

UK /GERMAN

Dual Standard 61-23

Fuel Cell Supplement 01

Draft 7

Dated 19th June 2008

AMENDMENT RECORD

Amd No	Date	Text Affected	Signature and Date

REVISION NOTE

This is a new supplement.

HISTORICAL RECORD

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PREFACE

Standards for Defence Specification for Fuel Cell Supplement 61-23/1

draft 7

dated 19th June 2008

- a. This supplement shall be read in conjunction with Def Stan 61-23.
- b. This supplement provides a definitive specification for the electrical, physical, performance and nomenclature requirements for a Self Contained Man Worn Man Portable Methanol Fuel Cell System (MWMPMFC).
- c. This supplement has been agreed by the authorities concerned with its use and is intended to be used whenever relevant in all future designs, contracts, orders etc. and whenever practicable by amendment to those already in existence. If any difficulty arises which prevents application of this Defence Standard and its associated supplements, the UK Defence Standardization (DStan) shall be informed so that a remedy may be sought.
- d. Any enquiries regarding this standard in relation to an invitation to tender or a contract in which it is incorporated are to be addressed to the responsible technical or supervising authority named in the invitation to tender or contract.
- e. Compliance with this Defence Standard shall not in itself relieve any person from any legal obligations imposed upon them.
- f. This standard has been devised solely for the use of the Ministry of Defence (MOD) and its contractors in the execution of contracts for the MOD. To the extent permitted by law, the MOD hereby excludes all liability whatsoever and howsoever arising (including, but without limitation, liability resulting from negligence) for any loss or damage however caused when the standard is used for any other purpose.

TEXT
Standards for Defence
Specification for Fuel Cell Supplement 61-23/1
draft 7
dated 19th June 2008

GENERAL REQUIREMENTS

0 INTRODUCTION

It is Ministry of Defence (MOD) policy to purchase fuel cells against performance specifications whenever possible. Defence Standard 61-23 and its series of supplements has been generated to address the current requirements for batteries. This supplement is applicable when invoked directly by an MOD invitation to tender, contract, or when referred to by other MOD battery specifications.

1 SCOPE

This supplementary standard defines the Environment and Performance tests for a Self Contained Man Worn Man Portable Methanol Fuel Cell System (MWMPMFC) here after referenced as the fuel cell.

This system will operate without the need for an external hybridised battery or other energy source and will be limited to providing dc outputs that do not exceed 60V d.c. and power output that does not exceed 240 watts. As such, the externally accessible circuitry is considered as circuits that are "SELV" as defined in IEC 60950-1.

2 HEATH & SAFETY WARNING

The Ministry of Defence (MOD), like its contractors, is subject to both United Kingdom and European laws regarding Health and Safety at Work, without exemption. All Defence Standards either directly or indirectly invoke the use of processes and procedures that could be injurious to health if adequate precautions are not taken. Defence Standards or their use in no way absolves users from complying with statutory and legal requirements relating to Health and Safety at Work.

3 REFERENCE STANDARDS

The publications shown below are referred to in the text of this standard and its associated supplements. Publications are grouped and listed in alpha numeric order. These documents are subject to frequent change and or amendments.

Designation	Title
Dual Standard 61-23	Generic Fuel Cell Standard
AECTP 300 method 313	Climatic Environmental Test - Sand & Dust
EN 60721-3-7	Classification of Environmental Conditions
EN62282	Fuel Cell Technologies. Fuel Cell Modules
IEC 60529	Degrees of Protection Provided by Enclosures (IP Code)
Mil-std 1474	Noise Limits
AECTP 500	Electrical/Electromagnetic Environmental Tests

Reference in this standard to any related document means in any invitation to tender or contract the edition and all amendments current at the date of such tender or contract unless a specific edition is indicated.

In consideration of above, users shall be fully aware of the issue and amendment status of all related documents, particularly when forming part of an invitation to tender or contract. Responsibility for the correct application of standards rests with users.

DStan can advise regarding where related documents are obtained from. Requests for such information can be made to the DStan Helpdesk. How to contact the helpdesk is shown on the outside rear cover of Def Stans.

4 ABBREVIATIONS

For the purpose of this standard and its associated supplements the following definitions apply:

Designation	Title
AP	Allied Publication (NATO)
BS	British Standard
BS EN	European Standard
BSI	British Standards Institute
Def Stan	Defence Standard
IEC	International Electrotechnical Committee
MWMPMFC	Man Worn Man Portable Methanol Fuel Cell System
The fuel cell	Man Worn Man Portable Methanol Fuel Cell System

5 DEFINITIONS & TERMINOLOGY

Alarm:	State of the fuel cell system after a user repairable failure, e.g. fuel shortage or overheating. Part of the balance of plant components are still turned on but the fuel cell it self is not delivering power or consuming fuel.
Authority	Defined as the responsible technical or supervising authority named in the invitation to tender or contract.
Delivery:	Fuel cell system as supplied by the manufacturer, partly disassembled and without fuel cartridge. Initial mounting and run-in may be required.
Fuel	A methanol or methanol/water solution regardless of the concentration that is used to produce electricity in a MWMPMFC system.
Generic Standard	Defined as a standard that combines the general requirements and procedures applicable to a number of fuel cell types.
Idle:	The fuel cell system is running and consuming fuel but does not deliver power to an external consumer
Mandatory Clauses	Defined as clauses that use the word "shall". Optional or non-mandatory clauses use the word "should".
Notice:	It must be possible for any unskilled user (Soldier) to change the state of the fuel cell system between the states Off, Stand-by, Idle, Operating and Alarm without the usage of any tool.
Off:	State the fuel cell assumes after switch-off by user. The fuel cell system must restart after switch on.
Operating:	Fuel cell is running, consuming fuel and delivering rated power or rated current to an external consumer.
Self Contained	The Fuel Cell system will operate without the need for an external hybridised battery or other energy source
Stand-by:	Optional state in which the fuel cell system does not deliver power to external consumer but is turned on in parts and consuming fuel in order to accelerate the period to power delivery. If a stand-by state is available for a fuel cell system, fuel consumption during stand by must be specified by the manufacturer.

Stealth Use:	A hybridised fuel cell system can operate in stealth mode if, under the control of the operator, the fuel cell and the balance of plant can be shut down to reduce noise whilst the battery/capacitor within the hybridised system maintains the specified output for a declared period of operation. Following operation in stealth mode, it shall be possible to start the fuel cell (without external power) to recharge the battery/capacitor whilst providing a specified output.
Storage:	State of the fuel cell in which it can be stored for a longer period of time (> 6 months). Fuel cell may be partly dismantled so that transfer into operation requires skilled personnel. Special procedures for storage or transport under special conditions like very low or high temperatures or low pressure as encountered on cargo deck of cargo aircrafts may be given.
Supplement	Defined as a supplement to the generic standard for an individual Fuel Cell type, which invokes or tailors the relevant sections from the standard as required.
Thermal Equilibrium	Is assumed to be reached when the temperature of the unit remains constant $\pm 2^{\circ}\text{C}$ for a period of 30 minutes.
The Fuel Cell (MWMPMFC)	A small DC power unit that includes a fuel cartridge, provides not more than 60Vdc output voltage and 240W output power, and is connected to a hand held or wearable electronic device.

6 TEST PERFORMANCE.

Note 1: Fuel Cells consume air and produce moisture during testing therefore care must be taken to ensure the test environment remains within the specifications detailed in dual standard 61-23.

Note 2: Each test Group is to be performed in the numerical sequence shown

Note 3: Testing shall be carried out in accordance with section 6 of dual standard 61-23 unless otherwise stated in this supplement.

Note 4: All performance evaluation shall be carried out independently of any external energy source (battery).

Test Description	Supplement Clause	Sample Allocation (Test Group)			
		1	2	3	4
Start Up Duration	6.1.1	*(0.5)	*(0.5)	*(0.5)	*(0.5)
Rated Power & Voltage	6.1.2	*(1)	*(1)	*(1)	*(1)
Intermittent Power Generation	6.1.3			*(0.5)	*(0.5)
Power Generation After Storage	6.1.4				*(91)
Start Up, Operation and Storage Tests at Low & High Temperatures	6.1.5				*(1.5) *(1.5)
Fuel Consumption & Efficiency Test	6.1.10	*	*	*	*
Power Generation under Low & High Humidity	6.1.6				*(2)
Test at Minimum Partial Load	6.1.7			*(1)	*(1)
Altitude Test	6.1.8				*(1)
Power Quality Test	6.1.9			*(1)	*(1)
Test of the Bridging Time	6.1.11			*	*
Shut Down Test	6.1.12				*
Rain Water Test	6.1.26			*	
Immersion Test	6.1.27			*	
Vibration Test	6.1.14			*	
Shock Test	6.1.15			*	
Bump Test	6.1.16			*	
Dust Test	6.1.17			*	
Sand Test	6.1.18			*	
Thermal Characteristics for IR	6.1.19	*			
Thermal Characteristics for Safety	6.1.20	*			
EMC Characteristics (Susceptibility)	6.1.21				*
EMC Emission Test	6.1.22				*
Audible Noise Characteristics	6.1.23	*			
Chemical Characteristics (Emissions)	6.1.24				*
Chemical Environment (Susceptibility)	6.1.25				*
Orientation	6.1.28	*	*		
System Operational Life	6.1.29		*		
System Cyclic Endurance Life	6.1.30	*			
Drop Test	6.1.13				*

Table 1: Test Sequence

6.1 Power Generation Characteristics

6.1.1 Start up test duration

The purpose of this test is to verify the starting duration of the Fuel Cell system.

This test method may be utilized as part of other test criteria in this supplement.

The Fuel Cell system under test shall be conditioned in the off state under the standard testing environment for a minimum of 4 hours prior to this measurement. The conditioning period must be sufficiently long in order to allow for all system components to equilibrate with the environmental conditions. With the external load connected the system shall be turned on and shall reach a stable voltage of at least 90% of the rated voltage at the rated output power (defined by the manufacturer) and shall maintain this for a minimum period of 30 minutes.

The start up duration to achieve 90% of the rated voltage shall be less than 5 seconds.

6.1.2 Rated Power Test & Rated Voltage Test

The purpose of this standard test is to verify the rated power and the rated voltage of the Fuel Cell system.

6.1.2.1 The Fuel Cell system under test shall be conditioned in the off state under the standard testing environment, such as clause 6.2 of the generic Fuel Cell standard, for a minimum of 4 hours unless otherwise stated prior to this measurement. The conditioning period must be sufficiently long in order to allow for all system components to equilibrate with the environmental conditions.

6.1.2.2 A voltmeter and a constant load shall be connected so as to draw the constant rated power (watts) in accordance with the manufacturer's specifications. During the test, the fuel cell or fuel cell module in the fuel cell power unit must be generating power by consuming the fuel. The rated power must be delivered over a period of at least 4 hours. If the system cannot deliver the rated power, terminate the test and do not perform the output voltage test below.

The output voltage shall be measured continuously to determine whether or not it is within the upper and lower limits of the operating voltage range specified by the manufacturer. The operating voltage range specified by the manufacturer shall be indicated in the test report. The duration of measurement and the fuel consumption measurement during the standard testing environment referred to above shall be recorded in the test report.

(Note: fuel consumption noted in accordance with 6.1.10 to ensure fuel cell operating and not powered by the internal battery)

6.1.3 Intermittent Power Generation Test

The purpose of this test is to verify the performance of the Fuel Cell power systems after intermittent power generation.

In preparation of the test, the sample must be operated at rated power conditions for at least 2 hours immediately before the beginning of the test cycles. The intermittent power generation cycle shall consist of a 10-minute power generating period, during which the Fuel Cell power system is generating power at the rated power specified by the manufacturer, followed by a 10-minute off period, during which the external load is disconnected. The intermittent power generation cycle shall be continued for 2 hours (6 cycles). The voltage of the Fuel Cell during each on period must be in the operating voltage range specified by the manufacturer.

6.1.4 Power Generation Test after Storage

The purpose of this test is to verify the performance of Fuel Cell systems after a period of storage.

Rechargeable batteries or capacitors should be in the fully charged state at the beginning of the test. The Fuel Cell shall be conditioned by subjecting them to a period of pre-use, during which it is operated at the rated power specified by the manufacturer, followed by a period of storage, during which it will be in the off state. The minimum duration of pre-use shall be 2 hours. Afterwards the system should be shut-down, following the shut-down procedure specified by the manufacturer, if required. The duration of storage shall be 90 days. Subsequently the start up duration and rated power & rated voltage should be verified following the procedures given in sections 6.1.1 and 6.1.2.2.

6.1.5 Start Up, Operation and Storage Tests at Low & High Temperatures.

6.1.5.1 Start Up and Operation Test at Low Temperatures

The purpose of this test is to verify that the Fuel Cell can start at 1°C and then operate at -20°C for the given period.

The Fuel Cell shall be conditioned in the off state at 1°C for a minimum of 4 hours prior to undertaking this measurement. With the external load connected the system shall be turned on and transferred to -20°C. Once the fuel cell has been transferred to -20°C clause 6.1.2.2 should be completed at this temperature.

6.1.5.2 Start Up and Operation Test at High Temperatures

The purpose of this test is to verify that the Fuel Cell can start at 55°C and then operate at this temperature for the given period.

The Fuel Cell shall be conditioned in the off state at 55°C for a minimum of 4 hours prior to undertaking this measurement. With the external load connected the system shall be turned on and clause 6.1.2 should then be completed at this temperature.

6.1.5.3 Storage Test at Low Temperature

The purpose of this test is to verify that the Fuel Cell can be stored in the off condition at -32°C. The system may require preparation in accordance with the manufacturers instructions before and after the storage period. The system shall be stored for 24 hours at -32°C before being conditioned at the standard testing environment for 20 hours and then subject to completing clause 6.1.2 .

6.1.5.4 Storage Test at High Temperature

The purpose of this test is to verify that the Fuel Cell can be stored in the off condition at 70°C. After preparation iaw the manufacturers instructions the system shall be stored for 24 hours at 70°C before being re-commissioned and conditioned at the standard testing environment for 20 hours and then subject to completing clause 6.1.2.

6.1.6 Power Generation under Low & High Humidity

The purpose of this test is to verify the performance of Fuel Cell systems under low and high humidity conditions.

The system shall be stored in the off state at a test humidity level of 15% relative humidity (RH) for a period of 4 hours and subjected to the test procedure at 6.1.2.2.

The system shall be stored in the off state at a test humidity level of 95% relative humidity (RH) for a period of 4 hours and subjected to the test procedure at 6.1.2.2.

6.1.7 Test at Minimum Partial Load

The purpose of this test is to verify the manufacturers specified minimum power output of Fuel Cell systems.

The Fuel Cell system under test shall be conditioned in the off state under the standard testing environment for a minimum of 4 hours prior to this measurement. The conditioning period must be sufficiently long in order to allow for all system components to equilibrate with the environmental conditions. A voltmeter and a constant load shall be connected so as to draw the manufacturers specified minimum power (watts). During the test, the fuel cell or fuel cell module in the fuel cell power unit must be generating power by consuming the fuel. The manufacturers specified minimum power must be delivered over a period of at least 4 hours. If the system cannot deliver the manufacturers specified minimum power, terminate the test and do not perform the output voltage test below.

The output voltage shall be measured continuously to determine whether or not it is within the upper and lower limits of the operating voltage range specified by the manufacturer. The operating voltage range specified by the manufacturer shall be indicated in the test report. The duration of measurement and the fuel consumption during the measurement shall be recorded in the test report. (Note: fuel consumption noted to ensure fuel cell operating and not powered by the internal battery)

6.1.8 Altitude Test

The purpose of this test is to verify the performance of Fuel Cell systems under reduced atmospheric pressure as defined by the minimum altitude of 2000m and maximum altitude of 4000m or as defined by the user requirements.

Rechargeable batteries or capacitors should be in the fully charged state at the beginning of the test. Samples shall be conditioned by operating at the rated load at the test pressure for a minimum of 2 hours prior to the measurement.

A voltmeter and a constant load shall be connected so as to draw the rated voltage specified by the manufacturer, and the output voltage shall be measured at a pressure of 94 ± 1 kPa (2000m). The unit should then be tested at 87 ± 1 Kpa (4000m) for 4 hours or at the user requirement. During this measurement, the Fuel Cell power unit must be generating power by consuming the fuel. At altitudes above 2000m reduced power output may be acceptable however the power quality must be maintained.

6.1.9 Power Quality Test

EN62282-3-2 clause 7.3.1 identifies requirements for Electric Power – CF discussed test proposals and will report results on completion.

6.1.10 Fuel Consumption & Efficiency Test

The purpose of this test is to measure the quantity of fuel consumed by a Fuel Cell system when it is operated continuously for 6 hours at the rated current or at the rated power.

A Fuel Cell power system shall be operated either at the rated current or at the rated power. If at the rated current, the total fuel consumption, micro fuel cell power system voltage and duration of power generation shall be measured. If at the rated power, the total fuel consumption and duration of power generation shall be measured. The total fuel consumption shall be measured as the weight difference of the fuel before and after the electrical measurement. The electrical measurements shall be taken with the system operating continuously in the steady state for a certain period of time specified by the manufacturer for such measurements. The fuel consumption per unit time and the electrical energy per unit fuel mass shall be calculated using the measured values by the following equations:

Fuel consumption rate:

$$\text{Fuel consumption per unit hour (g/h)} = \frac{\text{Weight of fuel consumed (g)}}{\text{Hours of generation (h)}}$$

$$\text{Generated electrical energy per unit fuel weight (Wh/g)} = \frac{P(W) \times t(h)}{\text{Weight of fuel consumed (g)}}$$

Where: P = Rated power (W) (the rated power operation)
 t = Hours of generation
 or P = I x U (the rated current operation)
 I = Rated current (A)
 U = Time average of the measured voltage (V)

The specific energy of 100% methanol is 6300 Wh/kg
 Fuel consumption shall be the mass of liquid consumed regardless of concentration and efficiency shall be based on the specific energy of the fuel.
 The concentration of fuel shall be recorded in the test report.

The system efficiency (η_{sys}) is calculated from the fuel consumption using the following equation:

$$\text{Efficiency } \eta_{sys} (\%) = \frac{P(W) \times t(h)}{\text{Fuel consumed (g)} \times \text{Specific energy (Wh/g)}} \times 100 (\%)$$

Where: P = Rated power (W) (the rated power operation)
 t = Hours of generation

Note: if fuel of less than 100% methanol is used the specific energy of the dilute fuel must be used in the above calculation. – HO to supply graph which will be added in support

6.1.11 Test of the Bridging Time

Where a manufacturer specifies a Bridging Time this test should be performed to verify this time, which is defined as the time between the moments where the user of the Fuel Cell system is alerted to refuel the system and when the system shuts down because of fuel shortage.

In preparation of the tests the system should have been operated at nominal power conditions at the beginning of test for at least 2 hours. If applicable, the system can be equipped with a partly loaded cartridge or be only partly fuelled to shorten the test. However, at the beginning of the test the fuel level should exceed the low fuel alert level. The system is connected to a constant power load to be run at the rated power specified. The system is operated at rated load until the system shuts down due to fuel shortage. The time between the first alert on low fuel level and the shut-down is measured and recorded as measured value.

6.1.12 Shut Down Test

The purpose of this test is to ensure that the system will shut down promptly and safely.

With the external load connected the system shall be turned on and shall reach a stable voltage of at least 90% of the rated voltage at the rated output power (defined by the manufacturer) and shall maintain this for a minimum period of 30 minutes. The Fuel Cell will be switched off and in less than 5 seconds the Fuel Cell should stop producing power and no noise should be audible with the system being left in a safe and stable condition.

6.1.13 Drop Test

To assess the effects on a Fuel Cell with a full fuel cartridge installed shall be subjected to a simple standard test intended to be representative of the fall likely to be experienced during rough handling, or to demonstrate a minimum degree of robustness, for the purpose of assessing its suitability for service use.

The sample shall be tested to the requirements of BS EN 60086-2-32 Part 2.1 Test Ed Free Fall onto a steel surface.

Prior to undertaking the test the fuel cell shall be visually examined, electrically and mechanically checked and then subjected to the Rated Power Test defined in clause 6.1.2.

The Fuel Cell shall be dropped from a height of 1m and subjected to one drop from each of the three mutually perpendicular planes such that each surface is facing the drop surface prior to release. This shall comprise a total of 6 drops.

After each Free Fall the Fuel cell shall be subjected to the start up test to confirm that it is still functioning. It shall be turned off during the Free Fall assessment.

On completion of the 6 drops the Fuel cell shall be again subjected to the Rated Power Test defined in 6.1.2 and shall meet the requirements defined by the manufacturer.

The unit shall be visually examined and electrically and mechanically checked.

The Fuel cell shall be deemed to have failed if it cannot comply with the requirements of 6.1.2, or any of the components fail by cracking or become detached during the sequence of Free Falls.

Note: Should any leakage of liquid occur at any point during the test this could indicate failure of the fuel integrity which is hazardous and the test shall be halted and adequate precautions taken.

6.1.14 Vibration Test

The Fuel Cell system shall be subjected to vibration in accordance with BS EN 60086-2-6 Part 2: Test Fc: Vibration (Sinusoidal).

Prior to undertaking the test the fuel cell shall be visually examined, electrically and mechanically checked and subjected to the Rated Power Test defined in 6.1.2.

The Fuel Cell system shall be secured to the platform of the vibration machine without distorting it and in such a manner as to properly transmit the vibration. The frequency range: 10 to 500 Hz, amplitude: 0.75 mm or an acceleration amplitude of 10 g_n (whichever is the less severe) shall be applied. The test to be carried out shall be endurance by sweeping, and shall consist of 10 sweeps in each of the three mutual perpendicular axes.

After completion of testing in the three axes the Fuel cell shall be subjected to the start up test to confirm that it is still functioning. It shall be turned off during the vibration assessment.

Note: Should any leakage of liquid occur at any point during the test this could indicate failure of the fuel integrity which is hazardous and the test shall be halted and adequate precautions taken.

6.1.15 Shock Test

Prior to undertaking the test the fuel cell shall be visually examined, electrically and mechanically checked and subjected to the Rated Power Test defined in 6.1.2.

The Fuel Cell shall be mounted on the shock machine by any suitable method. The test severity shall be 30 g_n peak acceleration, half-sine pulse shapes for a duration of 18 ms in accordance with BS EN 60086-2-29 Part 2 Test Ea. Three shocks shall be applied in each direction of the three mutually perpendicular axes (i.e. a total of 18 shocks).

After testing at the required shock regime the Fuel Cell shall be subjected to the start up test to confirm that it is still functioning. It shall be turned off during the shock assessment.

Note: Should any leakage of liquid occur at any point during the test this could indicate failure of the fuel integrity which is hazardous and the test shall be halted and adequate precautions taken.

6.1.16 Bump Test

This test is applied to the Fuel Cell to assess its ability to withstand repetitive shocks which could occur in transportation and use. It also provides a means of assessing the quality control. The sample shall be tested to the requirements of BS EN 60086-2-29 Part 2 Test Eb: Bump.

Prior to undertaking the test the fuel cell shall be visually examined, electrically and mechanically checked and subjected to the Rated Power Test defined in 6.1.2.

The Fuel Cell system shall be secured to the platform of the bump machine without distorting it and in such a manner as to properly transmit the bump regime. The regime shall comprise a peak acceleration shall be 40 g_n with a corresponding pulse duration of 6 ms. 1000 \pm 5 bumps in each direction of the perpendicular axes at a rate between 1 and 3 bumps per second.

After the required bump regime the Fuel cell shall be subjected to the start up test to confirm that it is still functioning. It shall be turned off during the bump assessment.

Note: Should any leakage of liquid occur at any point during the test this could indicate failure of the fuel integrity which is hazardous and the test shall be halted and adequate precautions taken.

Performance test the fuel cell shall be visually examined, electrically and mechanically checked and subjected to the Rated Power Test defined in 6.1.2.

6.1.17 Dust Test

Evaluate potential clogging of the filters iaw AECTP 300 method 313

6.1.18 Sand Test

Evaluate erosion effects iaw AECTP 300 method 313

Performance test the fuel cell shall be visually examined, electrically and mechanically checked and subjected to the Rated Power Test defined in 6.1.2.

6.1.19 Thermal Characteristics for IR

The purpose of this test is to establish the temperature of the external surfaces and exhaust emissions of the Fuel Cell. The unit shall be subjected to 6.1.2 at the standard test environment with suitable thermal measuring devices used to determine that exhaust temperature does not exceed 50°C or that the skin temperature does not exceed 40°C, under standard test environments, at any point once the unit has reached thermal equilibrium.

Note: Standard test environment defined in clause 6.2 of the generic standard.

6.1.20 Thermal Characteristics for Safety

(Surface Temperature): ~~CS to seek advice~~ - delete clause as should be covered in safe systems of work regulations (HSE) & 6.1.19 above

6.1.21 Electromagnetic Susceptibility Test

The Fuel Cell's susceptibility to the electromagnetic spectrum should be tested iaw AECTP 500 method 502.

6.1.22 Electromagnetic Emission Test

Electromagnetic emissions from the Fuel Cell shall be tested iaw AECTP 500 method 502.

6.1.23 Audible Noise characteristics

Noise produced by a fuel cell power system shall be measured through the operating process; (startup to shutdown) in accordance with 7.3.13 and Table 3 of IEC 62282-3-2/FDIS in order to get the maximum value.

Corrections for background noise shall be made in accordance with ISO 3744.

The maximum corrected noise level and the corresponding operating conditions and output power level shall be reported.

Noise produced by the fuel cell power system shall be measured using a sound level meter as defined in IEC 61672-1 and IEC 61672-2. The test shall be conducted in accordance with ISO3744.

The following parameters will be determined in accordance with ISO 3744:

- a) measuring surface (at distance from the body of fuel cell power system);
- b) number of measuring points;
- c) influence of background noise.

The noise level will be measured at a distance of 1m from any face and shall not exceed 40dB.

6.1.24 Chemical Emissions

The fuel cell system shall not emit dangerous levels of emissions.

The maximum emission rate for each of the constituents of interest shall be less than the emission rate limit value in Table 1. These emissions should be measured both during operation at rated power and for a period of 5 minutes after the Fuel Cell has been shut down.

Note: emissions have been demonstrated to increase after shutdown.

	Concentration limit	Emission rate limit*
Water	Unlimited	No limit
Methanol	260 mg/m ³	2600 mg/h
Formaldehyde	0.1 mg/m ³ **	0.6 mg/h
CO	29 mg/m ³	290 mg/h
CO ₂	9 g/m ³	60 000 mg/h***
Formic acid	9 mg/m ³	90 mg/h
Methyl formate	245 mg/m ³	2450 mg/h
Hydrogen	800 mg/m ³ **** (1%, 10000 ppm)	8000 mg/h or < 3 ml/min from any single point source

* The emission rate limit was based on 10 m³ ACH, selected as the product of the reference volume times the air changes per hour (ACH) because it covers the reasonably foreseeable environments where micro fuel cell power systems will be used. The interior space in a small car and the minimum volume per person on commercial aircraft is at 1 m³. The minimum ACH used on passenger aircraft is 10 and the lowest ventilation setting in cars is 10 ACH. Homes and offices may have ACH levels as low as 0,5, but the per person volume is over 20 m³, so a product of 10 is conservative.

** WHO guideline limit is 0,1 mg/m³. Background levels are 0,03 mg/ m³.
The emission limit cannot push the background level above the guideline limit.

*** A seated human adult has a CO₂ emission rate of 30 000 mg/h. The fuel cell plus human adult emission rates are limited such that the CO₂ concentration does not reach the WHO eight-hour concentration limit of 9 g/ m³. In an environment with 10 m³ * ACH, this limits the contribution from the fuel cell to 60 000 mg/h.

**** Hydrogen value must be <25% LFL (4%) = 1 %. In reference volume this equates to 10000 ppm or 800 mg/m³. The total emission rate shall be < 8000 mg/h but the rate from any single point source shall be < 3ml/min as this is the minimum rate which can support a flame.

Table 2: Chemical characteristics

6.1.25 Chemical Susceptibility– Further discussion / work required

The Fuel Cell system is environmentally tolerant and being operated in chemically harsh environments may affect the systems performance levels.

The following test is an initial proposal to canvas opinion and establish further criteria to be considered for the future development of the Chemical Environment test.

The fuel cell system must be able to supply its rated power for the rated time between services in a chemical environment.

The unit should be tested for a period of 8 hours at its rated power under a chemical environment as defined by the maximum limits of EN60721-3-7 A23C class 7C4. The chemical environment as defined by class 7C4 should be modified to include those additional contaminants which may have an adverse effect on fuel cell systems. The Fuel Cell should be exposed and tested against each contaminant separately. These are listed below

Contaminant	Concentration (mg/m ³)
CO	23 mg/m ³ (20 ppm)
Toluene	160 mg/m ³ (50 ppm)
HCN	8.3 mg/m ³ (7.5 ppm)

Table 3: Chemical Environment

To pass the unit should deliver not less than 90 % of its rated power throughout the test.

6.1.26 Rain Water Test

The Fuel Cell should be tested iaw IEC 60529

6.1.27 Immersion Test

Carry out test 6.1.1 power down and immerse the Fuel Cell in water to a minimum depth of 300mm for 10 minutes and repeat 6.1.1.

6.1.28 Orientation

The Fuel Cell should operate at rated power at all orientations from its normal operating position.

The Fuel Cell should operate at rated power at all orientations up to 95° from its normal operating position independently of the fuel level within the cartridge. When the unit exceeds this angle the fuel cell should shut down automatically and must restart automatically once the angle is less than 95°.

Performance test the fuel cell shall be visually examined, electrically and mechanically checked and subjected to the Rated Power Test defined in 6.1.2 during the orientation test to confirm that the fuel cell is operating.

6.1.29 System Operational Life

Carry out test specified in 6.1.2 re-fuelling when necessary for 2500 hrs or until the unit records less than 85% of its rated power. The resulting time should be recorded and reported in the data report.

6.1.30 System Cyclic Endurance Life

Carry out test specified in 6.1.2, cycled at 4 hour intervals, re-fuelling when necessary for a minimum of 250 test cycles at the end of which the unit shall deliver greater than 85% of its rated power.

7 TRANSPORT REGULATIONS

Transportation & Dangerous Goods Classification:

Methanol Fuel Cell cartridges are designated as UN 3473 Class 3 Dangerous Goods Model Regulations (ST/SG/AC.10.1). The designations also apply to equipment containing such cartridges or when the cartridges are packed with equipment.

Consequently some products require assessment and testing to demonstrate compliance with constructional and performance requirements. All supplied products shall comply with the relevant constructional, performance, packaging and labelling requirements of the civil dangerous goods transport regulations governing land sea and air modes of transport. Except where specified in the contract or excluded in the regulations, this shall include requirements for carriage on mixed passenger and cargo aircraft.

8 CONNECTOR INTERFACES

Further discussions are required between German BWB and UK MOD to establish the best connector that promotes interoperability between NATO partners.

Initial proposal is to utilize the 7 pin connector Glenair Mighty Mouse 804-005-07ZNU6-7SC as the preferred choice for use with Fuel Cells specified by this supplement.

Pin 1	Power output (+ve)
Pin 2	Common Ground (-ve)
Pin 3	Power input (+ve charge)
Pin 4	SM-Bus DATA
Pin 5	SM-Bus CLK
Pin 6	Communication port (UTX)
Pin 7	Communication port (URX)

9 USER INTERFACE

The user interface shall be defined in the user requirements document.

10 LABELLING

The Fuel Cell shall have an identification plate attached to the casing with the following specified in addition to that detailed in the User Requirements Document:

- Voltage Output
- Rated Power
- Input Connectors
- Output Connectors
- NATO Stock Number
- Manufacturer Part Number
- Manufacturer Serial Number

Rear Cover