

TENDER FUNCTIONAL SPECIFICATIONS

Case no. 2026-0071

Acquisition, installation, commissioning and training related to
a Spray-coating system for thin film deposition on electrodes

The Tenderer declares that they have read this document and that they agree to it in its entirety

Drafted in:

On:

Company name:

Signatory's name and position:

Company stamp, Signature preceded by the handwritten words "Read and Approved", and initials on every page of this document.

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1 General overview

1.1 Purpose and scope

The purpose of this specification is to acquire an ultrasonic spray coating system for the controlled and homogeneous deposition of catalytic inks on different types of substrates. This equipment will be used as part of IFPEN's research and development activities, dedicated to the development of innovative electrocatalytic technologies. The system sought must allow the production of functional thin films with a fine control of the deposition parameters (flow, homogeneity, thickness, temperature, scanning speed, etc.), in order to guarantee the reproducibility of the experimental tests and the quality of the electrodes developed. The equipment must be compatible with the deposition of inks based on catalytic nanoparticles of polymers and various solvents, on conductive or insulating substrates of different sizes and types (membranes, carbon papers, metal plates, glasses, polymers, etc.).

1.2 Background

This project is part of an energy transition approach aimed at reducing CO₂ emissions and developing more sustainable electrochemical conversion processes.

In this context, the ultrasonic spray coating system will be used for the realization of catalytic deposits on membranes and electrodes for electrolysis devices. This manufacturing step is a major technological lock, as the electrochemical performance of the systems depends heavily on the quality, homogeneity and reproducibility of the layers deposited.

1.3 Aims

- To acquire equipment capable of producing homogeneous and reproducible deposits, which are essential for the development of advanced catalysts in electrocatalysis.
- To ensure versatility of equipment to handle a variety of substrates (e.g., glass, FTO glass, membranes) and to cover extended thickness ranges to meet diverse experimental needs.
- Integrate ergonomic, intuitive software compatible with the IFPEN laboratory's existing IT tools, in order to facilitate iterative tests and precise control of deposits.
- Ensure maintenance follow-up and efficient technical support to guarantee the durability and operational efficiency of the equipment.

1.4 Appendices to the specifications

Documents	Reference	Date	Rev.	attached version ¹	
				Electronic	Paper
Booklet on deviations from the Golden Rules	vf			☒	☐
Memo on safety in Lyon outside companies			V5	☒	☐
Computer Questionnaire		07/02/22	V3	☒	☐

¹ Check if the document is appended to the specifications.

2 Definitions

Equipment	Spray Coater
Bidder	A natural or legal person who is submitting a proposal in response to this request for tenders.
FAT – Factory Acceptance Test	Shop / Factory acceptance
SAT – Site Acceptance Test	In situ acceptance at the IFPEN site
Contract holder	Contract holder on completion of this tendering process

3 Requirements

3.1 Functional expression of requirements

In the following table, the priority level of the expected functions is as follows:

- **A – Essential function**

Function directly linked to requirements which must be provided

- **B – Important**

Function which is considered useful, but not at any price

- **C – Desirable/Optional**

Practical or comfortable, this function will only be selected if it does not incur significant costs or require major modifications.

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Spray Coating system			
P	Functions expected	Expected performance	Acceptance min max
A	Spray Coating Technology	Ultrasonic spray coating system or equivalent technology for the homogeneous deposition of liquid catalytic inks containing solid particles	
A	Homogeneous and reproducible deposition	Generation of homogeneous thin films on various substrates with controlled surface mass loading between 0.1 and 20 mg/cm ²	Variation $\leq \pm 5\%$ on usable surface
A	Automatic ink loading	System expected to act in a stand alone mode, without the need to manually refill ink during spraying	
A	Compatibility with catalytic inks	Compatibility with aqueous (1<pH<13) or organic suspensions containing nanoparticles, ionic polymers and solvents (IPA, water, ethanol, etc.)	
A	Ink concentration range	Compatible with inks containing solids between 0.1% et 10% by weight	
A	Agglomeration prevention	Agitation and/or sonication system to limit sedimentation and agglomeration of particles before and during deposition	
A	Supported substrates	Compatibility with ion exchange membranes (AEM/PEM) (sustainion, nafion...), glass/ FTO/ITO, metals, carbon papers, flexible substrates, rigid substrates.	
A	Substrate Dimensions	Supports substrates from 10 x 10 mm to 100 x 100 mm minimum	

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A	XYZ Movement Control	Programmable XYZ Motorized System	Minimum stroke of 400 x 400 mm
A	Positioning Resolution	Precise control of displacements and deposit repeatability	Resolution $\leq 10 \mu\text{m}$
A	Spray Parameters	Independent adjustment of flow rate, slew rate, nozzle-to-substrate distance, number of passes and atomization parameters	
A	Droplet size control	Controlled and stable droplet generation for homogeneous deposits	
A	Adaptation to substrate wettability	Deposition possible on hydrophilic and hydrophobic substrates	
A	Spray coating reproducibility	Repeatability of the mass deposited between two successive deposits	$\leq \pm 5 \%$
A	Substrate Thermal Control	Built-in heated tray for drying and evaporation control	Ambient up to 150°C
A	Thermal homogeneity	Temperature uniformity on the surface of the tray	$\pm 1^\circ\text{C}$
A	Intermediate heating between passes	Possibility of programmable intermediate drying step between successive passes	
A	Environmental control	Fully integrated enclosure limiting contamination and aerodynamic disturbances	
A	Humidity control / inerting	Can be used in a controlled atmosphere (N ₂ or dry air)	
A	Atmosphere control and ventilation	System for the collection and evacuation of emitted steam solvents	Regulatory compliant
A	Solvent safety compatibility	Materials and components compatible with flammable solvents	CE compliant

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B	Simplified cleaning	Quick disassembly and simple cleaning of nozzles and fluid lines	Cross contamination between successive sprays should not be detected by elementary analysis
C	Maintenance	Provision of a preventive maintenance plan	
B	System Evolutions	Ability to easily add options or add-ons fo	Documentation of possible evolution to enclose

Management / Software

P	Functions expected	Expected performance	
		min	Acceptance max
A	The PC will be provided by IFPEN	The tenderer will attach the IFPEN computer questionnaire, completed beforehand, to their bid, together with, if necessary, the specifications of the computer(s) required.	
A	Control software	Integrated software for complete control of deposition parameters and trajectories	
A	Recipes management	Saving, editing, and recalling user recipes	CSV or any exploitable format handling text/numbers
A	Data export	Export of main spraying parameters and sensors history	
C	Viewing camera	Real-time visualization of deposition and nozzle	

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¹ The IFPEN's IT department requires that antivirus software be used on all of its workstations and will assume responsibility for installing it. The product used by IFPEN is McAfee VirusScan 8.8 and the McAfee Agent 4.6 component. The tenderer will need to indicate whether there are any known incompatibilities between this antivirus software and the proposed software (or application) and/or whether its configuration needs to be optimized in order to reduce its impact.

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Hygiene – Safety – Environment			
P	Functions expected	Expected performance	Acceptance min max
A	Be installed and brought into service by authorized operatives Chemical Risk	Authorized Installers Chemical Risk 1 and 2	Ownership of authorizations

Technical documentation			
P	Functions expected	Expected performance	Acceptance min max
A	Supply of user and maintenance manuals on delivery	- Written in French or English - Archived in paper format (1 copy) and electronic format (to be defined).	

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Associated assistance, support, or training services			
P	Functions expected	Expected performance	Acceptance min max
A	Start-up assistance	The Contract holder shall be responsible for implementing all the means and resources necessary to get started with the Equipment until definitive acceptance is confirmed.	
A	Training of IFPEN operators	The purpose of this training stage is to: • train users to use the Equipment, • train users to perform level 1 maintenance operations.	

Maintenance and after-sales services			
P	Functions expected	Expected performance	Acceptance min max
A	Warranty	Minimum warranty duration: 12 months from the date of the Equipment's qualitative acceptance, without reservations. Under the warranty, the Contract holder shall: • ensure that the Equipment remains available, • carry out all preventive maintenance operations on the Equipment, • replace all equipment and spare parts supplied which are deemed faulty, • carry out all the necessary operations so as to repair any damage and / or re-establish normal usage conditions. Coverage: diagnosis, dismantling, replacement and reassembly of the parts found to be faulty, and all costs relating to the movement of personnel and the packaging and transport of equipment in order to refurbish the Equipment.	

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		During the warranty period, the Contract holder undertakes to: • Telephone support response time: 24 h • On-site response time: 48 h • Part change time: to be contractually specified by the supplier	
	After-sales service	In its bid, the bidder shall specify the maximum response time for handling all requests, as well as the maximum time for performing diagnostics	
C	Maintenance contract to be offered as an option	• Annual preventive maintenance included with the possibility of an optional maintenance contract • Spare parts warranty: 10y • Support response time: 24h • Call-out time: 1 week	

Eco-design and energy efficiency		
P	Expected features	Expected performance
A	Maximum optimization of the energy used	Transmit the energy consumption of the Supply and the details of the solutions provided for any energy optimization during the use of the Supply
A	Labels	The candidate will attach to its offer any label related to the Supply
A	Short-court	The candidate must indicate in its tender the number of intermediaries between the producer of the raw materials and IFPEN
A	Seconhand	Alternative Secondhand

3.2 Type of samples/fluids and operating conditions

- **Fluids:** Aqueous or non-aqueous suspensions containing solid particles.
- **Operating conditions:** Atmospheric pressure, flow rate adjustable between 0.01 and 0.125 mL/min in terms of flow rate of the solution to be deposited
- **Representative substrates:** Treated glass (FTO), polymer membranes, complex parts.
- **Temperature:** Ambient, and up to 150° on the substrate being printed

4 Expression of constraints

4.1 Legislation, regulations, standards in force

The Equipment provided and the services provided by the holder must comply with the regulations in force.

In particular, the equipment must comply with Directive No. 2006/42/EC of 17 May 2006 on machinery and any other directive applicable to it (in particular the Low Voltage Directive, electromagnetic compatibility, equipment used in potentially explosive atmospheres, pressure equipment, simple pressure vessels, etc.).

The machine must have a separately affixed CE conformity marking.
It will be delivered with the following documentation:

- EC declaration of conformity to the applicable directives,
- Legal instruction notice providing, in particular, the indications so that commissioning, use, adjustment and maintenance can be carried out without risk,
- Technical documentation relating to the means implemented to ensure the compliance of the machine. If the machine has pressure vessels, the documentation will describe their pressure characteristics, mini/maximum permissible temperature, volumes in order to check and carry out, if necessary, the monitoring in regulatory service in France. It will also describe the characteristics and adjustment values of safety accessories (safety valves, bursting discs, etc.).

4.2 CE Marking

In accordance with regulations, the Equipment supplied must bear CE marking and be delivered with a CE certificate of compliance.

4.3 Safety

Safety is a priority concern for IFP Energies nouvelles' Directorate General. Personnel working at IFP Energies nouvelles sites will be required to comply with the following guidelines:

- Memo on Safety for external companies
- Deviations from the Gold Rules

4.4 IT – Management – Software

When a particular IT configuration (hardware, software) is proposed with the Equipment, the constraints relating to the IT configuration and the documents required must be specified in the Excel file annexed to the specifications. In particular:

- Computer equipment is purchased separately by IFPEN, in accordance with technical specifications given in the bid.

- Software

Installation sources (media or download link) and associated documentation must be shipped with the software.

Desktop office software (MS Office) can be delivered and installed by IFPEN's IT department.

- Licenses

Licenses must be provided with a license certificate, together with the EULA (End User License Agreement). This must include information about the duration of the license and any other restrictions governing usage.

- Workstation security:

The IFPEN's IT department requires that antivirus software be used on all of its workstations and will assume responsibility for installing it. The product used by IFPEN is McAfee VirusScan 8.8 and the McAfee Agent 4.6 component. The tenderer will need to indicate whether there are any known incompatibilities between this antivirus software and the proposed software (or application) and/or whether its configuration needs to be optimized in order to reduce its impact.

4.5 Usage environment

The Equipment will be installed in an environment with the following external settings:

- Room/Location: Dolomite Building, Laboratory B10
- Average temperature: 21°C
- Available space: under hood on the north side, to the left of the existing bench
- Power grid: yes 220 V
- Fluid available: yes, N2, compressed air
- Other:

These values are given for information. It is the responsibility of the bidder to conduct a visit of IFP Energies nouvelles' premises in order to establish that they meet the environmental and technical requirements imposed by the manufacturer. **A visit report must be submitted to IFP Energies nouvelles before any contracts can be entered into.**

The bidder is responsible for informing IFP Energies nouvelles of the environmental and usage constraints to which the Equipment is subject under normal conditions of use and maintenance. In particular:

- the utilities needed for the Equipment to operate:
 - voltage and electrical power requirements,
 - the required fluid types and network pressures,
- precautions for use,
- the necessary safeguards.

4.6 Recovery and disposal constraints

Takeover of obsolete or non-compliant equipment at the end of the life cycle.

5 Equipment assessment tests

If required

The laboratory wishes to evaluate, by conducting tests on representative samples, the technical solution proposed by the tenderer and its main features, before entering into any contracts.

- **Deposition performance:** Validation of uniformity and thickness, and absence of aggregates ($<3\mu\text{m}$) by scanning microscopy on catalytic deposits made (base 120mg of carbon at 40% reduced Cu crushed passivated $<1\mu\text{m}$, suspended with 3%pds of surfactants in 40mL of isopropanol, dispersed on a polymer membrane at 1 ± 0.05 mg/cm²)
- **Software interoperability:** Verification of compatibility with IFPEN systems.

6 Arrangements for acceptance of the Equipment and associated services

6.1 Workshop/factory acceptance (Factory Acceptance Test)

This stage must enable IFPEN to see how much progress has been made on the Equipment's design and its compliance with the features, functions and performance described in the Functional Specifications.

The solutions and substrates (membrane and plate) for the tests below will be sent to the supplier prior to the completion of the FAT by IFPEN at the request of the service provider.

The results of the tests to be carried out described below should be sent by email to IFPEN for validation of the sending of the equipment to the IFPEN website:

Tests	Tested functions	Expected performance	Acceptance conditions
Test no.1	XYZ Move	Stroke Verification and Repeatability	Repeatability and positioning accuracy over two repetitions.

Test no.2	Temperature control	Verification ambient range-150°C	±1°C
Test no.3	Exhaust	Solvent extraction operation	Discharge rate is acceptable to IFPEN toward safety limit.
Test no.4 (representative deposition test)	Homogeneous deposition	Filing a MoS2/ FTO	
Test no.5 (representative deposition test)	Homogeneous deposition	Deposition of the Cu@C on a sustainion membrane	

6.2 In situ acceptance (SAT)

The acceptance tests for this step must be carried out at the IFP Energies nouvelles site, in accordance with the procedures described below:

Tests	Tested functions	Expected performance	Acceptance conditions
Test n°1 (representative deposit)	Homogeneous deposition	MoS2/ FTO deposit	
Test n°2 (representative deposit)	Homogeneous deposition	Deposition of the Cu@C on a sustainion membrane	
Test n°3	Reproducibility	3 successive comparable deposits	Variance ≤ ±5%

IFPEN undertakes to conduct the SAT tests within 8 weeks.

Final acceptance shall be pronounced once IFP Energies nouvelles has signed the Acceptance Report. Acceptance, as defined above, triggers the start of the warranty period.

7 Logistical Requirements

7.1 Expected implementation calendar

Requested delivery date: Delivery before the end of 2026

7.2 Delivery address

IFP Energies nouvelles, Rond-point de l'Échangeur de Solaize, 69360 Solaize, France

7.3 Packaging - Transport - Delivery

7.3.1 Packaging - Transport

The Contract holder shall assume responsibility for:

- the proper packaging of the Equipment and its accessories, required for its transport, The Contract holder shall be held liable for poor or insufficient packaging used to transport the Equipment.
- the transport of the Equipment and its accessories, from its workshops to the place of delivery indicated on the order.

7.3.2 Unloading – Handling – IFPEN Intra-Site transfer

When the Contract holder is in charge of installing the Equipment, as well as when there are special cases for loading, unloading or handling the Equipment, the Contract holder must:

- deliver the Equipment to its place of use; the person responsible for the delivery must first come to the Reception desk and hand over the delivery slip,
- unpack the Equipment.