DIRECT FUELCELL® DFC300MA™ STANDARD POWERPLANT SPECIFICATION SUMMARY

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1.0 INTRODUCTION

This document summarizes specifications of the standard DFC300MA™ Direct FuelCell® (DFC®) powerplant. The DFC300MA™ is capable of providing high quality baseload electric power using natural gas using an efficient, environmentally clean fuel cell technology. The powerplant consists of three subsystems (see Figure 1) including:

- Mechanical Balance of Plant (MBOP): Fuel and water are cleaned to remove impurities, and heated to the required system operating temperature. The MBOP also includes the powerplant control system
- Fuel Cell Stack Module : The electrochemical conversion of fuel to DC power
- Electrical Balance of Plant (EBOP): The fuel cell DC power is converted to utility grade AC power.

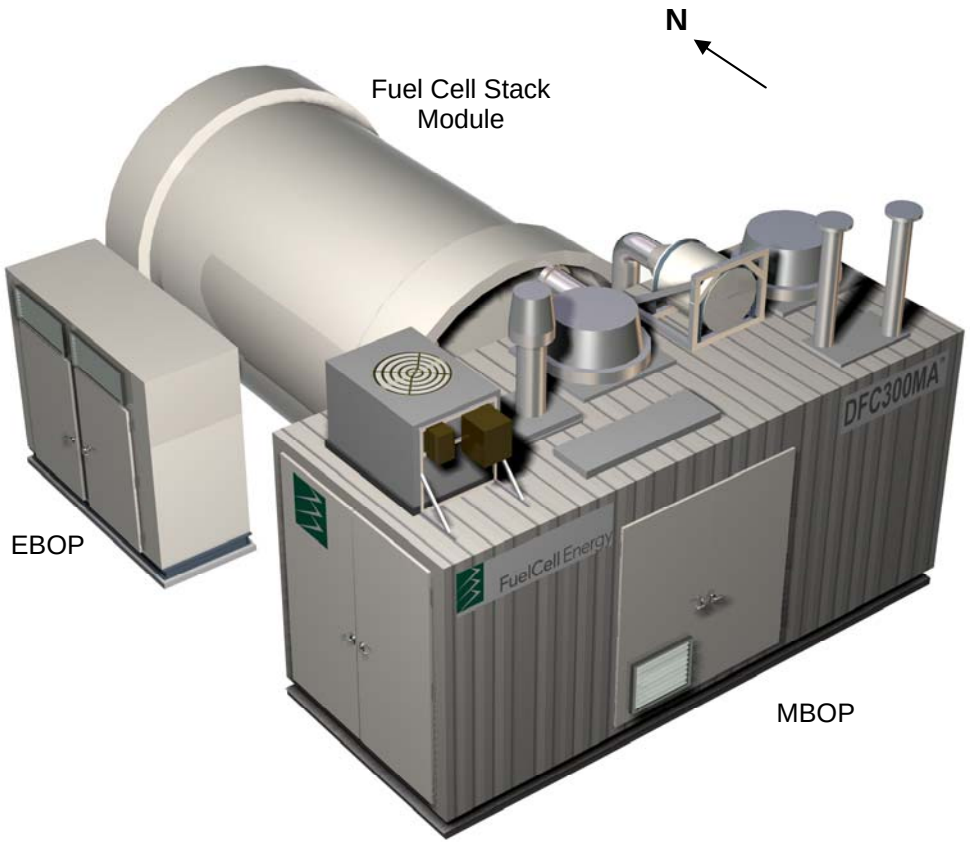

Figure 1
DFC300MA™ Powerplant

This model of the DFC300 powerplant has been provided with enhanced access areas for ease of maintainability. At one end of the MBOP (the west end in Figure 1) a set of double doors provides access to an enclosed area with the control system HMI touch screen, BOP equipment electrical panels, and the water treatment system. A set of double doors at the east end of the MBOP enclosure provides access to the major mechanical equipment in the plant – the fresh air and recycle blowers, valves, fuel humidifier, etc.

The stack module, MBOP, and EBOP are provided as factory assembled units which are interconnected at the site (see section 2.6, below for scope of supply). The systems have been built to general industry standards as well as standards that have been developed specifically for the fuel cell industry.

The DFC300A powerplant is certified to the following standards, and the DFC300MA™ plant will be certified to the same standards:

- CSA-FC1 Standard for Fuel Cell Powerplants
- UL 1741 Standard for Power Conversion Systems
- California Rule 21
- CARB 07 “Standard for Distributed Generation Unit Emissions (CCR 94200-94214) for Operation on Natural Gas”

The powerplant complies with the following standards:

- IEEE 1547
- NFPA 70 (National Electric Code)
- NFPA 853 Standard for Installation of Fuel Cell Powerplants
- ASME piping and vessel codes, as applicable per process conditions
- OSHA General Industry Standards – 29 CFR Part 1910

2.0 PLANT PERFORMANCE AND OPERABILITY CRITERIA

2.1 Overall Design Criteria and Specifications:

Table 1 summarizes the nominal specifications of the powerplant

Table 1, Plant Specifications

Dimensions and Weights	
Stack Module	
Height, feet	8.4
Width, feet	8.2
Length, feet	15.0
Weight, lbs	40,000
MBOP	
Height, feet	
Main Enclosure	9.6
With ship-loose items installed	14.6
Width, feet	8.0
Length, feet	19.8
Weight, lbs	27,000
EBOP	
Height, feet	9.5
Width, feet	3.5
Length, feet	9.0
Weight, lbs	15,000
Power Output, ISO conditions	
Power at Plant Rating, kW	250
Standard Output Voltage, Volts	480.0
Standard Frequency, Hz	60
Optional Output Voltages	460, 440, 420,400,380
Optional Output Frequency	50
Efficiency at Rated Output at ISO conditions	
LHV Efficiency, percent (see Note 1)	47 +/-2%[1]
Fuel Consumption at Rated Output	
Natural gas (at 930 Btu/ft3), scfm	32.5
Water Consumption at Rated Output	
Average, gallons per minute	2
Peak during WTS backflush, gpm	10
Water Discharge at Rated Output	
Average, gallons per minute	1
Peak during WTS backflush, gpm	10
Available Heat at Rated Power	
Exhaust Temperature, deg F	650
Exhaust Flow, lb/h	2800
Allowable Backpressure, iwc	5
Noise (see Note 2)	72dB(A) at 10 feet [2] 65 dB(A) option available
Emissions	
NOx, lb/MWh	0.02
SOx, lb/MWh	0.001
CO, lb/MWh	0.05

Note 1: Efficiency at acceptance shall be based on on-board instrumentation. Performance testing with additional high accuracy instrumentation is available for an additional fee. Power output and efficiency are subject to ISO correction according to FCE document # 5841. Efficiency value is based upon natural gas fuel meeting FCE's fuel specification. Fuel composition or ambient condition changes after acceptance testing may affect performance as described in the FCE Fuel Specification document #5665.

Note 2: Noise specified is estimated noise level 10' from plant perimeter in free field. Specific site conditions, such as proximity to other structures or equipment, will impact actual noise level at site.

2.2 General Operability Criteria

2.2.1 Plant Control:

The plant is designed for unattended operation with local and remote dispatching/control. The unit has a local control panel that displays basic operating information (see below) and provides inputs for selecting desired power output level or mode transition.

2.2.2 Operating Modes:

Heatup

Plant is heating up through various stages from ambient to full temperature.

Cooldown

Plant is cooling down through various stages from ambient to full temperature.

Hot Standby

Plant at temperature needed to initiate power generation.

Grid Connected Power Operation

Plant Power Conditioning Unit is synchronized to the utility grid and is exporting power as determined by plant operating settings.

Grid Independent Power Operation

Plant is disconnected from the utility grid and is supplying local loads.

Island Hot Standby

Plant is operating in Grid Independent Power Operation mode but is only supplying its own parasitic loads.

The DFC300MA™ plant is not capable of black start.

2.3 Plant and Subsystem Operation

The design life target for the overall plant is 30 years, assuming appropriate maintenance and component replacement. The current fuel cell stack has a replacement schedule of 25,000 hours[1]. During operation of these stacks, performance gradually decreases; this performance degradation results in a loss of efficiency and power output each of approximately 10% over the life of the stack. Operation of the stacks beyond these lifetime windows may be possible, but at restricted power output and lower efficiency.

[1] "Hours", as referred to here, implies hours of fuel cell operation above 900^{o}F.

2.4 Operation and Maintenance Requirements

The DFC300MA™ powerplant will require periodic replacement of the following equipment and consumables:

- Fuel cell stack, as discussed in section 2.3 (also see section 2.5.1)
- Water treatment chemicals and components
- Sulfur sorbent (fuel cleanup)
- Anode Cover Gas (FCE P/N 2735)
- Bottled Nitrogen
- Preconverter Catalysts
- Miscellaneous materials for normal operation and maintenance (O&M) of the plant (including filters, lube oil, etc)

The estimated initial quantities and annual consumption rates of major catalysts and chemicals for the DFC300MA™ powerplant are listed in Table 2.

Table 2
Catalysts and Chemicals Summary

ITEM	INITIAL AMOUNT	SERVICE LIFE
Fuel Preparation		
Sulfur Sorbent	22.8 ft^3	6 months – 2 years (2)
Preconverter Catalyst	2.5 ft^3	3 years
De-Oxidizer Catalyst (1)	0.2 ft^3	3 years
CO Polisher		3 years
Water Treatment		
Salt	800 Lbs.	3 month to 1 year

Notes:
(1) Required for peak shave gas option only
(2) At 100% capacity, dependent on type of odorant in natural gas

Labor requirements for O&M are expected to be limited to labor to replace these consumables and periodic checks of the plant.

2.5 Installation and Site Issues

The powerplant is designed for installation in a wide variety of sites, with a range of conditions. Sites that have conditions other than those described below may require modifications and/or additional equipment. The following subsections discuss the modularization, transportation, and site issues.

2.5.1 Installation and Access

The design of the plant facilitates rapid installation at the plant site. Prime consideration has been given to minimizing skid size while providing access to critical plant components for inspection and maintenance work (such as catalyst / sorbent replacement, valve maintenance, filter change out, etc.) The DFC300MA™ powerplant is shipped as three main units (MBOP, EBOP, and Stack Module) plus ship loose items (exhaust stacks, HVAC, etc.) On arrival at the plant site, the equipment is typically positioned directly on a foundation. Installation of gas, water, and electrical wiring to the buyer's system is then completed. Piping connections between the MBOP and Stack Module are also completed at this time.

Access space is required around the powerplant for routine maintenance and stack replacement. A 15' x 8' area needs to be reserved in front on the mechanical equipment end of the MBOP (in addition to the door opening space) to allow fork lift access for maintenance of mechanical components. Space needs to be allowed for ingress and egress access of the forklift to this area. This space can also serve as a crane spotting area for future stack module replacements. A 4 foot long areas needs to be reserved in front of the Control/WTS end of the MBOP, and 4 foot clearances need to be provided around the EBOP for access and code clearances. These clearances are noted on Figure 2 below.

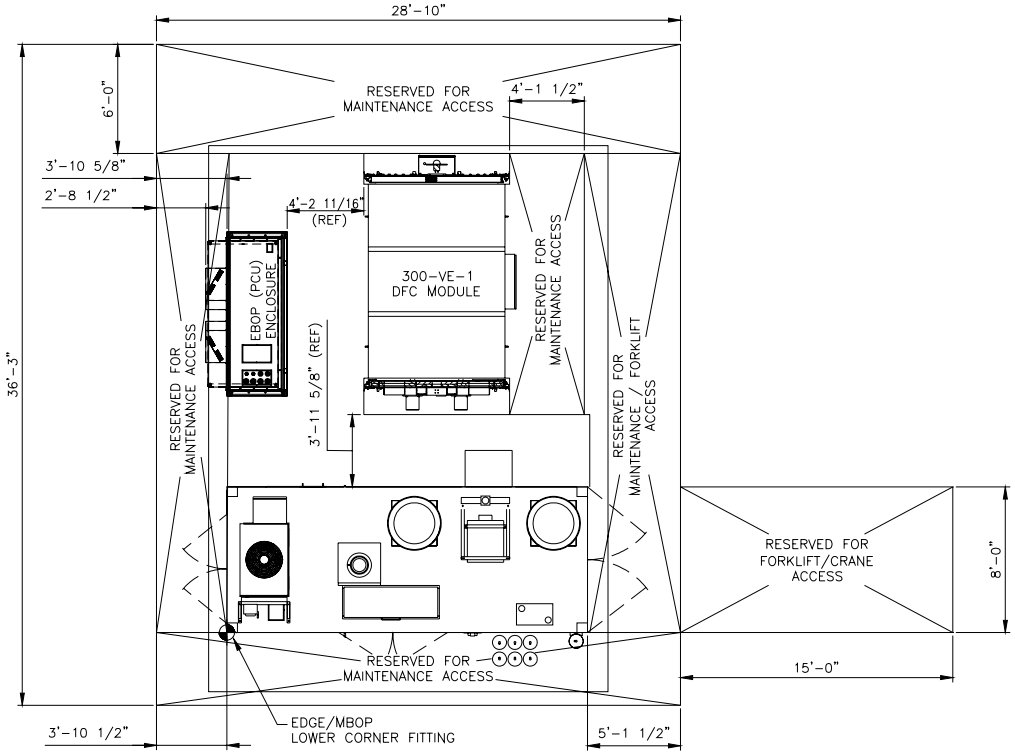

Figure 2: Typical Access Requirements

2.5.2 Site Conditions

The powerplant is designed for outdoor installation (indoor installation is possible with appropriate ventilation provisions.) Site and ambient design conditions for the plant are listed in Table 3. These conditions have been developed to allow the plant to be installed at most sites around the world. The "design conditions" data refer to the range of conditions that the standard plant must operate under. Host sites with ambient conditions other than those below may require modifications, additional equipment and/or may result in a reduced performance. The "performance point" data refers to the conditions at which the plant will provide its rated output and efficiency.

TABLE 3
SITE DESIGN CONDITIONS(1)

CATEGORY	DESIGN CONDITIONS	PERFORMANCE POINT(2)
Elevation above Sea Level	0 to 5000 ft	0 ft
Ambient Temperature	-20 to 104°F	59°F
Relative Humidity	0 to 100 %	60 %
Wind Loading @ 33 ft	30 PSF (3)	
Snow Load	30 PSF (4)	
Precipitation	2.5 inches/hour	
Seismic	UBC Zone 4	
Ambient Dust Loading, Ave./yr	27 micro-gram/m^3	
Ambient Gaseous Halide, Hypochlorite, or Halogen Concentration, Ave./yr	20 ppbw	
Ambient Gaseous Sulfur Dioxide Concentration in Air	< 10 ppb	

Notes:
(1) Highway access is required. Rail siding is not required.
(2) Basis for DFC300MA™ powerplant performance calculations.
(3) This wind load of 30 PSF is based on a wind speed of less than 90 mph and Exposure C. Exposure C is defined as "Open terrain with scattered obstructions having height generally less than 30 feet" (American Society of Civil Engineers standard ASCE 7-95).
(4) This snow load is equivalent to a ground snow load of 40 PSF and a snow exposure factor of 0.7 per Uniform Building Code UBC-97.

2.5.3 Plant / Site Interfaces

The plant is designed for the following interconnections at the plant boundary limit:

- Pipeline natural gas supply
- Municipal quality potable water supply
- Waste water discharge
- Flue gas discharge to safe location (if indoors)
- Safety relief valve discharge to safe location (if indoors)
- Discharge of ventilation gases (if indoors)

The plant also includes connections for telephone and/or data lines. These lines can be used for interconnection of the controller and fire alarm control panel with the buyer's control center, dispatch facility, local fire department, FCE, etc.

A connection to the electric grid is also required. Whenever the fuel cell is not generating power (such as during plant startup and shutdown), electric power for the plant auxiliaries will be back fed from the electric grid. During heatup the powerplant will draw up to 150kW power for BOP loads and heatup power. Average power use during the 80 hour heatup will be about 70kW.

Minimum requirements for gas and water quality are described in the next sections.

2.5.3.1 Fuel Quality Requirements

The plant is designed to operate with natural gas or anaerobic digester gas that meets the criteria listed in FCE specification 5665. Operation with oxygen containing peak shave gas requires additional equipment.

2.5.3.2 Water Quality Requirements

The plant is designed to operate with municipal potable water makeup that meets FCE Specification 5680. Water quality outside this range will typically require more frequent maintenance intervals or additional treatment equipment.

2.5.3.3 Powerplant Performance Correction to ISO conditions

As noted above, the power output and efficiency basis is ISO standard conditions. Correction of power output to ISO conditions for operation at non-ISO conditions is done per FCE Specification 5841.

2.6 Powerplant Scope of Supply for FCE and Customer

FCE Scope of Supply:

- Power plant system, comprised of
  - MBOP mechanical balance of plant skid, including fuel heatup and treatment, water treatment, and control equipment
  - EBOP electrical balance of plant skid, including DC to AC power conversion equipment
  - Fuel Cell Module
- Interconnecting piping and insulation between MBOP and Fuel Cell Module
- Ship loose components, such as exhaust stack, HVAC units, etc
- First fill catalyst materials (provided by FCE separately from BOP per DOT requirements)

Customer Scope of Supply

- Installation at Jobsite, including setting on foundations, installation of interconnect piping and ship loose components
- Installation of initial fill of FCE-supplied catalyst
- Rigging and off-loading equipment from transport vehicles
- Power and control wiring between skids
- Fuel and water quality testing
- Local, state, or federal permits
- Power sale or fuel supply agreements
- Emissions monitoring equipment, if needed
- All site design, preparation, and civil work including but not limited to soil testing, grading, foundations, foundation bolts, grounding grid, underground conduits, road access, fencing, and equipment laydown area
- Supply of utilities, including start-up power, fuel supply, water supply, wastewater discharge, nitrogen & purge gas cylinders (usually leased locally), calibration gas, communications and electrical interconnections