is responsible for construction maintenance and refurbishment; and Detroit Edison's own System Completion Organization (SCO), which is responsible for final construction completion and interfacing with the Nuclear Operations Department during checkout and initial operation (CAIO) and preoperational (PRET) and acceptance (ACPT) phases of testing.

Construction on the Fermi 2 project is conducted on an area basis,with contractors responsible for their specific discipline within given areas of the plant. Construction is graded on the expeditious placement of massive quantities of steel, concrete, pipe, and wire, under stringent quality requirements. It is common for contractors of several different disciplines to be working on a system located in several areas of the plant.

The Enrico Fermi 2 plant has 141 major systems, most of which interface directly in some mode. Start-up is graded in simple terms on the number of systems that are successfully checked out, operated, and turned over to Nuclear Production. The transition from a bulk philosophy to a system philosophy is difficult, both in concept and practice. Ideally, a system should be essentially construction complete before preoperational testing can be effectively executed. While a system may be statistically 99.99% construction complete, omission of a critical valve, pump, or I & C equipment and wiring can severely hamper or delay successful testing. On the other hand, testing cannot be delayed until a system is 100.00% complete, since this introduces far longer delays in a project

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[1] Enrico Fermi Atomic Power Plant - Unit 2; Project Procedures Manual - Edition 2, Part 1 - Policies and Responsibilities

the size and complexity of EF2. In reality, checkout and preliminary testing of equipment and subsystems can, and should, begin in parallel with construction completion. The obvious goal is to minimize interferences and maximize the use of resources.

The preoperational and acceptance testing effort at EF2 is conducted by the Detroit Edison start-up group within the Nuclear Operations Department. Project jurisdiction for systems in preoperational and acceptance testing remains within the PMO until the final system transfer from the PMO to the Nuclear Operations Department. The start-up group is in a unique position of being situated organizationally within a department that is not yet responsible for the equipment undergoing testing. The start-up group, as a result, wears two hats; working day-to-day with the construction PMO, while being formally a part of the Nuclear Operation Department. They are cognizant of the day-to-day pressure for construction completion since the PMO cannot sign off a system until preoperational and acceptance testing is satisfactorily complete. Nuclear Production, also within the Nuclear Operations Department, is wary of systems recommended for final transfer but not, in their opinion,necessarily meeting all the requirements for final transfer. Start-up then, in addition to its normal duties, becomes the middleman in the transfer process between the PMO and Nuclear Operations. The Start-up group is a matrix organization that will functionally disappear once plant operation is achieved. It is comprised of DE personnel and employees of the General Electric Company, Stone and Webster, NUS Corporation, Bechtel, and other contract organizations as required. Start-up monitors construction progress, requests work completion on a system/subsystem or component basis, and reviews construction test results, as applicable.[1] Start-up is also responsible for writing test procedures, evaluating test results, and writing test reports applicable to the tested system. Start-up works closely with SCO even though each belongs to different DE organizations. SCO concentrates on the critical component completion needed to facilitate testing.

The testing sequence employed at EF2 involves four general phases: 1) construction, 2) check-out and initial operation (CAIO), 3) preoperational (PRET) and acceptance (ACPT) tests, and 4) start-up tests. The tests encompass the entire gamut of activities necessary to take a plant from the end of construction to full power operation. During the construction phase, tests such as hydrostatic tests, hanger and restraint checks, initial aligning of rotating equipment, initial lubrication, electrical equipment installation inspections, and instrument and control (I & C) installation checks are normally performed. These tests are normally the responsibility of the construction contractor. During this phase, system jurisdiction is retained by the applicable contractor. Transfer is achieved at a pre-agreed point in the schedule, or when the construction manager reports that construction is complete. Once transfer is achieved the responsibility for the direction of system completion is removed from the contractors and assumed by DE.

After the transfer of a system or identifiable subsystem to SCO, CAIO testing is performed by the Start-up Group. These tests normally involve initial equipment energization, flushing and cleaning, calibration of instrumentation, electrical wiring and equipment tests, valve tests, initial equipment and systems operations, and equipment

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[1] Enrico Fermi Atomic Power Plant - Unit 2; Test and Start-Up Adminstrative Procedures Manual

refurbishment and upgrading. Once these tests have been completed, analyzed, and the results approved, the system is then ready for preoperational (PRET) or acceptance (ACPT) testing. This is the final level of testing prior to the turnover of a system to NUC OPS. It involves an integrated test of system components to demonstrate that the system is fully operable and in compliance with design requirements. Most PRET/ACPT testing is performed prior to fuel load. Chapter 14 of the EF2 Final Safety Analysis Report (FSAR) lists all PRET tests and selected ACPT tests that Detroit Edison has committed to perform satisfactorily prior to fuel load and power ascension. PRET tests represent the culmination of a successful test effort during construction and CIAO, and are intended to verify that each system is ready to operate in a manner compatible with safe and efficient plant operation, and in accordance with their design basis. PRET tests must demonstrate, as closely as possible, the performance of a given system under actual operating conditions. Each test must survive a rigorous process that includes procedure development, procedure approval by the Technical Review Committee (TRC), test performance and documentation, results review and evaluation, report development, quality assurance review and, finally, performance approval of the test package by the TRC prior to a system being released for potential acceptance by the NUC OPS. ACPT are similar in nature to PRET tests except that they now involve safety related equipment. The preoperational test phase in total consists of 91 PRET and 39 ACPT tests.

Once a preoperational test on a given system is complete, including all required documentation and approvals, the system is submitted to NUC OPS for acceptance. NUC OPS will then review the system, including test documentation, system configuration, and outstanding punch list items to determine if, in fact, the system is acceptable to NUC OPS. The review includes a walkdown of the system by the responsible start-up test engineer and nuclear shift supervisor, or their designees. Once accepted by NUC OPS, responsibility for system operation, maintenance, and record retention are transferred, although resolution of outstanding or open punch list items are still the responsibility of SCO. The Superintendent - Nuclear Production is ultimately responsible for accepting or rejecting a system. If a system is rejected, it remains under the jurisdiction of the PMO until the reasons for rejection are resolved.

The plant start-up test phase commences with preparations for initial fuel load, continues through power ascension, and concludes with the 100 consecutive-hour, 100-percent full-load warranty run. Fuel load can take place only after the required PRET tests have been completed and approved by the Technical Review Committee, the appropriate systems transfered to the NUC OPS, approval of both the Technical Review Committee and Augmented Onsite Review Committee has been obtained, plant security and access controls established, and approval from the NRC through receipt of the operating license has been obtained. Once fuel load has been accomplished and the remaining PRET completed, a set of integrated plant start-up tests are performed to verify the performance of the 141 major plant systems under actual operating conditions, and interrelated system performance and overall reactor and plant operation and control. The start-up test phase confirms that the plant operates safely within design limits. Systems and components which could not fully be checked out in the preoperational test phase are tested at specific pressures, temperatures, and flows. A series of simulated transients, trips, and conditions are introduced as required to check and verify full system operation and response. The start-up test phase is divided into four plateaus; 1) pre-fuel load, initial fuel load, and open vessel testing, 2) heatup and test condition 1; 3) test conditions 2 and 3; and 4) test conditions 4 through 6, including warranty run. The test conditions represent successive levels of reactor output. Since the majority of the start-up tests are conducted with a fully loaded reactor, it is an NRC requirement that most of the test operations be performed with licensed plant operators. The Lead Startup Test Phase Engineer within the Startup group is responsible for preparation and performance of the start test phase procedures, including detailed test planning and scheduling, the performance of the test procedures, data analysis, and generation of required test reports. After the start-up test procedures are written, they require approval by the Augmented On-Site Review Committee. Final acceptance of the procedure is given by the Superintendent-Nuclear Production. The Startup Test Phase Engineer has primary responsibility for completion of the test. Close coordination is required with the Nuclear Shift Supervisor, given his direct responsibility for overall safety and operation of the plant. During performance of a test, the Nuclear Shift Supervisor will direct all plant operations through the plant operators. A description of the start-up test phase and related tests is also contained in Chapter 14 of the EF2 FSAR.

The six-level test condition format for reactor power ascension used at EF2 is a standard GE test program used for GE boiling water reactors of EF2 vintage. DE, at the time of Staff review, had scheduled a 364-day period from the initiation of fuel load through the completion of the warranty run. The actual time through the completion warranty run will vary, depending on the degree of problems encountered during start-up. DE's schedule, however, is representative of the experience of other BWR owners.

One final organization impacting testing progress is Operational Assurance. As a section of Project Quality Assurance, it is responsible for plant operation QA activities, beginning with CAIO and continuing through the warranty run. Quality Assurance is a continuous, ever-present requirement that begins during project inception and continues through the end of a plant's operating life.

3. Staff Approach

General site interviews and documentation reviews indicated that the start-up process was behind relative to current project schedules. Project Control Trend Reports that were issued during the period Staff was onsite indicated that completion of testing activities and turnovers of systems to NUC OPS were consistently below the level necessary to meet a projected fuel load date of December 1983. (This was later revised to June 1984.) Furthermore, the Staff developed an impression that the progress trends associated with these reports were deteriorating. The Staff, therefore, concluded that a review and determination of the causative factors was in order. The Staff benefited from the fact that start-up was the current critical function ongoing at the project at the time of the review. It was possible to observe first-hand interfaces between project organizations involved to develop an understanding of the magnitude of events both within and out of DE's direct control that impacted start-up and the EF2 Project. Secondly, start-up generated a documented history of events for each major system in the plant. Review of selected segments of this information provided insight into major design and construction problems encountered over the project history.

Individuals interviewed included the Manager-Nuclear Operations, who was also serving as Start-up Manager, Director of the Systems Completion Organization, Superintendent of Enrico Fermi 2, the General Electric-Project Manager, and Project Manager of Stone and Webster. The Staff also conducted an extensive document review that included: 1) Project Manager's Monthly Reports; 2) Monthly Project Schedule Analysis Reports; 3) the EF-2 FSAR; 4) P.M.O. Meeting Minutes; 5) Technical Review Committee Minutes; 6) Start-up and SCO Manuals; and 7) System start-up files within the Start-up Information Resource Center.

The results of the Staff review are summarized into two general categories. Problems contributing to project delay are highlighted and discussed. Since start-up is but one function of the project, it is difficult to attribute specific incremenents of project delay to start-up alone. Many factors may delay preoperational or start-up testing, but not impact the project critical path. In addition, problems outside the start-up area involving engineering, procurement, construction or quality assurance may delay testing. For this reason factors delaying start-up progress are discussed, but evaluation of the financial impact of total project delay is left to other chapters of this report. Secondly, the review uncovered specific reconstruction, refurbishment, or design changes that, in the Staff s opinion, are imprudent from a ratemaking standpoint. These items are highlighted in detail within the body of this chapter.

4. Staff Discussion Of Testing

The Start-up organization for the Enrico Fermi 2 Project has been in existence since April 1973. Administratively, it has always been an entity of DE. By intent, this would provide DE the opportunity of obtaining first-hand start-up and operating experience and demonstrate to the NRC that they can successfully start-up and operate the plant. DE also felt that their start-up experience at Monroe and Trenton Channel would prove beneficial, even though EF2 was DE's only nuclear unit since their lead involvement in the experimental Enrico Fermi 1 project in the early 1960's.

The Start-up organization was disbanded during the 27-month financial shutdown in the mid-1970's. The organization was re-established in March of 1977 at the time of project reactivation.

Start-up efforts in 1977 and 1978 primarily centered on organizational staffing, preparation of system boundary packages, initial development of functional system descriptions and material identification lists, original drafting of the start-up manual, training, and preparation of test procedures. The project schedule during this period envisioned a fuel load date of January 1, 1980. The fuel load date was subsequently pushed back six months in September 1978 for reasons unrelated to start-up.

In late 1978, the initial transfer of components and systems began, followed shortly by CAIO testing. The transfer process, prior to the creation of SCO in November 1981, involved the direct transfer of systems from DIC's System Completion and Turnover Group to DE's Start-up Group. The effectiveness of this transition process evolved into a major problem, ultimately leading to creation of DE's SCO. From the onset, the transfer of systems and equipment were at a rate less than adequate to meet the official projected fuel load dates. DIC experienced difficulty in turning over complete systems and critical equipment in the order and in the condition needed to meet testing schedules. This was later compounded by the Three Mile Island incident in March 1979, which left the project in a complete vacuum with respect to scheduling and licensing. The project schedule was almost immediately bumped one year, even though the exact scope of post-TMI requirements was unknown. Through mid-year of 1979, only 128 of the scheduled 170 construction turnovers necessary to meet the fuel load schedule had been accepted for preoperational testing. Start-up attributed CAIO testing delays to: (1) no QA level 1 turnovers for preoperational testing being turned over; (2) support systems required not being turned over in the order requested and required; (3) punchlist items on turned-over systems are not being cleared in a timely manner; (4) greater than anticipated equipment problems; and (5) rework on turned-over systems, due to incomplete or defective construction.[1] Item (5) will be discussed in the next section of this chapter. Problems of this nature continued in various degrees throughout the entire test effort.

DIC responded by reorganizing its System Completion Group. A total of four reorganizations were implemented by DIC prior to the creation of SCO in 1981. Other program modifications included the subscoping or breaking down of major systems, thus allowing partial turnover of systems and the elimination of a requirement that previously necessitated the completion of all construction documentation prior to system transfer. The second modification permitted CAIO testing of near physically -

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[1] Enrico Fermi 2 Power Plant Monthly Report - April 1979

complete subscopes in parallel with the completion of necessary construction documentation and signoffs.

DIC, although responsible for construction and system completion, was impacted significantly by project problems during this period. A multitude of design changes, procurement difficulties involving spare parts, and, according to Daniel, shortage of manual crafts due to budget limitations slowed DIC's construction process.

While the events at TMI cast substantial doubt on the timing of EF2 completion and the NRC licensing process, the EF2 project continued to operate under a build-as-is directive until the impact of TMI was fully defined. In January 1980, the Project Management Organization agreed that design and construction of the base plant should continue as originally planned, except where specifically directed to incorporate changes resulting from TMI. An additional six-month delay was assumed in budget preparation, although a revised schedule was not released until August 1980. The official revision pushed back the projected fuel load date by 18 months to November 1982.

The EF2 Project was reorganized in January 1980. The reorganization resulted from a joint project evaluation by DE Senior Management, D , and the Management Analysis Corporation in late 1979. DE assumed direct administrative control over quality assurance, project controls, specific contract administration, and document control. The format of the transfer process between DIC and DE remained temporarily unchanged. DE also assigned the Project Manager to the EF2 site on a full-time basis. The push to punchout the plant on a system-by-system basis and the reorganization, resulted in the joint development of integrated Level II and Level III schedules by Start-up and Project Controls. A DE field engineering group was established in April 1980, to assist in the prompt resolution of design deviations and deficiencies, and improve communication between the site and offsite engineering groups. The development of integrated schedules merged many separate functional schedules under one project schedule. The biggest impact occured in the engineering areas, where engineering schedules were now formally integrated with construction and start-up schedules. Engineering was also assigned via a matrix concept to the Project Management Organization. The schedule integration, administrative realignment of engineering, and a full-time onsite project manager greatly improved project coordination. Functional project problems involving engineering, construction, and preoperational testing were the point responsibility of the EF2 Project Manager. Resolution of such problems became more manageable from an administrative standpoint. The reorganization, however, did not address jurisdictional disputes between the PMO and Nuclear Operations. There still was no one onsite with authority to mediate concern between these two DE organizations.

The Bechtel Power Corporation was also brought onto the project in early 1980 to act as a maintenance contractor. DE management had decided that it would be beneficial to have a contractor of Bechtel's ability available for maintenance services once EF2 became commercial. Bechtel would be able to provide experienced assistance during scheduled outages when manpower requirements for maintenance are high. The contract between DE and BPC provided for support in the maintenance, procurement, and start-up areas. The contract was later expanded when equipment refurbishment and reconstruction requirements escalated. Bechtel became the logical contractor given the fact that equipment refurbishments is, for all practical purposes, a maintenance function. Bechtel's duties were further expanded to include electrical completion activity and modification of the radwaste building.

The Staff is of the opinion that DIC, in its role as a construction manager, emphasized bulk construction completion, given the resources available. Project completion on a statistical basis, as a result, continued to show progress. This did little, however, to satisfy the emerging need for resolution of punch list items necessary to provide essentially construction-complete systems for testing. DIC's attempts to improve system completion emphasis yielded less than desirable results from DE's perspective. As a result, start-up, in their view, operated in a constrained mode, never fully receiving systems when or in the condition required. Start-up during the period never received or accepted sufficient systems or components to be pressured by testing work loads. DIC responded that untimely deliveries were the result of shortages of craft, lack of refurbishment parts and materials, late engineering changes, and an apparent lack of DE aggresiveness in the preoperational testing area to drive systems or equipment into the testing mode.

The 1979-1980 period was one of lean financial resources for the EF2 Project. Budgets were constrained and much effort was expended to stay within authorized limits and, in certain instances, reducing expenditures. Engineering was also a problem for DIC. In the pre-TMI period, normal resolution of engineering changes prompted by regulatory requirements adversely impacted construction schedules. Many of the changes, such as in the hanger area, made it difficult to meet schedules. This, coupled with the post TMI engineering crunch, substantially changed the project scope and diverted necessary resources. In retrospect, the turnover process was a particularly painful area. The commitment to system completion was never successfully accomplished. TMI, the major cause of schedule delay in this period, provided time relief although necessitating major project scope changes. Even absent TMI, it is doubtful whether the schedules that existed in the pre-TMI era would have been met given the constrained resources, high level of engineering changes, reconstruction requirements, DIC's emphasis on bulk construction, and DE's lack of aggressiveness.

In 1981, project conditions improved with the clarification of post-TMI requirements. Testing difficulties, however, continued to impact the project. By late summer, the project was lagging some 5 months behind the official fuel load date of November 1982. The Start-up group issued a report on October 27, 1981 reviewing the ongoing CAIO process and identifying problems that were impacting the start-up progress. The problems, in the Staff's opinion, were consistent with those encountered throughout the testing program. The report analyzed generic causes of delay for three specific systems. The three systems in question were the Residual Heat Removal System (E11-00), Core Spray System (E21-00), and Fuel Pool Cooling and Cleanup System (G41-00). The report summarized the problems as follows:

"III. General CAIO Problems

In reviewing the causes for delays of E11-00, E21-00 and G41-00, several problems affect more than one system, indicating the problems may be generic (i.e., not being able to obtain a work or QC copy of a pull card to make wiring changes). Discussed below are five (5) problems which have been identified as being significant:

1. Systems are turned over to Startup for CAIO before they are ready for testing. When systems with extensive lists of Category Code II items are turned over, the completion of this work must be performed during the CAIO phase. This adds to the paperwork and tracking required by the STE, and often delays testing until the work is completed.

2. The Startup Test Engineer (STE) does not have an efficient means of clearing Category Code II and RRR items that may impact testing. Once a PN21 is issued to have work done, work is scheduled by someone other than the STE, in priority with all other construction work. It is ineffective for the STE to be responsible for completing Category Code II or RRR work if he cannot schedule when the work will be done.

3. Design changes impact the Startup CAIO schedule by delaying the start of testing until the changes are incorporated, adding to the amount of testing to be performed; and causing retesting of previously completed procedures. The engineering paperwork and approval, procurement (if necessary), and construction involved in a change is time-consuming. Approximately 30,000 actual design changes have been issued for the job, a portion of which directly affect CAIO. Each design change has been revised, on the average, two or three times, so that, conservatively, 60,000 to 70,000 design revisions have been published. Since January, 1981, design changes have been issued at a rate of about 1000 per month. Design changes not finalized prior to Turnover significantly impact the CAIO schedule by delaying all following activities.

4. A problem that does not actually impact CAIO procedures, but does affect the CAIO schedule, is that the scheduled durations are based on the following assumptions:

   a. All Forms 7.8 are written for a system beforehand, so testing can begin immediately.

   b. No time is allowed for Category Code II or RRR work to be done during CAIO.

   c. Paperwork and approval will not delay CAIO critical path.

   d. The schedule durations are only for calibrating and testing.

   Most important is item (b.) above, because rarely is a system's CAIO completed without some rework and/or retesting.

5. The paperwork process required to initiate and complete all testing is cumbersome and is not conducive to supporting the schedule.

In addition to the problems just discussed, the following additional problems were noted:

a. Startup Test Engineers need to be more attentive to punchlisting post-turnover design changes and incorporating them into their systems. Of approximately 3100 post-turnover design changes that have been distributed by Configuration Control since 3/31/81, about 1000 have been punchlisted, and about 360 have been completed.

b. Spare parts inventory is insufficient (i.e., high failure rate items such as overload relays).

c. Personnel turnover in Startup, and the reassigning of responsibility for systems, causes a discontinuity in completing CAIO.

d. Retesting and recalibrating of components impacts the scheduled CAIO duration. Some of the causes of retesting and recalibrating are: 1. Design change work after testing; 2. Repair work after testing; 3. Repair work to other components of system; 4. Removing instruments which invalidates calibration; 5. Manufacturer supplied vendor documentation data is sometimes insufficient.[1]

The report made the following recommendations:

IV. <u>Recommendations</u>

1. A dedicated effort by Engineering is required to resolve all design changes, especially those identified in the later construction and testing phases, to minimize the impact to Startup.

2. Construction should clear all Category Code II and RRR items in the priority given by Startup.

3. Startup should review their procedures and corresponding paperwork in an effort to streamline and expedite their testing program.

4. Startup should more actively participate in early CAIO testing.

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[1] DE Memo Walker to Noetzel F2581-2910, Checkout and Initial Operation Evaluation Report, October 27, 1981

5. Startup should prioritize the Category Code II items by milestone (Flush, CAIO, RPV Hydro, Type "A" Turnover) prior to Turnover.

6. Startup should identify which punch list items require an outage.

7. Startup Test Engineers should be prepared to initiate testing as soon as possible by having all 7.8's, PN21's, and other paperwork available prior to the (5) start of CAIO."

The report and recommendations not only illustrate the nature of the problems involved in the startup process, but also demonstrate the complexity of performing preoperational and start-up testing for a nuclear project in this day and age. While the Staff's primary efforts were directed in delineating problems with the Start-up process, recognition is given here that the job at hand was difficult at best. Conflicts on a job of this size and complexity, and involving the various project groups, was inevitable. In many cases, the conflicts were positive in forcing project changes.

In 1981, DE further reorganized the EF2 Project by assigning a new Assistant Manager of Nuclear Operations in charge of Start-up Testing (in January 1981) and creating the System Completion Organization within the PMO in October 1981. DE also assigned a Vice President to the site full time. The existence of a corporate Vice President onsite aided in the resolution of project problems requiring senior decision-making authority, and also provided site resolution of many internal DE problems involving the PMO and Nuclear Operations. As previously described, the SCO was intended to optimize the transfer process by providing a DE intermediary that was responsible for construction completion on a system basis, and secondarily, easing the transfer of systems since the process now involved two DE organizations. A further benefit of SCO resulted from the fact that, at the point of official jurisdictional transfer, a system walkdown was performed to identify any outstanding system deficiencies. These items were construction punchlisted which were, in turn, incorporated into a master integrated punch list. This punch list represented the first accurate project indication of work remaining on a system basis. SCO experienced initial success in improving transfers; however, as their scope was expanded to encompass more systems, SCO, like DIC's System Completion- Turnover Group, became bogged down. The SCO was now responsible for ensuring that:

1. The intent of all quality-related requirements are complied with.

2. Planning and scheduling activities meet organization objectives.

3. Startup testing proceeds with priority.

4. Unified Punch list or Punch List Cards (PLC's) are issued.

5. Paperwork and technical reviews are done.

6. Repair Rework Requests (RRR's) are completed.

7. Refurbishment is initiated as required.

8. Systems are suitable for transfer to Nuclear Production.

9. System Completion Engineers are monitored to meet organization objectives.

10. New DCP's are implemented and completed.

11. Construction support is provided to start-up as required.

12. Hydro's and punch list items are completed on transferred systems.

13. Configuration control is maintained.

14. Planning schedules are implemented.[1]

The responsibility for timely and orderly system completion was now on DE's back. Actual completion work under SCO's direction was performed by Bechtel, DE Construction, and remaining site contractors. While turnover rates and CAIO testing progress improved significantly in 1982, actual performance was still at a rate less than necessary to meet the scheduled November 1982 fuel load. Punch list items were increasing at a rate faster than they were being cleared. PRET testing was being impacted by SCO's inability to complete hydrostatic tests, lack of craft support, failure to complete DCP work, and the overloading of certain System Completion Engineers.[2] By mid year, it was apparent that the November 1982 fuel load was unreachable. Testing progress through July 1982 was as follows:

<u>CAIO Testing Status</u>

1. Electrical group is scheduled to have 95% CAIO testing completed; presently 70% is complete.

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[1] Enrico Fermi Atomic Power Plant - Unit 2; System Completion Organization Procedures Manual

[2] Enrico Fermi 2 Power Plant Monthly Report - April 1982

2. I & C group is scheduled to have 50% CAIO testing completed; presently 29.2% is completed.

3. BOP I group is scheduled to have 64% CAIO testing completed; presently 54.7% is completed.

4. BOP II group is scheduled to have 97.3% CAIO testing completed; presently 39.7% is completed.

5. NSSS group is scheduled to have 85.1% CAIO testing completed; presently 43.4% is completed.

Preoperational Test Phase

1. Electrical group is scheduled to have 14.9% PREOP/ACPT testing completed; presently 14% is completed.

2. I & C group is scheduled to have 0% PREOP/ACPT testing completed; presently 0% is completed.

3. BOP I group is scheduled to have 50% PREOP/ACPT testing completed; presently 13% is completed.

4. BOP II group is scheduled to have 74.1% PREOP/ACPT testing completed; presently 9.5% is completed.

5. NSSS group is scheduled to have 54.4% PREOP/ACPT testing completed; presently 1.6% is completed.

In August of 1982 the projected fuel load date was rescheduled to June 1983. While start-up was by no means the sole reason for the extension, delays in testing were contributory. Through 1982, approximately

22,000 punch list items were closed and another 8,000, on the average, remained open. While CAIO continued, although somewhat impacted, specific equipment problems and new issues impacted PRET/ACPT testing. Design, rework and refurbishment problems discovered during CAIO also delayed PRET/ACPT testing. Specific examples included vibration of the RHR system and core spray lines, core spray and CRD pump motor rebuilds, HCU/CRD accumulator refurbishments, HPCI & RCIC turbine alignments, emergency diesel generator modifications and re-wedging, hanger resolutions, motor operated valve rework/refurbishment, and electrical retesting, due to test revisions or rework of equipment. Examples of new issues or engineering concerns impacting PRET/ACPT testing include modifications for 10 CFR 50 Appendix R cable separation requirements, Phase I & II drywell structural steel analysis and modifications, torus attached piping modifications, RHR steam condensing mode elimination, and IHSI pipe modifications.

Completion of PRET/ACPT tests, preparation of test packages, and approval by the Technical Review Committee makes a system eligible for transfer to Nuclear Operations. Prior to this point, however, all activities involving a specific system such as testing, results and test documentation, QA approval, equipment identification and deficiency identification must converge. Nuclear Production, a department within the Nuclear Operations Department, reviews the entire system package for acceptability. Once accepted, Nuclear Production then assumes jurisdictional responsibility for the system. Few systems were being accepted by Nuclear Production during the period of the Staff review. From February 27, 1983 through August 9, 1983, only four systems were turned over. From April 29, 1983 through August 9, 1983, no systems were turned over.

While the wave of testing responsibility still remained within Start-up, continuation of this trend could seriously impact fuel load. While the initial turnover involved a corporate jurisdictional transfer between the contractor and DE-PMO, the second turnover involves an internal DE transfer between the PMO and the Nuclear Production Department. While the second turnover appears to be a mere formality on the surface, since corporate responsibility remains within DE, strong and valid organizational concerns exist between the two entities. The PMO is a temporary organization entrusted with the responsibility of constructing the plant. Once the plant is satisfactorily completed, the PMO for EF2 will cease to exist. On the other hand, Nuclear Production will be responsible for the safe, reliable. and efficient operation of the plant for its 35-40 year life. Although the PMO is concious of the need to build a safe plant, daily pressures exist to complete the plant and show progress. The PMO can get caught in the same construction-completion trap previously experienced by DIC. On the other hand, Nuclear Production must live with the plant through its entire operating life. They, therefore, want design, construction, and preoperational test demonstration done correctly the first time. This leads to the inevitable question of "how good is good enough?" This question must ultimately be addressed at the final point of transfer for each plant system. The resolution follows much debate as the system test criteria, test results, and outstanding punch list items are evaluated by both DE organizations.

The Staff reviewed some of the factors resulting in this bottleneck. Arguments ranged from criticism of Nuclear Production for wanting a perfect plant and fear of assuming responsibility, to criticism of the PMO for concern only with construction schedules and attempting to turn over inoperable systems. This final turnover involves a degree of compromise between the organizations to be timely-accomplished. Start-up must assure that each system PRET was performed, test results within specification, all paperwork finalized, exceptions to tests noted, outstanding punch list items noted, and that the system will operate within design limits. Nuclear Production, on the other hand, receives this package and evaluates it to determine if, in fact, they are receiving a safe and reliable system with appropriate documentation; and whether the PRET test was, in fact, successful. In few instances do they receive a totally complete system. Open punch list items are transferred with the system. Nuclear Production must determine whether these items violate the intent of the PRET test requirements. Another factor affecting the transfer is the mechanism for resolution of punch list items once transfer is accomplished. Actual physical resolution of punch list items is performed by the SCO. The SCO, in straddling both sides of the fence, however, appeared to have dedicated stronger efforts towards eliminating punch list items restricting CAIO and PRET testing, since the bow wave of systems were in this mode of testing. Consequently, Nuclear Production would prefer that a system remain under the PMO until open items were cleared, given their experience with resolution of open items once a system was accepted. This condition could change in the future when SCO clears restraints to CAIO and PRET testings and changes emphasis to open items of systems transferred to Nuclear Production.

A second factor delaying transfers is that, during the period of the Staff review, turnover to and acceptance by Nuclear Production was in its genesis. Nuclear Production, therefore, took more time reviewing the initial packages to develop ground rules and confidence in the quality of packages being turned over. Documentation reviews of test packages and quality assurance signoffs were also taking longer than anticipated.

This last transfer point represented an exposure to project delay rather than an area of realized delay at the time of Staff review. As more and more systems become eligible for transfer, problems causing the bottleneck must be resolved. If improvement is not made, visible delay to start-up testing will be incurred. On the other hand, Nuclear Production must receive operable systems, since the presence of system deficiencies could create licensing problems, fuel load delays and prolong power ascension. The Staff did detect, in early periods of this review, reluctance by Nuclear Operations to drive or push the project by agressively requiring system transfer, much in the way start-up appeared reluctant to drive construction testing in the early stages of checkout and initial operation testing. This can be attributed partially to DE's lack of experience in the nuclear industry. In the Staff's opinion, given DE's position on the learning curve relative to nuclear operating experience, caution was the rule in Preoperational and Start-up testing.

5. Rework - Refurbishment

The final area having direct influence on testing progress is refurbishment and rework of delivered and installed equipment. The progress of testing can be adversly affected when the degree of refurbishment and rework discovered during testing is larger than anticipated. Delays result when time is required to return equipment to a testable and operable condition. Secondly, rework/refurbishment present a ratemaking regulatory concern when a ratepayer is asked to pay for a service or equipment twice. Without strong justification to the contrary, rework/refurbishment, from a regulator's perspective, represents an area ripe for determining imprudency. As discussed earlier in this chapter, rework/refurbishment was one factor that negatively influenced the testing schedule. The Staff noted numerous instances where problems involving rework encountered during start-up adversely impacted testing progress. The Staff is of the opinion that the degree and severity of rework encountered at EF2 during testing was both surprising and frustrating to the PMO. The testing schedules contained little or no contingency for rework/refurbishment. The problem was further compounded by difficulties in obtaining spare parts once the need for rework/refurbishment was established. A case in point is the refurbishment for Limitorque Controllers on motor operated valves. Whether or not individual delays in testing actually delayed project completion is debatable. The testing process is but one critical path to project completion. The financial impact of testing delays will not be fully known until all other project critical paths are defined, resolved, and the impact evaluated. Aside from delay, the Staff identified and documented specific instances where, in the Staff's opinion, rework/refurbishment added to project cost unnecessarily and, therefore, was imprudent.

Before enumerating specific areas of rework/refurbishment, it is necessary to define the Staff's ground rules for determining imprudency. The EF2 project has experienced three major construction delays. The first occurred in the early 1970's when the project's construction permit was delayed because of the Calvert Cliff's decision. The second delay occurred from October 1974 to January 1977 when the project was shut down for financial considerations. The third delay resulted from the events at Three Mile Island and, even though site construction continued, ultimate completion of the project was delayed. Partially as a result of these factors, the cumulative project duration has exceeded the expectations of all involved with the construction of EF2. Much of the major equipment and components were ordered to meet the original commercial operation date of February 1974. Delays impacting project schedules imposed new requirements on DE for this equipment, such as delivery deferral, equipment storage and layup, and prudent maintenance practices once the equipment was delivered or installed. In some cases, as in Limitorque, new codes and standards rendered original equipment obsolete. DE is, and was, responsible for preserving the equipment once in their possession. Costs associated with improperly performing the above, therefore, from a regulatory view, are imprudent. The Staff is of the opinion that if the causes for delay are beyond DE's direct control, reasonable costs associated with maintaining such equipment are prudent. In addition, specific refurbishment that was performed as a condition of extending equipment warranties, such as on specific components of the Nuclear Steam Supply System, in the Staff's opinion, are also prudent. However, in situations where costs were incurred because of maintenance and storage neglect, defective construction, or engineering error and indecision, the Staff has no recourse but to recommend disallowance. The following is a summary of major items discovered by the Staff:

P41-00 General Service Water System

The General Service Water System (GSW) is designed to remove heat from the reactor building and turbine building closed-cooling water loops, and selected emergency equipment, in order to maintain proper equipment temperatures during changing ambient conditions and plant operating modes. The GSW system also provides the source of water for the plant fire protection system and is a source of makeup water for the RHR complex. The once-through GSW discharges into the stations circulating water system (CWS), where its heat load is rejected into the two natural draft cooling towers, thus serving as a source of cooling tower makeup. During CAIO testing of the GSW, several areas of concern were discovered. These concerns involved the design, construction, maintenance, testing, and documentation of the system's major components. The components affected included the pumps, backwash strainers, pressure control valves, header relief valves, pressure transmitter, test line, major valves, trash rake, and instrumentation.[1] The problems uncovered eventually led to change of design concept, rework of pumps, valves, and piping configurations, plus additional testing.

P42-000 Reactor Building Closed-Cooling Water System

The reactor building closed-cooling water system (RBCCW) is designed to transfer heat from reactor auxiliary equipment to the GSW to maintain proper equipment temperatures, considering variations in service water temperatures and plant operating conditions. The RBCCW consists of three 50%-capacity pumps and associated motors, two 100%-capacity heat exchangers, PME makeup tank, and related piping, valves, instrumentation and controls.

In May and June of 1981, start-up discovered leaks in the two heat exchangers of the RBCCW. Subsequent analysis revealed that the leaking was caused by ammonia-induced stress corrosion to the admiralty brass tubes within the heat exchangers. The presence of the ammonia in the heat exchangers was attributed to the improper storage of the heat

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[1] DE Memo Odden to Arora SU-7422
July 23, 1981

exchangers when in service.[1] The storage problem evidently occured because of a breakdown in communication between the project and start-up, resulting in failure to drain the heat exchangers when not in use. The heat exchangers were subsequently retubed with 304L stainless steel tube material.

P43-00 Turbine Building Closed-Cooling Water System

The turbine building closed-cooling water system (TBCCW) removes heat from the turbine accessories and auxiliary equipment located in the turbine and radwaste buildings. The TBCCW consists of three 50%-capacity pumps which circulate water through one of two 100%-capacity heat exchangers. One circulating water pump and one heat exchanger are provided for standby. After the discovery of cracking in the RBCCWS heat exchangers, an examination was performed to determine the condition of the heat exchangers for the TBCCWS. Analysis revealed similar ammonia-induced stress corrosion resulting in plugging of degraded tubes.

B21-00 Main Steam Isolation Valves

In a direct-cycle nuclear power plant, the reactor steam goes to the turbine and other equipment outside reactor containments. All pipelines that penetrate primary containment and have a potential release path for radioactive material are provided with redundant isolation capability. The main steam lines, given their large size and mass flow rates, are given special consideration. Automatic isolation valves immediately inside and outside primary containment provide main steam line isolation capability. The main steam isolation valves (MSIV) also aid in preventing

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[1] DE Memo Devine to File P42 SU-7958
November 11, 1981

damage to the reactor by limiting the loss of reactor coolant in the event of a major steam pipe breaking outside of primary containment.

As a part of the NSSS refurbishment program, the eight air-operated MSIV's were refurbished to return the valves to an "as-shipped" condition. Refurbishment required an initial inspection and replacement or renewal of parts found to be deficient. In this particular case, the scope of refurbishment included the replacement of six valve stems that were found with gouges and pitting corrosion, the recoating of all air cyclinder inner surfaces, the replacement of the hydraulic speed control system due to the absence of spare parts for the original system, valve seat grinding and polishing, the replacement of consumable gaskets and packings for the valve operator and main valve, and the removal of corrosion and debris within the main steam lines.

B31-00 Reactor Recirculation System

The Reactor Recirculation System (RRS) pumps reactor coolant through the core to remove energy generated in the fuel. This is accomplished by two recirculation loops external to the reactor pressure vessel (RPV), but inside primary containment. Each loop has one motor-driven recirculation pump. The recirculation pump speed can be varied to allow control of reactor power level though the effects of coolant flow rate on moderator void content. The pump motors are powered by individual, electrically-driven, variable-frequency, motor-generator (MG) sets. Each set consists of a constant-speed, 9,000 hp motor, a fluid-drive system, and an electrical generator.

The RRS pump motors and MG sets were refurbished as a necessary condition for placement of GE equipment under warranty coverage. After refurbishment, the MG set-drive motor "B" was run on September 11 and

September 16, 1982, at which time it failed at 75% of the no-load RPM. The motor was subsequently reworked in Chicago and placed back under warranty after rework and performance of the flow-induced vibration testing. DE, at the time of Staff review, had submitted a claim against GE which GE. countered with a shared-cost resolution.

C11-50 Control Rod Drive Hydraulic System

When a scram is initiated by the reactor pressure system, the Control Rod Drive (CRD) system inserts the negative reactivity necessary to shut down the reactor. Each rod is individually controlled by a hydraulic control unit (HCU). When a scram signal is received, high-pressure water stored in an accumulator in the HCU forces its control rod into the core. The 185 CRD-HCU's were to be refurbished under the conditions of the GE warranty extension. DE started refurbishment in 1982 by replacing gaskets, O-rings, and seals for which shelf life had expired. During refurbishment, DE noted certain accumulators contained water and internal surface discoloration, pitting, blistering, and flaking. A subsequent GE invoice for the additional refurbishment was rejected by DE. A GE analysis indicated corrosion damage due to an oxygenated water/moisture environment over an extended period as the likely cause. The units had been in a stored or in stanby mode at the site for eleven years prior to discovery of the corrosion. GE further contended a chemical spill at EF2 as the cause, and questioned the need for additional refurbishment.[1] At the time of the Staff review, DE and GE were still in dispute over this claim.

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[1] GE Letter Johnson to Seibert TOEC-4494
May 11, 1981

The high-pressure water in each hydraulic control unit accumulator is provided by one of two 100%-capacity CRD water pumps with motors. These pumps were ordered by DE in 1968. They were delivered to the site and installed in 1971. Under the terms of the GE-DE Warranty Agreement, both pumps required refurbishment prior to extension of their warranty. Following refurbishment during CAIO testing, start-up discovered that both the A and B pumps seized up periodically following operation. The B pump was returned to the vendor for modification to the pump shaft and pump internals. During shop testing, the pump failed to provide adequate pumping head thus necessitating further modification. The A pump was subsequently modified by maintenance at the site.

E11-00 Residual Heat Removal System

The Residual Heat Removal System (ORHR) consists of pumps, heat exchangers, and piping that fulfill the following functions:

a) Remove decay heat during and after plant shutdown.

b Remove heat from the primary containment following a loss of coolant accident. (LOCA)

The system restores, and maintains, if necessary, the water level in the reactor vessel after a LOCA so that core is sufficiently cooled to prevent fuel cladding. The system also removes decay heat and the heat from the reactor primary system during shutdown so that the reactor can be refueled and serviced. In addition, the system cools the suppression pool and fuel pool water, and provides for containment cooling spray when required. From this description it is apparent that the RHR System is a complex, multi-faceted system entrusted with a major safety function within the nuclear steam supply system. The RHR system through the course of design and construction has experienced several design problems and revisions, as well as rework during testing.

During preoperational testing, problems were experienced in trying to control RHR flow rates (10,000 gpm) with valves F017A and B. The valves in question are 24-inch, Y-globe, motor-operated valves, supplied by the William Powell Company. The vendor was contacted to determine the flow control capabilities of these valves. Investigation by Powell indicated that these valves were not suited for severe throttling service required during cooling shutdown, and would experience cavitation under the conditions where valves are required to throttle under 20%.[1]

Because of the long lead times involved in securing proper control valves, it was necessary to develop an interim fix to satisfy near-term preoperational test requirements. The fix included installation of an 18-inch bypass line around each F017 valve, procurement and installation of two 20-inch motor operated gate valves from the Tennessee Valley Authority, and the installation of three orifices in each bypass line down stream from the gate valves. The orifices were sized to control single pump flow in the bypass lines during shutdown cooling to 10,000 gpm while avoiding excessive pipe vibrations.[2] The interim fix may become permanent if the gate valves and orifices perform satisfactorily. The fix was necessitated by a design oversight in the original F017 valves.

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[1] DE Memo Vance to Nunley EF2-60101
October 4, 1982

[2] DE Letter Levine to Johnson EF2-64277
June 13, 1983

Later, it was determined that while faulty valves contributed to the RHR vibrations, the RHR pumps were a primary cause of the problems. Major pump refurbishment was undertaken. This became a critical path item in 1983.

In April 1982, DE re-evaluted the need and potential operational problems of the steam condensing mode of the RHR system. This mode of operation was originally included in the RHR system design to allow the RHR heat exchangers to act as direct steam condensing units during extended periods of reactor standby operation. As a result of the evaluation, the steam condensing mode of operation was abandoned. The piping associated with this mode of operation was removed since engineering and construction efforts associated with leaving the components in place were estimated to be more than those required to remove them.[1]

The two RHR system heat exchangers also underwent two significant modifications. The modifications involved design inadequacies with the heat exchanger relief valves and the flow capability of the heat exchangers themselves. The relief valve problem surfaced in January 1979, when Ge and DE discovered, while responding to a NRC question, that the relief valves had a design capacity of 21,000 lbs/hr instead of the required capacity in excess of 150,000 lbs/hr. The problem was offically reported to the NRC in 50.55(e) Report #14. The fix involved replacement of the valves and associated piping.[2] The second problem was discovered by GE while evaluating the design flow through the heat exchanger. The evaluation determined that the original design did not meet industry

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1 DE Memo Lusis to Nunley EF2-64277
June 13, 1983

2 DE Memo Deora to Fahrner EF2-44360
February 12, 1979

standards. The heat exchangers were modified by removing baffle plate, thus meeting flow requirements. The cost of the repair was backcharged to, and accepted by, GE.

E21-00 Core Spray System

The Core Spray System (CSS) is designed to provide two independent reactor core spray cooling system loops which provide a redundant means for the removal of decay heat generated from the reactor core following the postulated design basis LOCA. This prevents the fuel cladding from reaching temperatures of the magnitude and duration necessary to cause fuel cladding fragmentation, or that which supports a metal-water reaction which could endanger the integrity of the primary containment. The equipment for each CSS loop consists of two 50%-capacity, AC motor-driven, inline pumps, one sparger ring, spray nozzles, and the necessary piping, valves and instrumentation.

The Core Spray System is one of the systems of the NSSS System that required refurbishment prior to extension of the GE warranty coverage. In 1978, one of the four core spray motors was found (pump motor D) to have cracked upper end shield and housing damage from excessive upthrust. It was subsequently determined that the motor was dropped onto a trailer bed when a skid collapsed during shipping. DE was reimbursed for the cost of the repair less the Company's $50,000 deductible by the Insurance Company of North America. The original purchase order for this equipment was placed on September 16, 1968. Delivery was made on August 5, 1971. Actual installation was completed on January 12, 1978. Consequently, the motors had been onsite nearly 6½ years prior to installation. The refurbishment connected with this item involved shipping, disassembly, lead repairs, rotor repairs, and metallizing and machining of upper and lower bearing supports, testing, and balancing. As of the writing of this report, two motors have yet to be placed back under warranty status because additional repair to replace sheet metal shrouding and lower end bells was needed. The Staff has taken the general position that refurbishment for warranty extension work of the nature described above constitutes a motor rebuild and not, in the Staff's opinion, normal refurbishment. Consequently, the Staff is recommending a partial disallowance detailed in the attached exhibit.

Control Rod Drive Penetrations

On May 28, 1981, DE notified the NRC of discovery of a problem with thermal growth clearance for CRD penetrations between the biological shield and primary containment. The problem involved questionable clearance, allowing for thermal growth of the primary containment vessel, with respect to CRD penetrations in the biological shield. Reactor Controls Incorporated (RCI), in completing installation of the CRD lines, noted instances where the specified slope of the CRD lines had been exceeded. The affected CRD sleeve assemblies were removed by core drilling a series of forty 51/2" diameter holes around the perimeter of each of four sleeve assemblies. The holes were drilled through a 1/2" steel plate, 61/2' of concrete, and a second 1/2" steel plate. The holes were drilled around a 3" pipe sleeve which contains a 1" diameter tube projecting approximately 2' outside the sleeve. The interior of the sleeve assembly block (approximately 8 tons each) was removed as a unit by jacking and lowered to the first floor with a hoisting frame. The drilled concrete penetration face surfaces were prepared at the CRD penetrations in the biological shield wall and fabricated shield planks installed. The re-installation of the four assemblies was completed in May 1982.

N71-00 Circulating Water Pumps

Cooling water to the condensor of the turbine/generator is supplied by a closed-cycle system consisting, in part, of two natural draft cooling towers, a cooling reservoir and five circulating water pumps. During CAIO testing, start-up discovered that the #1 water pump motor could not be rotated by hand. An inspection determined that moisture and dust had entered the oil lubrication system and damaged thrust and radial bearings. As a result of this condition, all five circulating pump motors were refurbished.

6. Conclusions and Recommendations

The Staff, in its review of preoperational and start-up testing, identified several specific instances where delay was incurred or expenditures increased because of project error. Because of time and resource limitations, the Staff focused primarily on problems signifying imprudence from a regulatory standpoint. The Staff, through the review process, recognizes that start-up is a complex process fraught with challenges and problems. This chapter neither directly nor indirectly was intended to oversimplify the start-up function. Nonetheless, the Staff did find areas where evidence exists of imprudency, thus contributing to increased project cost.

The financial impact of delays attributed to start-up are evaluated in the "Project Delays" section of this report. The Staff identified several instances where problems within start-up delayed timely completion of preoperational and acceptance testing. However, these occurences, by themselves, do not necessarily equate to a similar delay in project completion, given the numerous parallel critical paths that were present at this stage of the project. Start-up difficulties, therefore, can be considered as only one item contributing to project delay. The following Staff conclusions are examples of problems that delayed completion of preoperational and acceptance testing. The numerical order assigned does not represent order of significance.

1. Daniel International Corporation appeared to be primarily concerned with bulk construction activity and not with system completion. This impacted the orderly and timely transition into the start-up mode, thus contributing to project delay. The Staff learned that Jim Ard, Jr., brought in by DIC, was assumed to be systems oriented. He was only mildly successful.

2. The DE start-up group, prior to the creation of the SCO, was more cautious than aggressive in accepting construction transfers from DIC. This cautiousness prevailed through most of the testing and turnover effort.

3. Project financial constraints and allocations in 1979 and 1980 slowed construction activities, thus impairing Daniel's ability to complete the project and meet turnover schedules. The transfer difficulties between DIC and DE were never satisfactorily eliminated and resulted in the creation of the Systems Completion Organization.

4. The effects of Three Mile Island created a project vacuum in 1979 and 1980 and directly delayed start-up and project completion. This represented the major contributing factor to project delay through 1981. Absent delays associated with TMI,

early problems in the transition to start-up, along with the degree of refurbishment requirement experienced, would have almost certainly impacted project completion.

5. The creation of the Systems Completion Organization by DE was a positive step by DE management to remedy the problems in the transistion process. However, SCO later became bogged down as its involvement increased and DE used SCO to prematurely phase out site contractors.

6. The transfer of systems from construction to preoperational testing and later to Nuclear Operations was delayed by an apparent reluctance of the receiving DE organization to aggressively drive the transfer process. In the Staff's opinion, this can be attributed to DE's lack of operating experience in the nuclear industry and a general cautiousness by DE as they expanded their learning curve.

7. Equipment refurbishment and reconstruction was significantly larger than anticipated, and thus caused specific delays in start-up and increased project expenditures. The problem was caused by premature equipment ordering and delivery, instances of improper storage protection prior to, and after installation, and instances of defective construction.

8. At the time of the Staff review, Nuclear Production was not accepting systems for turnover from start-up. While this did not impact the project schedule at this time, continuation of this trend could ultimately delay plant start-up and commercial operation.

9. The Staff takes the position that expenditures associated with normal equipment maintenance and refurbishment due to warranty extensions is reasonable. Expenditures for rework and refurbishment resulting from defective construction, improper equipment protection, and inadequate engineering are imprudent. The specific instances of work deemed imprudent by the Staff and its associated cost is listed in Attachment A.

Disallowances

1. P41-00 General Service Water System

Direct Modification	$ 241,000
Engineering	$ 750,000
Retesting	$ 100,000
Overheads @ 10%	$ 24,000
AFUDC (1981)	$ 164,000
Total	$ 1,279,000

2. P42-00 Rx Building Closed Cooling System

Direct Modification	$ 441,000
Engineering & Analysis	$ 100,000
Overheads	$ 44,000
AFUDC (1981)	$ 86,000
Total	$ 671,000

3. B21-00 Main Steam Isolation Valves

Direct Refurbishment	$ 577,000
Engineering	0
Overheads	$ 58,000
AFUDC (1982)	$ 32,000
Total	$ 667,000

4. B31-00 Reactor Recirculation System

M/E Stator Rewind		$ 312,000
Removal & Installation		$ 50,000
Overheads		$ 36,000
AFUDC (1982)		$ 20,000
	Total	$ 418,000

5. C11-50 CRD/HCU Accumulators

Rebuild + 10 End Caps		$ 555,000
Site Removal & Installation		$ 250,000
Engineering		$ 100,000
Overheads		$ 80,000
AFUDC (1982)		$ 49,000
	Total	$ 1,034,000

6. C11-50 CRD Pump Rebuild

Direct Rebuild		$ 285,000
Site Labor		$ 50,000
Engineering		$ 50,000
Overheads		$ 30,000
AFUDC (1983)		0
	Total	$ 415,000

7. C11-00 CRD Penetration Fix

Direct		$ 421,000
Engineering		$ 750,000
Overheads		$ 42,000
AFUDC (1981)		$ 223,000
	Total	$ 1,436,000

8. E11-00 RHR F017 Bypass

Modification		$ 1,314,000
Engineering		$ 284,000
Overheads		$ 130,000
AFUDC (1982)		$ 86,000
	Total	$ 1,814,000

9. E11-00 Steam Condensing Mode Elimination

Direct Removal Cost		$ 30,000
Engineering Removal Cost		$ 250,000
Direct Installation Cost		$ 398,000
Engineering Installation Cost		$ 150,000
Equipment Salvage Valve		(100,000)
Overheads		$ 42,000
AFUDC (1982R - 1974)		$ 411,000
	Total	$ 1,181,000

10. E11-00 RHR Heat Exchanger Relief Valve

Valve Cost		$ 33,000
Direct Installation		$ 50,000
Engineering		$ 50,000
Overheads		$ 9,000
AFUDC (1982)		$ 7,000
	Total	$ 149,000

11. RHR Heat Exchanger Flow Deficiency Back Charged to GE 0

12. E21-00 Core Spray System

Dropped Core Spray Motor Insurance Deduct	$	50,000
Removal & Installation	$	50,000
AFUDC (1978)	$	41,000
Total	$	141,000

13. E21-00 Core Spray System

Motor Lead Repair, Rotor Repair	$	127,000
Direct Labor	$	50,000
Overheads	$	18,000
AFUDC (1982)	$	10,000
Total	$	205,000

14. N71-00 Circulating Water Pumps

Repair 5 Motors	$	303,000
Site Labor	$	75,000
Overheads	$	41,000
AFUDC (1980)	$	101,000
Total	$	502,000

15. Retesting Due to 3/28/80 Suspension of Level I Electrical Testing

Retesting	$	178,000
Overheads	$	18,000
AFUDC (1980)	$	47,000
Total	$	243,000

16. Snubber Reduction Program

Construction		$ 200,000
Engineering		$ 500,000
Overheads		$ 20,000
AFUDC (1982)		$ 36,000
	Total	$ 756,000

17. Drywell Deformation $ 300,000

18. Comstock Reinspections

Included in L.K. Comstock Contract Evaluation

19. Rx Pressure Vessel Flange Distortion

Included in G.E. Contract Evaluation

TOTAL -- 1982 $11,200,000

J. Fermi 2 Engineering

This section reviews the Detroit Edison performance as the primary Architect/Engineer (AE) on the project. Sources for this review include: EF-2 Project Procedures Manual; PMO and Engineering progress reports; design change documents; numerous interviews with key individuals involved with engineering including project engineers from Stone & Webster, Sargent & Lundy, and General Electric, and written responses to numerous specific information requests.

As we have said previously, engineering completion determines the pace for a nuclear project. It is the road map to construction and drives all other major activities. The key elements present in a good engineering effort include:

a. Organization structure which permits good coordination and control between various engineering disciplines; project and field engineering; design change control procedure; planning and scheduling; and document control.

b. Good understanding and definition of various systems, including safety and non-safety systems, NRC technical requirements, system optimization, economic and efficiency considerations.

c. Design development and design completion. This is a key element in a successful engineering effort. Importance of design function is often minimized as a mundane and routine activity at a nuclear job. In our opinion, this is one of the greatest pitfalls. Design function at a nuclear project is not only enormous in size, but is extremely complex compared to a fossil project. Care must be taken in design isometrics; 3-dimensional space requirements in order to minimize interferences, meet safety codes, load conditions, etc. The detail design must carefully consider the constructability, operability and maintainability. Incomplete designs, missing bill of material, specifications, are other sources of enginering deficiencies.

d. Design change control function. A nuclear project is characterized by a large number of engineering design changes - many of them induced by external sources; principally NRC regulations, guides, and industry code changes. As the project evolves, design deficiencies surface which must be corrected. Also, design changes are impacted by efficiency considerations.

Design changes may be categorized such as "must have", "nice to have", needed before or after fuel load, COD, etc. An important factor in evaluating a design change is its impact on the project schedule. A design change may be benign and desirable at the early stage but imprudent if implemented towards project completion.

A prudent management dictates very rigorous design change evaluation and control procedures. Besides impact on project cost and schedule, lack of adequate design change control has important safety considerations. NRC concerns in this regard are reflected in requirements such as independent design verifications (IDV). Design change control demands corporate management interface. Also, DCC must be evaluated by someone outside the project engineering.

e. Engineering planning and scheduling. As has been expressed several times, engineering scheduling is the most critical--and yet difficult--activity to control. Engineering groups are notorious in this respect. They resist being tied down to the schedule set by others, especially construction. Engineers like to establish their own schedule. Construction, on the other hand, uses its own scheduling to put pressure on the engineering: to drive the project. This apparent conflict often demands management attention.

f. Engineering budgets and resources. Design of a nuclear project requires highly skilled and technical manpower. Nationwide, many projects compete for these same resources. It is critical that a project realistically estimate the resource needs and employ them efficiently. Similarly, financial resources, if inadequate, can cripple the design function and adversely impact the project completion.

Staff evaluation of Fermi 2 engineering shall be made in light of the above-mentioned factors.

As has been noted earlier, Edison's decision to assume all responsibility for project engineering and design was unusual in the industry. This decision has been discussed at length elsewhere and will not be dealt with here.

1. Organizational Structure

Edison Project Engineering is the architect/engineer of record for the project and has the ultimate responsibility for design, engineering and licensing. Under the Project Management Concept, the project engineering is headed by the Asst. Project Manager - Engineering, who functionally reports to the EF-2 Project Manager; who in turn reports to the Vice President of Engineering & Construction. The VP-E & C is the contact person to the Edison senior management. Briefly, following are the major functions within the project engineering as outlined in the project Procedures Manual.

ASSISTANT PROJECT MANAGER - ENGINEERING provides administrative and technical direction to the Project Engineering organization.

TECHNICAL DIRECTOR provides overall technical direction for licensing, regulatory compliance, design, design change, startup testing and nuclear operations.

ASST. TO ASSISTANT PROJECT MANAGER - ENGG. spearheads communications, document control, and schedule monitoring between various project engineering groups.

DIRECTOR, PROJECT DESIGN manages, reviews and approves the development of all design documents and design change documents, including in-house and out-of-house engineering and vendor documents. He is responsible for assigning QA levels for structures, systems and components.

DIRECTOR, PROJECT ENGINEERING ASSURANCE performs audits and evaluation of engineering procedures, documents and computer design programs to assure compliance with quality requirements.

DIRECTOR, PROJECT FIELD ENGINEERING provides interface between design and construction activities, provides engineering support for construction and startup, approves all field initiated design change requests. As the project nears completion, this group plays an increasingly important role.

DIRECTOR, PROJECT ENGINEERING SERVICES performs budgetary, accounting and document control and other administrative services for the engineering groups.

DIRECTOR, PROJECT A/E MANAGEMENT provides interface and contract administration between Detroit Edison engineering and outside A/E groups - of which there were several at Fermi 2.

DIRECTOR, PROJECT SYSTEMS ENGINEERING defines system criteria and reviews design and change documents for compliance regarding constructibility, availability, maintainability, economy, operability, safety, regulations; and monitors industry experience. This group has profound impact on the course of the project.

DIRECTOR, PROJECT ENGINEERING - PLANNING AND SCHEDULING performs long and short-term planning and scheduling in support of project milestones. The critical function of coordination between engineering and construction is the responsibility of Project Controls. All three entities report to the Project Manager. Although not listed among his responsibilities, it is assumed that EF-2 Project Manager has the authority to resolve scheduling conflicts between the two principal groups. (Organizational charts are attached in Fig. 1-3 of this Section.)

Although the organizational structure shown above is the current one, over the years the basic structure has remained the same. Many individuals have been moved in and out of the project engineering and many functions physically relocated. We discussed the evolution of the project engineering with many key individuals associated with this function in the past and future. Some of them are: Robert Vance, W. F. Colbert, E. Lusis, C. A. Kus, Syl Noetzel, E. G. Sliper, Dave Spiers, Bob Lenart, Harry Arora and several others.

In our judgment, the basic structure of project Engineering Organization and its relationship to other project activities is quite sound. All the basic elements of good project engineering function appear to be present. As it should be, various engineering activities are funneled through the Project Manager. This organizational structure permits the

VP (E & C) and the Senior Management to keep abreast of major activities. Yet their interference in the day-to-day activities is minimal.

As has been previously discussed, in the early project development, most decisions on system parameters and design, were made by the powerful Engineering Committee. Indeed, then Chairman Cisler exercised strong influence on these decisions. Although decisions were taken after detailed support analysis provided by the generation engineering department, the Engineering Committee dominated the process.

In more recent years, this decision-making has been rightfully placed in the hands of the Project Organization.

Discussions with key project engineering personnel convinced us that Edison has a highly competent, technical organization. Their knowledge of systems--nuclear and non-nuclear--is indeed impressive. Therefore, given the talent and knowledge and the supporting organizational structure, Edison Management's confidence in its abilities was justified.

An otherwise efficiently structured organization of Project Engineering, however, did not operate efficiently. Many factors impacted day-to-day and long-term decisions. Some of these were:

a. Personal conflicts existed at all levels, including at the management level, as evidenced from project correspondence.

b. Although in principle responsible for all project activities, in essence, the Project Manager did not have control over the engineering groups - whether design, scheduling or work completion. Engg. group was essentially responsible directly to VP (E & C) - Mr. Harry Tauber for the most part.

c. Too much fragmentation within the project engineering groups and disciplines. This caused lack of coordination and much antagonism within the disciplines. This was particularly so in handling the design change functions, as will be discussed later.

d. Engineering Organization has a tendency to concentrate all design authority in Troy head office. Field engineering has inadequate role and level of authority. Despite recommendations by MAC, Daniel and other groups, field engineering staff was tightly controlled. In 1980, field engineering was somewhat strengthened. Resident engineers in all disciplines were assigned in the field to respond to construction questions and problems. They were also assigned to oversee Comstock on site electrical design, managing large bore hangar review and redesign effort, and small bore piping and hangar redesign. (These were previously W & B and Daniel responsibilities.) In 1982-83, field engineering activity grew enormously as the refurbishment, startup and testing activities increased. In mid-1983, field engineering had over 225 people on site (including AE). In our judgment, Project Engineering resisted this.

A broad based engineering organization on site with adequate authority is essential to the large construction project. It helps construction groups in interpretation of drawings, resolve interference problems, defective design issues, design changes and, most importantly, it permits the Project Manager to exercise necessary control over engineering schedules, completion, etc.

As has been discussed elsewhere, the logistics of Project Engineering located in Troy, some 70 miles from the project site, posed serious difficulties in resolving engineering issues. Reluctance to provide field engineering support only aggravated this. Besides, Edison established a cumbersome and arduous paperwork and routing system. Turnaround time on minor engineering items typically ran into weeks - waiting for Troy approval. Later, Edison set up expediting systems such as F.A.S.T. (Field Action Sheet Troy) to monitor the engineering responses and D.C.P. progress meetings.

Finally, the engineering activities and response time suffered due to various outside A/E groups who were remotely located, S & W (hangar design) in Boston; S & L (pipe analysis) in Chicago. All their inputs were to be coordinated by Troy office. Later in 1983, some AE design groups were located at Fermi 2 site. For example, the latest drywell steel modification design is being done by a large crew from S & L, at the site.

During the period of our investigation, Staff met several times with the Director of field engineering, Mr. Dave Spiers. In our opinion, he is well respected, competent and well qualified for the job. In our judgment, he should have been allowed greater authority and responsibility towards the project completion. Attempts to revise procedures granting more flexibility to field staff were turned down by Troy (see DCP weekly notes, February 24, 1983).

2. Role of System Engineering

As had been noted in several places, one of the strengths of Detroit Edison was a highly technical and competent Systems Engineering Group. The project System Engineer is involved in all phases of system development and frequently encounters a wide spectrum of special assignments requiring technical expertise in nuclear power. Above all, he must be able to develop systems and prepare design instruction to assure CAMEOS i.e., constructability, availability, maintainability, economy, operability and safety.

This technical ability facilitated communication with the outside AE groups, upper management and with field construction - although this last one less successfully. Technical competence of the Edison Systems Engineering Group was also commended by other principal AEs and GE Project Managers involved at Fermi 2 and also NRC (see SALP Report 1982).

Concern for safety permeated throughout the general Edison philosophy. As a result, Project Engineering had a tendency to overdesign and err on the side of safety. Some of the examples of this overcautiousness are:

a. All controls at Fermi 2 are centralized in the main control room. Typically, other nuclear units have dual controls for major systems: the main controls and the local controls. Edison determined that, for safety reasons, no local controls be provided because people walking around the plants may be pushing buttons, etc.

   While this decision may improve safety, it caused significant difficulties during the testing phase. In repeated testing process, pumps, motors, and valves had to be opened and closed from the main room requiring additional communication and delays.

   Secondly, cable termination and instrumentation had to be completed before a system could be centrally controlled. As we have noted, cable pulling and termination rates were the poorest at EF2. Therefore, in our judgment, the "single control" decision caused testing problems.

b. By design, EF2 radiation levels were set lower than required by NRC at the time. (See comments by McCarthy, Engg. Committee Meeting, Nov. 1969.) Subsequently, however, the NRC raised the standards to ALARA.

c. Buildings were designed QA1 level when they didn't have to be; for example, RHR and auxiliary buildings. Similarly, higher than required Q-levels were used for piping design in the turbine building. As has been noted, all cables at EF2 were QA1 level.

d. FSAR prepared by Edison in 1973-74 was too detailed and included many non-safety items and informational items. Also, specifications were lifted from vendor catalogue (e.g., HVAC Systems) and not carefully reviewed. Edison engineers did not fully realize the importance of commitments in the FSAR, or were overcautious. Now NRC considers FSAR a binding document. FSAR should only have included safety items. As a result, NRC holds Edison accountable for everything specified in the FSAR, which is a lot more than required. Also, Edison has boxed itself in by specifying higher test standards than necessary. NRC holds them to these commitments. The situation has led to some testing problems. In their 1983 SALP report (Pre-op testing was ranked "3" i.e., poor), NRC raised these issues with the Fermi Management. We discussed the issue with the PM who admitted some problems. FSAR is being upgraded or re-written (FSAR must be completed and approved prior to the fuel load). As an example:

- The initial FSAR specified that the reactor building overhead crane (used for fuel rod movement) shall be inspected/maintained once a year (per ANSI standards). Since fuel reload will be required every 18 months, Edison now feels that annual crane inspection (which is quite a costly and cumbersome procedure) is unnecessary. The FSAR was re-written to specify that the crane will be inspected prior to each reload, and if required for any other purpose, it will be ensured that inspection has taken place within the previous twelve months.
- FSAR specified clean steam testing of the HPCI, RCIC and the main turbine. The last one is a non-safety system and doesn't belong in FSAR. Some engineers at Edison feel that it is an NRC commitment.
- In the 1983 SALP report, NRC noted deficiencies in the Pre-op testing because test results did not match the higher FSAR performance criteria as in the case of power supply and battery systems (already turned over to NUC OPS). It should be noted that a significant portion of EF2 FSAR came out of GE specicifications. GE also reviews many test specs and test results on safety systems.

Overall, Staff believes that the System Engineering Group for Fermi 2 has been the backbone of Project Engineering Organization. The group has technically capable people who understand nuclear systems and can interact with NRC and AE groups. In our judgment, existence of this group preserved the project during shutdown and prevented its disintegration. One disadvantage of competent engineering group was that they always strived for perfection and continual improvements at the expense of target schedules. Engineers have to learn to quit fiddling.

3. Project Design Group

Performance of design groups (both in-house and out-of-house AE's) has been the single-most failure in the Fermi 2 project. Several factors contributed to this performance, including:

- organizational and internal problems
- gross underestimation of detail design efforts from the inception of project
- excessive redesign of systems
- poor control and supervision of design efforts and lack of coordination between several speciality AE's and DECo; over-fragmentation between disciplines
- excessive turnover of qualified design engineers over the project history.

As has been noted, Edison paid scant attention and importance to the detail design effort necessary in a nuclear project. At first, Edison felt confident that it could handle most of the detail design work in-house with some outside help. Pretty soon it discovered that, not only could it not meet the project schedules, but the quality of design work was deficient. As we have discussed in the case of the radwaste system, south pump house and general service water, the systems were poorly designed for both operability and maintainability. Costly modifications had to be made later to correct deficient design. Careless design of systems shows hundreds of elementary mistakes such as:

- defective pipe routings, valve locations, lack of redundancy, radiation protection;
- maintainability was virtually ignored. Lack of space for service equipment; service rails; missing rigging points; the maintenance shop poorly designed, e.g., 5 ft. door too small, etc.;
- ignored room for thermal expansion. As a typical example, in 1983 it was found that fan blades in the RHR mechanical cooling towers expanded in summer and were rubbing against the liner of the CT. Blades were shimmed to make room for expansion. Similar problems with chiller realignment in RHR; and control rods thermal expansion.

Staff noted hundreds of such examples of negligent design. The design group was also notorious for incomplete drawings, missing specifications, incomplete purchase requisitions (which held up purchasing), incomplete or incorrect QA data. In many instances, drawings were lost or misplaced.

After the first few years, Edison realized that it could not handle the design work. Large portions of work were contracted out to Sargent & Lundy, Stone & Webster, NUS and other groups. While this improved the work progress, coordination, paperwork and document control became a major problem, adding to the already cumbersome bureaucratic system of engineering approvals. Besides, duplicative administrative set-up was not cost effective. Perhaps the biggest failure of the design group was their inability to meet deadlines. This will be discussed later. Inadequacy of Edison design capability has been the subject of conflicts among the senior management. Replacement of the Director of Project Design has been an issue (see MAC report, January 1981).

4. Design Change and Control Procedures

Design changes occur throughout the construction of a nuclear project. Design changes are caused for the most part by regulatory reasons, efficiency improvements, defective design or installation and interferences. An efficient procedure and control must be set up to track and accomplish the necessary change.

The design changes may be small, such as: DDR, DCN, DCR or significant changes known as Design Change Packages (DCP). A typical DCP may require 500 manhours and 2 to 12 months to complete. Construction of a DCP may take an additional 6-12 months.

DCP has system and safety implications, requiring a higher level of authority. Between January 1981 and July 1983, over 325 DCP's were completed. Throughout the project, several thousand other design changes have been made of various types.

At Fermi 2, orderly processing of DCN, DCR, DDR, FMR, etc. has been a chronic problem. Excessive routing and paperwork for a small change can hold up testing, pipe installation, etc. For the large part, such changes are a nuisance and impact effic ent functioning of various construction and testing activities. The lack of control and delays in DCP completion have a major project impact. Over the years, several attempts were made to establish Design Change Control Organization - in each case with little success. The latest Design Change Freeze Board, established in June 1983, has been somewhat more successful. One reason, in our opinion, for unsuccessful design freeze efforts is the fact that, often, such a group is controlled by the engineering group which is part of the problem in the first place. It should be noted that under Mr. Holland, the design control has been more successful. Proposed changes are carefully reviewed if they require physical activity. A peer group reviews the changes proposed.

The lack of control in DCP was a unanimous complaint of the PMO members, Daniel and construction groups.

The DCP problem is further substantiated by PMO minutes, DCP status meetings and weekly engineering progress meetings.

As an illustration, some of the items discussed at DCP status meetings between September 1982 and February 1983 are listed here. They are also illustrative of the generic problems of engineering at EF2.

9/23/82:

- serious problems in receiving cable pull cards
- problems in identifying engineering required on SB/LB hangars; Engg. must provide design completion date with their field review of DCP
- "ARMS" breakdown. Site document control not getting DCPs on time to construction
- a memo of understanding between site document control and Troy, Engg.

10/7/82:

- A. Guilfstrof reported that construction of SB started without drawing for P4200 and that construction and drawing not the same.
- 4 valves in DCP G100I01 holding up construction for more than a month. Need disposition from Engg.
- serious problems with pull cards. Manpower problems cited at Troy.
- Delay due to incomplete material shown on purchase requisition.

10/21/82:

- Pull cards not to be sent to Troy if needed immediately. Too low error rate and reduced delay. Note: this is an example of unnecessary tight Troy control.
- DCP's being issued without identifying system #s.
- Project controls delaying review of 11 DCP's. Three week delay.

11/4/82:

- Material info missing from DCP's.
- Zelmanski identified two instances where DCP review comments were not responded to by Troy. This caused interim design change document (IDCD) to be issued by field. In the future, all comments sent to Troy must receive a response.

11/18/82:

- DCP #S P3323I (02 and 03) needed immediately, to support LLRT. Construction held up. Also pull cards and SB design approvals pending from Troy.
- DCP 1100M01 will be delayed because a drawing was lost in Troy.
- Confusion in DCP work direction involving control center. After a period of open discussion, problem was resolved.

11/18/82:

- Meeting to be set up between Troy, Field Engg. & SCO to determine how to provide construction contractors with complete and workable packages.
- More than a month delay on P.R. from Troy for DCP P4400Q01.

12/20/82:

- Engg. should promise realistic dates because construction plans and schedules are being based on these dates.

12/20/82: (cont.)

- P3320I05: Purch. Req. lost in Troy.
- Hangar designs not being included in DCP. Need understanding between Troy and field.

1/6/83:

- A. Guilstrof requested engineers who produced DCP T2100-A-6 to come to site to resolve access and support detail problems. System design without regard to constructability.

2/28/83:

- A revised method conceived for field engineering SB group to use advance information to schedule work. Troy turned down the procedure. Could delay construction.
- Incomplete information on P3321-I03, returned to Troy; now on hold.
- QA levels need corrections on IDCD.
- Several DCP's issued to construction but no Purch. Req. sent to Purchasing. Construction on hold.
- Need for urgency in processing P.R.
- Too many IDCD pending.
- Duplication of DCP/FMR. Need DCP cancellation.
- P.R. not sent to site for DCP 3321-I04. This is a long lead time item.
- Unneeded DCP's being issued in control center. Need only FMRs.

Finally, to highlight the DCP problem, we reproduce from a memo written by Asst. to Project Manager to the Asst. Proj. Manager - Engg. regarding the DCP situation in Fire Protection System, in November 1982:

The issuance of DCPs for the fire protection/detection systems to say the least has become completely chaotic, and unless rectified, will become uncontrollable. The attached listing of associated DCPs demonstrates the problems which the field is experiencing. DCPs are being issued and then cancelled. Fire systems are being built and readied for (either/or) turnover or testing, only to find that more work is being called for on these same systems. We have been forced to ho. up cable pulls in order that some DCP can be rushed out of Troy. We are finding it nearly impossible to develop a demobilization plan for Phoenix, the fire systems contractor. Please also note the volume that has been generated in the past few weeks.

Your help is sincerely requested in resolving this turmoil. Control must be brought to bear in this area if we are to have any chance of meeting the June 1983 fuel load requirements. We must finalize engineering in the fire protection/detection area so that we may concentrate our efforts on other areas requiring attention.

(Note: Phoenix later filed delay and interference claims against DECo.)

One reason for inefficient engineering performance is that Edison tends to break down the work into too many small packages. for example, in the case of DCP's, too many disciplines (elect., mech., instrumentation, etc.) get involved and fragment the DCP. This adds to the routing and control problems and subject to delays from each subgroup. A more efficient approach would be to assign a DCP to a single work group which can draw individuals from various disciplines. This provides better control, coordination, and accountability. It is our understanding that more recently a similar approach is being used. Overall, the DCP program at EF2 has been extremely inefficient.

5. Engineering Scheduling

Throughout the project, the engineering schedule has been the cause of continuing bottlenecks, impacting the ability to perform or efficiently schedule construction activities. With Edison taking responsibility for many detail system designs, e.g., piping and electricals, they were unable to cope with the construction demands. As early as 1970, serious problems were developing in the engineering completion to support project schedule. Some of the examples are cited from 1971-74 PMO meetings:

Feb. 71: Engg. 4 months behind. Difficult to establish and maintain an optimum construction supervisory staff, labor force, construction equipment. This has resulted in high unit costs for some of the work to date.

Aug. 71: Turbine building substructure and pedestal construction on critical path, and awaiting engineering. Engg. 6 months behind; construction 8 months behind.

Feb. 72: Rebar steel and anchor bolts causing congestion in RPV pedestal. Steel placement holding for redesign.

July 72: RPV pedestal rebar on hold, pending pipe restraint design. Missile problem not resolved by GE. May have further impact on RPV pedestal and pipe restraint. Proceed with design completion, will fix later.

Aug. 72: Construction effort on project running too close to engineering, making it exceedigly difficult to maintain a balanced work crew, causing sporadic hiring and lay-off, impacting performace and morale. Shortage of qualified engineering manpower.

Jan. 73: Field progress severely restrained by engg. delays. Critical systems are the auxiliary boiler house, turbine building structural steel, pipe hangars, drywell penetration sleeves and reactor building structural drawings.

March 73: More work being assigned to outside engineering firms; organizational changes made. Delays continue to impact construction. Manpower shortages.

June 73: Engg. hangar releases lagging. Drywell cooling penetration designs holding up construction. Auxiliary boiler building design lagging; will impact heating needed for winter 73-74. GE seismic information still a major construction hold.

Oct. 73: GE end-of-life core calculations show performance deficiencies. Probable schedule impact. GE transient analysis, underway since 1971, cannot be completed due to manpower. DE looking for a consultant.

Dec. 73: GE final solution to overpressure transient problem is to change four safety valves. Major plant modifications.

March 74: FSAR deadline for 9/74 submittal is severely impacting engineering manpower.

July 74: Plant to continue engg. through shutdown to reduce further construction delays. But out-of-house engg. work stopped.

Dec. 74: Expecting large engg. work load in 1974 to respond to AEC questions on FSAR.

Overall, the rate of engineering drawing completion rate was less than 50% of the target rate during the early 70's.

Serious problems of engineering delays impacting project schedule were pointed out by Daniel in their 1974 review. The reported status of engg. completion was seriously challenged.

The Edison Management recognized the problem as mentioned in the comments on Daniel findings by the Project Manager, Mr. Jens. Much of the problem was attributed to lack of Edison experience in the nuclear area. The hope was to improve the situation by (a) contracting more work outside and (b) catching up on engg. during shutdown.

As has been mentioned, this was not accomplished. Instead of increasing outside contracts, they were essentially terminated during shutdown.

In 1974, the output of the number of drawings peaked at 2,847. During the caretaker years 1975-77, the number of drawing releases dropped to 48%, 35% and 21% of the 1974 level. In 1978, this level jumped back to 1,905 drawings. December 1977 PMO report shows that engineering was still significantly affecting construction. For example, cable pulling was 89% behind awaiting L.K. Comstock QC inspection and engg. release of cable routing and drywell penetration designs. Also, RHR building concrete was 47% behind due to structural design change drawings.

An additional factor was that regulation had become tougher after AEC reorganization, and due to Browns Ferry accident.

The 1978 schedule evaluation by Gen. Construction Dept. (see assign. 264) showed that EF2 design was behind in relation to fuel load schedule and % construction. Comparison with other BWR's in the same class showed the following:

Name	F/L date	% Completion Engg.	Constn.
1. Fermi 2	1/80	50	45
2. Grand Gulf	10/80	77	42
3. WPSS #2	3/80	88	40
4. LaSalle 1	3/79	82	51
5. LaSalle 2	3/80	65	41
6. Susquehanna 1	5/80	62	40
7. Susquehanna 2	11/81	62	27

It should be noted that in the same review, Bechtel held a different opinion and indicated that EF2 F/L may be achievable because: (a) Engg. completion is reported to be at a higher level in relation to construction than historical projects were at this stage of construction; (b) Material deliveries appear to be more complete than other projects at the same stage. Bechtel, of course, was using the status estimates provided by Edison.

A major problem with engineering was the fact that the project did not integrate the engineering schedule with procurement and construction activities--so-called Integrated Schedule Planning, until very late in the project. The field people never had reliable engg. status or completion dates (see assign. 264). This supports our belief that the project managers throughout this job did not exercise adequate control over the engineering function. In essence, engineering was responsible only to the Manager (and then VP) of Engg. and Construction. Mr. Tauber was in that position for the most part.

6. Engineering Budgets and Manpower Commitments

An important tool to evaluate engineering performance and completion is to review the historic engg. budgets--estimates and actuals.

- Original engineering budget at EF2 was estimated at about $5 million for total project cost of $228 million. By 1970, $2.7 million had been spent and the estimate revised to $7.4 million.

- By December 1972, engg. budget jumped to $17 million, of which $11 million had been committed.

- By December 1974, the budget jumped to $34.7 million, with $26 million committed. Total project forecast at this point was $702 million.

- By December 1976, the PMO was reporting over 90% engg. completion (two years later, other assessments showed only 50% completion in May 1978). The engg. budget was forecast at $58 million with total project cost of $914 million.

- December 1977, budget estimate for engg. was still $58 million.

- December 1978, engg. estimate is $75 million; project total is $988; (Staff feels that at this point Edison was beginning to realize the extent of the engg. problems). Already, $62 million had been committed.

- In 1980, $29 million was spent on engg.; total authorized engg. expenditure was $105 million. Already, $105.3 had been spent. The total project cost was estimated at $1.8 billion.

- December 1981, engg. budget doubled to $186 million. The project cost increased by $200 million; half of it for engineering.

- December 1982, engg. budget is now $241 million, of which $220 million has been spent. Project is $2.35 billion.

- In November 1983, Edison revised project cost to $3.075 billion; with engg. estimate of $315 million.

(This evolution of engg. expenditures is summarized in fig. 6.)

The evolution of engineering budgets in relation to the total project indicates that, in the beginning, Edison grossly underestimated the project engineering needs. The estimators in 1969 seem to have totally ignored (a) the complex interaction of redundant safety systems, (b) stringent quality assurance standards, and (c) significant technical demands of licensing, FSAR, etc. Fermi 2 began in 1969 with a quantum leap in scale by a factor of 5 or 6, to 1200 MW units. Yet, the same assumptions were being made as in the earlier turnkey-type jobs. The unresolved regulatory issues were also being ignored.

In our judgment, it was a significant failure of Detroit Edison Management to make such a gross underestimation of engineering needs by, first undertaking the responsibility in-house, and secondly, by allocating insufficient funds. Further, in our judgment, there was a misallocation of funds--too much was being spent by ordering early equipment and construction, while too little being allowed for engineering. The result of this wrong priority was that equipment (which had to be paid for, in part contributing to the 1974 financial crisis) was sitting at the plant, unprotected, unmaintained and often being damaged, while basic engineering, e.g., piping, hangars, cable pulling was falling further and further behind.

When realization came, in 1980 or so, the choice was to contract out more work at much higher expense.

As of December 1982, total manhours spent on engg. were 8.135 million; 58% performed by outside AE. Cost-wise, 71% of the total $220 million, has been spent on outside AE. (What is worse, Edison has flip-flopped between doing in-house or out-of-house, as in 1975. This caused overlaps and design control problems.)

The 1983 engg. expenditure is over $60 million, with over $40 million for outside work.

To further evaluate the prudency of engineering expenditures, the Staff compared the share of engg. to the total project costs in the construction industry. Industry data shows that, typically, for large complex projects, the engineering expenditures run around 10% of the total project cost; (four percent for less complex projects). At EF2, this ratio was 2.4% in earlier years and, only in 1982-83, increased to over 10% (see fig. 4). It should be noted, however, that to bring the total engg. level to 10% of the total project, much higher than 10% was allocated in recent annual EF2 budgets.

It is expected that, in a typical construction project, the relative engineering costs would rise rapidly at the front end and taper off as the project nears completion. The construction cost curve would generally lag behind the engineering expenditures.

It is not uncommon in nuclear projects, however, that the engineering expenditure flow would remain relatively high (when start-up testing is in progress) and then sharply decline. In the case of Fermi 2, the engineering budgets have grown exponentially in the years 1980-83. To a large extent, this was the result of inadequacy during earlier years. Unfortunately, this has non-linear effect on the total project including engineering budgets, because of overtime, higher wage rate of outside AE, material lead time, and construction hold-ups.

Besides budget constraints, manpower shortages also impacted Fermi engineering. Fermi was being built in a period when several large nuclear projects were in progress. Turnover among engineers, designers and nuclear experts was very high. Uncertainties due to shutdown further aggravated this situation.

7. Performance of Outside AE Firms

As has been noted in several places, Edison came to rely on outside AE firms for major portions of design and systems work; over 70% of total engineering expenditure. Two firms, Sargent & Lundy and Stone & Webster, have received over $120 million from Fermi 2. The Staff interviewed the project managers of these two firms assigned to Fermi. Based on project documents and discussions, we present this assessment of their performance. No detailed evaluation of their technical work was made, however.

As a general observation, it is the Staff's opinion that technically, the Edison engineers appear more competent. This is especially so in their knowledge of nuclear and non-nuclear systems. (This has sometimes had a negative effect because they have a tendency to challenge AE decisions and caused debate and delay in a final resolution of the problem. Steam condensing mode is one example of this). The strength of the outside firms lies in the fact that they have designed more than one nuclear unit. S & L, for example, has designed several BWR's for Commonwealth Edison. This was the principal reason for their selection by Edison. Another advantage is that an AE can supply a large number of body shop personnel to meet the detail design needs and their flow can be regulated to fit the project. An AE can reassign people between several projects to optimize his work force. AE's may differ in their design concepts and approaches. One disadvantage of AE is that the Owner does not fully control the quality and background skills of the designers.

A. Sargent & Lundy

S & L has been involved at EF2 since 1968. S & L has done much of the structural work in the reactor building, RHR Complex, piping and hangar analysis (not design), cable tray drawings and seismic analysis. After TMI, S & L designed the Technical Support Center and Emergency Response Information Systems (ERIS).

Recently, S & L's major involvement has been in stress analysis and design of drywell steel modifications. It is a critical path item to fuel load. Since its original design by S & L, many loads (pipes, hangars, restraints) have been added to the drywell. Stresses from these additional loads must be reconciled towards the end of construction.

Loadings were analyzed in drywell and other Class I buildings in 1977. In 1982, a re-analysis was performed based on loads added until March 1982. Modifidations were done in steel reinforcements (Phase I). It was presumed that a routine final analysis (Phase II) will be performed when all construction was essentially complete. In the project cost update (May 1983), the drywell modification task was assumed non-critical. Upon re-evaluation in September, using computerized models, major deficiencies were discovered in the drywell structure. What was thought to be a routine final analysis became a major issue. Extensive redesign and modifications are needed. It was a major setback to the project in 1983.

Staff investigation suggests that S & L shares some responsibility for the drywell problems, when the following factors are considered.

- Similar drywell problems have been experienced at most other BWR containment vessels designed by S & L.

- S & L failed to adequately warn Edison of potential DW problems, despite repeated concerns expressed by Edison during 1980-82. For example, assumption was made that all loads were centered. Phase I found many eccentric loads. Similarly, Phase II requires many torsional fixes. In early 1983, S & L admitted that DW had major load problems.

- By design, S & L allows too high construction tolerances, i.e., leaves insufficient room for changes.

- Anchor design specifications of S & L are less reliable. S & L uses strap-anchors (others use Nelson studs). Concrete embedments and whip-restraints have ripped out many straps. (Whip restraints were an NRC requirement. Later, this was waived for PWR's, but has not been so far acted on BWR's. Phase II work could be considerably reduced if whip restraints were eliminated). In Phase II, Edison considered welding Nelson studs from under the RPV side into the drywell first floor, but later rejected it due to load conditions.

- As a general observation, the Staff learned that S & L is straightlaced, i.e., goes by the book and less innovative. For example, in the case of rattlespace and 2/1, S & L seemed overly concerned and proposed to undertake an extensive walkdown. Later, it decided to perform a series of worst-case analysis first. As a result, the problem was considerably lessened and walkdown shortened. Final analysis of walkdowns is underway (December Report).

This is not to suggest that S & L was entirely responsible. Detroit Edison controlled the loadings in the DW. Chaotic situation in piping and hangar design permitted loads to be added without adequate controls. Many contractors were working in the DW and adding loads: Giffels doing hangar trays, S & W adding hangars, etc. Lack of coordination and control was a serious problem. Edison did not provide complete information on load additions to S & L. The Staff fails to understand why DW loads were not analyzed prior to their physical installation, given the modern computing capability. (At present time, there is an on-going Analysis and Load Control Program in DW.)

In November, S & L brought a large design crew on site to complete the DW modificiations. Physical installation is planned to be complete by February 1984. (The Staff is concerned about the lack of experience of the S & L crew, based on informal meetings.)

It is the Staff's recommendation that the drywell Phase II, IIA modification should be reviewed for prudency when the final cost reconciliation is performed. Disallowance may be made for direct construction and engineering expenses. Delay effects of DW modification have already been considered.

B. Stone & Webster

S & W has been involved at EF2 since 1978. Over the years, S & W has performed over 95 separate tasks at Fermi 2, including:

- Design of station security system and guardhouse (vendor TenneComp was recommended by S & W, who later went bankrupt).

- Pipe Stress Analysis and hangar design

- Appendix "R" wrappings

- Engg. evaluation and inspection of pipe supports (found that 100% supports meet the criteria)

- TMI-related Safety Review and other third-party reviews

- Start-up & testing assistance. Provides start-up engineers working under DE direction.

- S & W has been involved in several design activities: fire protection, MSIV leakage control system, and lots of redesign work.

The Staff found that S & W performance has been satisfactory. S & W's extensive nuclear experience has been helpful to Fermi (it should be mentioned that S & W designed Shoreham, an 800 MW BWR notorious for cost overruns and delays).

Our understanding is that, in contrast to S & L, the S & W design concepts are more creative and innovative, and make reasonable allowances for future changes.

S & W has helped the start-up effort at Fermi 2 in a significant way. In our judgment, more S & W help at earlier start-up phase would have been desirable. As we have noted, just like the design efforts, Edison undertook the start-up responsibilities, only to find that the task was overwhelming. A large number of outside technicians were brought in.

(Some improprieties were found by Internal Audit in the S & W travel expense claims. In one instance, several S & W employees did not turn over refunds on unused airline tickets. S & W suggested to terminate these employees. Edison advised only discipline, but no termination, as their technical skills were needed at EF2.)

In our discussions, both S & W and S & L repeatedly pointed out that their roles were limited, that Edison made all the decisions, and they disowned any responsibility. In the Staff's opinion, something is unfair about the fact that the AE firms got all the money but no accountability.

8. To summarize the engineering performance, the Staff finds as follows:

1. Edison grossly underestimated the engineering demands of the Fermi 2 project.

2. Edison lacked necessary nuclear experience, especially in detailed design of piping, supports, and electrical systems.

3. In early years, resource priorities were misplaced by emphasizing material procurement and construction, while providing inadequately for engineering (rushed into construction).

4. The organization structure was adequate, but internal conflicts and infighting impacted work completion.

5. The Design Change Control process was inefficient and generated changes too easily, too cumbersome paperwork and routing. Several design freeze efforts were made, but were ineffective.

   The DCP handling was highly inefficient and too fragmented.

6. Shortages of technical manpower and turnover problems seriously affected progress.

7. The Project Manager(s) lacked control on the engineering function, despite their overall project authority. Troy wanted tight control of the field.

8. The systems engineering was highly competent, while the design group was inadequate to the task.

9. Engineering lacked planning and scheduling functions and was not integrated in the project.

10. Other Staff observations concerning engineering:

    - More problem finders than solvers. Emphasized perfection over practicality.

    - Individually very competent, but collectively, not very effective.

    - Contrary to what the PM told us, we found very thorough and detailed economic evaluations of major modifications (e.g., clean steam, radwaste) by Edison engineers.

    - Edison used Fermi 2 as a big training ground for its engineering.

- Concern regarding "after Fermi what?" was a disincentive and demoralized engineering staff. Burn-out factor was very high.

- Edison engineers displayed an "elitist" attitude which trickled from the top management. For example, MAC audits showed that engineers were reluctant to move to Monroe--considering it a backward region. (In 1982, MAC was hired to study the problem of relocating Edison Engineering personnel to the Fermi Operations. Many individuals were interviewed. In general, individuals were reluctant and many threatened to quit rather than move to Monroe. Reasons ranged from social adjustments and school systems, to economic and financial hardships.

  The Staff is not convinced that such a MAC study was warranted. Given the fact that over the years, Edison has taken good care of its technical employees, their loyalties should be counted on when it was needed most, i.e., during operation of EF2. Refusal or reluctance to move to EF2 is wholly unjustified. Management should quit "playing footsie" and act aggressively in the interest of the organization.)

A direct confirmation of our findings is contained in the following conclusion from a report on the project estimates prepared by project engineering in February 1972:

(1) The major cause of Project budget increases is the inability to estimate the plant that is being designed. 50% of the most recent cost increase and 70% of the total cost increase to date is attributed to this cause.

Remedy

a. Perform more of the engineering and licensing prior to making a definitive cost estimate.

b. Introduce great cost awareness during plant design by assigning one or more cost engineers to project engineering. Set cost goals in the design instructions and monitor adherence to these cost requirements through periodic design reviews.

(2) The other cause of Project budget increases is due to delays, inability to plan construction due to lack of engineering information, and inability to contract for work on a fixed price basis. 50% of latest increase and 30% of the total cost increases to date can be attributed to this cause.

Remedy

a. In future nuclear projects, don't start construction of the plant until engineering and licensing is essentially completed.

b. Provide the detailed engineering design and specifications sufficiently early to permit fixed price labor contracts.

(3) Engineering costs have increased by 170%. Some of this increase is due to learning, some resulting from re-engineering caused by licensing, but by and large, the increase is due to a low initial estimate of the engineering required. This underestimate has caused large delays because of an inadequate number of engineers assigned early to the Project. The Project is still under-manned considering the status of construction.

Remedy

a. Add a significant number of engineers to the Project to finish up the work as soon as possible.

(4) Some cost increases can be attributed to penalties due to delay and escalation provisions.

Remedy

a. Negotiate labor contracts more favorable to Edison considering the potential for delay and escalation.

9. Disallowances

As discussed in the foregoing, Staff believes that engineering deficiencies have had a significant impact on project cost and schedule at EF2. Some of the direct engineering cost impacts have been estimated and disallowed. Staff believes that excessive engineering costs resulted from the organizational decisions, lack of experience, poor coordination and control within the engineering function. The engineerng costs exploded in the period 1980-83. It is impossible to identify specific cost impacts of these deficiencies. Further, Detroit Edison had inadequate records of engineering costs incurred on thousands of modifications, redesign and design change packages. Even in the case of major modifications such as the radwaste system, the engineering data was at best estimated by the utility.

As noted previously, the general standards (Means Building Construction Cost Data) for engineering expenses as a portion of the project cost ranges between 4% to 10%, based on complexity of the project. The Staff believes that 10% engineering cost as a percentage of total project is more than adequate for a nuclear project. As an example, the two-unit Susquehanna project estimates that direct engineering costs of Bechtel (the A/E) was 10% of their total cost, 12% when a 20% home office costs are allowed. However, this results in engineering costs at Susquehanna to be about 6% of the total project costs. Since Susquehanna is a two-unit project, the engineering percentages tend to be smaller.

Prudency of Fermi 2 engineering expenditures was further evaluated by reviewing other independent sources. One source is the comprehensive data research performed by the United Engineers & Constructors (U E & C). The program, called Energy Economic Data Base Program (EEDB) initiated by

U E & C and sponsored by the D.O.E., provides periodic updates of consistent technical and cost information of significance in planning civilian nuclear power programs and evaluating alternate energy options. The program started in 1978 and is updated annually. The results for the years 1978-82 have been published by the Oak Ridge National Laboratory entitled, "Trends in Nuclear Power Plant Capital Investment Cost Estimates - 1976 to 1982". ORNL/TM-8898.

The EEDB data is developed for typical 1139 MW PWR and BWR light-water reactors in hypothetical "middletown" locations. It utilizes the design features of Seabrook for PWR and the General Electric Technical Reference Plant Design for the BWR.

Results of the studies show that home office, non-manual manhours (this includes mostly, but not entirely, the engineering and design) were estimated at 2.2 million for a project starting in 1976. This increased significantly to 7.3 million manhours by 1982. The field non-manual manhours (which includes field engineering, but largely other project non-manual, such as administration and supervision) increased from 1.7 million in 1976 to 5.1 million for projects starting in 1982.

In contrast, Fermi 2 estimates (1984 Update 2) show 10.4 million engineering manhours, including 1.8 million for field engineering. These estimates are for unit completing (not starting) in 1984. Further, Edison estimates do not include design work performed by construction contractors (W & B, Bechtel, and Comstock all had their design groups at the site).

The cost comparison between EEDB estimates (see Table 3.2. p.31, of above referenced ORNL/TM-8898) and EF2 show that on a typical project, engineering costs are 7.3% of the total project, compared to 10.3% for EF2. (Note: 3% of EF2 cost amounts to $90 million.)

To obtain further understanding of the EEDB program, the Staff discussed the issue with the Project Manager of the EEDB program at the U E & C. These discussions and the EEDB report suggest that based on experience at approximately 30 plants:

- Engineering manhours have ranged from 2 to 14 million manhours. Typical (median) engineering hours are about 8 - 9 million for a BWR.

- Some utilities, especially with 2-unit projects, have done pretty well.

- In some places, e.g., Region 3, enforcement is more tight, which adds to engineering.

- Considerable amounts of rework and redesign adds to the costs.

- The EEDB 1983 updates show that for an 1190 MW BWR plant, the engineering costs are $325 million in 1983 dollars. This includes direct payroll, loadings, support of purchasing, and quality control activities, etc.

In comparison, the EF2 estimate is $318 million in nominal dollars (between 1968-1983). If 30% (AFUDC component) was used as the 1983 conversion factor, the engineering costs at EF2 would be $413 million.

The EEDB update 5 attributed increases in nuclear plant costs to the following factors:

1. Retrospective application of new or revised regulations to system designs, and new interpretation of existing standards.

2. Promulgation of new and revised industry devloped voluntary standards which incorporates leading edge of state-of-the-art advances in engineering analysis, design, and construction technologies.

3. Application of precise analysis for Seismic Category I, safety-class designs and the resulting implementation of close tolerances, which are dictated by the analytical process.

4. Conservative interpretation of regulatory requirement by regulators, applicants, design reviewers, and quality assurance auditors that require time-consuming negotiations to resolve differences.

5. Correction of systems, equipment, component, structures, and physical interferences that lead to re-analysis, redesign and rework; particularly in the area of safety system pipe support.

6. Inclusion of QA programs that leads to preoccupation with procedures, design review, design change control, periodic audit, and documented responses.

The issues of engineering manhours and costs were also discussed with S & W and EPRI personnel knowledgeable on the subject.

To summarize the discussion, the Staff concludes that:

1. There are vast variations in the engineering and design costs on nuclear projects.

2. There are also significant variations in the bookkeeping and allocation of these costs.

3. Individual utility approach to project organization, accent on safety, regulatory interpretations, engg. change procedures, and design control discipline all have significant impact on costs.

4. Multi-unit plants cost significantly less on design and engineering. Many studies (Susquehanna) show that engineering costs for 2-units are comparable with 1-unit plants.

5. For a typical unit, 8 - 9 million manhours on the engineering effort is a reasonable estimate.

6. Engineering manhours increase significantly towards the end of a nuclear project.

7. If an average rate of $30/hr was used (between 1968-1983), then 9 million manhours will amount to $270 million for Edison engineering.

The Staff recommends that, as a conservative estimate, engineering costs at Fermi should be held at 10% of the total project cost, excluding the nuclear operations expenditures. This latter is not a direct project cost in the Staff's opinion. The disallowances are calculated as follows:

1.	Current engineering estimate (1984)	$317.8 million
2.	Total project estimate, less Nuc. Ops. and excluding engineering estimates	$2,429 million
3.	Total adj. project cost with engineering at 10% (2 ÷ .9)	$2,699 million
4.	Allowable engineering cost	$270 million
5.	Excess engineering cost to be disallowed (line 1 - line 4)	$47.8 million

THE DETROIT EDISON COMPANY - ENRICO FERMI 2
Chronological History of Cost Estimates
($000)

Year	Construction	Engineering	Nuclear Operations	General Overheads	AFUDC	Property Taxes	Total
1969	192,500	5,003		2,528	24,495	4,330	228,856
1970	213,000	6,072	2,612	4,188	37,930	5,438	269,240
1971	268,291	7,372	2,612	9,282	45,022	4,650	337,209
5/1972	314,218	13,372	2,612	14,370	69,815	8,436	422,824
9/1972	329,418	15,372	2,612	16,672	79,658	7,794	451,526
1973	336,100	26,900	8,512	25,987	99,554	13,747	510,800
1975	566,700	37,600	12,518	45,182	233,640	18,360	914,000
1977	560,700	43,600	12,518	45,182	213,340	18,360	893,700
1978	545,300	59,000	21,818	35,882	218,300	14,000	894,300
12/1978	603,000	69,000	25,318	49,182	225,700	15,600	988,300
1979	763,000	90,000	58,800	59,200	313,400	18,600	1,300,000
1/1981	977,000	171,000	99,800	70,200	456,100	25,900	1,800,000
7/1981	1,014,971	186,500	182,300	82,129	508,200	25,900	2,000,000
1982	1,227,979	241,188	190,000	102,233	553,164	35,436	2,350,000
5/1983	1,348,000	275,000	239,000	147,000	692,000		2,700,000
11/1983	1,451,410	317,800	326,800	173,500	804,500		3,075,000

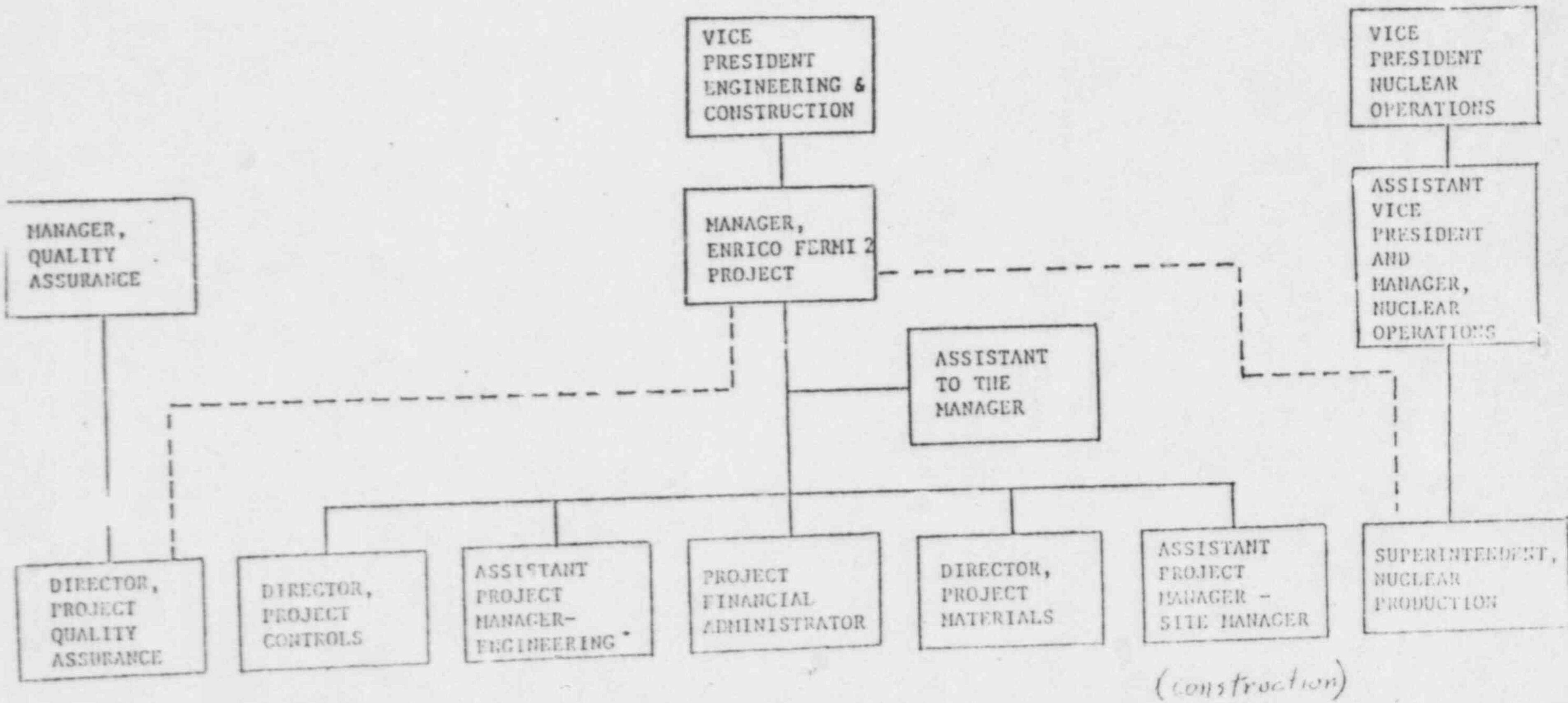
Source 1. Fermi 2 Rate Case Task Force Reconciliation Preliminary Issue

2. Presentation to the Board of Directors - May 23, 1983/November 28, 1983

Figure 1

Enrico Fermi 2 Project Procedures Manual

PMO

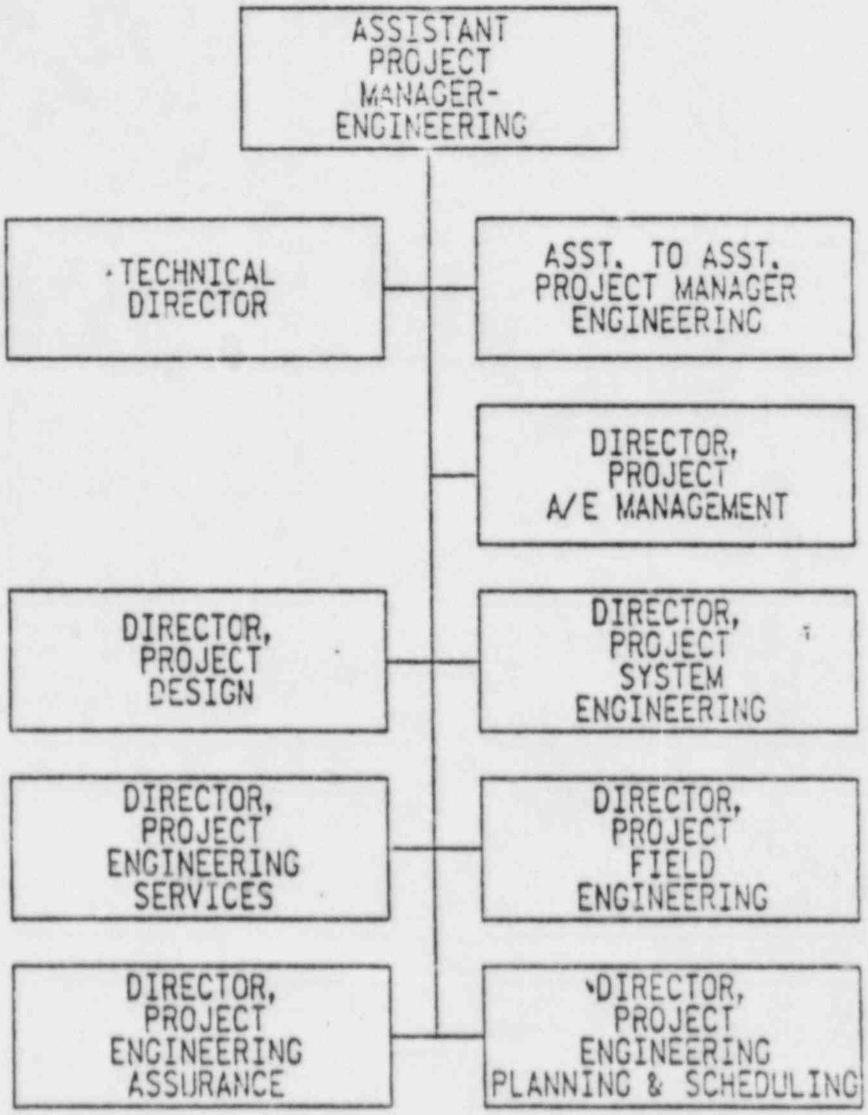


SIGNATURE

10/1/82

DATE

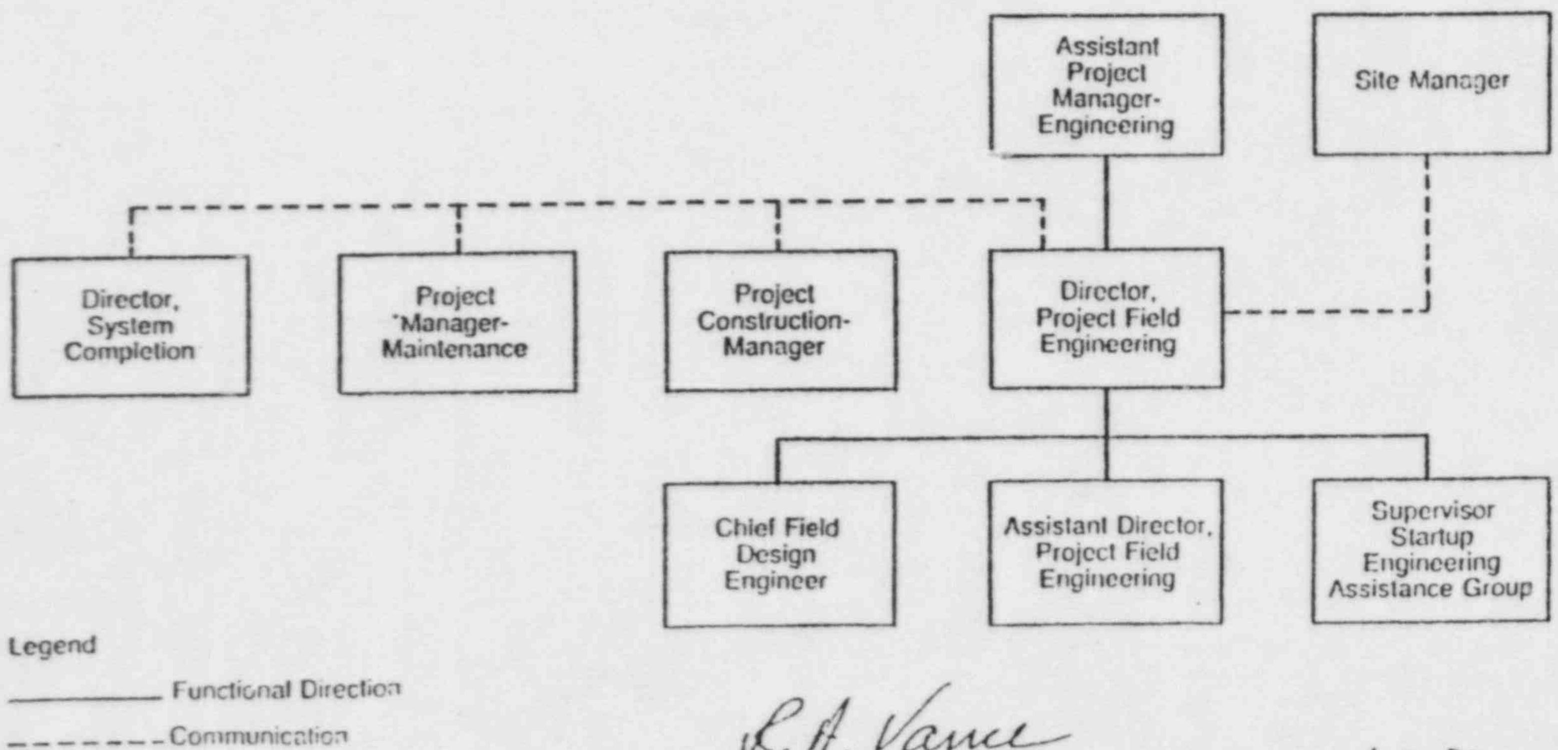
Figure 2
Project Engineering Organization



R. A. Vance
SIGNATURE

3-23-83
DATE

Figure 3
Project Field Engineering Organization



R. A. Vance
Signature

4-2-82
Date

FIGURE 4

TOTAL ENGINEERING BUDGET / TOTAL PROJECT BUDGET

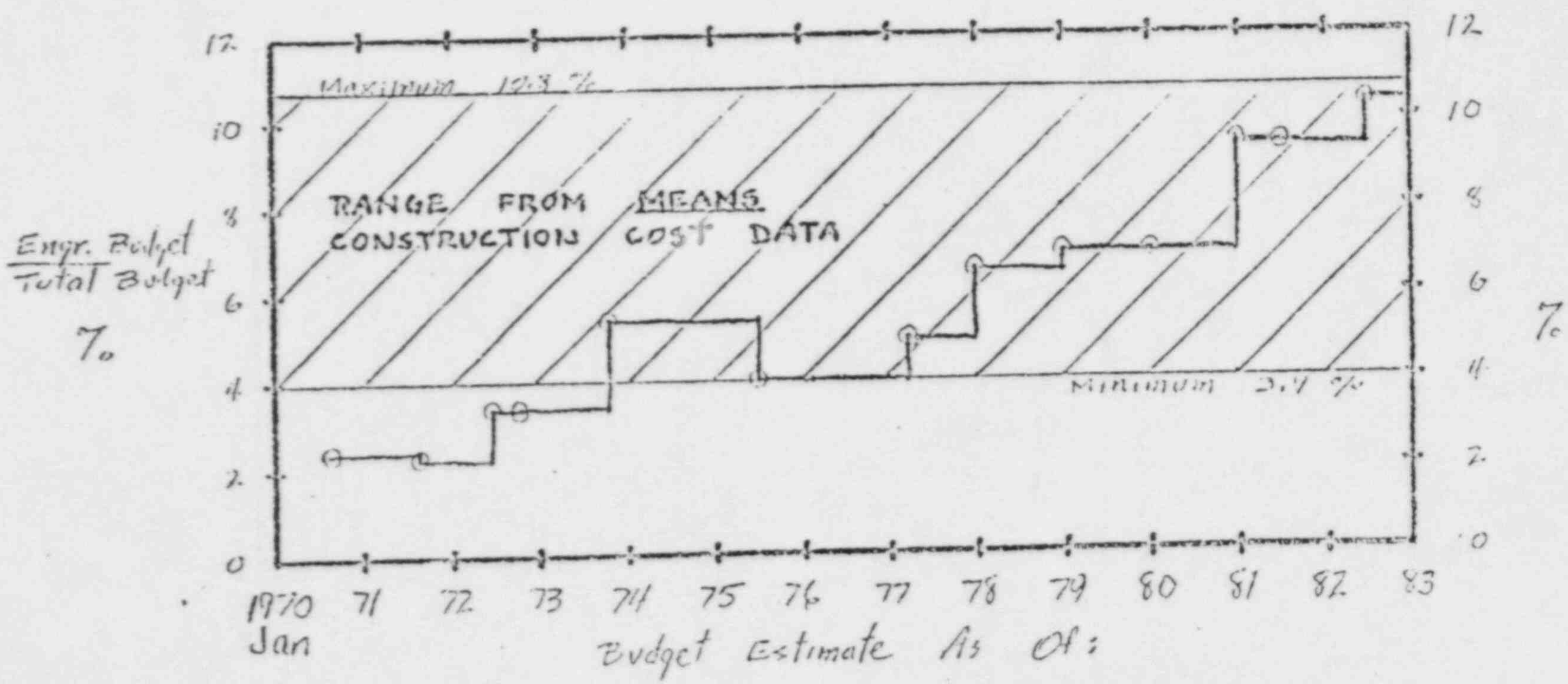
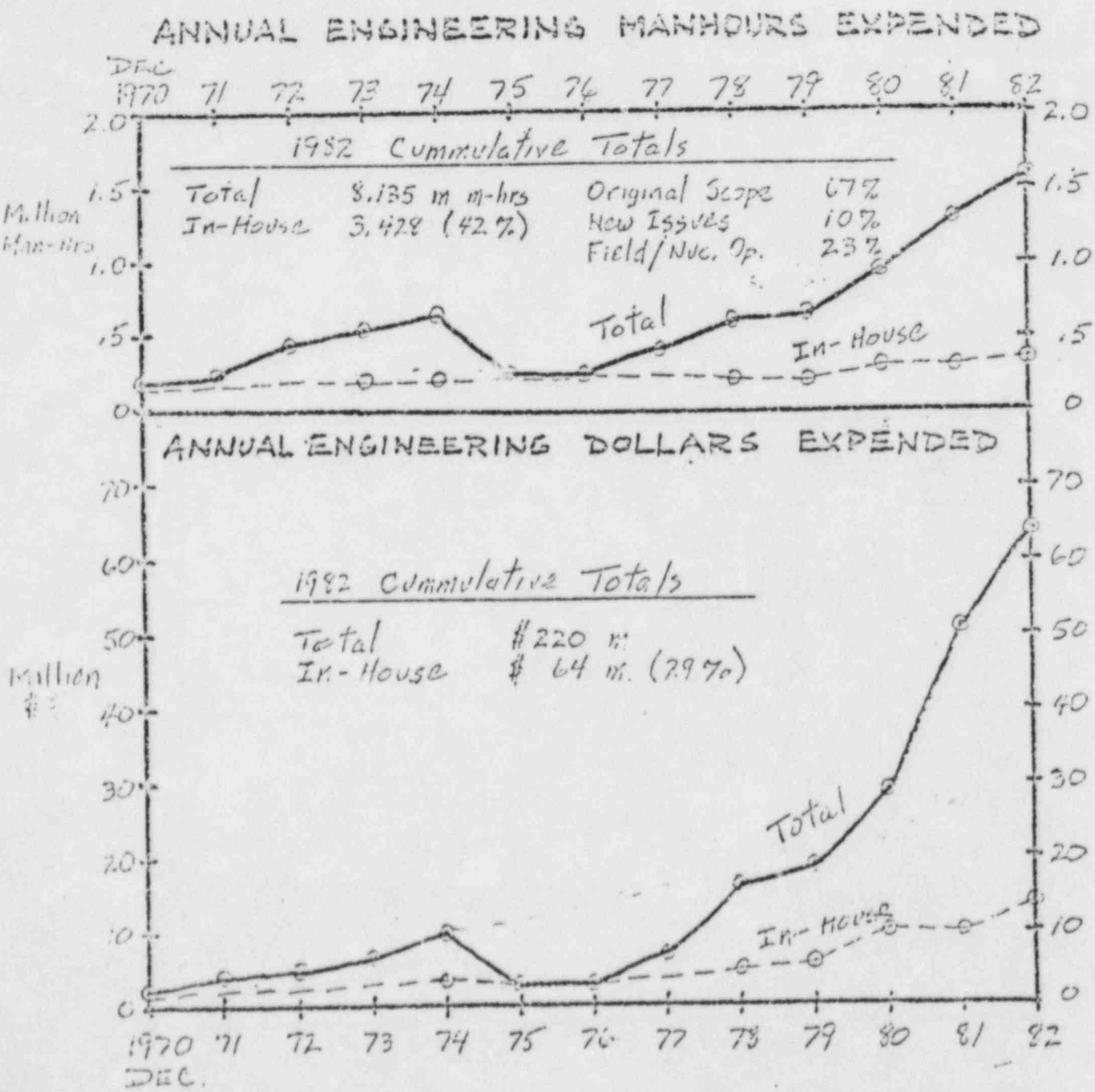


FIGURE 5

	OVERHEAD	CREW	DAILY OUTPUT	UNIT	BARE COSTS MAT.	LABOR	EQUIP.	TOTAL INCL O&P
[illegible]	ARCHITECTURAL FEES [illegible] construction, minimum			Project				[illegible]
	Maximum							[illegible]
	For alteration work, to $500,000, add to fee							[illegible]
	Over $500,000, add to fee							[illegible]
[illegible]	CLEANING UP after job completion, allow			Job Cost				[illegible]
	[illegible] removal, see division 18. 1.00							
	Cleanup of floor area, continuous	A-5	8.0	M.S.F.	1	25	26	[illegible]
	Final	"	11.5	"	1	17.20	18.25	[illegible]
	(1) CONSTRUCTION COST index for 162 major U.S. and Canadian cities, total cost, minimum			%				[illegible]
	Average							[illegible]
	Maximum							[illegible]
	(4) CONSTRUCTION ECONOMIES							
	CONSTRUCTION MANAGEMENT FEES $1,000,000 job, minimum			Project				[illegible]
	Maximum							[illegible]
	$5,000,000 job, minimum							[illegible]
	Maximum							[illegible]
10	(12) CONSTRUCTION TIME requirements							
11	CONTINGENCIES Allowance to add at conceptual stage			Project				15%
[illegible]	Schematic stage							10%
[illegible]	Preliminary working drawing stage							7%
[illegible]	Final working drawing stage							2%
12	(14)(16) CONTRACTOR EQUIPMENT see division 1.5							
13	CREWS for building construction, see foreword, p. V to XII							
15	ENGINEERING FEES Educational planning consultant, minimum			Project				0.6%
[illegible]	Maximum			"				2.5%
[illegible]	(10) Electrical, minimum			Contract				4.1%
[illegible]	Maximum							10.1%
[illegible]	Elevator & conveying systems, minimum							2.5%
[illegible]	Maximum							5.0%
[illegible]	Food service & kitchen equipment, minimum							8.0%
[illegible]	Maximum							12.[illegible]
[illegible]	Landscaping & site development, minimum							2.5%
[illegible]	Maximum							6.0%
[illegible]	Mechanical (plumbing & HVAC), minimum							4.1%
[illegible]	Maximum							10.1%
120	Structural, minimum			Project				1.0%
12[illegible]	Maximum			"				2.5%
16	(2) HISTORICAL COST Indexes back to 1935							
[illegible]	(4) INSURANCE Builder's risk, standard, minimum			Job Cost				.16%
[illegible]	Maximum							.60%
[illegible]	All-risk type, minimum							.11%
[illegible]	Maximum							.67%
[illegible]	Contractor's equipment floater, minimum			Value				0.8%
[illegible]	Maximum			"				1.5%
[illegible]	Public liability, average			Job Cost				0.8%
[illegible]	(7) Workers compensation & employer's liability, average							
[illegible]	by trade, carpentry			Payroll		6.1%		
[illegible]	Clerical					2.2%		
[illegible]	Concrete					4.6%		
[illegible]	Electrical					3.1%		
[illegible]	Excavation					8.2%		
[illegible]	Glazing					6.1%		
[illegible]	Insulation					5.6%		

Means Building Construction Cost Data

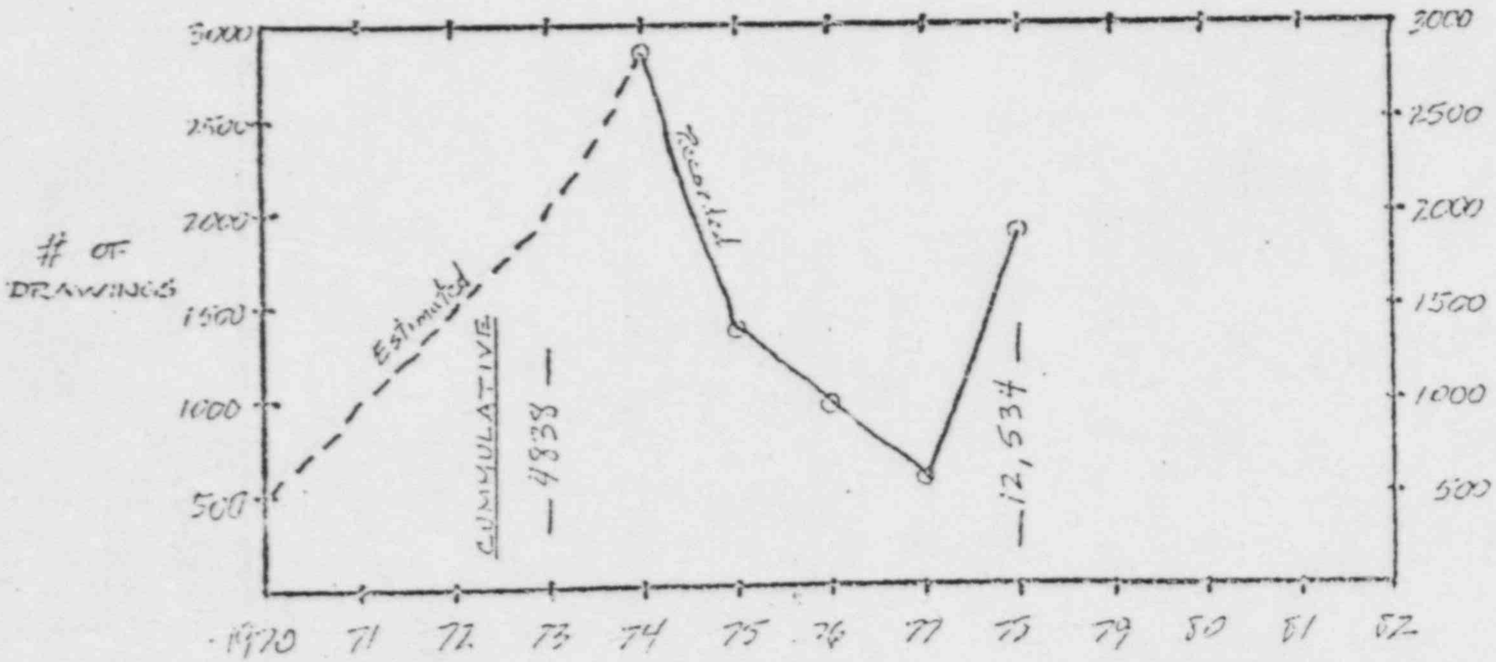
FIGURE 6



ANNUAL ENGINEERING MANHOURS EXPENDED
DEC 1970 71 72 73 74 75 76 77 78 79 80 81 82
1982 Cummulative Totals
Total 8.135 m m-hrs
In-House 3.428 (42%)
Original Scope 67%
New Issues 10%
Field/Nuc. Op. 23%
Million Man-hrs
Total
In-House
ANNUAL ENGINEERING DOLLARS EXPENDED
1982 Cummulative Totals
Total $220 m
In-House $ 64 m. (29%)
Million $
Total
In-House
1970 71 72 73 74 75 76 77 78 79 80 81 82
DEC.

FIGURE 7

ANNUAL ENGINEERING DRAWINGS RELEASED



K. Project Delays

Delays are a constant companion of a nuclear project. They are also the single-most cause of cost overruns. Controlling cost is synonymous with controlling delays. The most severe impact occurs when the project is delayed towards its completion cycle because a large investment is accumulating financing charges at a rapid rate.

Fermi 2 has been plagued with delays from its very inception. It would be fruitless to identify and analyze all the factors which contributed to the Fermi 2 delays. We shall categorize the project into four broad phases and then analyze the reasons for delay.

1. Pre-Construction Permit Period (1968-1972)

In 1968, Fermi 2 completion was scheduled for February 1974. As we have discussed previously, schedule estimates were based on the experience known at other completed, but much smaller, turnkey projects at the time. No project of Fermi 2 size had been finished at the time. Schedule estimates were highly suspect. Edison grew rather optimistic when the PSAR was submitted in a relatively short time. We have also mentioned some of the factors which made the 1974 completion very unrealistic, e.g., engineering delays, inexperience with nuclear jobs, and increasing environmental concerns. Delays in the construction permit, which Edison claims came 30 months beyond the expected date, shattered all hopes of meeting the 1974, or even the 1976, completion date.

Although construction permit delays were significant in that Fermi 2 became subject to greater regulation, the cost effect of the delay was small. Indeed, the estimates and schedule at this point became more realistic.

2. <u>Project Construction Shutdown (1974-1977)</u>

As discussed elsewhere, financial circumstances forced Edison to indefinitely shut down most construction activities at Fermi 2. Contractors were demobilized, equipment on order was being delivered, and stored on site. The reasons for financial conditions and prudency of shutdown will be discussed in another section. The project was remobilized in February 1977. The most significant effects of the shutdown on the project completion were:

Slowdown in start-up activity
Maintenance problems and refurbishment of equipment
Increased regulations resulting from Browns Ferry accident and other NRC requirements.

3. <u>Period Between Restart and TMI (1977-1979)</u>

No external events impacted the project schedule in this period; although increased regulation, inflation, and high interest rates impacted the completion costs.

In April 1978, the official projected completion date was January 1980. Several schedule analyses, however, were indicating project delays of 11 to 15 months (see Project Schedule Reviews by Gen. Engg. Assign. 264).

As has been discussed, the principal contributors to project delays in this period were:

- Inadequate installation quantities, especially cables, terminations, and small bore hangars.

- Inadequate start-up activity.

- Engineering and procurement delays.

Although these factors were significantly impacting the completion schedule, it was still felt that the project could be completed by the end of 1982.

Had Fermi 2 been completed in 1982, the project duration would have been about 13 years. Making allowance for the 27-month shutdown, the project duration would be about 11 years. If an allowance was made for construction permit delays, the duration would be even less. This compares well with the completion schedules of other nuclear projects in that timeframe, e.g., LaSalle, Susquehanna, and Sequoyah 1 & 2. (Note: It is not the Staff's intention to make a comparable plant study here.) If Fermi 2 was fuel loaded by 1982, and this review was performed at this time, then in the Staff's opinion, Edison would not be faulted for undue schedule delays at Fermi 2.

In evaluating the causes of delays and whether Edison exercised prudent management to minimize delays, it is the delays beyond the December 1982 fuel load which will be the focus of our attention. This was the anticipated completion date announced in January 1981. Thus, in order to put our analysis in proper perspective, it is useful to go back to 1980 and trace the circumstances which contributed to further delays.

4. Post - T M I Delays

In April 1980, a Safety Review Task Force prepared a report called "The Impact Assessment of Potential Scope Changes for Enrico Fermi Unit 2". The report was prepared for the task force by Stone & Webster Engineering Corporation. The report was the result of potential scope changes identified by the Detroit Edison Project Engineering as a result of TMI and other safety concerns. The S & W report is one of the most complete and exhaustive documents on the cost and schedule impact of potential design and scope changes at Fermi 2. At this time, the F/L schedule was unofficially assumed to be November 1982.

A total of 144 items were identified as potential additions to Fermi 2. Another 34 items were identified and listed for continuity. The 144 add-on items were categorized into 3 categories:

Category I: DE priority code assigned to action plan item having a high schedule impact and/or high cost.

Category II: Items not classified as Category I or III.

Category III: DE priority code assigned to action plan items having little or no schedule impact.

The 178 items were identified on the basis of:

a) Fermi 2 Safety Review Task Force, January 1980

b) Fermi 2 Interim Safety Evaluation Report

c) NUREG-0578: TMI-2 Lessons Learned Task Force Status Report and Short-Term Recommendations

d) NUREG-0626: Generic Evaluation of Feed Water Transients and Small Break LOCA in GE-designed operating plants and Near-Term OL Applications.

e) NUREG-0660: NRC action plans developed as a result of TMI

f) Project Engineering concerns and those of others.

Thus, all the scope/design changes known in April 1980 (post-TMI) were incorporated in this report. Known TMI changes were identified in NUREG-578 and NUREG-0660. Later, both these were consolidated in NUREG-737.

For each item, the report includes:

- Cost and resource impact
- Attached schedule for implementation and
- Assessment of impact on the overall schedule due to incorporating the item in the Fermi 2 plant design.

The cost and schedule data was developed from information supplied by Detroit Edison Engineering. The Edison Management adopted all recommendations of the SRTF.

The total implementation cost of all 144 items was estimated to be $88 million. Total engineering and design estimate of all estimated items was 766,414 manhours or $26 million. Of this, 78,452 hours or $2,697,000 had already been committed to S & W. The cost estimate for implementing TMI-related items was about $35 million (Edison, in their cost history, attributes $200 million to TMI cost).

On the basis of review of this report, the Staff concludes as follows:

Contrary to Edison Contention, TMI-Related Design Changes Did Not Impact Fermi 2 Scheduled Fuel Load Beyond 1982.

Discussion

The S & W report estimated the schedule impact of the 144 items as follows:

1. Forty-four items will either extend fuel load date or have a zero float.

2. Five of these 44 items with negative float are Category I items. The Category I item with the most impact of -82 weeks is "Post Accident Sampling System" (item 104). DE had already committed to S & W to design this system. The implementation cost of this item was $3.7 million.

3. Eight of the items with negative float were Category II items. The most impacting one being "High Pressure ECCS Review". It had a negative impact of -118 weeks. Implementation cost of this item was estimated as $1.75 million.

4. Three of the items in Category III have negative float with major impact of -38 weeks caused by "Use of Non-ECC Systems in Analysis" (item 166).

5. Eleven items affected the scheduled FSAR submittal date of November 1, 1980. The major impact is by item 97; "Relief and Safety Valve Test" --a TMI item.

6. The 13 items listed in (2) and (3) above will cause an impact on pre-op testing. The most significant impact (-118 weeks) will be caused again by "High Pressure ECCS Review".

It is quite clear from the report that the single-most item impacting pre-op testing and fuel load date is the "High Pressure ECCS Review".

Detroit Edison (see History of Fermi 2 prepared by DE) described this modification as part of the TMI action plan. It states on page 72:

> "As part of multi-tier defense-in-depth design of Fermi 2, a standby feed water system, powered by an electric pump, is added to the design as a backup to the emergency core cooling system to better assure that the reactor core remains covered at all times with water".

The S & W report, however, describes the same problem somewhat differently. Item 3 "High Pressure ECCS Review and Implementation (HPCI)" is described in the S & W review as:

> "The HPCI System with a steam-driven turbine powering the pump has a history of unreliable operation. A failure rate of one in ten attempts has been noted. Equipment failures include sensing devices, valves, power supplies, and auxiliary pumps".

The scope of modification for this item included "Develop the cost schedule impact of modifications required to improve the reliability of the HPCI System and provide a backup system. The backup system will include:

1. Motor-driven auxiliary feed pump
2. Estimated cost of modification--$1,750,000
3. Will have a 118 week impact on pre-op testing".

The S & W report also states that the HPCI backup modification is as a result of the Safety Review Task Force recommendation and NUREG-0626: Generic Evaluation of GE-designed Feedwater Transients.

The HPCI modification was necessitated by unreliable steam-driven turbine design. It was not a result of TMI-action plan, contrary to the Detroit Edison contention. The primary reason for this modification was to ensure that the fuel core was not burnt during an accidental shutdown mode. According to one Senior Edison Project Engineer, it was designed to protect the "fuel investment" and was more of an efficiency improvement than a safety issue.

The Staff further should point out that here was a less than $2 million item which was impacting 118 weeks on the schedule, potentially costing several hundred million dollars. Even assuming the next highest impact item, "Post-Accident Sampling System", which had an 82-week impact and was TMI related; the net impact of the HPCI modification was estimated to be 36 weeks. The actual schedule impact of HPCI modification was much smaller.

The largest TMI-related modification (Post-Accident Sampling System) was not a new issue item. It was to review and upgrade the original design capability to obtain samples from the reactor coolant system and containment atmosphere under high radioactivity conditions. The modifications were extensive and a direct result of TMI. The cost and schedule for this item was estimated as:

a. Cost (incl. engg., construction, etc.) $3,762,000

b. Schedule: Start date: February 18, 1980
End date: January 3, 1983

The design modification was performed in late 1983, and construc- was being planned in January 1984 (see October Monthly Analysis). The reason for this delay is that it must be done after much of other construction, to build sampling stations.

It may be helpful to list significant TMI-action items incorporated at Fermi, and assess their impact on the November 1982 fuel load schedule. They are identified in the S & W report and in the Fermi Cost History, Chapter XI, by Detroit Edison. Each of these issues were reviewed with Edison Project Engg. for accuracy.

1. Main control room, instrument consoles and panels are relabeled and rearranged to more clearly identify major control functions.

Comments

- This is identified as item 135 in the S & W report.
- Had negativity of 6 weeks on fuel load.
- Major changes were not in the control room design, but were rather the result of other system modifications which affected CR panels, etc. Some CR changes due to Appendix R to provide remote shutdown capability.

2. ERIS: Emergency Response Information. Designed to provide faster analysis of certain critical conditions under accident.

Comments

- Edison participated with BWR owners group to minimize developmental costs.
- This was more of a licensing problem.
- Had no impact on fuel load.

- This computer for ERIS was received on site on November 2, and powered on November 14, 1983.

3. Hydrogen recombiner and containment inerting.

Comments

- DE went through several gyrations on this. Initially wanted to inert the containment. But the NRC had allowed BWRs to go without this. So, DE decided not to implement. After TMI, DE decided to go back and install. Now the NRC mandates it. All BWR-4 are inerted, except Yankee-Vermont.
- Recombiner was initially an added safety feature installed by Edison. Later, the NRC waived this for new units. However, DE had to retain it since they had it. Recombiner is less necessary with inerting. However, DE must maintain both systems.
- Both these are non-TMI items but have been influenced by TMI.
- S & W report shows a 31-week impact on F/L.

4. Post Accident Sampling System.
(This has been previously discussed as a direct-TMI item.)

Comments

- This system is being installed, and not fully tested.
- Initially, DE had a normal process sample system. Now, the NRC requires a more elaborate system with several sampling stations located in secondary containment.
- This item has not had a schedule impact, although this was assessed by the S & W report to be the largest TMI-related impact item (-82 weeks).

5. New auxiliary feed water backup pump.

(This has been previously discussed to be a non-TMI item.)

It was the largest impact item (-118 weeks).

6. (a) Fire protection modifications, e.g., fire walls, cable-tray fireproofing, and sprinklers.

(b) "Harsh environment" and "equipment qualifications".

Comments

- These are not TMI items, but a result of Appendix A, Criterion 3 and Appendix R. The SRTF discovered several violations of fire protection and separations criteria (see item 50, 56, and 93) which had to be resolved. Corrections of these violations were estimated to have a -8 week impact on fuel load. Subsequently, Appendix R revisions had a significant impact on cable tray hangar and insulation, and certification of non-metallic components to withstand harsh environment. This later was essentially a "paper chase" problem to satisfy the NRC that the equipment will withstand the environment.

- Appendix R revisions were known in 1981.

7. Technical Support Center:

This had zero float but no impact on F/L schedule. This facility was completed in 1982. It was a licensing requirement.

8. Fermi 2 simulator:

It is a faithful replica of the Fermi 2 control room. The simulator has been completed and factory tested. It will be delivered on site in March 1984.

The simulator completion had zero float but no impact on fuel load (item 89).

9. Disturbance Analysis and Surveillance System (DASS):
This is a joint DOE/EPRI project to develop a sophisticated computer brain to automatically analyze pre-accident conditions and advise.

Comment

- DASS is just a hare-brained idea and an NRC pipe dream. No application of this is anticipated in the foreseeable future. It is in the category of EPRI's futuristic projects. To our knowledge, no special funding has been made by Edison for DASS. This item is not related to EF2.

From the above discussion, it is the Staff's conclusion that:

TMI-related items had an impact on fuel load if the F/L was planned prior to 1983.

At the time of the 1980 assessment, the critical path items in F/L were non-TMI related.

5. Factors Impacting Fuel Load

By early 1982, Edison recognized that the November 1982 F/L could not be met.

In June 1982, a revised cost and schedule was announced. The new fuel load date was June 1983 and C.O.D. of November 1983. At this point, the project was reported 91% complete.

Almost from the first day, the projected fuel load began slipping. This was the phase when the project was rapidly turning over the completed or near-completed systems to the newly formed Edison System Completion Organization (SCO). Major activities in the later part of 1982 included:

a) Identification of missing or incomplete systems (P/L items).

b) Schedule activities to procure and complete the physical work on the P/L items.

c) Schedule C & IO (check-out and initial operation) activity in preparation of system testing and start-up activity.

d) Develop momentum within the start-up group for the final push. Major milestone FIVT.

e) Nuclear operations group was preparing to accept completed and tested systems. Also, completion of operator training, document and warehouse control, and other housekeeping activities were underway.

f) The completion of succesful RPV hydrotests in July 1982 brought euphoria and new optimism to the project.

Acting against the project schedule were several factors:

- Edison found during C & IO and testing that the P/L items and incomplete or missing components were significantly far more than anticipated in a normal phase. This slowed down testing efforts considerably. Further, inexperienced start-up group was unable to complete testing as planned (See "Pre-Op Testing" discussion).

- Refurbishment and maintenance programs required a very extensive and expensive effort. Many components to be ordered had long lead times.

- The new "environment qualifications"; separations criteria "Appendix R" had created major new work activities. In the case of "environment qualifications", the NRC issued a bulletin pointing out that thousands of electrical components in the plant may not withstand radiation, steam, waterproofing, and other harsh environment. The burden was on Edison to respond. The options being:

  - to prove by "paper chase" that item qualifies
  - to replace
  - to shield, or
  - to relocate

It was a painful process and tied up lots of Edison people. As of June 1983, about 63% of components were qualified, 20% replaced, 6% relocated, and the remaining 11% had yet to be tested. Edison hired outside firms to assist in this certification (Wiley-Lab, Bechtel), and also joined the users group.

- Some problems were discovered during the load reconciliation analysis in the drywell and slab-over torus.

- A major problem was discovered in the RHR system. Vibrations in the pump were a serious problem item which had to be addressed.

- Serious problems in emergency diesel generators.

- Rattlespace and 2/1 issued had yet to be fully resolved. These were first identified in the 1980 SRTF report, but not expected to have F/L impact (item 82).

These last four were significant and among the top ten critical path items. Yet the principal delay factors at the time were incomplete systems (P/L; refurbishment) and progress in testing.

By February 1983, it was recognized that the June 1983 fuel load was unattainable. In May 1983, the new F/L was announced to be December 1983.

Reasons behind the project delays were further analyzed from the Monthly Schedule Analysis reports prepared by Project Controls. The Project Schedule Analysis (PSA) reviews the project highlights and major problems, and identifies the critical path items impacting project milestones. It is a principal information document used by the PMO to monitor schedule progress. The PSA provides the most comprehensive status report of various systems and their schedule impact.

The following pages summarize the schedule analysis between January 1981 and October 1983, as reported by Edison.

January 1981

- Since August, 1980, project has fallen behind at least one month for each month worked.

- RPV hydro milestone has been delayed by 6 months.

- Causes of these delays: late engg. releases, inadequate S.B. and L.B. hangar production, and increasing scope of weld repairs.

- Further delays of 7 months in RPV hydro are imminent. Manpower shortage for weld repairs has serious impact; unit rates too high (157 mhs/hangar, estimated 57 mhs/hangar).

- Fuel load milestone will be directly impacted by RPV hydro.

- 16-month delay anticipated in Data Acquisition System.

<u>April 1981</u> F/L Target-Nov. 1982

- Radwaste modification continues to be one of the most critical activities. Ripout will start April 1981.

- Work for T-G erection has progressed significantly.

- Critical items:

  a) Expedite engg/procurement for radwaste modification.

  b) Increase RPV hydro turnover of hangars.

  c) Expedite security system deliveries from Johnson Controls.

July 1981

- RPV hydro milestone is now September 1981.
- Most critical path item is completion of new issues. Impact by 11 months.
- Second critical item is nuclear operations training--8-month impact.
- Third critical item is RPV hydro 7-month impact
- Fourth critical item is CRD system 7-month impact

September 1981

- RPV hydro now projected for May 1982
- Fuel load impact of 8 months due to:
  a) New issues (182; 205) -- 35-week negativity
  b) BOP -- 34-week negativity
  c) Torus modification -- 29-week negativity

C.O.D. now projected for July 30, 1984.

Corrective actions needed to improve F/L:

- Engg. and documentation be completed simultaneously
- Need identification of long lead time procurement items

- Construction should concentrate on more complete systems to minimize purchase list

October 1981

- Disposition of DDR is restraining the reactor internals work

- Numerous restraints on construction due to paperwork, material deliveries and engineering completion

December 1981

- Integrated Project Summary:
  - Start-up & testing -- 25-week impact on F/L
  - RPV hydro -- 22-week impact
  - Radwaste -- 12-week impact
  - New issues -- 25-week impact
  - Plant security systems -- 16-week impact
  - CRD internal & system -- 18-week impact

July 1982 F/L Target - July 1983

- RPV completed in July 1982

- Each activity on IPSS has slipped. Current impact is 6 months on fuel load

- Critical path items:
  - C.P. 1: Containment Pressure Control, inerting and purge system
  - C.P. 2: ICWU, i.e., instrument calibration, loop and scheme checks. I & C shop must complete 2,000 per month. Current rate is about 1000/month.
  - C.P. 3: Reactor internals installation has 5-week impact even when working 7 days a week around the clock. Access problems.

<u>September 1982</u> Estimated F/L - June 1983

Estimated C.O.D. - December 1983

- All "must F/L" engg. must be completed by January 1, 1983
- All hangars must be done by April 1983
- 34-week negativity to F/L

<u>Major Problems</u>

a) MG-set due back from repair (9-week impact)

b) Reactor building HVAC (9-week impact)

c) Testing slow due to large number of P/L and DCP and refurbishment program

d) LLRT (type "B" and "C") - 24-week impact

e) Stop-work action on QA1 conduit has impacted testing and restrained completion of reactor recirculation pump. Stop work order has been lifted.

f) RHR pump vibration and core spray system vibration remain unsolved. (Note: This problem continues to impact F/L as of this day, i.e., December 1983.)

g) Clean steam for testing HPCI and RCIS was to be made available on September 27, 1982. It did not occur because modifications in HPCI and RCIS not complete.

h) Miscellaneous work items have 24-week negativity.

<u>October 1982</u>

- RPV internals for FIVT completed. FIVT will be delayed by 2 months.

- Clean steam for HPCIS, RCIS not available.

- Rate of final acceptance of LLRT is well below that necessary to support ILRT.

- Number of systems impacting fuel load are steadily increasing. Negativity has increased for all milestones. New projected F/L is September 1983.

<u>November 1982</u> F/L Target - October 31, 1983

a) First C.P. item is Primary Containment Monitoring System (20-week negativity).

Restrained by inspection of QA Level 1 conduit.

b) Second C.P. is Primary Containment inerting and purge control--16-week negativity.

c) Third C.P. is High & Low Pressure heating drain system--14-week negativity.

d) Other problems:

- ICWU and pipe support installation warrant management attention.

- Several thousand feet of non-conformance cable has been reported missing (potential problem that it has been incorrectly installed).

- Jurisdictional transfer of conduit and cable tray scheduled for August 12. No turnover to date.

- EDG Div. I start-up milestone was to be completed by October 11, 1982. Now it is projected for May 16, 1983. (This is due to serious wedge problems in EDG discussed elsewhere.)

- Plant Security System Acceptance test postponed from November 8 to January 17, 1983.

- Drywell steel modifications has a potential impact on PCILRT.

- Total negative float to June 1983. F/L is 20 weeks.

February 1983

Highlights:

a) Heater drain system complete, greatly reducing potential F/L impact.

b) FMR rate improved.

c) RPV internals transferred to SCO.

d) S.B. design group has completed all "original scope" work for hangars.

e) CRDHS: Pre-testing occurred only after 8 days' delay.

Major Problems

a) Start-up activity dropped to 2.7%, far short of the required 10.6%.

b) Scope of second phase rattlespace in DW being evaluated. Potential F/L impact.

c) EDG #11 performance problems has 4-week impact; also, EDG #12, 13 and 14 each have 4-week impact. (This is the C.P. problem.)

d) Painting effort has impacted testing and punch list in radwaste.

e) Disposition of rework of cables due to DDR is creating a large retesting effort and significant schedule impact.

f) Large number of holds on hangars have been identified and must be cleared.

g) RHR pump vibration problem continues to represent potential significant impact if the current resolution is not accepted.

Note: Three most significant C.P. items identified in February 1983 PSA continue to be the most critical in November 1983. These are:

- RHR pump vibration
- Drywell steel modification (Phase II, IIA)
- Emergency diesel generators

These problems are not a result of regulatory or outside factors.

March 1983

Highlights:

a) Insulation installation rates have improved.

b) Bypass fix being recommended for RHR. Two 2" valves are being procured. If successful, will reduce criticality and fuel load impact.

c) 55% of NRC commitments closed

d) Venting and coupling of 120 CRD completed

Major problems

a) Phase II of 2/1 seismic rattlespace impacting fuel load.

b) Start-up rate too low (2.4%).

c) Changes in security system becoming critical.

d) 420 hangars have been added to the project scope (16% increase).

e) 41% increase in scope of hydro tests.

f) A plastic knob from head set fell in the R vessel.

g) Replacement of auxiliary relays due to manufacturing defects will cause repeat of EDG #11 start-stop test.

h) Appendix R: Engg. for fire protection may call for more hangar trays, due to weight of the wrappings (did impact installation schedule).

i) RHR pump vibration continues to be critical.

j) The remaining MSIV may have to be dismantled, stems inspected due to gouging problem found on one valve.

k) HCU accumulators have failed pressure test due to leakage at threaded connections.

June 1983

- Highlights:

  a) 5th Floor RB turned over to Nucl. Prod.

  b) Neutron boron testing of HD fuel racks completed. All but 8 cells acceptable.

  c) Engg. and P/L activities improved.

Major Problems

a) No systems have been accepted by Nucl Prod. since April 29; only four since February. This is 10% of the required rate.

b) Start-up reported 2.1% of the total C & IO; should be 5%. Only 8.6% done since February; should be 19.2%.

c) ICWU continues to be a major impact on F/L. (Note: Project discovered in September 1983 that this issue had been overstated. The ICWU rate improved significantly and it was no more a C.P. item at this time. It should be noted also that ICWU is a continuing problem because regulations require recalibration of safety instruments every six months.)

d) High temperatures in relay room (80-85°F) have caused overheating in cabinets, area radiation monitoring system, annunciators, and over 100 probe buffer cards in panel H11P615. (Note: This seems to be a case of simple negligence.)

e) Wedge problems continue to arise in EDG (R30-00).

<u>July 1983</u> Estimated F/L - December 1983

a) Longest C.P. item is original scope ICWU-- 18-week impact.

b) Second C.P. item is a 15-week impact due to Appendix R, Nuclear Boiler System and Start-Up Recording System.

c) Combination of new scope and schedule slippages has resulted in the number of activities increasing from 318 to 1611 with less than 50-day float to December 1983 fuel load.

<u>August 1983</u>

<u>Progress</u>:

a) Seven systems accepted by Nuclear Production.

b) CRD hydraulic system 98% completed.

c) Type "C" LLRT approved and released.

d) Condensor vacuum milestone completed.

e) Turbine building turned over to Nuclear Production.

f) ICWU improved to 2459/month, highest ever. Backlog lowered to net 355. However, new work units will be generated when systems are completed.

g) First fuel shipment received.

Problems:

a) Two major generic problems in EDG unresolved: reliability of "J" relays and component failures; much CAIO retesting.

b) RHR pumps not meeting performance curves.

c) Field work restrained due to lack of unrestrained work packages, material, engineering, and package preparation delays.

d) Engg. detail for slab-over torus structural modifications not projected to be complete until December 1983. Impact on F/L cannot be determined.

e) Availability of replacement parts is becoming a major problem. Equipment which is found damaged or damaged during testing must often have standard spare parts. O-rings, gaskets, etc., are ordered after the need has been identified. Also, older parts are difficult to locate and sometimes impossible.

(Note: The Staff has identified the spare parts unavailability as a significant item adversely impacting the project now and in future maintenance. Due to long duration of the construction, many original vendors are out of business or have discontinued items. Further, poor economy has affected production of valves, pumps, etc.)

September 1983

a) Dry well Phase II above 585' elevation is most critical item.
Final design has not been released.

b) G11-35: Solid radwaste also has zero float. If permanent system is not ready, measures must be taken for alternate system.

c) There are 500 activities with less than 15-day float, and 700 with less than 25-day float. This indicates a very tight schedule, with little room for slippage in activities or testing schedule.

October 1983 Projected F/L - April 1984

Progress:

a) Secondary containment leak rate test commenced.

b) NRC appraisal of emergency response plan was conducted.

c) Of the remaining 42 milestones, 41 have slipped, 27 of them by more than a month.

Critical Areas:

a) RHR Complex outage - 8-week impact

b) Engg. for Phase II, II A of drywell steel modification is on schedule for December 30, 1983.

The construction will be finsihed by February 17, 1984. This will be followed by retesting of DW cooling system, and turned over to Nuclear Operations. Expected 6-week impact on April 29, 1983 fuel load.

c) Engg. modification for slab-over torus have not remained on schedule. Final design issuance slipped by more than a month. This could be a major project impact.

On November 28, 1983, Edison announced the revised projected schedule fuel load date of June 30, 1984 and commercial operation date of December 30, 1984.

6. Staff Summary and Recommendations

It is obvious that in 1982 a number of new problems developed on the project which necessitated delays beyond the December 1983 fuel load. The more significant of these were:

1. Drywell steel modification Phase II, II A.

2. RHR pump vibrations.

3. EDG wedge and relay problems. Also, problems in EDG service water pump (documentation flows missing).

4. Appendix R: Cable tray hangar installation.

5. General delays in engineering completion and material unavailability.

6. Slab-over torus steel modifications.

7. Extremely slow rate of start-up testing. This was, in turn, impacted by items 1 through 6 above; although generic start-up problems persisted. A significant amount of CAIO testing to repeated, due to relay modifications in EDG and other equipment.

It should be pointed out here that one generic problem impacting testing was the Edison decision that all systems shall be controlled only from the main control room. This was for safety reasons. However, it caused considerable inconvenience during testing when pumps, valves, etc., had to be continually turned on and off. It required extra communication and manpower to conduct testing with remote shutdown. Many other units generally call for a dual-control points, local and central. The Edison decision further required that cable pulling and terminations must be relatively complete in order to perform the testing. As we know, the Edison cable installation and termination rate seriously lagged behind throughout the project.

In our opinion, none of these are a result of new regulation, TMI, or outside factors; but rather, caused by inadequate attention, poor maintenance, and inability to effectively manage problem resolution. It is, in our judgement, a case of imprudent management, as it failed to anticipate the start-up difficulties.

In early 1983, Edison took a number of serious steps to meet the December 1983 fuel load. Among them:

- Mr. W. Holland, V.P, was brought on site in November 1982.

- Attempted to break deadlock in the start-up activity. A large number of outside start-up experts were brought in to create momentum in this group.

- INPO report had pointed out serious inadequacies in the operator training program. Edison got alarmed and beefed up the

training program. The results were very successful. In the first licensing group, 22 out of 23 passed the examination--all with good scores. In the second group, now underway, at least 18/20 are expected to pass. The NRC has been very complimentary of the Edison operator training program.
(INPO inspections also noted instances of inefficient test procedures.)

- The Phase I drywell modifications were completed successfully by June. Phase II was expected to be a much lesser effort and not impact fuel load. (The Staff challenged this assumption and discussed it with the Director of Project Controls. The PMO was estimating 10,000 craft manhours to complete Phase II, starting in September. Given the limited accessibility and manpower loading in the drywell, modifications and the remaining testing could not be completed prior to the December fuel load.)

- ICWU (instrument control work units) was considered a serious impact item in early 1983. The progress on this issue was amazing--the completion rate was doubled to 2,000 units/week. By September, it was no more a C.P. item.

- The P/L had been reduced from more than 23,000 open items to less than 3,000 by September.

All in all, considerable progress was made to resolve issues and remove restraints to F/L by August through September 1983. Further, Edison utilized the opportunity to perform IHSI and some other post-F/L or post-commercial work. Although the project schedule had developed some negativity by mid-summer, there was a realistic hope that F/L could occur by December or January 1984.

The project suffered a major setback in September through October 1983. The most critical problem was the Phase II load reconciliation re-analysis in the drywell area. Phase I analyzed and fixed the loads placed in DW up to March 1982. Phase II was to reconcile by second iteration for loads placed subsequently. DE and S & L grossly underestimated the extent of the problem and its impact on fuel load.

Drywell modification Phase II, and now Phase II A, is likely to impact fuel load by at least four months. Many systems cannot be fully tested due to restraints and inaccessibility to the DW.

A second critical issue holding up F/L is the RHR pump vibration problem. Although the problem was first detected in late 1981, it has not been fully resolved. The main problem was that Edison could not determine the cause of the problem. GE blamed it on a faulty valve that DE had ordered, while DE blamed it on GE's faulty pump. It has now been established that both the defective pump and the wrong valve were contributing to the vibration. The piping system previously thought to be part of the problem is no more so.

At any rate, the poor handling of both drywell and the RHR pump dashed all hopes of fuel load before December 1983. A revised schedule was announced in November 1983. The fuel load date is anticipated to be June or July 1984.

Staff Findings and Recommendations

Based on the foregoing discussion and the project review, the Staff concludes that:

1. Fermi 2 schedule delays were a result of a combination of circumstances. Some of them were beyond Edison control; in others, Edison exercised imprudent judgement.

2. It was impossible to load fuel at Fermi 2 prior to December 1982 for reasons beyond Edison's control such as:

   - delays in earlier stages of the project resulting from construction permit delays;

   - shutdown period between November 1974 and February 1977;

   - nuclear events such as Browns Ferry and TMI accidents and resulting regulations;

   - overall financial constraints on the project, including securities case in 1981.

3. There was a reasonable chance that fuel could be loaded by June 1983. However, extensive equipment refurbishment effort resulting from long shutdown and Edison inexperience in system testing and start-up made this date unattainable. Further, Edison made good use of this six-month window to perform certain activities, e.g., IHSI, which had been previously deferred until after fuel load. This was a cost-effective move in that any physical activity is far more expensive after the plant goes operational.

Moreover, NRC enforcement had increased considerably in terms of operator training, quality control inspections, and document control. Serious licensing problems were raised at Diablo Canyon and Zimmer Units during 1981-1982. Units which had loaded fuel, such as Grand Gulf, were having second thoughts about the prudency of their decisions, and indeed, postponed pre-commercial testing to address remaining concerns.

In the circumstances, it appears prudent on the part of Edison to exercise caution in testing, document controls, and equipment and design verifications. Rushing into fuel load would have been imprudent in our judgement.

The Staff is not entirely convinced, however, that the period between 1982-1983 is entirely justifiable from the ratepayers' standpoint, notwithstanding the foregoing discussion.

The Staff recommends that Detroit Edison has the additional burden to establish that the inability to fuel load during 1982-1983 was justifiable and reasonable.

4. Delay in fuel load beyond December 1983 is largely as a result of Edison's inadequate attention to the problems in the drywell steel reinforcement, inability to identify, control and early resolution of the RHR vibration, and several other similar problems (RHR problem was first detected in August 1981). The November 1983 announcement acknowledged that the latest revision was not a result of NRC or other regulations.

In the Staff's judgement, Edison management must be held accountable for fuel load delays past December 1983.

The Staff recommends disallowances of all project expenditures incurred between December 31, 1983 and June 30, 1984 (the current F/L date), except the following:

1. Direct Construction Expenditures

   These should not be disallowed since they are not delay expenditures. They are assumed to be part of necessary construction work which would have been performed prior to 1984. Specific items of construction, e.q., defective work or rework, is to be treated separately.

2. Direct Engineering Expenditures

   For reasons as 1 above, this expenditure is not as a result of delay.

3. Start-Up and Testing Expenditures

   This is a necessary phase of the project and should not be disallowed. However, only the direct start-up and support activities must be included here.

4. Property Taxes

   These are not related to delay.

In summary, therefore, the delay related cost disallowances are computed as follows:

Delay disallowances (Based on DE 1984 budget)	$	(000)
1. Construction Management & Site Operations		
a) Daniel Expenditures for entire 1984	$	4,246
b) Site Operations and Material (Jan. - June 1984)	$	15,514
Subtotal	$	19,760
2. Engineering (Nucl. Op. Support)	$	300
3. Nuclear Operations & Nuclear Administration (Jan. - June 1984)		
a) Nuclear Production	$	24,000
b) Nuclear Administration	$	10,700
c) Nuclear Engineering	$	6,800
Subtotal	$	41,500
4. General Overheads (Jan. - June 1984)		
a) Edison Purchasing	$	440
b) Administration & General	$	768
c) Edison Site Costs	$	3,490
d) Project Controls	$	292
Subtotal	$	4,990
5. General Plant (Jan. - June 1984)	$	1,622
Total Base Disallowance	$	68,172
6. Computation of AFUDC disallowance (Jan. - June 1984)		

Alternate 1.

a)	AFUDC Estimated by Edison for Jan. - June	$ 89,383
b)	Average Rate Base to which AFUDC applied at 10.73% yr.	$1,666,039
c)	Less RB disallowed between Jan. - June 1984)	$ 68,172
d)	Net base allowable	$1,597,867
e)	AFUDC on net base	$ 85,726
f)	Total delay disallowance (c + e)	$ 153,898

Alternate 2.

Since customer receives benefit of delay by paying in cheaper dollars, the AFUDC disallowed should be reduced by the inflation rate between January and June 1984. Assuming 4% annual rate, a 2% adjustment for six months period is used. This provides an adjusted AFUDC rate of 6.73% per year.

The revised calculation for the AFUDC disallowance is as follows:

e')	AFUDC on net base	$ 53,768
f')	Total disallowance for delay	$ 121,940

Recommendations

1. The Staff recommends Alternate 2, i.e., $121,940,000 for the project delays.

2. The current Fermi 2 schedule projects fuel load in June 1984. If this schedule is not met, then a further delay disallowance may be considered.

3. In case it is found that the 1982-83 fuel load delay is imprudent, then the delay costs for the period may be calculated in the same manner as the post-1983 delay costs computed above.

CHAPTER 4: CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the findings of the investigation and recommendations developed in the body of this report. The specific disallowances associated with various issues are gathered in this chapter to provide a summary listing of items and the associated dollars.

A. Summary Conclusions and Findings

1. Project Beginning and Organization

a. Edison had plans to embark on a major nuclear program in the 70's and 80's. Fermi was the first commercial project in the series.

b. Enrico Fermi 2 project needs were grossly understated in time, cost and the complexity of the task. Even though the estimates were based on evaluations by S & L and experience at other units, little room was left for the regulatory and quality control requirements, size of the unit and lack of industry experience in this class of nuclear units.

c. Edison rushed into ordering and delivery of vendor equipment, construction and other phases of the project with inadequate planning and budget for engineering and design. The scope and complexities of design function were grossly understated.

d. Further, the decision to retain in-house design responsibility was a miscalculation on the part of management. In the post-mortem analysis, the Senior Management tacitly acknowledged this mistake. As a result, the engineering and design work throughout the project was fragmented, lacked adequate control and was inefficient.

e. Edison had a highly competent, knowledgeable systems engineering group which guided the project on critical issues of systems integrity, safety and efficiency.

f. Communications between engineering and the management were excellent due to the technical background of both of the entities. On the negative side, the engineering organization enjoyed a certain degree of protection from the management.

The competence and knowledge of the engineering organization was sometimes a handicap because it strived for perfection, improvements and often plain nit-picking. This interfered with the performance of outside design AE and construction groups who often relied on their practical experience. Also, it made design change control and freeze functions very difficult.

g. Significant construction was performed prior to construction permit and under limited work authorization. In the Staff's judgement, this was imprudent because it created engineering and material constraints, construction hold points and inefficiencies. For example, when all below grade work was completed in 1971, no further work could be done in reactor and auxiliary buildings; and construction moved in the turbine area. Thus, work progress was haphazard and uncoordinated.

Recent studies* show that at least four years should be allowed between the start of the project and the start of construction. Fermi 2 construction began in less than a year of the project announcement.

More importantly, premature construction blocked out options to redesign and improve major systems. As the nuclear power technology was evolving in its commercial applications, Edison missed some opportunities. One principal example of this is the consideration of Mark II or III configuration for the containment vessel. At least two other utilities switched to the new design configuration in the same vintage of plants. Edison stayed with the original Mark I design. As has been discussed in this report, the size of the light bulb containment posed serious construction problems due to access, interference, and loading limitations. (Recently, Edison decided to install a monorail in the drywell to improve access during maintenance.)

h. The Project Management concept was a proper and logical approach to project organization. Technical and manpower resources appeared adequate in the area of project and construction management. Shortages of skilled design and

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* "Trends in Nuclear Power Plant Capital Investment Cost Estimates- 1976 to 1982", NUREG/CR-3500, p 22

engineering personnel with nuclear experience seriously impacted the progress. Turnover was a serious problem in this area during much of the project.

Simultaneous work on EF3 PSAR in 1972-73 further taxed the technical resources.

2. Environmental and Safety Concerns

Safety and environmental concerns were paramount to the Edison management throughout the Fermi project. Compliance in many cases was voluntary (e.g., cooling towers) beyond the regulatory requirements and in some cases, pre-emptive. Staff findings are mixed on this issue.

On the one hand, Edison exhibited good judgement, responsible corporate attitude and respect for public concerns. These paid off throughout the project in terms of public understanding, intervenor opposition and local and state support for the project. The importance of this to the project, Edison, and ultimately to the ratepayers, should not be minimized. On many issues, Edison came out ahead because of their anticipatory actions.

On the other hand, the Staff was troubled by the fact that, in many instances, Edison exhibited near-paranoid concern for environment and safety and acted to placate any potential opposition. The Staff is left with the impression that Edison was attempting to build a self-contained, self-sufficient complex insulated from outside environment, elements and forces. Numerous examples of these were found: on-site storage, RHR building, shore barrier protection, and cooling towers.

3. Relationship with the Nuclear Regulatory Commission

Because of the management philosophy on safety issues as described above, there was inherent respect for the nuclear regulatory process. Management directives attached great importance to regulatory compliance and a non-adversial relationship to the regulators. This went beyond lip service or good public relations into substantive matters. Sincerity of purpose and mutual responsibility was recognized. As a result, one of the major success stories at EF2 was it's NRC relationship and record. The importance of this has been brought home by a recent rash of QA-related nuclear disasters. Edison should be commended for their efforts in this area.

4. Project Construction

a. In general, the construction progress has been at the mercy of engineering, material procurement and quality control inspection functions.

b. The construction management organization has generally performed well and been staffed with competent people. One criticism in this respect is the fact that Edison tends to move their people around too often, both within the project and across projects. Second, (and this is a generic problem with the Edison organization), management tends to over-protect its own people. Even when significant performance deficiencies were found, management took benign action. This will be further discussed later.

c. The craft productivity suffered at EF2 due to a variety of factors, principally excessive redesign, rework, conflicting or incomplete instructions, poor supervision and inspection delays. Further, emphasis on safety, work quality and resulting delays affected the craft motivations. However, the work progress, but not the quality, suffered as a result.

   In the Staff's estimate, the overall work productivity at EF2 was 5 to 10% lower than the norm. Using the current project estimate of 44 million construction manhours, this amounts to $50 to $100 million in excess cost. Other factors affecting productivity were economic conditions, inadequate use of overtime and multiple shifts. On the positive side, aggressive efforts were made to measure, monitor, and spur productivity throughout the project duration. Innovative work sampling techniques were implemented to improve performance.

d. The major weaknesses in the craft area were in the electrical, piping and hangar installation. Poor contractor management and supervision (W & B) were the principal causes of piping performance. An acute shortage and turnover of welders and pipefitters severely handicapped the work progress.

   In the Staff's opinion, piping design and quantities and installation rates were grossly understated by the project management. Further, the major equipment delivery (pumps, valves, etc.) was not synchronized with the piping design and installation schedule. As a result, equipment delivery schedules were non-optimal, which resulted in storage costs, maintenance and cash flow problems.

e. Edison obtained an advantageous labor agreement at the beginning of the project. Although sometimes resented by the workers, generally labor relations were good. Very few incidents of walkouts or strikes were noted. The quality of craft performance was superior as expected from highly skilled trade in this region.

f. The decision to terminate Parsons as General Contractor and hire Daniel as Construction Manager was reasonable. Management acted prudently and exercised good judgement by reviewing and restructuring the project.

g. The performance of Daniel as Construction Manager has been generally good. They were strong and aggressive in contractor supervision and administration, but somewhat weak in financial administration, planning and scheduling. In general, Daniel rendered good advice to Edison in bid evaluations, contractor selection and project estimates. In this regard, the Staff believes that in general, cost reimbursable contracts were more practical and workable than hard money contracts.

h. In the area of project controls, Fermi 2 suffered from a lack of integrated planning and scheduling. While short-term activities (e.g., 2-week schedule) were reasonably planned, the broad long-term plans (level 1) were not fully developed or implemented. The situation improved in the last two years of the project largely due to the efforts of Mr. Robert J. Buckler.

i. Construction activity also suffered from conflicting signals between emphasis on bulk construction vs. system completion. Tensions between construction and non-construction groups existed during most of the project duration.

In summary, the Staff recognizes that the physical construction phase is one of the most stressful segments of the nuclear project. The Project Manager must resolve many conflicts within the project, negotiate contract revisions, delay and escalation claims, ensure QA/QC performance and thousands of other functions. At the same time, he must operate within budget, material and design constraints and in a cost-effective manner. For example, in the area of contract renegotiation - there were hundreds of these - the manager must use a combination of persuasion, toughness, contract terms, coaxing and incentives to maintain job continuity, quality and overall goals to get the job done. It is virtually impossible to terminate a major contractor in the middle of a nuclear project. The contractors understand this and have a tendency to exploit the owner's dilemma. Often, replacement is no improvement, as was demonstrated by RCI which replaced GE (I & SE). For this reason, the PM often tolerates performance and contractor demands which would otherwise be unacceptable.

In view of these considerations, and notwithstanding the criticisms in the body of this report, the Staff is of the opinion that the construction organization at Enrico Fermi 2 has performed in a reasonable and prudent manner. This is particularly true when compared with other segments of the project in terms of cost overruns and schedules.

The Staff commends Mr. William Fahrner who shouldered this responsibility as Project Manager during most of the project's long duration. The Staff also commends Mr. Syl Noetzel who provided competent and aggressive supervision of the construction activities. We learned of several instances where Mr. Noetzel resisted engineering excesses.

5. Material Procurement, Availability and Management

a. Procurement and material availability had a significant impact on the construction progress. Material delays were often the result of incomplete engineering specifications, bill of material and purchase requisition packages.

b. Material shortages in steel, fabrication and other areas held up construction in the early years of the project. The oil embargo affected turbine-generator construction in England.

c. Material inventory management and warehousing was often inadequate and inefficient. Edison employed obsolete and often pedestrian methods of material management, and never utilized automated sophisticated techniques to optimize inventory levels. Further, duplications resulted from multiple contractors carrying their own inventories of consumables, tools and spare parts. Material management was not well integrated with the project. Later, component control systems and hangar control systems, etc. were adopted to better control bulk quantities.

d. Bulk item inventories were often in disarray both in location and record keeping. Several instances of defective or missing quantities and mis-tags were noted in cable, piping, power struts, etc.

e. On occasions, Purchasing showed good judgement and innovation in some cases (e.g., F017 Valve) by purchasing from TVA and thereby saving project time and money.

6. Project Engineering

a. As has been discussed in detail, overall engineering performance was a "let down" and major progress weakness. This, despite (and sometimes because of) one of the most talented engineering organizations present within Detroit Edison.

b. Much of the engineering performance, however, was the result of nuclear inexperience, underestimation of budget and manpower and skill shortages. Many of these flow from the management's decision to assume the AE function in-house.

c. Troy Engineering controlled the project too tightly. Further, the logistics of locating Project Engineering at Troy, 70 miles from the site, had an adverse impact in terms of document controls, turnaround and construction interface. Field Engineering was inadequately staffed, especially prior to 1980. All of this slowed down construction.

d. Although the organizational structure of Project Engineering appeared adequate, personnel conflicts and internal infighting impacted efficient and timely resolution of the issues. Conflicts sometimes were reflected at senior managerial levels. The Staff impression is that individually, Edison engineers were competent, but collectively, less effective.

7. Pre-Operational Testing and Start-Up

a. Edison recognized the importance of start-up and pre-op testing functions very early in the project.

b. Early efforts at organizing this function started in 1973-74; start-up manuals were prepared and personnel organized. However, the effort was abandoned due to project shutdown in November 1974. Many technical people involved in start-up left the project.

c. The start-up group was reassembled in 1978. As a general philosophy, Edison decided to maintain control and responsibility for start-up within Detroit Edison. This was advantageous for many reasons. It allowed pre-op experience to be useful during actual plant operation, improved better understanding of systems and components. Above all, the NRC favored increasing control of start-up and testing by the owner.

d. Edison relied on their experience in the start-up of fossil plants. The Fermi 2 testing was to be performed by Edison personnel supplemented by outside start-up expertise.

In Staff's judgement, the Edison approach to retain control for start-up was prudent and reasonable.

However, Edison's inexperience in large nuclear plants was not fully realized. In the early stages (1979-1981), inadequate use of outside expertise slowed down the start-up effort considerably. (Due to unfamiliarity with systems, start-up was over-cautious and afraid to push buttons.) A more efficient approach is to bring in experienced start-up teams (mercenaries) who would work under Edison's direction.

Later in 1982-83, Edison hired a large contingent of start-up technicians and experts from S & W, Bechtel, NUS, GE and MAC.

e. Many other factors adversely impacted the testing progress, among them:

   Too many incomplete systems being turned over to start-up. Punch list items exceeded 20,000 in 1982 when the project was reported 85% complete. An earlier piecemeal approach to test incomplete subsystems proved inefficient; retesting was often as high as 30%. Finally, the NRC frowned upon testing incomplete systems. Warnings were issued to Edison on this.

   Equipment damage, poor maintenance and refurbishment were the singlemost cause of start-up restraints. The availability of spare parts and components aggravated this problem due to vintage and early installation.

The construction organization was being pressured (by management) to turn over premature systems. This caused conflicts between construction and testing groups. Each blamed the other for the problems and poor progress. In our judgement, SCO formation was a good strategy. However, its effectiveness was diluted by allowing it to take over too many, often critical, incomplete systems. SCO became another layer of the construction organization.

There is evidence that test specs and test procedures written by Edison engineers (and verified by GE) were too stringent and boxed them into performance standards higher than demanded by the NRC. Edison had been somewhat careless in writing FSAR in 1974-75. Equipment performance and tolerances were lifted from vendor catalogues which later were not met during test procedures. The NRC demanded FSAR adherence. Further, the decision to provide for single central control for major equipment and systems slowed down testing.

f. Although General Electric was the supplier of NSSS and many safety systems, in the Staff's judgement, GE played an inadequate role in the start-up phase. This was for several reasons. First, the agreement between Edison and GE limited GE's role essentially to equipment supply. Second, Edison felt it could handle the job by itself. Third, in our opinion, GE had de-emphasized the nuclear industry and was withdrawing from the nuclear business, especially after TMI. As a result, many experienced managers and technical people had left General Electric (later some of them joined MAC and were hired as consultants by Edison). Therefore, despite its sincere desire to help Fermi 2, GE was unable to render much technical assistance. This became particularly evident during the resolution of the RHR pump vibration problem. The inadequacy of GE's role was also pointed out by Zimmer and Susquehanna project reviews. Staff understanding is that Westinghouse plays a larger role in start-up functions at their PWR units.

g. As a result of the factors described above, start-up activity was at a dead center during the middle of 1983. Management became painfully aware that the project was drifting once again; however, aggressive efforts were taken to bring it under control. Start-up testing was given the central role to direct and drive the project. Encouraging results and progress were achieved by the end of 1983. Testing is not the most critical path item at this point, although several systems have yet to be tested in the drywell area.

8. Financial Management and Controls

a. The project had an adequate financial and cost reporting system, consistent with good accounting practices. Sample studies and audits indicate that the project expenditures properly reflect the actual expenditures incurred. The Staff, however, recommends a final reconciliation audit when the project is closed out. The procedures for overheads and AFUDC computation appear to be reasonable.

b. Establishment of a strong internal audit group had a positive influence on the project. The internal audit group performed several investigations and audits on a variety of technical and financial issues. The group enjoyed independence and support from the senior management. In the Staff's judgement, the manpower levels assigned to this group were inadequate, especially in the earlier years. Also, the Staff found some evidence of nit-picking and overbearing on the part of internal audit. This generated discord between construction groups and internal audits. The Staff heard complaints that the group was finding problems to justify its existence. This tends to be supported by numerous mentions by IA that they have saved the project more than their department budget. In the Staff's judgement, this is a poor motivation. On the whole, however, Staff is of the opinion that IA was aggressive and technically competent. It was beneficial to the project and reflects good management.

c. Financial controls on the project were generally weak. The role of the project financial controller (though well emphasized in the project procedures manual) was severely limited and understaffed. In the early stages, Daniel was given broad authority in this area without adequate verification and monitoring by Edison. Later in 1980, the site financial management was somewhat strengthened.

9. Major Modifications, Rework and Refurbishment

a. The Staff finds that a significant amount of rework, modification and refurbishment was performed at EF2 which added to the cost and, more importantly, to the schedule. The major causes of rework/modification were the regulatory requirements imposed by the NRC. New standards and increased enforcement, particularly after the Browns Ferry and TMI incidents, added to the complexity and redesign of many systems. Fermi 2 was particularly impacted since it was nearing completion when new regulations were imposed.

b. Significant modifications and rework also were necessitated due to Edison's own fault and inadequate attention to design control. The Staff has identified several items such as radwaste modification, RHR pump vibration, general service water system, clean steam test program, and drywell steel reinforcement. In the Staff's judgement, these resulted from poor design, equipment or installation. The refurbishment program was a direct result of improper maintenance and protection during the shutdown. This cost several million dollars and significant delays. Specific disallowances have been recommended on these issues.

c. Some equipment was repaired or replaced due to obsolescence and revised standards such as "environmental qualifications", new computer applications and improved technology. In the Staff's judgement, these were necessary and prudent and would, in the long run, benefit Fermi 2 operation and performance.

d. In this vein, the Staff warns that Edison should take the necessary steps to procure critical components, spare parts and equipment to build up an adequate inventory for future maintenance. There was evidence to the contrary during the testing and refurbishment program. The problem can be critical at Fermi 2 due to the vintage of much of the equipment (pumps, valves, motors,). Many vendors are out of business or have discontinued these items. The Staff understands that Edison is planning to join the owners group under GE sponsorship to maintain major equipment spares inventory (PIMS programs). Recent cancelled units may be another source of spare equipment.

10. Project Delays

a. The Staff finds that the initial estimates of scheduled completion were unrealistic and over-optimistic. Uncertainties in nuclear regulations and inexperience within the industry and the company made definitive completion schedules an informed guess work, at best.

b. Initial design difficulties, manpower shortages and inadequate budgets set the project behind in a significant way.

c. The project shutdown (1974-77), resulting in the most part from financial conditions, had some impact on the project completion. The Staff finds, however, that the status of the project at the time (as identified by Daniel review) was such that a slow down in the construction activity was imminent. The project needed regrouping to reassess the engineering needs and to reallocate priorities. Considerably more design work needed completion before proceeding with equipment procurement and costruction.

In the Staff's judgement, the impact of construction shutdown has been overplayed. The true impact of shutdown was due to

(a) failure to catch up on engineering and (b) inadequate maintenance and neglect of equipment on site.

d. The Three Mile Island accident had a major impact on the project schedule during 1980-82. It is Staff's verdict that as a result of TMI, Fermi 2 completion was extremely improbable prior to December 1982. However, Staff also believes that TMI had little impact on project completion and fuel load beyond 1982.

e. In the period between January 1983 and December 1983, there was a reasonable chance of fuel load at EF2. Many factors, however, prevented this: lack of progress in turning over complete systems, an exceedingly high rate of punch list generation, and failure to get a grip on start-up and equipment check-out functions all slowed down progress. Edison was directly or indirectly responsible for these factors.

On the other hand, Edison acted prudently in exercising caution and care in accepting systems. At this point, NRC inspections (prior to issuing Operating License) had become intense. Several problems had developed at Zimmer, Diablo Canyon, and Shoreham. These were all at the same completion stages when issues of document control and quality assurance were raised in 1982-83. Grand Gulf, which had obtained permission and loaded fuel, was having second thoughts. Rushing into fuel load was not a prudent step given the status of Fermi and the experience of others. Moreover, the Staff recognizes that Edison made good use of the additional time to improve the operator training program and rectify some post-commercial items. The successful completion of IHSI treatment was one of them.

The Staff is, therefore, of the opinion that Edison acted reasonably and showed good judgement by not rushing into fuel load. At the same time, the Staff cannot exonerate the Company entirely for being in the situation it found itself. The Staff recommends that the Company has the burden to prove its case for failure to load fuel during 1983.

f. The Staff concludes that delays in fuel load beyond December 1983 are entirely unjustified. They are directly a result of the inability to resolve issues such as RHR vibration, drywell steel, EDG wedging, relays etc.

In the Staff's judgement, by now Edison has run out of excuses and must be held accountable. A Company spokesperson, in announcing November 28, 1983 revisions, confirmed that the latest cost and schedule delays were not a result of any regulatory or other outside factors.

The Staff has recommended specific disallowances of delay-related expenditures between January 1984 and June 1984 (estimated current fuel load date). Fuel load delays beyond this date may be further reviewed to determine the causes and make appropriate recommendations.

11. Senior Management: Involvement and Decisions Related to EF2

a. Throughout the project, senior executives have maintained an active role in Fermi 2. As a result of their technical and engineering orientation, communication between project management and executives has been excellent.

b. In the early years, Senior Management had direct input into system selection, vendor and contractor selection and project estimates. These decisions were made at a very high level through the powerful Engineering Committee comprising of executive management.

In this regard, the Staff notes that the Staff criticism of earlier decisions, e.g., Mark I containment, the purchase of English Electric turbine, and the cooling towers is directly aimed at the Senior Management at the time. Further, in our judgement, undue pressures were exerted on the project through unrealistic estimates, completion dates and rapid fire resolutions of systems and equipment (most equipment and vendors were finalized between 1968 and 1970). The problems created by these were later left for project managers to resolve. At the same time, resources devoted to design and engineering work were woefully inadequate. The Staff holds Management directly responsible for this.

c. The Management decision to shut down construction was a major setback to Fermi 2. Although Management contributed to this financial crisis by ignoring earlier warnings in 1972-73 and overexpanding the construction program, the Staff cannot ignore the fact that severe economic and financial conditions (in Michigan and the United States) precipitated this decision. The oil embargo, Consolidated Edison's action and financial market conditions severely curtailed outside funds during the period. In our opinion, Edison was in a technical bankruptcy or very close to it. Edison, therefore, acted responsibly by cutting down on major construction expenditures.

The Staff further finds that the slow down of Fermi 2 construction was also dictated by reasons unrelated to financial circumstances. Project assessments in 1974 had indicated that it was disorganized and farther behind. The project needed rearranging and restructuring. More emphasis on engineering completion and less on physical work was required. The Edison decision to give top priority to Greenwood 1 Unit was also related to this factor as the need for power was estimated to grow in the immediate future.

d. The Staff finds that although Management maintains intense familiarity with the Fermi 2 issues and progress, the overall management has been less aggressive. Senior executives admitted that they maintain an open style of management and hands-off policy, allowing PMO to conduct the project. While this style is admirable, it appeared less effective at Fermi 2 and created a number of internal conflicts and a general lack of discipline. Staff also notes that the Edison Management has been generally protective of its employees. Management, however, became much more aggressive towards 1982-83 and demanded better performance and results.

e. Generally, Management had difficulty putting policies into practice. One example of this is the difficulty in implementing design freeze programs.

f. Finally, the Staff finds that the Fermi 2 project has been largely directed by executives who were technical people. The corporate financial managers have exercised inadequate role and input to the project. This was a point of criticism and one reason for Wall Street concern about Edison financing in 1974. In the Staff's judgement, this raises further questions of financial and budgetary controls at Enrico Fermi 2.

Financial management, as perceived by the investment community, must have improved after 1975. Edison was able to raise external funds to support large construction budgets (approaching a billion dollars annually) despite high inflation, interest rates and tight money between 1979 and 1982.

B. Staff Recommendation on Disallowances

This section summarizes disallowances developed in Chapter 3:

Item	Section	Amount ($ X 10^6)
* 1. General Electric (nozzle repair)	B- 2	1.60
* 2. English Electric (T-G supply)	B- 4	6.82
* 3. Aycock, Inc. (turbine installation)	B- 4	9.16
* 4. Parsons' termination	B- 6	.44
* 5. Daniel International	B- 7	1.31
* 6. Radwaste Modification	B- 8	26.38
7. Clean Steam Testing	B- 9	3.00
8. Wismer & Becker (piping)	B-10	58.03
9. L.K. Comstock (electrical)	B-11	26.46
*10. Cooling Towers	B-13	15.84
*11. RCI	B-14	7.60
*12. TenneComp (security system)	B-15	2.39
*13. Project Shutdown (1974)	G- 7	15.20
*14. Refurbishment Program	I	11.20
15. Project Engineering	J- 7	47.80
16. Project Delays	K- 6	121.94

a. Subtotal	$355.17 million
b. Items marked (*) were based on AFUDC thru 1982. To update to 1983, they should be increased by 10.53%. Sum of (*) items is $97.94 million.	$ 10.31 million
Total Staff Recommended Disallowance	$365.48 million

C. A Final Word

By design, this investigation highlights only the weaknesses of the Fermi 2 project management. It deserves mention here that throughout the project we noted numerous examples of superior performance, good judgement and responsible management. These have received inadequate attention in our report.

As we mentioned in the beginning of this report, constructing a nuclear plant is a complex, massive undertaking. It calls for a long sustained commitment by the utility - commitment both in skilled manpower and financial resources. The construction of nuclear projects has become particularly agonizing due to increasing public pressures, regulations and safety concerns. Fermi 2 is a far cry from the project that Edison set out to build in 1968.

The management has faced thousands of issues, dilemmas and decisions. In the main, we believe they have been resolved in a reasonable and prudent manner, notwithstanding all the questions raised in the body of this report.

A positive characteristic of Edison Management is that it was never afraid of self-evaluation and self-criticism in order to improve the efficiency and performance at EF2. Scores of project reviews in-house and by third parties attest to that. Also, whenever weaknesses were pointed out, Management took appropriate action. It should be recognized that an owner does not always control events and circumstances. Nor can he predict the outcome of his own actions or those of others. Often Edison, as owner of EF2, paid for events or misjudgements of others unrelated to EF2 occurring elsewhere. The TMI accident is a glaring example of this.

A second positive aspect of Edison Management is the humanitarian approach with which it dealt with complex human problems. Despite all its engineering and technical aspects, construction of a nuclear plant still involves complex human interactions. In the Staff's opinion, Edison took a fair minded and compassionate approach in resolving disputes, motivating craft and contractors. Perhaps in todays world of competition these are considered unnecessary impediments to efficiency and progress. The Staff believes that they are an essential ingredient of a successful project, particularly when public safety is involved.

On the important but delicate issue of safety, regulations and NRC compliance, Edison has walked a tightrope. All evidence indicates that Edison made safety of paramount concern and remained on guard to prevent a major quality control infraction. Whenever it came to the Management's attention, quality control and safety issues were faced squarely and courageously (terminating Parsons, taking over QA function from Daniel). On safety issues, Management did not compromise and often erred on the side of safety. Edison also showed good corporate responsibility on environmental concerns. Surely, in the Staff's judgement, they resulted in a somewhat more expensive plant. In the end, the Staff believes that Edison, and therefore its ratepayers, got a quality-built plant which will serve Michigan energy needs efficiently and reliably for years to come.

November 8, 1983

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