FCgen®-1020ACS /FCvelocity®-1020ACS Fuel Cell Stack

Product Specification

Model Name: FCgen®-1020ACS/FCvelocity®-1020ACS
Part Number: 5127049 through 5127063, 5133354, 5133801-5133812, 5134318

Document Number: SPC5103429 0E
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Ballard Power Systems Inc.
9000 Glenlyon Parkway
Burnaby, BC V5J 5J8
Canada
Technical Support: (604) 454-0900

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1.0 GENERAL

1.1. Scope of Specification

This document describes the specifications for the FCgen®-1020ACS/FCvelocity®-1020ACS Fuel Cell Stack that has been developed by Ballard Power Systems. Unless noted otherwise, all specification values stated are applicable at the beginning of operational lifetime. Some characteristics will change over time as the fuel cell stack is operated.

1.2. Product Configurations

The FCgen®-1020ACS/FCvelocity®-1020ACS stack is available in sizes ranging from 10 cells up to 80 cells.

Table 1. 1020ACS product configurations.

Number of Cells	v2.1 P/N (DRW5117682)	v2.2 P/N (DRW5122456)
10	5127049	5133801
12	5127050	5134318
13	5127051	5133802
18	5127052	5133803
20	5127053	5133804
28	5127054	5133805
36	5127055	5133806
39	--	5127056
46	5127057	5133807
56	5127058	5133808
64	5127059	5133809
66	5127060	5133810
70	5127061	5133811
73	5127062	5133812
80	5127063	5133354

1.3. Glossary

Term	Description
A	Ampere
BOL	Beginning of Life
ºC	degree Celsius
cc	cubic centimeter, evaluated at 1 atmosphere and 0°C
kPa	kiloPascal (absolute unless otherwise specified)
IEC	International Electrotechnical Commission
mm	millimeter
ms	millisecond
mV	milliVolt
PEM	Polymer Electrolyte Membrane
PM2.5	Particles up to 2.5 micrometers in diameter
PM10	Particles up to 10 micrometers in diameter
ppm	parts per million
slpm	standard liter per minute, evaluated at 1 atmosphere and 0°C
V	Volt

1.4. Reference Documents

- DRW5117682 Stack assembly, Iteration 2, 1020ACS family, Interface Control Drawing
- DRW5122456 Stack Assembly, FCgen-1020ACS v2.2 and FCvelocity-1020ACS v2.2, ICD
- MAN5100319 1020ACS Product Manual and Integration Guide
- SPC5102171 Component Design Requirements, Stack Hardware, 1020ACS
- SPC5102842 Component Design Requirements, Unit Cell, Iteration 2, 1020ACS

2.0 SPECIFICATION

2.1. Stack Performance

The stack performance shown in Table 2 is based on the FCgen®-1020ACS/FCvelocity®-1020ACS stack being operated at the conditions as listed in Table 3.

Table 2: Stack Performance at Beginning of Life

Performance Parameter		Stack Current (A)						
		0	7.3	14.5	29.0	51.7	65.3	75.0
Average Voltage Greater Than	V/cell	0.93	0.80	0.77	0.73	0.67	0.63	0.59
Average Power Greater Than	W/cell	0	5.8	11.2	21.2	34.6	41.1	44.1
Average Voltage, Typical	V/cell	0.99	0.83	0.80	0.76	0.70	0.66	0.62
Average Power, Typical	W/cell	0	6.1	11.6	22.0	36.2	43.1	46.5

2.2. Operating Conditions

Table 3: Stack Operating Conditions

Stack Current (A)		**0**	**7.3**	**14.5**	**29.0**	**51.7**	**65.3**	**75.0**
Recommended Stack Temperature, Steady-State	°C	26	30	34	41	53	61	66
Cooling/Oxidant (Air)								
Minimum Inlet Stoichiometry, Steady-State	20							
Inlet Pressure/Altitude	Optimal: Sea Level Allowable range: -400m to +7600m with de-rate at high altitude							
Inlet Temperature	Optimal: 10°C to 40°C Allowable range[1]: -20°C to +52°C							
Inlet Humidity	Allowable range: 0 to 100% RH non-condensing with de-rate at low RH/high temperature no added humidification required							
Fuel (Hydrogen)								

[1] Performance will be degraded when operating outside of the optimal range of inlet temperature.

Inlet Stoichiometry (Dead-Ended Operation)	~1.07 optimum
Optimal Inlet Pressure (Operating)	136 kPa absolute
Inlet Pressure Range (Operating)	116 to 156 kPa absolute
Maximum Allowable Inlet Pressure (Safety Limit)	200 kPa absolute
Range of Allowable Inlet Temperatures	–15°C to +65°C
Humidity	Dry fuel preferred No added humidification required

2.3. Ambient Environment Specifications

Table 4: Ambient Environmental Conditions

Ambient Conditions	
Operating Pressure/Altitude	-400m to 7600m[2]
Ambient Temperature, Operation	-40°C to +52°C
Ambient Temperature, Standby and Startup	-10°C to +52°C[3]
Relative Humidity	0 to 100% RH non-condensing[4]

Shock/Vibration	Tested to[5]:
	• NEBS GR-63-CORE
	  ○ Transportation Vibration Test
	  ○ Zone 4 Earthquake Test
	  ○ Office Vibration Test
	• Vibration: UL2267
	• Shock: 15g, 11ms, 1000 cycles (based on IEC-68-2-27, Ea and IEC-68-2-29, Eb)

[2] Stack performance will be degraded at altitude.

[3] Allowable number of sub-zero start-ups may be limited.

[4] Storage below ~10%RH may increase time required to achieve rated power upon start-up. See MAN5100319 for details.

[5] Testing conducted using spring-cap mounting option. See DRW5117682 for mounting details.

2.4. Reactant Specifications

Table 5: Oxidant Specification (Ambient Air)

Description	Specification	
	Nominal	Peak[6]
Chemical		
Sulfur Dioxide (SO_2)	< 0.01 ppm	<0.18 ppm
Nitrogen Monoxide (NO)	< 0.025 ppm	<0.20 ppm
Nitrogen Dioxide (NO_2)	< 0.05 ppm	<0.25 ppm
Volatile Organic Compounds (e.g. Benzene C6H6, Toluene C7H8)	< 0.008 ppm	<0.050 ppm
Hydrogen Sulfide	< 0.04 ppm	<0.04 ppm
Ammonia	< 0.01 ppm	<0.1 ppm
Ozone	< 1 ppm	<1 ppm
Carbon Monoxide	< 5 ppm	<32 ppm
Carbon Dioxide	< 1% vol	N/A
Particulate		
Airborne Particles		
Coarse Particles (PM 10)	< 90 $\mu g/m^3$	N/A
Fine Particles (PM 2.5)	< 15 $\mu g/m^3$	N/A

Table 6: Fuel Specification

Description	Specification	
	Nominal	Peak[7]
Composition	Hydrogen Gas	
Total inert gases	< 500 ppm (99.95% H2 min)	<19000 ppm
Water	< 5 ppm	<19000 ppm
Total hydrocarbons	< 2 ppm	< 2 ppm
Oxygen	< 5 ppm	< 5 ppm
Helium	< 300 ppm	< 300 ppm
Nitrogen, Argon	< 200 ppm	< 4000 ppm
Carbon dioxide	< 2 ppm	< 2 ppm
Carbon monoxide	< 0.2 ppm	< 10 ppm
Total sulfur compounds	< 0.004 ppm	< 0.004 ppm
Formaldehyde	< 0.01 ppm	< 0.01 ppm
Formic acid	< 0.2 ppm	< 0.2 ppm
Ammonia	< 0.1 ppm	< 0.1 ppm
Total halogenated compounds	< 0.05 ppm	< 0.05 ppm

[6] Extended exposure to peak oxidant contamination levels will result in performance degradation. See MAN5100319 for details.

[7] Peak fuel contaminant levels are intended to accommodate brief, infrequent transients. Extended operation at these levels may result in permanent performance degradation and damage to the fuel cell stack. See MAN5100319 for details.

2.5. Emissions (BOL)

Table 7: Beginning of Life (BOL) Emissions

Fuel (H_2)	
External Fuel Leak[8]	< 5 cc/min H_2 per cell @ 36 kPa (g)
Fuel Purge	Recommend 20 cc/cell per purge (~6 slpm/cell)
Water	
Liquid Water or Condensate	Liquid water may collect at fuel outlet

2.6. Shipping/Storage Conditions

Table 8: Shipping and Storage Environmental Conditions

Environmental Condition Limits	
Temperature Range	-40°C to +70°C with duration limits; see Table 9
Total Allowable Freeze-Thaw Cycles	>470
Relative Humidity Range	0% RH to 100% RH non-condensing
Shock and Vibration	Standard Ballard packaging meets the FedEx International Packaging Test for packages < 75 lbs

Table 9: High Temperature Storage Limits[9]

Storage Temperature Range (ºC)	**Maximum Storage Duration**
3 to 30	2 years
30 to 50	1 month
50 to 70	3 days

[8] External fuel leak is expected to increase over stack lifetime

[9] When stored under these conditions the stack will be able to start and operate at nominal conditions

2.7. Stack Weight and Dimensions

Table 10: Weight and Dimensions

Stack Length (mm)	Height (mm)	Width (mm)	Dry Mass (kg)	Thermal Mass (J/°C/cell)
55.4 + (Number of Cells x 5.5)	103	351	2.1 + (Number of Cells x 0.16)	100

All dimensions are nominal. Refer to the stack interface drawing (DRW5117682) for details.

2.8. Stack Degradation Rate and Lifetime

There are generally two key life-limiting failure modes that will prevent the stack from performing as required in a given application: voltage loss and fuel leakage. Voltage loss is seen as a steady degradation in maximum power. Fuel leakage will lead to increased fuel consumption and increased H2 emissions in the coolant air exhaust stream.

Table 11: Typical Degradation Characteristics

Typical stack degradation characteristics	
Performance Degradation per On-Off Cycle (Air-Air Start)	30 μV/cycle/cell
Performance Degradation During Steady State Operation at 65.3 A	12 μV/h/cell
External Fuel Leak at 1500 h and 1000 on-off cycles	12 cc/min H_2 per cell @ 36 kPa(g)

Stack degradation depends primarily on the number of on/off cycles that occur with an air-filled anode. Other factors, such as the number of operating hours, are less significant.