Molten Carbonate Fuel Cell Product Development Test

**Annual Report
October 1992 - September 1993**

December 1993

Work Performed Under Cooperative Agreement No.: DE-FC21-92MC28065

For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia

By
M-C Power Corporation
Burr-Ridge, Illinois

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Morgantown Energy Technology Center
P.O. Box 880
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MASTER

December 1993

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Abstract

This report summarizes the technical progress that has been made in conjunction with Cooperative Agreement Number DE-FC21-92MC28065, Molten Carbonate Fuel Cell Product Development Test (PDT) in 1993.

Advanced fuel cell active components have been developed and scaled up from laboratory scale to commercial scale. Full width components of both the stabilized nickel cathodes and the low chrome anodes have been successfully cast on M-C Power's production tape caster.

An improved design for a fuel cell separator plate has been developed. The improved design meets the goals of lower cost and manufacturing simplicity, and addresses performance issues of the current commercial area plate.

The engineering that the Bechtel Corporation has completed for the MCFC power plant includes a site interface design, a preliminary site layout, a Process Flow Diagram, and specification for the procurement of some of the major equipment items.

Raw materials for anode and cathode components were ordered and received during the first half of 1993. Tape casting of anodes was started in late summer and continued through August.

In addition to the technical progress mentioned above, an environment assessment was prepared in compliance with the National Environmental Policy Act of 1969 (NEPA). As a result, the PDT has received a categorical exclusion from the Air Pollution Control District permit requirements.

The PDT is configured to demonstrate the viability of natural gas-fueled MCFC for the production of electricity and thermal energy in an environmentally benign manner for use in commercial and industrial applications.

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Executive Summary

M-C Power Corporation and the U.S. Department of Energy (DOE) have entered into Cooperative Agreement Number DE-FC21-92MC28065, Molten Carbonate Fuel Cell Product Development Test (PDT). M-C Power will install, test and evaluate a 250 kW Proof-of-Concept Molten Carbonate Fuel Cell (MCFC) Power Plant. The plant is to be located at the Kaiser Permanente Medical Center in San Diego, California. The DOE is providing funds for two 250 kW natural gas-fueled IMHEX[®] MCFC stacks to be manufactured and shop tested by M-C Power. The Gas Research Institute (GRI) is providing funds for the balance of plant engineering and construction. San Diego Gas and Electric Company (SDG&E) will host the PDT. The Electric Power Research Institute (EPRI) is providing funds through a tailored collaboration agreement with SDG&E.

The scope of work of the PDT is an integral part of M-C Power's program to commercialize molten carbonate fuel cell (MCFC) technology. The MCFC stack technology is based on the IMHEX[®] separator plate design. The Institute of Gas Technology holds a patent for the IMHEX[®] separator plate.

M-C Power has formed a team with the Bechtel Corporation and Stewart & Stevenson Services. M-C Power will design and manufacture MCFC stacks. The Bechtel Corporation will perform balance of plant and engineering and administration. Stewart & Stevenson Services will fabricate the balance of plant equipment onto a skid that can be truck transported to the power plant sites.

As host of the PDT, SDG&E will construct and then operate the power plant. SDG&E will coordinate all site related activities including the securing of the necessary construction and operating permits. SDG&E is coordinating the power plant design with the site owner, the Kaiser Permanente Medical Center.

In addition to the funds provided by GRI and EPRI, in-kind cost sharing is provided to the project by the Bechtel Corporation, Stewart & Stevenson Services, and SDG&E.

The PDT project represents the first truly integrated MCFC power plant in a cogeneration application. The power plant will be fueled by natural gas and it will furnish electricity to the SDG&E electrical distribution grid. It will also furnish thermal energy in the form of saturated steam to the Kaiser Hospital. The Kaiser Hospital was chosen as the site for the PDT because hospitals represent a potential market for natural gas fueled cogeneration power plants.

This report summarizes the technical progress that has been made in conjunction with this project in 1993.

Advanced fuel cell active components have been developed and scaled up from laboratory scale to commercial scale. Full width components of both the stabilized nickel cathodes and the low chrome anodes have been successfully cast on M-C Power's production tape caster.

An improved design for a fuel cell separator plate has been developed. The improved design meets the goals of lower cost and manufacturing simplicity, and addresses performance issues of the current commercial area plate.

The engineering that the Bechtel Corporation has completed for the MCFC power plant includes a site interface design, a preliminary site layout, a Process Flow Diagram, and specification for the procurement of some of the major equipment items.

Raw materials for anode and cathode components were ordered and received during the first half of 1993. Tape casting of anodes was started in late summer and continued through August.

In addition to the technical progress mentioned above, an environmental assessment was prepared in compliance with the National Environmental Policy Act of 1969 (NEPA). As a result, the PDT has received a categorical exclusion from the Air Pollution Control District permit requirements.

The PDT is configured to demonstrate the viability of natural gas-fueled MCFC for the production of electricity and thermal energy in an environmentally benign manner for use in commercial and industrial applications.

I. Introduction

M-C Power Corporation will design, fabricate, install, test and evaluate a 250 kW Proof-of-Concept Molten Carbonate Fuel Cell (MCFC) Power Plant. The plant is to be located at the Kaiser Permanente Medical Center in San Diego, California. The project is defined as "MCFC Product Development Test" (PDT) and has been developed in accordance with Department of Energy guidelines under Cooperative Agreement Number DE-FC21-92-MC28065.

In 1993 technical progress has been made in four distinct project areas.

1. Advanced fuel cell active components have been developed and scaled up from laboratory scale to commercial scale. Full width components of both the stabilized nickel cathodes and the low chrome anodes have been successfully cast on M-C Power's production tape caster.
2. An improved design for a fuel cell separator plate has been developed. The improved design meets the goals of lower cost and manufacturing simplicity, and addresses performance issues of the current commercial area plate.
3. The engineering that the Bechtel Corporation has completed for the MCFC power plant includes a site interface design, a preliminary site layout, a Process Flow Diagram, and specification for the procurement of some of the major equipment items.
4. Raw materials for anode and cathode components were ordered and received during the first half of 1993. Tape casting of anodes was started in late summer and continued through August.

In addition to the technical progress mentioned above, an environmental assessment was prepared in compliance with the National Environmental Policy Act of 1969 (NEPA). It has been prepared in accordance with the President's Council on Environmental Quality regulation implementing NEPA and the DOE Guidelines for Compliance with NEPA. As a result, the San Diego PDT has received a categorical exclusion from the Air Pollution Control District permit requirements.

M-C Power has prepared a management plan to establish and define organizational roles and responsibilities, relationships, control systems, and procedures which are being used to execute the project. The plan was prepared in accordance with the requirements of the Cooperative Agreement.

The mission of this project is to carry out the planning, coordination, support, management, development, construction, and demonstration of a MCFC power generation facility utilizing the IMHEX[®] design. This project is configured to promote the commercialization of MCFCs by the demonstration of the viability of natural gas-fueled MCFC to produce electricity in an environmentally benign manner for use in commercial and industrial applications.

II. Purpose

M-C Power Corporation and the U.S. Department of Energy (DOE) have entered into a Cooperative Agreement: Research contract to design, construct and operate a MCFC PDT. The DOE will provide funds for two 250 kW natural gas-fueled IMHEX® MCFC stacks to be manufactured and shop tested by M-C Power. San Diego Gas and Electric Company (SDG&E) will host the PDT.

Project performance will be in accordance with the "Statement of Cooperative Agreement Objectives." The major objective of the project is to support the demonstration of a full-area, full-height 250 kW MCFC stack in order to accelerate commercialization of the MCFC technology. The participant (M-C Power) will provide management and technical direction of the project, manage the funds, and prepare required reports in accordance with DOE's Financial Assistance Reporting Requirements Checklist.

The following organizations are participating in this project and are referred to by their names and acronyms throughout this report:

DOE	-	Department of Energy
MCP	-	M-C Power
GRI	-	Gas Research Institute Providing Cost Sharing
SDG&E	-	San Diego Gas and Electric Company, Subcontractor and PDT host/operator
EPRI	-	Electric Power Research Institute Providing cofunding with SDG&E
Bechtel	-	Bechtel Corporation, Subcontractor for Balance of Plant (BOP) Engineering
S&S	-	Stewart & Stevenson Services, Subcontractor for BOP Fabrication
IGT	-	Institute of Gas Technology, IMHEX® MCFC developer

III. Technical Results

Task 2.1 Stack Design - Active Components

OBJECTIVE

The following is a summary of the advanced component development work completed in the last year. The main goal of this effort is to identify an advanced cell package with improved endurance, performance, sealing capability and thermal cyclability. A target date of January 31, 1994 has been set for specification of the advanced cell package. Bench top and production casting and sintering experience and the cost versus benefit for the following materials and technologies are being evaluated:

- Cathode: Stabilized Ni cathode
Large Pore Ni Cathode
- Anode: Low Cr Anode
- Electrolyte: $(\text{Li/K})_2\text{CO}_3$
 $(\text{Li/K/Ca})_2\text{CO}_3$
 $(\text{Li/Na})_2\text{CO}_3$

In 1993, a high density matrix was developed under DOE contract No. DE-AC21-90MC27394 and Cooperative Agreement No. DE-FC21-92MC28056 (PDT). Because of the lower cost, improved microstructure and tolerances, these matrices will be specified for the PDT stacks.

BACKGROUND

The initial development effort for scale up of tape casting and sintering took place in July through October of 1992 at M-C Power. The scale up efforts revealed several areas where further development would be required prior to producing full-area stabilized nickel cathodes at M-C Power.

M-C Power has initiated a comparison of the cost versus performance of the stabilized nickel cathode compared to placing the cathode stabilizing agents in the electrolyte. Bench-top and production casting and sintering trials of the large pore cathode were initiated in November of 1993 as an alternative to the stabilized

cathode. This cathode would be used with an electrolyte which is doped to mitigate cathode dissolution. The cost versus performance benefit of the large pore cathode with nickel dissolution stabilizing agents in the electrolyte are being evaluated at M-C Power.

In addition to the stabilized cathode and low chromium anode, a few alternate technologies have demonstrated endurance and performance at the 100 cm² level, and they are ready for transfer to the M-C Power manufacturing facility. These areas, outlined below, were targeted in 1993, and MCP is now preparing to manufacture the first 20 kW stack with advanced active area components.

SUMMARY OF 1993 WORK

The scale up and development efforts for the stabilized cathode and low Cr anode are outlined below.

Stabilized Cathode and Low Cr Raw Materials Vendors - Prior to 1993, all of the stabilized cathode cell testing and scale-up efforts used a single batch of precursor powder manufactured at the Institute of Gas Technology (IGT). The powder manufacturing process used was not suitable for commercial production. The fine Cr powder required to make the low Cr anode was separated from coarse materials using laboratory centrifugation methods.

The single largest barrier toward production of stabilized cathodes and low Cr anodes for stack testing was the inability to obtain a reliable commercial product in stack quantities.

Stabilized Nickel Vendor - IGT had initiated discussions with a powder manufacturer to make the precursor powder to specification. Since January 1993, M-C Power has been working with IGT and the vendor to develop the powder manufacturing processes in lot sizes sufficient for a 250 kW stack.

In January 1993, 100 pounds of powder was manufactured at a temperature lower than the calcining temperature originally specified by IGT. Analysis of the powder by X-ray diffraction revealed that the powder had not been sufficiently stabilized.

At M-C Power's request, the powder supplier identified a vendor for heat treating the powder at a higher temperature. The first shipment of powder was received in the middle of June 1993. Evaluation of the powder and comparison with the

laboratory manufactured powder was completed as shown in Table 1. A polished cross-sectional SEM micrograph of an electrode made from the vendor powder exhibited a similar microstructure to that of the laboratory grade powder. The stabilizing agent is well dispersed through the nickel cathode.

Table 1.
Comparison of Stabilized Nickel Powders

Analysis	IGT Powder	Vendor Powder
Relative Powder Bulk Density	1.0	1.0-1.3
Relative Green Tape Density	1.0	1.05-1.21
Relative Sintered Porosity	1.0	.97-1.03
Relative Mean Pore Size	1.0	.87-1.09

The powder is acceptable and has been used in tape casting and sintering scale up efforts. A 100-cm² cell test is due to begin in December of 1993 to verify the performance and endurance. As-received powder evaluation will continue through 20 kW stack manufacturing to characterize the allowable lot-to-lot variability, impurities, and the effect powder characteristics have on further processing and the sintered microstructure.

Fine Cr Powder - Smaller particle size Cr powder is required to enhance the degree of alloying between Ni and Cr during sintering of the anodes and to ensure a homogeneous dispersion of the Cr throughout the anode. IGT separated the fine Cr particles from a commercially available powder.

M-C Power initially conducted limited milling trials of Cr powder using production mills at a major manufacturer of production grade mills.

In early 1993, a project to demonstrate production scale milling of Cr powders was initiated. A batch of 135 pounds of Cr powder was milled. This is enough Cr powder to make a 250 kW stack of low Cr anodes. A 15 hour mill time was required for the 135 pounds of powder to obtain a particle size distribution comparable to the IGT powder.

SEM analysis of anode tapes cast using this powder and sintered in the laboratory furnace reveal a very uniform microstructure with little external Cr. Stack quantities of vendor-produced low Cr powder are now available.

Scale Up of Tape Casting Procedures - Full width components of both the stabilized nickel cathode and the low Cr anode have been successfully cast on M-C Power's production tape caster. Because of difficulties with a defoaming agent during sintering, a modification of the tape casting formulation with an alternative defoaming agent occurred late in the year. Two alternative defoaming agents have been identified. The antifoam agent did not alter the pore size distribution of the sintered anode. In addition, an alcohol+water formulation was tested to increase the production rates. Final scale up to continuous casting will occur during manufacturing of the active area components for the next 20 kW stack.

Production Sintering - The advanced components manufactured and tested at IGT were 6"x6" components sintered by a heat treating vendor. The parts were heat treated in a cracked ammonia environment in a humpback furnace. No other sintering trials or atmospheric conditions were tested prior to transfer of sintering to MCP's production furnace.

Sintering trials of the low Cr anode at M-C Power have been very successful. The pore size distribution and porosity specification have been met and full area sintering trials completed.

On the other hand, numerous sintering trials have been conducted in the last year to determine whether the stabilized nickel cathodes could be reduced and sintered in the M-C Power production furnace. The conclusion was that a high hydrogen atmosphere is a requirement for manufacturing the stabilized nickel cathodes and a furnace retrofit will have to be accomplished prior to manufacturing 10-ft² parts.

An attempt to identify heat treating vendors for sintering 1-ft² and 10-ft² parts was only partially successful. A vendor will sinter 1-ft² parts providing the binder is removed prior to shipping to the vendor. Without the binder, the parts are very fragile and this is not anticipated to be a viable option. No full area sintering vendors were identified.

The M-C Power production furnace will not be retrofitted for high hydrogen until spring of 1994. After retrofitting, scale up and definition of the sintering parameters will be defined for the production furnace.

Bench Scale Testing - The first 100-cm² cell test of the advanced cell package will start the first week in December of 1994. The stabilized nickel cathodes were heat treated in the lab furnace at M-C Power while the low Cr anode was heat treated in the M-C Power production furnace.

The test will run for 2000 hours of 3 atm pressurized operation at Unocal systems conditions and utilizations. The results will be compared to the numerous endurance tests of a similar cell package that have been run at IGT in the last few years. Post test analysis of the component microstructures and carbonate fill will be utilized to fine tune the manufacturing specifications prior to manufacturing the 20 kW components.

Task 2.1 Stack Design - Separator Plates

OBJECTIVE

Stack Design work included improved separator plates in addition to the advanced component development work. The goal of this effort was to define a cost effective, flexible separator plate that would be easier to manufacture and would address performance issues of the current design.

BACKGROUND

The design of the separator plates in use for the full-scale 20 kW stacks was based on the design of the plate used for the 1 ft² stacks with modifications based on hydrodynamic and structural analysis previously performed. The pressure drops in the 1 ft² stack tests were the impetus for the hydrodynamic studies. The goal was to design a plate with plate to plate gas flow variation less than 10%. The structural studies determined the allowable span between ribs based on the thickness and structural properties of the current collectors and active components.

The separator plates in use, MOD 2, are the first attempt at the full scale plates required for M-C Power. During plate assembly, and manufacture, and stack testing, areas have been found where improvements could be realized. Design modifications were addressed under this contract, resulting in the MOD 4 plate design. The modifications are intended to reduce manufacturing complexity and costs, reduce raw materials costs, and improve dimensional tolerances of the finished separator plate.

SUMMARY OF 1993 WORK

The conclusion of the year's work is the design of an improved separator plate that meets the goals of lower cost and manufacturing simplicity, and addresses performance issues of the current commercial area plate.

After determination of the changes to be accomplished, several new plate concepts were detailed, drawings were completed, and an analysis of how well the objectives were met was performed.

There were three plate concepts evaluated. Proposed changes included: new ribbed fields (larger oxidant channels), gas distribution fields, smaller anode manifolds, wider wet seals, and integrated feed passages. A new section for ribbed field and

gas distribution fields was developed to reduce the cathode-side pressure drop. The smaller anode manifolds are to minimize leakage between fuel and oxidant manifolds. Integration of the feed and exhaust gas passages into the plate will significantly reduce manufacturing costs. Improved flow through the feed passages is expected by controlling the orifice dimensions. Other changes relate to the number of dies needed to manufacture the plates.

After reviewing the advanced designs, cost of tooling, expected cost savings, and corporate strategy, the MOD 4 design was chosen for implementation. The MOD 4 design features a new corrugation field (unbalanced anode, cathode flow), a new gas distribution field, wider wet seals, integral feed and exhaust passages, use of one die, and lighter gage material all of which contribute to an anticipated cost reduction of approximately 40% from the current MOD 2 design.

The present design (MOD 2) has 13 pieces that are individually cut, pressed, annealed, and welded together. The MOD 4 design comprises two pieces which incorporate the feed and main rails into the plate pressing. Benefits of incorporation include cost reduction and simplified welding. Several labor saving features were included. Component handling in manufacturing, assembly, and separator plate masking of the feed rails prior to aluminization is reduced.

Mechanical improvements include:

- Elimination of the "cookie cutter" effect on the electrolyte matrix in the manifold areas.
- Wider sealing surfaces for flexibility and improved sealing.
- Thinner main rail material for flexibility.
- Modified manifold openings for reduced stress on the electrolyte matrix.
- Thinner current collectors, separator plates, and rail plates for weight reduction.
- Point-to-point clamping on the corrugation field.
- Height reduction which saves 10 inches on the 250 kW stack.

Task 2.2 Balance of Plant Design

OBJECTIVE

The objective is to design a molten carbonate fuel cell power plant, fueled by pipeline natural gas to be installed at the Kaiser Permanente Medical Center in San Diego, California. The design objectives include improved performance at reduced cost compared to the 250 kW demonstration in Brea, California. Other design objectives are:

- More compact packaging
- Longer unattended operation
- Increased reliability

Additionally, the experience gained during the design and construction of the Brea power plant will be incorporated. The power plant will be designed for compatibility with the San Diego Gas and Electric (SDG&E) electrical distribution grid.

BACKGROUND

M-C Power Corporation has subcontracted with the Bechtel Corporation to design a fuel cell power plant for the Kaiser Permanente Medical Center in San Diego, California. The power plant will contain a 250 kW fuel cell stack that will be manufactured by M-C Power. The Balance of Plant includes fuel processing, thermal management/heat recovery systems, controls, and the power conditioning system. A catalytic natural gas reformer will be provided by Ishikawajima-Harima Heavy Industries Co.,Ltd. (IHI) of Japan.

The fuel processing and the thermal management/heat recovery systems will be fabricated into a single skid by Stewart & Stevenson Services of Houston, Texas. The Stewart & Stevenson skid will be shop tested before shipment to San Diego.

SUMMARY OF 1993 WORK

The Bechtel Corporation conducted a site interface design. Bechtel inspected the demonstration site and, with information provided by SDG&E and Kaiser Permanente Medical Center, established site specific requirements and constraints.

The requirements and constraints were included in a Design Criteria Document which has been published by Bechtel. The Design Criteria Document is included as part of all major equipment bid packages. The Design Criteria Document, Bechtel Corporation Specification No. 22200-G-002 is included in Appendix A.

Bechtel has prepared a Process Flow Diagram complete with heat and material balance analysis. The Process Flow Diagram has been reviewed and approved by M-C Power and SDG&E. The Process Flow Diagram features a thermally integrated catalytic natural gas reformer, a single hot gas blower in the cathode recycle loop, and cool natural gas de-sulfurization. The system is designed to operate at 3 atmospheres and uses a 98 hp turbocharger with an electric blower start-up. The Process Flow Diagram, Bechtel Drawing No. B-101 is included in Appendix B.

A preliminary site layout has been prepared by Bechtel. The Fuel Cell Power Plant at the Kaiser Permanente Medical Center in San Diego will occupy the site of an unused building which housed a waste incinerator and a steam boiler. An additional area will be needed for the fuel cell and reformer purge gas system. SDG&E is coordinating the site location and layout with Kaiser Permanente. Bechtel Drawing No. GA-100, "Preliminary General Arrangement Plan and Section", Drawing No. GA-101, "Preliminary General Arrangement Control Building Plans", and Drawing No. SK-C-100, "Site Utility Interconnection Requirements" are included in Appendices C, D, and E respectively.

Bechtel has prepared technical specifications to procure long lead equipment items. The specifications have been assembled into bid packages for the hot gas recycle blower, the inverter, the heat recovery steam generator, and the catalytic natural gas reformer. The bid packages are being evaluated by the appropriate vendors. Bid packages for other long lead equipment items such as the distributed control system, natural gas de-sulfurization system, the gas recycle cooler, and the purge gas storage system are being assembled. A list of all major equipment items is presented in Table 2.

Bechtel has begun work on the Piping and Instrumentation Diagrams (P&ID). The P&ID are approximately 30% complete. The P&ID will define the plant piping and the function of the control and monitoring instrumentation. The control functions will consider plant start-up, normal operation, normal shutdown, warm standby, and emergency shutdown. The monitoring function will consider both local indicators and signals sent to the data acquisition system.

Table 2.
Fuel Cell Power Plant BOP
Major Equipment Items

Description	Quantity
Natural Gas Compressor System	2
Desulfurization Unit	1
Heat Recovery Steam Generator With Start-Up Burner	1
Turbocharger	1
Hot Gas Cooler	1
Cathode Recycle Blower	1
Turbocharger Start-Up Blower	1
IHI Reformer	1
Instrument Air System	1
Inert Gas System	1
Inverter	1
Motor Control Center	1
Electric Heaters	2
Distributed Control System	1

It has been determined that it will be most expedient to install a natural gas compressor system. The natural gas service to Kaiser Hospital is sometimes operated at a pressure less than 30 psig. That is not sufficient for fuel cell power plant operation. A higher pressure gas main is approximately 1000 feet away, but a line extension would require the excavation of a busy San Diego thoroughfare. SDG&E prefers not to install the line extension and to instead install a natural gas compressor to boost the pressure to a range sufficient for fuel cell power plant operation.

A vendor for a suitable natural gas compressor has been identified. The natural gas compressor must be a type that will not contaminate the natural gas with lubricating oil. A natural gas compressor system has been designed with 2 full-size natural gas compressors connected in parallel with a gas cooler and a pulsation dampener immediately down stream.

Task 3.1 Component Manufacturing

OBJECTIVE

The objective is to fabricate active area repeat and non-repeat components to assemble two 250 kW stacks.

BACKGROUND

The program comprises the manufacture of components for two 250 kW stacks. The first stack will be composed of current state-of-the-art formulations, and fabrication is to be completed in May 1994. Advanced technology components will be manufactured for the second stack. Fabrication is scheduled for completion in December 1994.

SUMMARY OF 1993 WORK

The first stack will be composed of these components:

- Cathode: Nickel-(In-situ oxidized to NiO)
- Anode: Nickel-10 Chrome
- Matrix: Reinforced Lithium Aluminate
- Electrolyte: Lithium/Potassium Carbonate

Raw materials for the anode and cathode components were ordered and received mainly during the first half of 1993.

In scaling up from short batch casting performed for the 20 kW stack tests to the two-shift full time casting for 250 kW stacks, numerous process changes are necessitated. Much of the scale up effort for the current formulations was accomplished under contract No. DE-AC21-90MC27394. However, to improve manufacturing capabilities, additional work for anode tape casting was performed under this program.

Tape casting of anodes was started in late summer and continued through August. A "design of experiments" trial was executed to determine critical processing characteristics and to improve the release of tapes after drying. Production was

stopped to allow time to fully analyze the test results. The processing characteristics were implemented in the production operation sheets.

The experimental process resulted in tape casting of slightly more than 25% of the first stack anodes. The components have not been sintered.

Appendix A.

Bechtel Specification No. 22200-G-002

Design Criteria

July 15, 1993

930069
A-200

BECHTEL CORPORATION

**DESIGN CRITERIA
22200-G-002**

FOR

**M-C POWER/ SDG&E FUEL CELL
PRODUCT DEVELOPMENT TEST PROJECT**

SAN DIEGO, CALIFORNIA

JOB. NO. 22200

△					
△					
△	7-15-93	REVISED AS NOTED			JK
△	6-15-93	ISSUED FOR PROJECT USE	SIGNED		
△	5-6-93	ISSUED FOR REVIEW AND APPROVAL	SIGNED		
No.	DATE	REVISIONS	BY	CHK	APPR
ORIGIN			JOB No. 22200		
			DESIGN CRITERIA	REV.	
			G-002	1	
			SHEET 1	OF 10	
		M-C POWER/SDG&E FUEL CELL PRODUCT DEVELOPMENT TEST PROJECT			

M-C POWER SDG&E FUEL CELL PRODUCT DEVELOPMENT TEST PROJECT

DESIGN CRITERIA FOR BALANCE OF PLANT

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M-C POWER SDG&E FUEL CELL PRODUCT DEVELOPMENT TEST PROJECT

DESIGN CRITERIA

1.0 GENERAL DESCRIPTION, LOCATION AND ACCESS

1.1 General Description

The M-C Power SDG&E Fuel Cell Product Development Test Project is a joint effort among the fuel cell manufacturer, M-C Power Corporation (MCP), Gas Research Institute (GRI), San Diego Gas & Electric (SDG&E) and Electric Power Research Institute (EPRI). The fuel cell power plant will be fully integrated and engineered by Bechtel Corporation and Stewart & Stevenson using the MCP internally manifolded heat exchanger (IMHEX) molten carbonate fuel cell stack design.

The nominal capacity of the plant is 250 kW with natural gas as the primary source of fuel. The plant will convert approximately 62,000 SCFD of natural gas into hydrogen and carbon monoxide and produce 300 kW of D.C. power from the fuel cell. The fuel cell will also produce about 300,000 Btu. per hour of by-product heat. The design life of the plant is 5 years.

The plant will have the following equipment:

- o. Reformer and Catalytic Combustor
- o. Fuel Cell Stack
- o. Desulfurizer, Heat Recovery Steam Generator (HRSG), Heat Exchanger, Recycle Blower, Turbocharger and Electric Heaters - all on one skid
- o. Inverter, Motor Control Center and Heater Controls - all will be housed in a building which will be provided with a ventilation system.
- o. Compressed Air System
- o. Nitrogen Storage System
- o. Carbon Dioxide Storage System
- A Distributed Control System (DCS) for controlling plant operation -will be located in a climate controlled control room.

1.2 Location and Access

The site is located at the Kaiser Permanente Medical Center, 4647 Zion Avenue, San Diego, California. It is approximately 10 miles northeast of the San Diego airport and Civic Center near the Community of Grantville. The plant is to be located in the southwest portion of the complex adjacent to an existing parking structure. The location is shown in Attachment 1.

Access to the site is through an existing city street, Orcutt Street, leading to the medical facility's delivery area and southwest parking lot. This access road allows transportation of construction material and fuel cell plant and equipment. Mission Gorge Road is the main access road from Interstate 8.

The plant will be installed outdoors and will be provided with a facade that will blend with the existing adjacent structures on the site.

2.0 SPECIFIC SITE CRITERIA

2.1 Climate

- Temperature Range:	32°F to 110°F
- Precipitation:	
- Annual Avg, in.	8
- Site Elevation, ft.	120 (MSL)
- Relative Humidity, %	45 to 85

2.2 Seismicity & Wind

2.2.1 Seismic Design

The site is located in Uniform Building Code (UBC) Seismic Zone 4 area. Structural and seismic design shall be in accordance with the applicable sections of the UBC. For seismic design the following factors shall be used: Occupancy Importance Factor = 1.0, and C (Coefficient in base shear formula) = 2.75

2.2.2 Wind Design

The mean wind speed is 5 miles per hour. All plant facilities shall be designed for wind loads in accordance with the UBC, using a basic wind speed of 70 mph, exposure C, and Importance Factor of 1.0. Prevailing wind direction is from the west.

2.3 Water Table and Soil Condition

The water table and soil bearing capacities are as follows:

- Water table elevation, ft. 100 (MSL) (Approx.)

In accordance with the soils report a bearing value of 8000 pounds per square foot may be used for foundations in undisturbed natural soil.

2.4 Utilities Available at the Site

The following utilities will be provided to the project at the site boundary by Kaiser/SDG&E.

2.4.1 Fuel Supply and Analysis

Natural gas will be supplied at 60 psig. (minimum) pressure at a flow rate of approximately 45 SCFM. A typical analysis of this gas is given below:

<u>Constituents</u>	<u>Percent (Vol.)</u>		
Methane	93.02		
Ethane	3.67		
Propane	0.64		
Butane	0.16		
Pentane	0.04		
Carbon Dioxide (Max.)	0.45		
Nitrogen	2.00		
Hexane plus	0.02		
Oxygen	0.00		

Total	<u>100.00</u>		
Higher Heating Value	1033 Btu/scf		
Lower Heating Value	932.3 Btu/scf		
Temperature (assumed)	60°F		
Specific Gravity	0.595 (relative to air)		
<u>Sulfur Compounds</u>		<u>Average</u>	<u>Maximum</u>
Total Sulfur		4.4 ppmv	6.4 ppmv
Hydrogen Sulfide		1.3 ppmv	1.9 ppmv
Tetrahydrothiophene and mixed mercaptans		3.1 ppmv	4.5 ppmv

2.4.2 Steam Supply

Steam is available at 80 psig pressure from two boilers, one of which is redundant for reliability, which supply the medical facility's steam needs. Each boiler is rated to deliver 12,000 pounds per hour steam. Steam to the fuel cell power plant will be supplied from an existing 3 inch line. Steam produced at 100 psig in the fuel cell plant can be supplied to the medical facility to augment their steam needs.

2.4.3 Boiler Feedwater Supply

Boiler feedwater is available from the plant at 190°F at 180 psig. This water is treated with sodium sulfite to control oxygen. It does not pass through a deaerator. The feedwater analysis is as follows:

<u>Constituent</u>	<u>Units</u>	<u>Dissolved</u>	<u>Total</u>
CATIONS:	PPM		
Calcium (CaCO ₃)	"	0.5	0.5
Magnesium (CaCO ₃)	"	<0.5	<0.5
Sodium as (CaCO ₃)	"	190.0	190.0
Potassium (K)	"	0.2	0.2
Copper (Cu)	"	0.3	0.4
Iron (Fe)	"	0.2	0.4
Ammonia (CaCO ₃)	"	1.9	
ANIONS:	PPM		
Bicarbonate Alkalinity (CaCO ₃)"		82.0	
Phosphorus (PO ₄)	"	3.6	4.5
Sulfur (SO ₄)	"	110.0	110.0
Silica (SiO ₂)	"	3.7	3.8
Boron (B)	"	<0.1	<0.1
Chloride (CaCO ₃)	"	37.0	
Nitrite (NO ₂)	"	<1.0	
Nitrate (CaCO ₃)	"	<0.1	
Sulfate (CaCO ₃)	"	110.0	
OTHERS:	PPM		
Alkalinity CaCO ₃ -Total	"	83.0	
Alkalinity (CaCO ₃)-Phenol	"	<2.0	
pH			8.3
Conductivity (umhos/cm)			476.0
Conductivity Neutralized (umhos/cm)			479.0

2.4.4 Cooling Water Supply

Cooling water (about 4 gpm) at 75 to 85 F temperature and 35 to 40 psig. pressure is available from the existing cooling tower at the site boundary for cooling purposes.

2.4.5 Fire Protection Water

A fire hydrant is available within 100 feet from the site. Water pressure in the main is 80 psig.

2.4.6 Potable Water

A 1.5 inch line is available for tap water at nearly 80 psig. pressure.

2.4.7 Other Plant Drain Disposal System

Blowdown (maximum flow 100 lbs/hr @ 125 psig.) from the fuel cell plant's HRSG will be sent to a new blowdown tank from where it will be disposed to the existing City's sewer.

2.4.8 Compressed Air and Gases

Compressed air and other gases such as nitrogen and carbon dioxide which are required for the process are not available from the existing facilities at the site. New facilities will be added to supply compressed air, nitrogen and carbon dioxide to the fuel cell power plant.

2.4.9 Electric Power Supply

Power supply available at the site:

480 Volts, 3 phase, 60 Hz

Voltage preference for motors:

Motors less than 3/4 Hp 115 V, single phase, 60 Hz.

Motors 3/4 to 250 Hp 460 V, 3 phase, 60Hz.

Approximately 320 kW power will be required during start-up of the fuel cell plant.

2.4.10 Kaiser Permanente Specifications for Fuel Cell Installation

None

2.4.11 Area Classification

The basis for the area classification shall be the recommended practices outlined in the National Fire Protection Association (NFPA) publication 497A. Electrical equipment, devices and installation methods shall conform to Article 500 of the National Electrical Code. Motor control centers, and panel boards shall be located in unclassified areas.

2.5 Emission Requirements

2.5.1 Air Emissions

All emissions of pollutants such as NOx, CO, UHC (unburnt hydrocarbon), etc. from the plant shall be minimized and shall meet the requirements of San Diego Air Pollution Control District (APCD) Rules and Regulations. Continuous emission monitoring for the fuel cell power plant is not required.

2.5.2 Noise

The Fuel Cell Project overall noise level should be limited to 55 DBA at the Kaiser Permanente Medical Center property line which is located at about 50 feet from the fuel cell plant.

2.6 Process Monitoring & Control System

The Fuel Cell Project will utilize a Distributed Control System (DCS) to monitor and control the process operation. All analog and discrete inputs/outputs (I/O) are to be interfaced into one DCS. Vendor Package Control, Subsystems will be interfaced with the DCS through hardwired input/output.

The DCS will be installed in a NEMA 12 cabinet and located in a climate controlled control room. The control room will not be manned continuously.

3.0 CODES, STANDARDS AND GUIDELINES

3.1 Codes and Standards

The design shall comply with applicable Federal, State and Local laws and regulations. The design shall meet the requirements of applicable portions of the following Codes and Standards:

- ACI American Concrete Institute
- a. Building Code Requirements for Reinforced
 Concrete, ACI 318-89

	b. Specifications for Structural Concrete for Buildings, ACI 301-89
AISC	American Institute of Steel Construction
	a. Specification for Structural Steel Buildings-Allowable Stress Design and Plastic Design, AISC 1989
	b. Code of Standard Practice for Steel Buildings and Bridges, 1986
	c. Allowable Stress Design, Specification for Structural Joints Using ASTM A325 or A490 bolts, 1985
AISI	American Iron and Steel Institute
	Specification for the Design of Cold-Formed Steel Structural Members, Parts 1 and 2, 1986
ANSI C2	National Electric Safety Code
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society, Structural Welding Codes, AWS D1.1-1990
ICEA	Wire and Cable Standards
IEEE	Institute of Electrical and Electronic Engineers
NEC	National Electric Code (NFPA 70)
NEMA	National Electrical Manufacturers' Association
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
SSPC	Steel Structures Painting Council
UBC	International Conference of Building Officials (ICBO), Uniform Building Code, 1991 Edition
UL	Underwriter's Laboratories, Inc

3.2 Guidelines

The design and operation shall comply with San Diego Gas & Electric's Rule 21 "CUSTOMER-OWNED GENERATION--QUALIFIED FACILITIES" Attachment 2.

4.0 GENERAL FABRICATION AND CONSTRUCTION REQUIREMENTS

4.1 Site Development

The site requires excavation and levelling. Concrete foundations will be required to support equipment skids and structures.

4.2 Foundations

Foundations will consist of mats, slab on grade, or spread footings. A bearing value of 8000 lbs. per sq. ft. will be

used for foundations in undisturbed natural soil. A settlement of up to 1/2 inch may be expected for more highly loaded foundations.

4.3 Electrical Room

An electrical room will be provided to house electrical equipment. The room will be provided with insulation to control noise level and ventilation system to control temperature.

4.4 Construction Materials

4.4.1 Concrete

Concrete design compressive strength at 28 days (f'_c) shall be as follows:

Structural concrete, including slabs	
on grade minimum, psi	4000
Lean concrete fill, if required	2000

4.4.2 Reinforcing Steel

Reinforcing steel shall be deformed billet steel conforming to ASTM A615, Grade 60.

4.4.3 Structural Steel

All structural and miscellaneous steel shall be ASTM A36

Structural bolts shall conform to ASTM A325, or ASTM A307, where specified. Anchor bolts shall conform to ASTM A36. Welding of structural steel shall conform to AWS D1.1.

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SITE PLAN

ATTACHMENT 1

RULE 21

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

A. General

1. This Rule presents the design and operating guidelines that should be applied to Cogeneration and Small Power Production Sources that meet the criteria for a Qualifying Facility (QF) as defined by Title 18, Code of Federal Regulations (CFR) Section 292.101(b)(1). These guidelines are necessary to facilitate safe integration of customer generation into the utility's system. In addition, the QF must also comply with the utility's applicable rules and regulations.
2. These guidelines will cover 1) customer design requirements and operating procedures and 2) utility design requirements and operating procedures.
3. For the purpose of simplicity, the term customer will be used in the guideline to refer to both cogenerators and small power producers.

B. Customer System Description

1. The customer may elect to use any of a variety of energy sources including solar, wind or other alternative energy sources, in addition to conventional fossil fuels. The end conversion for connection to the utility's system must provide 60Hz alternating current.
2. The customer may elect to run his generator in parallel with the utility or as a separate system with capability of non-parallel load transfer between the two independent systems. The requirements for these two methods of operation are outlined below.

C. Separate System (See Supplement I in Section K.)

1. A separate system is defined as one in which there is no possibility of connecting the customer's generation in parallel with the utility's system. For this design to be practical, the customer must be capable of transferring load between the two systems in an open transition or non-parallel mode. This can be accomplished by either an electrically or mechanically interlocked switching arrangement which precludes operation of both switches in the closed position. The customer will be required to provide protection to ensure adequate clearing of faults on his own system.

(Continued)

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RULE 21 (Continued)

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

C. Separate System (See Supplement I in Section K.) (Continued)

2. If the customer has a separate system, the utility will require verification that the transfer scheme meets the non-parallel requirements. This will be accomplished by approval of drawings by the utility in writing and, if the utility so elects, by field inspection of the transfer scheme. The utility will not be responsible for approving the customer's generation equipment and assumes no responsibility for its design or operation.
3. Many Uninterruptible Power Supply (UPS) systems do not specifically meet the separate system criteria. However, if they are not capable of backfeed they will be classified as a separate system. If they can backfeed, they must meet the requirements of parallel operation.

D. Parallel Operation

A parallel system is defined as one in which the customer's generation can be connected to a bus common with the utility's system. A transfer of power between the two systems is a direct and generally desired consequence. For this operation to be practical and safe, the customer's equipment must meet the following conditions:

1. General Design Requirements

- a. The customer's installation must meet all applicable national, state and local construction and safety codes.
- b. All interconnection equipment at the customer's facility shall be installed and maintained by the customer. If, after review of the customer's design, it is determined that in addition, equipment need be installed on the utility's system, the associated costs shall be paid to the utility through a power purchase or interconnection agreement with the customer and in accordance with this Rule.

(Continued)

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RULE 21 (Continued)

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

D. Parallel Operation (Continued)

1. General Design Requirements (Continued)

- c. A manual load break disconnect device shall be available at or near the customer's main service point(s). This disconnect device may be owned by either party but the utility must have preemptory control for utility outages or switching. The disconnect device must be capable of being locked in the open position if the customer has access to the disconnect device (see Section H.2.a.).
- d. Voltage regulation equipment will be required on the customer's generator to maintain service voltage within normal utility limits (not required under 100 Kw).
- e. Generator characteristics shall be specified and the connection to the utility's system shall be designed to limit voltage harmonic distortion to less than 3% for any single frequency and to less than 5% total harmonic content. If harmonic distortion causes interference to other utility customers, the responsible party will redesign his system to eliminate such interference.
- f. The customer shall submit drawings and schematics of inter-connecting equipment and associated protection to the utility for review and approval. Typical required drawings will include, but not necessarily be limited to the following prints: single line diagram, relay functional, metering one-line and switch gear details, circuit breaker open and close control circuits. The utility will review only those portions of the drawings and schematics which apply to metering and the protection of the utility system. The utility assumes no responsibility for review or approval of equipment or circuit drawings pertaining to the protection of the customer's system.

(Continued)

RULE 21 (Continued)

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

D. Parallel Operation (Continued)

2. General Operating Requirements

- a. The customer must maintain service voltage within normal utility limits. If high or low voltage complaints or flicker complaints result from operation of the customer's generation, such generating equipment shall be disconnected until the problem is resolved.
- b. The customer shall discontinue parallel operation when requested by the utility:
 - (1) To facilitate maintenance or repair of utility facilities;
 - (2) During system emergencies;
 - (3) When the customer's equipment is operating in a hazardous manner or is operating such that it is interfering with other customers on the system.

NOTE: The utility may disconnect the customer from the utility's system at any time without prior notification, as system conditions may dictate.

- c. The customer may not commence parallel operation of its generator(s) until final written approval has been given by the utility. The utility reserves the right to inspect the customer's facility and witness testing of any equipment or devices associated with the interconnection.
- d. The utility reserves the right to inspect the customer's facilities whenever it appears that the customer is operating in an unsafe or harmful manner to the utility's facilities, personnel or other customers.

(Continued)

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Sheet 5

RULE 21

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

D. Parallel Operation (Continued)

2. General Operating Requirements (Continued)

- e. To assure the continued and safe operation of the interconnection between the utility and the customer, the utility recommends that the customer maintain and calibrate his equipment and protective devices associated with the interconnection to the utility on a repetitive basis. The utility reserves the right to require customers to provide the utility with maintenance and calibration reports.

E. Customer Generation Less Than 100 Kw (See Supplement II in Section L.)

1. The utility shall provide and install metering, at a location acceptable to the utility, as necessary to comply with applicable customer generation gas and electric rate schedules, power purchase contracts, or utility requirements. The installation, operation, and maintenance costs of these metering facilities shall be borne by the customer, except as provided in Section J.1.d.
2. Where service is provided at or below 480 V, the customer is to be served by a dedicated distribution transformer except in the following circumstances:
 - a. The generator is under 10 kw, or
 - b. The generator is under 100kw and is an induction generator wherein the customer explicitly provides for 24-hour immediate utility access to all interconnection facilities as provided in Rule 16.A.1.a.(1).
3. The customer should maintain his power factor within a reasonable range. For small generators, power factor correction may not be desirable.
4. The customer will be required to provide suitable devices to ensure adequate protection for the following:
 - a. All faults on the customer's system.
 - b. All faults on the utility's system.
 - c. Backfeed or start-up of a customer's generator(s) into a dead utility bus.

(Continued)

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RULE 21 (Continued)

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

E. Customer Generation Less Than 100 Kw (See Supplement II in Section L.)
(Continued)

5. The following customer protective devices are required as a minimum to effect connection and separation of the utility and customer systems. For induction generators below 10 Kw, the following are recommended but not required. The customer will still be responsible for providing protection for the conditions of Section E.4.
 - a. Individual phase overcurrent trip devices.
 - b. Undervoltage trip devices.
 - c. Underfrequency trip devices.
 - d. Synchronizing or equivalent controls to ensure a smooth connection with the utility's system.
6. The requirements listed in Section E.3. are based on the utility's forecast that there will be a relatively small amount of customer generation versus load for any particular line on the utility's system. If a heavy saturation of small power production on some line(s) does occur at a future time, future customers may be required to provide additional protection at that time. Where an induction generator is to be installed, some of the trip devices may be waived. Permission to waive certain devices will be given only after a check of the supply circuit (for capacitance) has been made and it has been determined that the customer's generation will not be able to backfeed the utility's system.
7. The customer shall not reconnect his generator after a protective device trip unless his system is energized from the utility source or unless he has isolated his system from the utility.

(Continued)

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RULE 21 (Continued)

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

F. Customer Generation Capacity 100 KW - 1 MW (See Supplement III in Section M.)

1. The utility shall provide and install metering, at a location acceptable to the utility, as necessary to comply with applicable customer generation gas and electric rate schedules, power purchase contracts, or utility requirements. The installation, operation, and maintenance cost of these metering facilities shall be borne by the customer.
2. The customer's generator(s) shall be designed and operated to limit the adverse affects of reactive power flow on the utility's system under all reasonably probable load conditions. Generators shall be operated in a manner to satisfy the reactive power requirement of the customer's own load within the limits of the generator's capability unless otherwise specified by the utility.
 - a. For synchronous generators, sufficient generator reactive capability shall be provided to withstand normal voltage changes on the utility's system.
 - b. For induction generators, capacitor installations will likely be required for reactive power support. The cost of such capacitors will be borne by the customer.
3. The customer shall install relaying to provide adequate protection for the following:
 - a. All faults on the customer's system.
 - b. All faults on the utility's system.
 - c. Unbalanced or single phase conditions on the utility's system.
 - d. Backfeed or start-up of the customer's generator(s) into a dead utility bus.

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RULE 21 (Continued)

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

F. Customer Generation Capacity 100 KW - 1 Mw (See Supplement III in Section M.) (Continued)

4. Protective devices required are as follows:
 - a. Individual phase overcurrent trip devices.
 - b. Undervoltage trip devices.
 - c. Sensitive current unbalance relays.
 - d. Synchronizing controls; either automatic or manual.
 - e. Over/under frequency trip devices.
5. The customer shall not reconnect his generator after a protective device trip unless his system is energized from the utility source, or unless he has isolated his system from the utility. To prevent such hazardous connections, the protective devices specified in Sections F.4.b. and F.4.d. are required. In addition, generator control circuit(s) must be designed to prevent accidental generator connection to a dead utility system. Design variations are acceptable provided the requirements of Section F.3. are satisfied.

G. Customer Generation Capacity Greater than 1 Mw (See Supplement IV in Section N.)

1. The utility shall provide and install metering, at a location acceptable to the utility, as necessary to comply with applicable customer generation gas and electric rate schedules, power purchase contracts, or utility requirements. The installation, operation, and maintenance costs of these metering facilities shall be borne by the customer.

(Continued)

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RULE 21 (Continued)

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

G. Customer Generation Capacity Greater than 1 Mw (See Supplement IV in Section H.) (Continued)

2. The customer's generator(s) shall be designed and operated to limit the adverse affects of reactive power flow on the utility's system under all reasonably probable load conditions. Generators shall be operated in a manner to satisfy the reactive power requirement of the customer's own load within the limits of the generator's capability unless otherwise specified by the utility.
 - a. For synchronous generators, sufficient generator reactive capability shall be provided to withstand normal voltage changes on the utility's system.
 - b. For induction generators, capacitor installations will likely be required for reactive power support. Such capacitors will be at the expense of the customer.
3. The customer shall install relaying to provide adequate protection for the following:
 - a. All faults on the customer's system.
 - b. All faults on the utility's system.
 - c. Unbalanced or single phase conditions, or deteriorating voltage waveform conditions on the customer's generator(s).
 - d. Backfeed or start-up of the customer's generator(s) into a dead utility bus.
4. Protective devices required are as follows:
 - a. Individual phase overcurrent trip devices.
 - b. Sensitive ground protection.
 - c. Over/under voltage trip devices.

(Continued)

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RULE 21 (Continued)

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

G. Customer Generation Capacity Greater than 1 Mw (See Supplement IV in Section N.) (Continued)

4. (Continued)

- d. Sensitive current unbalance relays.
 - e. Synchronizing controls; either automatic or manual synchronizing supervised by a synchronizing relay.
 - f. Over/under frequency trip devices.
 - g. Telemetering or supervisory equipment (see Sections G.6., G.7., G.8. and I.2.).
5. The customer shall not reconnect his generator after a protective device trip unless his system is energized from the utility source, or unless he has isolated his system from the utility. To prevent such hazardous connections, the protective devices specified in Sections G.4.c. and G.4.e. are required. In addition, generator control circuit(s) must be designed to prevent accidental generator connection to a dead utility system. Design variations are acceptable provided the requirements of Section G.3. are satisfied.

6. Telemetering of Plant Output

Telemetering of the plant output (Mw, Mvar) to the Utility Control Center, at customer's cost, is required when the output of the customer's generation is greater than 2 Mw, and the generation is operating in parallel with the utility.

7. Utility Supervisory Control

When the customer is selling firm capacity greater than or equal to 5 Mw to the utility, one of the following is required:

(Continued)

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RULE 21 (Continued)

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

G. Customer Generation Capacity Greater than 1 Mw (See Supplement IV
in Section H.) (Continued)

7. Utility Supervisory Control (Continued)

- a. Complete supervisory control system allowing operation of plant generation from the Utility Control Center.
- b. Manning of generation facilities during all hours of operation and all periods in which customer's facility may be dispatched to allow operation as directed from the Utility Control Center.

8. Control and Indication of Customer's Main Breaker

When the total output of the customer's generation is less than 5 Mw, control and indication of the customer's main breaker will not generally be required. However, this decision will be made on an individual basis by the utility.

H. Utility System Description

1. The vast majority of, if not all, customers with generation will be connected to the utility's distribution system. This is a radial system and past experience indicates these loads are of a passive nature. The encouragement of customers to install onsite generation, however, will make backfeed a distinct possibility. The incorporation of protective devices on the customer's equipment cannot be relied upon to prevent all possibilities of backfeed. Since backfeed is probable, the following design and operating requirements must be incorporated.
2. Utility Design Requirements
 - a. A means of disconnection must be available on both sides of the utility metering; must be under the control of the utility; and shall be applied to all customers with parallel generation.

(Continued)

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RULE 21 (Continued)

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

H. Utility System Description (Continued)

2. Utility Design Requirements (Continued)

a. (Continued)

This can be accomplished with switches, load break elbows, cutouts or secondary breakers. Customer disconnects can also be used provided that:

(1) The switches meet with utility approval.

(2) The utility has pre-emptive control.

b. Transformers feeding customers with parallel generation shall be identified with a special tag attached to the transformer or pole. This will notify field crews of the possibility of backfeed. Incoming load data sheets should be flagged and used to initiate orders to tag poles.

c. All maps and diagrams used by System Operators to direct switching operations shall have sources of parallel generation identified.

d. A supervisory control and monitoring system will be incorporated for those customers as specified in Sections G.7. and G.8.

I. Utility Operation Procedures

1. As specified in Section H.1., backfeed from customer generation is a distinct possibility. To maintain safe working conditions, strict adherence to safety rules is required. Utility procedure is to ground de-energized lines and equipment upon which work will be performed.

2. The utility will exercise direct control over customer generation to the extent allowed by the contract and elsewhere in this Rule. A supervisory system is required for this control (see Sections G.7. and G.8.).

(Continued)

RULE 21 (Continued)

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

I. Utility Operation Procedures (Continued)

3. The utility must have discretionary control over all customer generation, independent of magnitude, during outages, equipment maintenance or emergencies.
4. Additional safety control or procedures may be required as experience dictates.
5. It is normal utility practice to utilize multi-shot high speed reclosing on its distribution circuits.

J. Interconnection and Line Extension/Line Upgrade Facility Costs

1. General -

- a. The installation and maintenance costs of facilities related to the interconnection of a customer's facility (interconnection facilities) to the utility's system, utilizing the utility's normal standards, shall be borne by the customer.
- b. The installation and maintenance costs of any line extension/line upgrade facilities, utilizing the utility's normal standards, shall be borne by the customer. Line extension/line upgrade facilities are defined as all facilities, exclusive of interconnection facilities, determined by the utility to be necessary to connect the utility's system to the customer's point of delivery in order to accept the output of the customer's generating facility. The cost of any portion of the line extension/line upgrade undertaken to serve future additional customers shall be borne by the utility.

*As used in this Section J. only, the terms "interconnection facilities" and "line extension/line upgrade facilities" refer only to such facilities to be owned and maintained by the utility.

(Continued)

RULE 21 (Continued)

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

J. Interconnection and Line Extension/Line Upgrade Facility Cost (Cont'd.)

1. General (Continued)

- c. The customer shall be responsible for the costs of exploring the feasibility of a project or its interconnection with the utility's system, including reasonable advance charges imposed by the utility for feasibility studies. A transmission line study for any customer shall be completed by the utility within the time period identified by the utility in accordance with the applicable procedures as established by the California Public Utilities Commission.
- d. The customer shall be responsible for costs of metering, telemetering (to the extent required under this Rule), and safety checks except to the extent that, under the utility's existing other rules, a comparable customer would not be similarly charged. Where the customer's generating facility is less than 20 kw, except those customers remaining on Schedule AD after June 30, 1987, and customer does not require that power delivered to the utility be measured on a time-of-delivery basis, the utility will bear the cost of installing, operating and maintaining one standard watt-hour meter (and current transformers if required) to measure power flows from the customer to the utility. The customer shall provide and install necessary meter sockets and enclosure equipment at or near the point of delivery.
- e. The customer shall be responsible for the installation and maintenance costs of only those future utility system alterations which are necessary to maintain the California Public Utilities Commission's adopted interconnection standards for the customer's particular interconnection facilities. Said standards shall be those in effect at the time customers and utility sign the power purchase or interconnection agreement. Should a line extension/line upgrade not be directly required by or beneficial to the customer, the customer shall be treated like any other customer on the utility's system.

(Continued)

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4/

RULE 21

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

J. Interconnection and Line Extension/Line Upgrade Facility Cost (Cont'd)

1. General (Continued)

- f. When the customer wishes to continue to reserve interconnection and line extension/line upgrade facilities which were previously paid for by the customer, but have been idled by an energy sale conversion, the utility shall continue to charge the customer an operation and maintenance (O&M) charge for these facilities. When the customer no longer needs the facilities for which he has paid, or fails to pay the required O&M charge, a termination payment due to the utility or customer shall be calculated in accordance with the applicable sections of this Rule and the power purchase or interconnection agreement.
- g. The utility shall treat any money collected from a customer for a line extension/line upgrade that accommodates a second customer in the same manner as customer advances would be treated under the utility's regular line extension rules for other customers.
- h. The O&M charge required under this Section J. shall commence at such time as the facilities are installed and able to be used.

2. Allocation of the Utility's Existing Line Capacity

For purposes of interconnecting the customer with the utility, existing capacity on the utility's transmission and/or distribution system and a priority to such line capacity will be allocated as follows:

- a. For a customer who receives either a final Standard Offer #4, a Standard Offer #2, or a Uniform Standard Offer #1, the following shall apply;
 - (1) for a customer who bids for and receives a final Standard Offer #4 Power Purchase Agreement, entitlement to existing capacity on the utility's transmission and/or distribution system and a priority to such line capacity will be established as of the date its bid is accepted by the utility;
or

(Continued)

RULE 21

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

J. Interconnection and Line Extension/Line Upgrade Facility Cost (Cont'd)

2. Allocation of the Utility's Existing Line Capacity (Continued)

a. (Continued)

(2) for a customer who submits an application for and receives a Standard Offer #2, entitlement to existing capacity on the utility's transmission and/or distribution system and a priority to such line capacity will be established as of the date the customer pays for and provides all information necessary for the utility to conduct either a preliminary or detailed interconnection study; or for an out-of-service area Seller, as of the date Seller pays the costs and provides all information necessary for the utility to conduct a Line Loss and Transmission Impact Study as defined in the Standard Offer #2 Agreement; or

(3) for a customer who signs a Uniform Standard Offer #1 Agreement, entitlement to existing capacity on the utility's transmission and/or distribution system and a priority to such line capacity, will be established as of the date the customer both pays the Project Fee and pays the cost of, and provides all information necessary for the utility to conduct, either a preliminary or detailed interconnection study, as defined in the Uniform Standard Offer #1 Agreement.

b. For a customer who signs a non-standard power purchase agreement, entitlement to existing capacity on the utility's transmission and/or distribution system and a priority for such capacity will be established per the terms and conditions specified in such non-standard agreement, consistent with the above or as otherwise provided in such non-standard contract.

c. If a customer fails to perform any of the obligations specified in the Commission's authorized bidding protocol or queue management procedures, whichever is applicable, or fails to meet one of the performance milestones specified in the power purchase agreement executed by the parties, the customer's allocation of existing capacity and priority to said line capacity shall be terminated and shall be reallocated to other uses.

(Continued)

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43

RULE 21

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

J. Interconnection and Line Extension/Line Upgrade Facility Cost (Cont'd)

2. Allocation of the Utility's Existing Line Capacity (Continued)

- d. In the event that the customer loses his priority for available line capacity but desires to continue the project, the terms of the power purchase agreement and applicable law, shall determine whether the power purchase agreement is subject to termination as a result of such loss of priority, and the manner in which new priority may be established.
- e. Where existing line capacity is allocated to a customer, the customer shall incur no obligation for costs associated with future line upgrades needed to accommodate other customers. If existing line capacity is not sufficient to facilitate the customer's capacity requirements, the customer shall bear the cost of any additional line upgrade necessary to facilitate the customer's capacity requirement. If two or more customers establish priority rights simultaneously, the customers shall share the costs of any additional line upgrade necessary to facilitate their cumulative capacity requirements. Costs shall be shared based on the relative proportion of capacity each customer will add to the line.

3. Customer Installation of the Interconnection and Line Extension/Line Upgrade Facilities (Exclusive of Metering)

At the option of the customer, installation of that portion of the customer's interconnection and line extension/line upgrade facilities (exclusive of metering) that is not covered by the utility's regular line extension rules may be performed by the customer's contractor under the guidelines of and subject to the conditions and exceptions contained in Rule 15, Section E.8. and the following:

- a. The customer signs a power purchase or interconnection agreement with the utility specifying the facilities to be installed by the customer;
- b. Prior to construction, the customer makes payment to the utility, for the utility installation of the metering required for the customer's installation. The payment shall include a CIAC tax gross-up and shall be made to the utility pursuant to the utility's extension rules; and

(Continued)

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44

RULE 21

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

J. Interconnection and Line Extension/Line Upgrade Facility Cost (Continued)

3. Customer Installation of the Interconnection and Line Extension/ Line Upgrade Facilities (Exclusive of Metering) (Continued)

- c. The customer makes payment to the utility of a monthly ownership charge which shall be calculated utilizing the following factors:

<u>Type of Facility</u>	<u>Monthly Charge</u>
Transmission	0.50 percent
Distribution	0.65 percent

The appropriate percentage above is applied to the sum of the actual installed cost of the facilities deeded to the utility plus the estimated or actual installation cost (as selected in accordance with Section J.4.b.) of the metering provided by the utility in calculating the total monthly ownership charge to be paid.

In the event that the customer terminates the use of the interconnection and line extension/line upgrade facilities at any time, the customer will make a termination payment to the utility which shall be determined as follows:

- (1) The estimated or actual* installation cost of the metering provided by the utility plus the estimated removal cost of the interconnection and line extension/line upgrade facilities, less
- (2) The salvage value of any materials removed and the fair market value of any facilities the utility will continue to use to service other customers rather than removing, less
- (3) The estimated or actual* installation cost of the metering that was previously paid in advance to the utility by the customer.

If the termination payment as determined above is negative, then the utility will refund that amount, without interest, to the customer.

* If the actual cost option was selected in Section J.4.b.

(Continued)

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RULE 21

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

J. Interconnection and Line Extension/Line Upgrade Facility Cost (Continued)

4. Utility Installation of the Interconnection and Line Extension/ Line Upgrade Facilities

At the option of the customer, installation of the interconnection and line extension/line upgrade facilities may be made by the utility, provided the type of facilities requested are acceptable to the utility and the utility agrees to the installation of the facilities, under the following conditions:

- a. The customer will execute a power purchase or interconnection agreement covering the installation of the interconnection and line extension/line upgrade facilities.
- b. Prior to commencement of the installation of the facilities and as part of the power purchase or interconnection agreement, the customer will choose to pay the cost of installation based on either actual cost or a binding estimate.
- c. Payment Method for Interconnection Facility

The customer will choose one of the following options to provide payment to the utility for the installation and maintenance costs of the interconnection facility:

(1) Option 1

- (a) The customer will advance to the utility, prior to construction, the estimated installed cost of the interconnection facilities and related engineering fees.
- (b) If the customer chooses to pay for installation based on actual cost (as specified in Section J.4.b.), the utility will, as soon as practical after the interconnection facilities are completely installed by the utility, either bill or refund to the customer, as applicable, any difference between the estimated and actual installed cost of the interconnection facilities.

(Continued)

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RULE 21

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

J. Interconnection and Line Extension/Line Upgrade Facility Cost (Continued)

4. Utility Installation of the Interconnection and Line Extension/ Line Upgrade Facilities (Continued)

c. Payment Method for Interconnection Facility (Continued)

(1) Option 1 (Continued) -

- (c) The customer will make payment to the utility of a monthly ownership charge which shall be calculated utilizing the following factors:

<u>Type of Facility</u>	<u>Monthly Charge</u>
Transmission	0.50 percent
Distribution	0.65 percent

The appropriate percentage above is applied to the sum of the estimated or actual installed cost (as selected in accordance with Section J.4.b.) of the interconnection facilities in calculating the total monthly ownership charge to be paid.

- (d) In the event that the customer terminates the use of the interconnection facilities at any time, the customer will make a termination payment to the utility which shall be determined as follows:
- (i) The estimated or actual* installation cost plus the estimated removal cost of the interconnection facilities, less
 - (ii) The salvage value of any materials removed and the fair market value of any facilities the utility will continue to use to service other customers rather than removing, less

 * If the actual cost option was selected in Section J.4.b.

(Continued)

RULE 21

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

J. Interconnection and Line Extension/Line Upgrade Facility Cost (Continued)

4. Utility Installation of the Interconnection and Line Extension/ Line Upgrade Facilities (Continued)

c. Payment Method for Interconnection Facility (Continued)

(1) Option 1 (Continued)

- (iii) The estimated or actual* installation cost of the interconnection facilities that was previously paid in advance to the utility by the customer.

If the termination payment as determined above is negative, then the utility will refund that amount, without interest, to the customer.

(2) Option 2

- (a) The customer will make payment to the utility of a monthly interconnection facility (IF) charge for a term of 60 months commencing when the utility begins work to install the removable and reusable interconnection facilities. The monthly charge will be 3.4% of the estimated installed cost of the removable and reusable interconnection facilities. Removable and reusable interconnection facilities may include such items as transformers, disconnect switches, circuit breakers, protective relays, and other related equipment which can be removed and reused by the utility in the event that the customer terminates the use of the interconnection facilities. The utility reserves the right to determine individually the removable and reusable interconnection facilities. This determination will be subject to confirmation by the utility at such time the customer terminates either his power purchase or interconnection agreement or his use of the interconnection facilities, whichever is earliest.

* If the actual cost option was selected in Section J.4.b.

(Continued)

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RULE 21

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

J. Interconnection and Line Extension/Line Upgrade Facility Cost (Continued)

4. Utility Installation of the Interconnection and Line Extension/ Line Upgrade Facilities (Continued)

c. Payment Method for Interconnection Facility (Continued)

(2) Option 2 (Continued)

(b) The customer will advance to the utility, prior to construction, the related engineering fees for the total installation and the estimated installed cost of those interconnection facilities that cannot be removed and reused by the utility.

(c) If the customer chooses to pay for installation based on actual cost (as specified in Section J.4.b.), the utility will, as soon as practical after the interconnection facilities are completely installed by the utility, calculate a revised monthly IF charge based on the actual installed cost of the removable and reusable interconnection facilities. The utility will either bill or refund to the customer, as applicable, to account for the difference in IF charge based on the estimated versus the actual installed cost of such facilities. Once the revised monthly IF charge is determined, future monthly payments by the customer to the utility will be at the revised monthly charge.

(d) The customer will make payment to the utility of a monthly ownership charge which shall be calculated utilizing the following factors:

<u>Type of Facility</u>	<u>Monthly Charge</u>
Transmission	0.50 percent
Distribution	0.65 percent

The appropriate percentage above is applied to the sum of the estimated or actual installed cost (as selected in accordance with Section J.4.b.) of the interconnection facilities in calculating the total monthly ownership charge be paid.

(Continued)

RULE 21 (Continued)

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

J. Interconnection and Line Extension/Line Upgrade Facility Cost
(Continued)4. Utility Installation of the Interconnection and Line Extension/
Line Upgrade-Facilities (Continued)

c. Payment Method for Interconnection Facility (Continued)

(2) Option 2 (Continued)

(a) In the event that the customer terminates the use of the interconnection facilities, the customer will make a termination payment to the utility which shall be determined as follows:

(i) The total estimated or actual* installed cost plus the estimated removal cost of the interconnection facilities, less

(ii) The salvage value of any materials removed and the fair market value of any facilities the utility will continue to use to service other customers rather than removing, less

(iii) The estimated or actual* installed cost of the interconnection facilities that cannot be removed and reused by the utility that was previously paid in advance to the utility by the customer, less

(iv) The capital contribution of the monthly IF charge as calculated by the utility.

If the termination payment as determined above is negative, then the utility will refund that amount, without interest, to the customer.

*If the actual cost option was selected in Section J.4.b.

(Continued)

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RULE 21

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

J. Interconnection and Line Extension/Line Upgrade Facility Cost (Continued)

4. Utility Installation of the Interconnection and Line Extension/ Line Upgrade Facilities (Continued)

c. Payment Method for Interconnection Facility (Continued)

(2) Option 2 (Continued)

(f) Prior to the utility's acceptance of this option, the customer shall provide and maintain one of the following:

(i) A Letter of Credit which will guarantee payment of the estimated installed cost of the interconnection facilities that is in excess of the advance payment made by the customer under Section J.4.c.(2)(b),

(ii) A Surety Bond, acceptable to the utility, which will guarantee payment of the estimated installed cost of the interconnection facilities that is in excess of the advance payment made by the customer under Section J.4.c.(2)(b),

(iii) A similar security, acceptable to the utility, which will guarantee payment of the estimated installed cost of the interconnection facilities that is in excess of the advance payment made by the customer under Section J.4.c.(2)(b).

(Continued)

RULE 21

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

J. Interconnection and Line Extension/Line Upgrade Facility Cost (Continued)

4. Utility Installation of the Interconnection and Line Extension/ Line Upgrade Facilities (Continued)

d. Payment Method for Line Extension/Line Upgrade Facilities

- (1) The customer will advance to the utility, prior to construction, the estimated installed cost of the line extension/line upgrade facilities and related engineering fees. The customer will make payment to the utility of a monthly ownership charge which shall be calculated utilizing the following factors:

<u>Type of Facility</u>	<u>Monthly Charge</u>
Transmission	0.50 percent
Distribution	0.65 percent

The appropriate percentage above is applied to the sum of the estimated or actual installed cost (as selected in accordance with Section J.4.b.) of the line extension/line upgrade facilities in calculating the total monthly ownership charge to be paid.

- (2) If the customer chooses to pay for installation based on actual cost (as specified in Section J.4.b.), the utility will, as soon as practical after the line extension/line upgrade facilities are completely installed by the utility, either bill or refund to the customer, as applicable, any difference between the estimated and actual installed cost of the line extension/line upgrade facilities.
- (3) In the event that the customer terminates the use of the interconnection and line extension/line upgrade facilities, the customer will make a termination payment to the utility for the line extension/line upgrade facilities which shall be determined as follows:
- (1) The estimated or actual* installation cost plus the estimated removal cost of the line extension/line upgrade facilities, less

 * If the actual cost option was selected in Section J.4.b.
 (Continued)

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RULE 21 (Continued)

CUSTOMER-OWNED GENERATION -- QUALIFIED FACILITIES

J. Interconnection and Line Extension/Line Upgrade Facility Cost
(Continued)4. Utility Installation of the Interconnection and Line Extension/
Line Upgrade Facilities (Continued)d. Payment Method for Line Extension/Line Upgrade Facilities
(Continued)

(3) (Continued)

(ii) The salvage value of any materials removed and the fair market value of any facilities the utility will continue to use to service other customers rather than removing, less

(iii) The estimated or actual* installation cost of the line extension/line upgrade facilities that was previously paid in advance to the utility by the customer.

If the advance payment for the line extension/line upgrade facilities was shared among more than one customer, the termination payment for each customer will be determined in the same proportion as each customer's advance payment bears to the total advance payment. If the termination payment as determined above is negative, then the utility will refund that amount, without interest, to the customer.

*If the actual cost option was selected in J.4.b.

(Continued)

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RULE 21 (Continued)

Sheet 27

CUSTOMER-OWNED GENERATION - QUALIFIED FACILITIES

K. Supplement I - Typical Separate System Installation.

NOTES:

1. SWITCHES INTERLOCKED SO BOTH CANNOT BE CLOSED AT SAME TIME.
2. ADDITIONAL PHASE AND GROUND PROTECTION MAY BE REQUIRED WHERE SERVICE IS TAKEN AT 12KV OR HIGHER.
3. COMPLETE ELECTRIC METERING REQUIREMENTS ARE NOT INDICATED. A SEPARATE METERING GUIDELINES PUBLICATION IS AVAILABLE FROM THE UTILITY.

RELAY IDENTIFICATION

M = METER

(Continued)

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RULE 21 (Continued)

CUSTOMER-OWNED GENERATION - QUALIFIED FACILITIES

L. Supplement II - Typical Installation of Under 100 KW.

SUPPLEMENT II-UNDER 100KW (NOTE 1) RELAY IDENTIFICATION

25 = SYNCHRONIZING
 27 = UNDER VOLTAGE
 81 = UNDER FREQUENCY
 51 = PHASE OVERCURRENT
 M = METER

NOTES:

1. TYPICAL PROTECTION AS REQUIRED BY UTILITY FOR INTERCONNECTION. NO PROTECTION OF CUSTOMER EQUIPMENT IS SPECIFIED FOR LOW VOLTAGE INSTALLATIONS.
 A. THERMAL MAGNETIC BREAKERS MAY BE ACCEPTABLE.
 B. P.T. & C.T.'S MAY NOT BE REQUIRED.
2. TYPICAL PROTECTION SHOWN ON GENERATOR BREAKER. PROTECTION CAN BE PLACED ON MAIN TIE BREAKER.
3. SYNCHRONIZING EQUIPMENT REQUIRED IF CUSTOMER DESIRES TO CLOSE BREAKER WITH BOTH SIDES ENERGIZED.
4. FOR CERTAIN CASES CAN BE WAIVED. SEE SECTION FOR UNDER 100KW.
5. COMPLETE ELECTRIC METERING REQUIREMENTS ARE NOT INDICATED. A SEPARATE ELECTRIC METERING GUIDELINES PUBLICATION IS AVAILABLE FROM THE UTILITY.

(Continued)

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55-

RULE 21 (Continued)

CUSTOMER-OWNED GENERATION - QUALIFIED FACILITIES

M. Supplement III - Typical Installation of 100 KW to 1 MW.

SUPPLEMENT III 100KW-1MW (NOTE 1)

(Continued)

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84-03-092 Vice President-Regulatory Services Resolution No. _____

RULE 21 - (Continued)

Sheet 30

CUSTOMER-OWNED GENERATION - QUALIFIED FACILITIES

N. Supplement IV - Typical Installation of 1 MW and Above.

NOTES:

1. DRAWING SHOWS ONLY TYPICAL PROTECTION REQUIRED BY UTILITY FOR INTERCONNECTION. NO PROTECTION OF CUSTOMER EQUIPMENT OR SYSTEMS IS SPECIFIED.
2. TYPICAL PROTECTION SHOWN ON GENERATOR BREAKER. PROTECTION CAN BE PLACED ON MAIN TIE BREAKER.
3. THIS PROTECTION MAY ALREADY BE PRESENT ON EXISTING CUSTOMER INSTALLATIONS.
4. SYNCHRONIZING EQUIPMENT REQUIRED IF CUSTOMER DESIRES TO CLOSE BREAKER WITH BOTH SIDES ENERGIZED.
5. TELEMETERING REQUIRED FOR PROJECTS WHOSE GENERATION OUTPUT IS GREATER THAN 2 MW AND THE GENERATION IS OPERATING IN PARALLEL WITH THE UTILITY.
6. COMPLETE ELECTRIC METERING REQUIREMENTS ARE NOT INDICATED. A SEPARATE METERING GUIDELINES PUBLICATION IS AVAILABLE FROM THE UTILITY.

RELAY IDENTIFICATION

25	= SYNCHRONIZING
27/59	= UNDER/OVERVOLTAGE
51	= PHASE OVERCURRENT
50	= INSTANTANEOUS
51N	= RESIDUAL OVERCURRENT
M	= METER
81	= OVER/UNDER FREQUENCY
52	= BREAKER AUXILIARY CONTACT
46	= PHASE BALANCE

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Appendix B.

Bechtel Drawing No. B-101

**Process Flow Diagram
Normal Operation at Nameplate Capacity**

October 18, 1993

This Page Intentionally Omitted

Appendix C.

Bechtel Drawing No. GA-100

**Preliminary General Arrangement
Plan and Section**

November 15, 1993

Appendix D.

Bechtel Drawing No. GA-101

**Preliminary General Arrangement
Control Building Plans**

November 16, 1993

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222004A.DWG

ELECTRICAL ROOM FLOOR PLAN

CONTROL ROOM FLOOR PLAN

SECTION A-A'

SECTION B-B'

NOT FOR CONSTRUCTION

REVISIONS		DATE	BY	CHKD	APP'D
1	REVISED AND REDESIGNED				
2	ISSUED FOR APPROVAL				
3	REVISED				
4	REVISED				
5	REVISED				
6	REVISED				
7	REVISED				
8	REVISED				
9	REVISED				
10	REVISED				
11	REVISED				
12	REVISED				
13	REVISED				
14	REVISED				
15	REVISED				
16	REVISED				
17	REVISED				
18	REVISED				
19	REVISED				
20	REVISED				

BECHTEL SAN FRANCISCO	
M-C POWER SINGLE TIE CELL PRODUCT DEVELOPMENT TEST PROJECT KAISER PERMANENTE FACILITIES SAN DIEGO PRELIMINARY GENERAL ARRANGEMENT CONTROL BUILDING PLANS	
JOB NO.	22200
DRAWING NO.	GA-101
REV.	B

6.3

Appendix E.

Bechtel Drawing No. SK-C-100

Site Utility Interconnection Requirements

November 18, 1993