VOLUMETRIQ

VOLUME MANUFACTURING OF PEMFC STACKS FOR TRANSPORTATION AND IN-LINE QUALITY ASSURANCE

Grant agreement no.: 671465

***Start date**: 01.09.2015 – **Duration**: 36 months*

***Project Coordinator**: Ashley Kells – Intelligent Energy*

DELIVERABLE REPORT

D2.2 STACK COMPONENT REQUIREMENTS	
Due Date	February 2016
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Workpackage	WP2
Workpackage leader	BMW
Lead Beneficiary	Intelligent Energy
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DISSEMINATION LEVEL		
PU	*Public*	***X***
PP	*Restricted to other programme participants (including the Commission Services)*	
RE	*Restricted to a group specified by the consortium (including the Commission Services)*	
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NATURE OF THE DELIVERABLE		
R	*Report*	***X***
P	*Prototype*	
D	*Demonstrator*	
O	*Other*	

SUMMARY	
Keywords	*Stack, bipolar plate, gasket, membrane electrode assembly, coated catalyst membrane, gasket, gas diffusion layer*
Abstract	*This document contains the key stack component requirements for the VolumetriQ project and covers, bipolar plate, gasket, sealed coated catalyst membrane and gas diffusion layer. The component requirements were derived from the stack performance and test requirements provided by OEM's.*

REVISIONS			
Version	**Date**	**Changed by**	**Comments**
1	29/02/16	AKE	Revision 1 Created

DELIVERABLE TITLE

CONTENTS

1 Purpose

To provide the stack component requirements with format and content that has been agreed by the partners in the VolumetriQ project for deliverable 2.2.

2 Scope

This document will cover the requirements specification for the following components:

- Gas diffusion layer (GDL)
- Sealed Catalyst Coated Membrane (CCM)
- Bipolar (flow field) plate
- Gasket

Any requirement marked as "TBD" has yet to be fully determined and shall be considered a placeholder for future evaluation and declaration.

3 Sealed Catalyst Coated Membrane

3.1 Purpose

This section defines specific requirements for sealed CCM components which have not been addressed through other applicable specification documents.

3.2 Scope

This specification applies to all sealed CCM components used within an evaporatively cooled fuel cell stack.

3.3 Definitions

EC	:	Evaporatively Cooled
BoL	:	Beginning of Life
EoL	:	End of Life
FCS	:	Fuel Cell System / Product
MEA	:	Membrane Electrode Assembly
PGM	:	Platinum Group Metal
CCM	:	Catalyst Coated Membrane
RH		Relative Humidity

3.4 Requirements

3.4.1 Packaging Handling, Storage and Transit Conditions

Ambient Temperature (sealed CCM in fuel cell - Shipping)	-40 to 85°C
Ambient Temperature (sealed CCM - storage at manufacturing location)	20 +/- 2 °C
Humidity (sealed CCM – storage at manufacturing location)	50 +/-10 %
Labelling	Anode and cathode orientation clear marked on CCM. A 2-D matrix containing information to be agreed between stack manufacturer and supplier.
Handling	CCM to be packed with an interleafing material to allow easy handling and avoid bending. The CCM's should be delivered in heat sealed bags to prevent the ingress of moisture during transit and storage prior to build.
Shelf life	2 years from date of manufacture

3.4.2 Operating Conditions

The sealed CCM is required to perform in a stack and FCS configurations under the following conditions:

Cell Operating Temperature	-40 to 95°C
Fuel (Anode)	>99.9% H_2
Inlet Pressure (Anode)	0.5 to 1.6bar.g
Hydrogen Quality	Compliant with ISO 14687-2 CO<0.2μmol/mol
Humidification (Anode)	0-30 %
Stoichiometry (Anode)	1.01 – 1.4
Stoichiometry (Cathode) min. at rated power	1.8
Outlet Pressure (Cathode)	0.0 to 2.5 bar.g
Humidification (Cathode)	90 - 100% RH
Differential pressure anode to cathode	1.5 bar

3.4.3 Material Properties

Membrane performance	
Membrane resistance	0.02 Ω cm^2 At max operating temperature and water partial pressures 40-80 kPA
Membrane thickness	≤20 μm Thickness uniformity guarantees ± 10 % based on statistical measures
Tensile strength	<150 MPa@70oC and 80% RH
QC	Absence of passing holes, membrane fractures and >100 μm thick inclusions on whole membrane roll with in-line QC
Sealed CCM performance	
Sealed CCM visual inspection[1]	See note [1]
Sealed CCM durability	>5000 h over 10 years
Hydrogen crossover rate	0.0015 mbar L/s beginning of life (max)
Cost	To be derived from target <100 € kW^{-1} at system level
Chemical durability[2]	>500 cycles with sccm crossover hours
Electrode Performance	
Total PGM loading	≤0.25 mg cm^{-2}

1. To be agreed with supplier
2. Procedure defined in US DoE targets

3.4.4 Other CCM requirements

Sealed CCM flatness	Free form flatness tolerance 2 mm. Wave pitch < 100 mm with an amplitude of <2 mm
Withstand pressure	2.4 bar.g
CCM Format	Ability to process in 5 layer format, CCM with sub gasket and bonded anode and cathode GDL

Parts should comply with Directive 2000/53/EC End of life of Vehicles, 'reuse and recovery shall be increased to a minimum of 95% by an average weight per vehicle per year'.

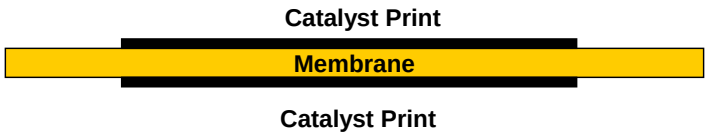
3.4.5 Dimensional Requirements

The component dimensions, alignment, and tolerances for the sealed CCM are detailed within an engineering drawing. Note: this drawing is for a sealed CCM with sub gasket, not a full 5 layer MEA with integrated GDLs. The overall dimensions of the stack shall be compatible with the dimensional requirements for the stack module set out in deliverable 2.1.

The supplier shall agree with the stack manufacturer an acceptable method for clearly marking the anode and cathode orientation of the sealed CCM.

3.4.6 Product Definitions

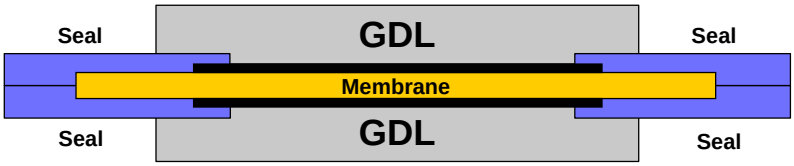
CCM – Catalyst Coated Membrane
Membrane with coated catalyst ink on either side.



Sealed CCM
CCM with edge seal films attached to both sides to encapsulate the membrane edges.

MEA – Membrane Electrode Assembly
Also referred to as 7-Layer MEA.

Sealed CCM with attached GDL – Gas Diffusion Layers.
GDL also referred to as GDM – Gas Diffusion Media or simply as Substrates.


Seal
GDL
Seal
Membrane
Seal
GDL
Seal

3.5 Target Values

The performance targets have been agreed as parts of the VolumtreriQ project and meet automotive requirements.

Beginning of Life (BOL) Performance (V @ I) Handover criteria	0.659V @ 1.68A/cm^2 0.60V cell @ 2.5A/cm^2
Time to reach BoL Performance (burn in)	<10 hours
EoL of Performance (mean cell voltage) (min cell voltage)	0.54V cell @ 2.5A/cm^2 >0.35V cell (during cold start)
Product Lifetime – Operating Hours	5000 h over 10 years with 10% degradation at nominal power
Stop Start Cycles	35 000
Cold start requirement	-25^{o}C
Warm stop start cycles	150 000
Max air temperature	85 ^{o}C

3.6 Verification of Requirements

Methods used to verify the requirements will be agreed between the stack manufacturer and the CCM supplier.

3.7 Quality control measurements

Quality control methods and measurements to be agreed with supplier.

4 Gas Diffusion Layer

4.1 Purpose

This section defines the specific requirements for GDL components which have not been addressed through other applicable specification documents.

4.2 Scope

This specification applies to all EC200 GDL components used within evaporatively cooled fuel cell stacks.

4.3 Definitions

EC	:	Evaporatively Cooled
BoL	:	Beginning of Life
EoL	:	End of Life
FCS	:	Fuel Cell System / Product
GDL	:	Gas Diffusion Layer

4.4 Requirements

4.4.1 Packaging Handling and Storage Conditions

Ambient Temperature (GDL in fuel cell - Shipping)	-40 to 85°C
Ambient Temperature (GDL - storage at manufacturing site)	20 +/- 2 °C
Humidity (GDL– storage at manufacturing site)	50 +/-10 %
Handling	GDL to be supplied in a roll format or sheet to be agreed by stack manufacturer and GDL supplier.
Shelf life	2 years from date of manufacture

4.4.2 Operating Conditions

The GDL is required to perform under the following conditions:

Cell Operating Temperature	-40 to 95°C
Fuel (Anode)	>99.9% H_2
Inlet Pressure (Anode)	0.5 to 1.6bar.g
Hydrogen Quality	Compliant with ISO 14687-2 CO<0.2μmol/mol
Humidification (Anode)	0-30%
Stoichiometry (Anode)	1.01 – 1.4
Stoichiometry (Cathode) min. at rated power	1.8
Outlet Pressure (Cathode)	0.0 to 2.5 bar.g
Humidification (Cathode)	90 - 100% RH
Differential pressure anode to cathode	1.5 bar

4.4.3 GDL Properties requirements

Working Dimension (target)	TBD
Through plane air permeability[1]	TBD
Tensile Strength[2]	>25 N /50 cm
Max. compressive load	TBD
In plane air permeability[3] @ 1 MPa	≤4.2 μm^2
In plane electrical resistance[3]	<0.8 Ω
Through plane electrical resistance[3]	≤4.5 Ω cm^2

1. DIN EN ISO 9237
2. DIN EN ISO 29073-3
3. Internal supplier measurement

These requirements are based on the current cell design and are subject to change based on optimisation with the project sealed CCM.

4.4.4 Other GDL requirements

GDL flatness	TBD
GDL properties	Ability to process in 5 layer format, CCM with sub gasket and bonded anode and cathode GDL

4.5 Target Values

The performance targets have been agreed as parts of the VolumtreriQ project and meet automotive requirements.

Beginning of Life (BOL) Performance (V @ I) Handover criteria	0.659V @ 1.68A/cm^2 0.60V cell @ 2.5A/cm^2
Time to reach BoL Performance (burn in)	<10 hours
EoL of Performance (mean cell voltage) (min cell voltage)	0.54V cell @ 2.5A/cm^2 >0.35V cell (during cold start)
Product Lifetime – Operating Hours	5000 h over 10 years with 10% degradation at nominal power
Stop Start Cycles	35 000
Cold start requirement	-25^{o}C
Hot stop start cycles	150 000
Max air temperature	85 ^{o}C

4.6 Dimensional and Other Requirements

The component dimensions, alignment, and tolerances for the GDL are detailed within the engineering drawing. The overall stack dimensions shall be compatible with the dimensional requirements for the stack module set out in deliverable 2.1.

Parts should comply with Directive 2000/53/EC End of life of Vehicles, 'reuse and recovery shall be increased to a minimum of 95% by an average weight per vehicle per year'.

GDL format and labelling requirements to be agreed with supplier

4.7 Quality control measurements

Quality control methods and measurements to be agreed with supplier.

5 Bipolar plate

5.1 Purpose

This section defines specific requirements for bipolar plate which have not been addressed through other applicable specification documents.

5.2 Scope

This specification applies to EC200 bipolar plates used within an evaporatively cooled fuel cell stacks. This specification is for the formed bipolar plate and does not include gasket.

5.3 Definitions

EC	:	Evaporatively Cooled
BoL	:	Beginning of Life
EoL	:	End of Life
FCS	:	Fuel Cell System / Product

5.4 Requirements

5.4.1 Packaging Handling, Storage and Transit Conditions

Ambient Temperature (bipolar plate in fuel cell - Shipping)	-40 to 85°C
Ambient Temperature (bipolar plate - storage at manufacturing site)	20 +/- 2 °C
Humidity (bipolar – storage at manufacturing site)	50 +/-10 %
Shelf life	2 years from date of manufacture

5.4.2 Materials Compatibility and properties

Compatibility with fluids and gases	Hydrogen, helium, oxygen air, carbon dioxide and carbon monoxide, DI water, acidic water (>pH 3)
Materials compatibility	PEN Carbon paper Hard plastic material e.g., polyamide imide or polyether imide

5.4.3 Operating Conditions

The information below details the operating condition and durability requirements for the finished bipolar plate:

Cell Operating Temperature	-40 to 95°C
Fuel (Anode)	>99.9% H_2
Inlet Pressure (Anode)	0.5 to 2.5 bar.g
Hydrogen Quality	Compliant with ISO 14687-2 CO<0.2μmol/mol
Humidification (Anode)	0-30 %
Stoichiometry (Anode)	1.01 – 1.4
Stoichiometry (Cathode) min. at rated power	1.8
Outlet Pressure (Cathode)	0.0 to 2.5 bar.g
Humidification (Cathode)	90 - 100% RH
Differential pressure anode to cathode	1.5 bar

5.4.4 Performance Requirements

The information below details the performance requirements for the bipolar plate without gasket.

Plate H2 permeation coefficient[1]	<1.3 x 10^{-14} Std cm3/(sec cm^2 Pa) @ 80°C, 3 atm 100% RH
Corrosion anode[1,2]	<1μAcm^{-2}
Corrosion cathode[1,3]	<1μAcm^{-2}
Areal contact resistance[1,4]	<10 mΩ cm^2
Electrical Conductivity	>100 S cm^{-1}
Cost target	To be derived from target <100 € kW^{-1} at system level

1. From US DoE target for bipolar plate
2. pH 3 0.1ppm HF, 80°C, peak active current <1x10-6 A/cm2 (potentiodynamic test at 0.1 mV/s, -0.4V to +0.6V (Ag/AgCl)), de-aerated with Ar purge.
3. pH 3 0.1ppm HF, 80°C, passive current <5x10-8 A/cm2 (potentiostatic test at +0.6V (Ag/AgCl) for >24h, aerated solution
4. Includes interfacial contact resistance (on as received and after potentiostatic test) measured both sides per Wang, *et al*. J. Power Sources 115 (2003) 243-251 at 200 psi (138 N/cm^2).

5.4.5 Other Requirements

Plate Identification	Plates will be laser marked with a 2d matrix, format to be agreed with stack manufacturer
Plate Cleanliness	To be agreed with supplier

Parts should comply with Directive 2000/53/EC End of life of Vehicles, 'reuse and recovery shall be increased to a minimum of 95% by an average weight per vehicle per year'.

5.5 Target Values

The performance targets have been agreed as parts of the VolumetriQ project and meet automotive requirements.

Beginning of Life (BOL) Performance (V @ I) Handover criteria	0.659V @ 1.68A/cm^2 0.60V cell @ 2.5A/cm^2
Time to reach BoL Performance (break in)	<10 hours
EoL of Performance (mean cell voltage) (min cell voltage)	0.54V cell @ 2.5A/cm^2 >0.35V cell (during cold start)
Product Lifetime – Operating Hours	5000 h over 10 years with 10% degradation at nominal power
Stop Start Cycles	35 000
Cold start requirement	-25^{o}C
Warm stop start cycles	150 000
Max air temperature	85 ^{o}C

5.6 Verification of Requirements

Methods used to verify the requirements will be agreed between stack manufacturer and the plate supplier.

5.7 Quality control Measurements

Quality control methods and measurements to be agreed with supplier.

6 Gasket

6.1 Purpose

This specification defines specific requirements for gasket material which have not been addressed through other applicable specification documents.

6.2 Scope

This specification applies to all gasket materials used within evaporatively cooled fuel cell stacks.

6.3 Definitions

EC	:	Evaporatively Cooled
BoL	:	Beginning of Life
EoL	:	End of Life
FCS	:	Fuel Cell System / Product

6.4 Requirements

These requirements will cover the bipolar plate gasket.

6.4.1 Packaging Handling, Storage and Transit Conditions

Ambient Temperature (bipolar plate and gasket - Shipping)	-40 to 85°C
Ambient Temperature (bipolar plate and gasket - storage at manufacturing site)	20 +/- 2°C
Humidity (bipolar plate and gasket – storage at manufacturing site)	50 +/-10 %
Shelf life	2 years from date of manufacture

6.4.2 Materials Compatibility and properties

Compatibility with fluids and gases	Hydrogen, helium, oxygen air, carbon dioxide and carbon monoxide, DI water, acidic water (>pH 3)
Materials compatibility	Stainless steel 316 with coating TBD PEN, PETP Carbon paper Hard plastic such as a polyamide imide or polyether imide Cross contamination between polymers over operating range
Adhesion between plate and gasket	Stainless steel 316 with coating TBD Hard plastic such as a polyamide imide or polyether imide
Compression set	<13% after 22 h at 175°C (ISO 815-1:2008)
Leachates from gasket material	Leachates will be dependent on the gasket material chosen, therefore will be specified at a later date

6.4.3 Operating Conditions

The EC200 gasket for pressed plate is required to perform under the following conditions:

Cell Operating Temperature	-40 to 95°C
Fuel (Anode)	>99.9% H_2
Inlet Pressure (Anode)	0.5 to 1.6bar.g
Hydrogen Quality	Compliant with ISO 14687-2 CO<0.2μmol/mol
Humidification (Anode)	0-30 %
Stoichiometry (Anode)	1.01 – 1.4
Stoichiometry (Cathode) min. at rated power	1.8
Outlet Pressure (Cathode)	0.0 to 2.5 bar.g
Humidification (Cathode)	90 - 100% RH
Differential pressure anode to cathode	1.5 bar

6.4.4 Performance Requirements

Product Lifetime – Operating Hours	5000h over 10 years
Pressure cycles	150 000 (hot start stop cycles)
Max air temperature	85 °C
Gasket transmits specific pressure	Yes
Flammability rating	UL94 V0
Hydrogen permeability[1]	<2500 x 10^{10} cm mm/ s cmHg

1. This value is typical for generic silicone gasket materials, target to be confirmed

6.4.5 Dimensional Requirements

The component dimensions, alignment, and tolerances for the gasket are detailed within the engineering drawing. The overall dimensions of the parts shall be compatible with the dimensional requirements for the stack module set out in deliverable 2.1.

6.4.6 Other Requirements

Withstand pressure[1]	2.4 bar.g

The gasket materials should be compatible with high volume production processes agreed with stack manufacturer, e.g., injection moulding, screen printing.

Parts should comply with Directive 2000/53/EC End of life of Vehicles, 'reuse and recovery shall be increased to a minimum of 95% by an average weight per vehicle per year'.

[1] target derived as 1.5 x maximum working pressure

6.5 Target Values

The performance targets have been agreed as parts of the VolumtreriQ project and meet automotive requirements.

Beginning of Life (BOL) Performance (V @ I) Handover criteria	0.659V @ 1.68A/cm^2 0.60V cell @ 2.5A/cm^2
Time to reach BoL Performance (break in)	<10 hours
EoL of Performance (mean cell voltage) (min cell voltage)	0.54V cell @ 2.5A/cm^2 >0.35V cell (during cold start)
Product Lifetime – Operating Hours	5000 h over 10 years with 10% degradation at nominal power
Stop Start Cycles	35 000
Cold start requirement	-25^{o}C
Hot stop start cycles	150 000
Max air temperature	85 ^{o}C

6.6 Verification of Requirements

Methods used to verify the requirements will be agreed between stack manufacturer and the gasket supplier.

6.7 Quality control Measurements

Quality control methods and measurements to be agreed with supplier.

End of Document