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Document Reference: DTS/CDC/2026/007

EQUIPMENT SPECIFICATIONS DOCUMENT

Pre-industrial tool for physical vapor deposition of precursors used for perovskite-based absorbers in the photovoltaic research field

EOTP	MACPV
OS	
Platform	Cellules PV
Ref Invest Plan	PEROKET

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Document Revision Table

Version	Date	Evolution description
A	03/04/2026	Creation

Purchasing Department - SMA Manager 1 copy (email)

Department - Head of Department +Deputy 1 copy (email)
 - Safety Engineer 1 copy (email)
 - Quality Engineer 1 copy (email)
 - Facility Manager 1 copy (email)

Division - Head of Division 1 copy (email)
 - Installation Manager(s) 1 copy (email)

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1. PURPOSE

This specification document defines the supply, on behalf of the CEA, of an equipment designated as "an industrially-compatible equipment for vapor-based deposition of inorganic precursors used to elaborate perovskite (PK) thin films on G12 (210x210mm²) textured Silicon wafers using a reproducible, conformal and homogeneous deposition process". The equipment must be installed at the site "CEA-INES" in the building "PUMA 2".

The installation work for the equipment will be subject to analysis following the selection of the equipment.

If the technical specifications or requested documents cannot be met, the supplier must clearly specify this in their commercial offer by at least filling out the comment section of Appendix 1 of this specification document.

2. DEFINITION

In this document, the contractor is referred to as "the supplier".

The instructing party is referred to as "CEA".

3. GLOSSARY

- LITEN : Laboratoire d'Innovation pour les Technologies des Energies Nouvelles et les nanomatériaux
- PMAD : Prise en Main A Distance (Remote control access)
- INES : Institut National de l'Energie Solaire (Bourget du Lac site)
- MTBF : Mean Time Between Failure
- MTTR: Mean Time To Repair
- MTBI : Mean Time Between Interrupts
- FAT : Factory Acceptance Tests
- SAT : Site Acceptances Tests
- PK : Perovskite
- VDM : Vapor Deposition Module
- LL : Load Lock
- CS : Control system
- LA : Loading area

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4. APPLICABLE DOCUMENTS

The supplier shall comply with the documents and all procedures in force at CEA/GRENOBLE. Below is a non-exhaustive list:

- EQ/CS23-10: Règles applicables aux entreprises extérieures (French version)
- EQ/CS23-11: Applicable rules for outside companies (English version)

These documents shall be available for consultation upon request by the supplier.

5. INTERFACE CLIENT – PRESTATAIRE

The technical contacts for the basic and additional services are:

Mrs Polyxeni TSOULKA

Tel : +33 (0)4 79 79 29 33

Email : polyxeni.tsoulka@cea.fr

6. CONFIDENTIALITY

The supplier undertakes to keep confidential and shall refrain from disclosing to any third party, without written approval from CEA, the whole or part of information and/or knowledge belonging to CEA or any third party, that it may obtain or may have obtained during the service performed on behalf of CEA.

7. TECHNICAL SPECIFICATIONS

7.1. Description of the main function

The equipment shall fulfil the requirements listed in Section 7, with the indicated flexibility degree:

F0: mandatory

F1: non mandatory option (with a stated price)

The tool will allow vapor deposition of inorganic precursors (PbX_2 and CsX precursors, with X=Iodine or Bromine or Chlorine) used in the PK-based PV research field and allow the addition of an extra deposition module in the future for other precursors used in the perovskite-based solar cells.

The equipment will be able to process at least one G12 (210 mm x 210 mm) textured Silicon wafer at a time. The tool should provide thin films that exhibit compositionally and morphologically uniform layers, e.g. thickness and compositional non-uniformity along a G12 wafer should be inferior to 3% . The equipment should provide a reproducible (from run to run) vapor process with less than 3% compositional and thickness difference between the runs. The tool should be compatible to (pilot) in-line industrial machines that allow fast loading-deposition (650nm PbI_2 and 65nm of CsBr)-unloading cycles (cycle duration < 30min).

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The deposition of inorganic materials (PbX_2 and CsX precursors, with X=Iodine or Bromine or Chlorine) can be based in a bottom-up or top-down configuration of industrial sources allowing the sequential or simultaneous (co-deposition) vapor deposition of the inorganic precursors.

The tool will contain a vapor deposition module with one or more chambers depending on the physical vapor deposition process. The main role of the VDM will be the physical vapor deposition of the precursors but it could also contain additional chambers that allow the thermal or/and the pressure conditioning of the substrates/carrier.

The tool should be designed in a way that allows the integration of additional chambers or vapor deposition modules in the future, enabling the deposition of the other precursors used for the elaboration of PK thin films.

The tool must provide individual and collective protection against exposure to toxic and Pb-based materials, allowing safe and user friendly filling-up of the sources, operation and maintenance procedure (F0).

The overall dimensions of the tool should not exceed :

6.5 m x 3 m x 2.5 m (length x width x height)

The overall dimensions of packaging should not exceed :

4.8 m x 3 m x 3 m (length x width x height)

Due to CEA's clean room constraints, the overall tool (including all options listed) should have a minimal footprint. The supplier should precise in its offer both the footprint and load area (in kg/m^2) of the modular cluster tool.

As the considered tool will deal with lead containing material the collective and personal safety should be taken into account :

- Requirements for decrease as much as possible the Pb contamination in order to achieve the highest collective and individual protection
- Room requirements
- Rules of conducts
- Other limitations to consider

7.2. Sub-functions of the equipment

Figure 1 illustrate two examples (version A and version B) of possible designs for the tool. If these two designs are not convenient for the supplier, he can propose a version C.

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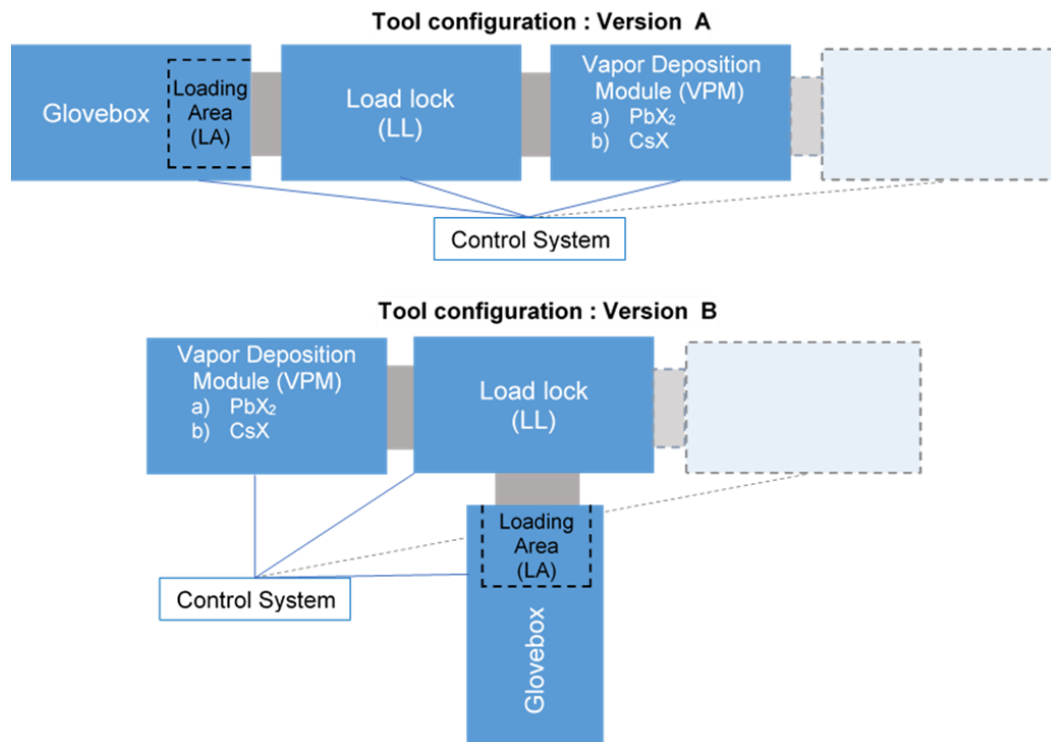


Figure 1: Overview of the version A and B configurations, of the preindustrial tool for vapor-based deposition of precursors used in the perovskite-based solar cells.

The system will include several modules as listed below :

- One Control System (CS)
- One Glove box containing a Loading Area (LA) and a storage area for the carriers.
- One Load Lock (LL)
- One or two vapor deposition modules enabling the vapor deposition of the precursors, the thermal or/and the pressure conditioning
- At least four carriers depending the design stored in the Glove box

and all peripherals (vacuum pumps, heating/cooling exchanger, maintenance tools etc...) are part of the delivery from the supplier.

The tool should allow to elaborate:

- At least one G12 Si wafer (210 mm x 210 mm)
- At least two ½ G12 wafer
- At least one glass substrate (200 mm x 200 mm)
- At least one M2 Si wafer (156.75 mm x 156.75 mm)
- At least sixteen 50 mm x 50 mm Si wafers or glass substrates

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per deposition run.

The design of the tool should allow the separation of the glovebox and the rest of the machine into 2 zones, e.g. the clean zone I and the grey zone II (see figure 2), in order to avoid any Lead contamination of zone I and ensure the collective and individual safety during standard operation of the machine and the loading/unloading of the samples.

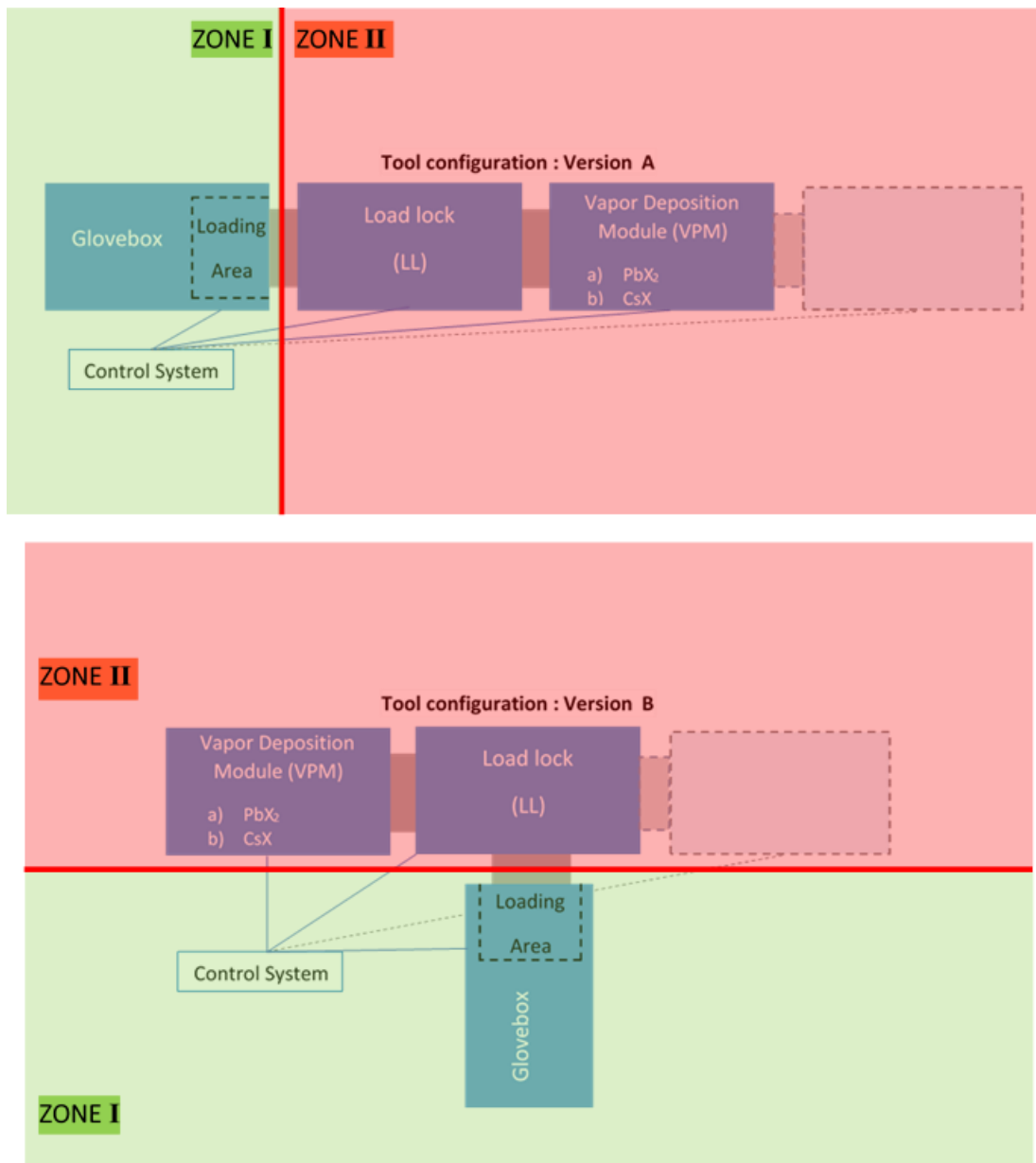


Figure 2: Zone I corresponds to the clean zone where no Pb contamination is allowed. Zone II corresponds to the grey area where the maintenance and the opening (under safe conditions) of the VDM are allowed.

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7.3. Expected performances

The different parts of the tool are described below.

The Glovebox

The glove box will be under inert atmosphere using nitrogen as working gas and it will operate under positive pressure. The glove box will be equipped with:

- Two antechambers 1 in order to be able to load/unload the small and big samples. Both antechambers will be connected to a vacuum pump and an independent “clean” nitrogen line to minimize the contamination of the antechamber during the refill/vacuum cycles
- Highly mechanically & chemically resistive gloves (reference will be specified)
- Lighting will be integrated to allow easy handling inside the equipment .
- Storage system for the substrate tools (masks, carriers etc), the evaporated materials and the tools needed to fill up the sources
- Filters and purification system
- H₂O and O₂ sensors that allow continuous monitoring of the glove box atmosphere
- Control unit that ensures the positive pressure and the purity of the glove box atmosphere (F0).
- Nitrogen gas gun
- At least 1 E-type (230V-50Hz) electrical socket inside the glovebox
- A storage area for the carriers (F1) and the G12 wafers
- A loading area (F0) where the samples will be positioned on the transport carrier at the process area in order to be automatically transferred into the LL . The loading/unloading of the samples should be safe and user friendly.

The filters, purification system, sensors and the control unit of the glovebox will ensure the purity of the working environment at O₂ and H₂O < 1 ppm.

The Load Lock

The LL enables the system to connect to the loading area and the VDM. The LL will enable the good positioning, pressure level and transport of the carrier from the LA to the VDM (F0).

The LL will be able to hold and transport at least one carrier. The LL will have an independent vacuum system with venting under nitrogen and it will be able to open independently from the other chambers.

Venting operation of the load lock should take place with dry nitrogen via a separate gas supply. During the venting process whirling effects will be minimized and other chambers should not suffer from this venting procedure (no increase in pressure in the VDM and the additional vapor module).

The Vapor Deposition Module

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The tool will contain a vapor deposition module with one or more chambers depending on the physical vapor deposition process. The main role of the VDM will be the physical vapor deposition of the precursors but it could also contain additional chambers that allow the thermal or/and the pressure conditioning of the substrates/carrier.

The VDM will be able to process one carrier containing at least one G12 textured Silicon wafer per deposition run. It will have a separated vacuum system and it will be able to open independently from the other chambers.

The deposition chamber will have three industrially compatible sources :

Source A: dedicated to the PbX_2 deposition

Source B: dedicated to the CsX deposition

Source C: dedicated to precursors used in the PK-based photovoltaic field

The sources enable co-deposition or sequential deposition of the two precursors at various ratios. The different deposition ratios should be precisely controlled by the operator. The tool should enable to precisely control the deposition ratio, temperature and power of each source.

The VDM could include left and right overrun areas so that the carrier can oscillate under the deposition region and allow homogeneous deposition onto the substrate. The carrier temperature will also be accessible to the operator during processes.

The vacuum system should allow constant monitor (and control F1) of the pressure in the chamber. Operating pressure measurement will be carried out with full range measurements (when the chamber is not operating and when material is being deposited).

The chamber(s) in the vapor deposition module should could be made from stainless steel. The internal walls of the chamber will be protected by easily removable shields if necessary. All the parts of the chamber (sources, transport module, shields, shutters, nozzles etc) should be covered with anticorrosive coating or the material used for this parts should prevent any corrosive phenomena. The sources should be separated to avoid possible cross contamination phenomena or any impact of their temperature value.

7.4. Specifications

The main characteristics of the system are listed in Table 1.

Table 1: list of the main specifications of the system

ITEM	Comment	Flexibility
Glovebox		
Antechambers	"Small" "Big"	F0
Gloves	Mechanically/chemically resistant	
O ₂ & H ₂ O sensors	≤1 ppm	
Control unit		
Filters and purification system		

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Loading Area	Load/unload the carrier and the substrates	
Storage Area	For the carrier(s) and the substrates	F1: storage area
Load Lock		
Independent Pump		F0
Pumping duration to reach the desirable pressure	< 15 min	
Transport from glovebox to VDM	Transport of one carrier	F0
Venting under N ₂		
Vapor Deposition Module		
Independent Pump		F0
Stainless steel		F1: material VDM
Pumping duration to reach the desirable pressure	< 1hour	F0
3 industrially compatible sources	50-700 °C (or higher) Accuracy: ±1°C	F0
	One source for PbX ₂ , one source for CsX and a third source for other precursor used in the PK field	
	The design should allow co-deposition and sequential deposition	
	Individual shutters or ways that allow the source's preconditioning without deposition	
	Design that decreases/eliminates the cross-talk between the sources	
Sources capacity	Sufficient for several consecutives depositions on G12 wafers	F0
Carrier movement	Carrier oscillation back and forth	F0
Deposition runs	The design should allow at least 12 depositions of 650 nm of PbI ₂ in a raw without opening the deposition chamber	F0
Additional vapor deposition module		
Interface that allows the integration of an additional vapor deposition module	The tool should give the possibility to add an additional deposition module. The tool will have a mandatory interface to another chamber for future extension of the tool	F0
Process Control / Layer properties		
Thickness homogeneity Along the G12 wafer	$(th_{\max}-th_{\min})/(th_{\max}+ th_{\min})*100\% \leq 3\%$	F0

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Thickness homogeneity From run to run	$(th_{\max}-th_{\min})/(th_{\max}+th_{\min})*100\% \leq 3\%$	
Atomic Ratio homogeneity Along the G12 wafer R= atoms A /atoms B	$(R_{\max}-R_{\min})/(R_{\max}+R_{\min})*100\% \leq 3\%$	
Atomic Ratio homogeneity From run to run R= atoms A /atoms B	$(R_{\max}-R_{\min})/(R_{\max}+R_{\min})*100\% \leq 3\%$	
Reproducibility between 2 consecutive deposition runs	Compositional difference $\leq 3\%$ Thickness difference $\leq 3\%$	
Edge exclusion	≤ 2.0 mm	
Process deposition control	The design should allow a precise control of the deposited thickness / second	
Source control	Temperature control Direct or indirect rate control Power control The control of the sources should allow a precise control of the deposited thickness every second	
Substrate/carrier temperature monitored	The carrier temperature should not exceed the 200°C The carrier temperature should be monitored The carrier temperature should be uniform Accuracy: $\pm 1^{\circ}\text{C}$	F0
Substrate/carrier temperature controlled	The carrier temperature should not exceed the 200°C during the deposition process The carrier temperature should be monitored and controlled during the process The carrier temperature should be uniform Accuracy: $\pm 1^{\circ}\text{C}$	F1
Cycle duration: Loading→Deposition→Unloading	The <i>Loading</i> → <i>Deposition</i> (650 nm of PbI ₂ and 65nm of CsBr)→ <i>Unloading</i> cycle should be performed in less than 30 min	F0
Auto (recipes)/manual mode		F0
Software management		
Data acquisition		
Substrates /Masks		

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Mask for Textured Silicon wafer (G12)	210 x 210 mm	F0
Mask for Textured Silicon (for two 1/2 G12)		
Mask for glass	200 x 200 mm ² and compatible to glass substrate thickness : 1100 ±50µm	F1: mask for glass
Mask for Silicon or glass	50 x 50 mm ²	F0
Mask for Silicon (M2)	156.75 x 156.75 mm ²	
Masks for Si	Should be compatible to Si substrate thickness : 100 - 400µm	
Masks for glass	Should be compatible to glass substrate thickness : 1100 ±50µm	
Edge exclusion	≤ 2.0mm	

7.4.1. Hardware and equipment specifications

The Facility Acceptance Tests (FAT) there will ensure the:

- Handling and process safety (check of handling during the refilling of the sources, the loading/unloading and the user friendly maintenance operation)
- The tool's compliance to the safety guidelines
- The Loading→ Deposition process→ Unloading cycle duration
- reproducibility,
- uniformity of the thin film thickness
- homogeneity of the composition
- pumping speed
- temperature rump-up time and control of the substrate and of the sources

The different safety tests, electrical and mechanical tests, operational tests, functionality tests, vacuum tests, transport tests and different deposition processes are listed in table 2 and 3.

Table 2: FAT operational and functionality tests

Test	Comment	Criteria
Safety tests		Compliance to CE
Carrier movement	Transport from glovebox to VDM	Transport from glovebox to VDM without mechanical or other issue
Pumping duration to reach the desirable pressure	Tests for all the chambers	<15 min for LL <1 hour for VDM
Load/unload the carrier and the substrates		User friendly process without mechanical or other issue

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Substrate/carrier temperature		Accuracy: $\pm 1^{\circ}\text{C}$ Max carrier temperature during process $< 200^{\circ}\text{C}$ Non-uniformity of the substrate temperature less than 1°C of difference along a G12 wafer
Cycle duration: Loading→Deposition→Unloading	Cycle: <i>Loading</i> → <i>Deposition</i> (650 nm and 65 nm in co-deposition mode)→ <i>Unloading</i>	< 30min
Refilling of the source		Safe and user friendly
Masks to process different wafer sizes (see table 1)		Should be available and according to the sizes mentioned in table 1
Source temperature heating ramp and cooling down ramp time		Check if there are any technical or electrical issues
Substrate temperature monitor		Check if there are any technical or electrical issues

During the FAT operational and functionality tests (table 2), process tests will be also conducted (see table 3). The tested material “A” will be decided between CEA and the supplier.

Table 3: FAT process tests

N°	Test	Material	Sources involved	Target Thickness	Method of measurement	Acceptance Criteria
1	Thickness homogeneity	“A”	A	Th=650 nm	Ellipsometry Or profilometry	$(th_{\max}-th_{\min})/(th_{\max}+th_{\min})*100\% \leq 3\%$ Edge exclusion $\leq 2\text{mm}$
2	Reproducibility	“A”	A	Th=650 nm		$(th_{\max}-th_{\min})/(th_{\max}+th_{\min})*100\% \leq 3\%$ Comparison of the thickness values of test N°1 : Less than 3% of difference
3	Thickness homogeneity	“A”	B	Th=650 nm		$(th_{\max}-th_{\min})/(th_{\max}+th_{\min})*100\% \leq 3\%$ Comparison of the thickness values of test N°1 and N°2 : Less than 3% of difference
4	Reproducibility source B	“A”	B	Th=650 nm		$(th_{\max}-th_{\min})/(th_{\max}+th_{\min})*100\% \leq 3\%$ Comparison of the thickness values of test N°1, N°2 and N°3: Less than 3% of difference
5	Co-deposition test	“A”	A+B	Source A 650nm Source B 65nm		$(th_{\max}-th_{\min})/(th_{\max}+th_{\min})*100\% \leq 3\%$

For all the above material/process tests:

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G12 wafers will be used or 16 samples of 5.0x5.0 cm² positioned on a mask that covers an area of 210x210mm².

The measurement points will be 25 as shown in the figure below.

One pre-prepared sample of certified thickness of 650 nm measured by SEM (or ellipsometry) will be used as reference to ensure that all the effected measurements during the FAT are reliable.

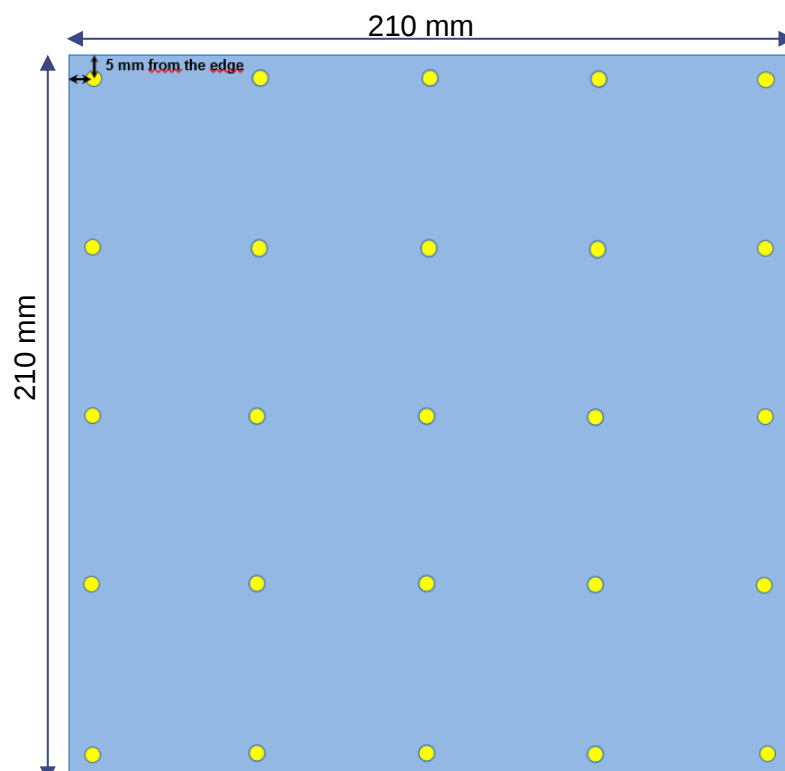


Figure 3: Measurement points for the FAT acceptance tests

During the FAT tests different parts of the tool will be contaminated by the deposited material during the process. The supplier will be responsible for cleaning the different contaminated parts of the machine before shipping.

7.4.2. Process specifications

As mentioned in the table 1 the supplier shall demonstrate the :

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1. Uniformity of the film's thickness deposited on a G12 Silicon wafer.

Criterion for acceptance:

- i. Inhomogeneity of the film's thickness (t_h) $\leq 3\%$
 - 25 measurements on a G12 Si wafer
 - Inhomogeneity: $(t_{h_{\max}} - t_{h_{\min}}) / (t_{h_{\max}} + t_{h_{\min}}) * 100\%$

2. Homogeneity of the film's composition in the co-deposition mode on a G12 wafer.

Criterion for acceptance:

- ii. Inhomogeneity of the film's composition $\leq 3\%$
 - 25 measurements on a G12 Si wafer
 - Inhomogeneity: $(R_{\max} - R_{\min}) / (R_{\max} + R_{\min}) * 100\%$,

where R is the atomic ratio between two materials $R = (\text{Atoms of material A}) / (\text{Atoms of material B})$

3. Reproducibility of the process between 2 consecutive depositions on G12 silicon wafers.

Criteria for acceptance:

- iii. Compositional difference between two consecutive deposition runs $\leq 3\%$
 - $(|R_1 - R_2|) / (R_1 + R_2) * 100\%$, where R_1 (or R_2) is the average atomic ratio value of the 1st (or 2nd) deposited thin film
- iv. Thickness difference between two consecutive deposition runs $\leq 3\%$
 - $(|t_{h1} - t_{h2}|) / (t_{h1} + t_{h2}) * 100\%$, where t_{h1} (or t_{h2}) is the average thickness of the 1st (or 2nd) deposited thin film

To determine the average thickness of the deposited thin film in each run, we will perform measurements of the thickness and the composition at 25 different points along the G12 wafers or 16 samples of 5.0x5.0 cm² positioned on a mask that covers an area of 210x210mm².

The measurement points will be 25 as shown in the figure 3.

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If the test conditions proposed by the CEA are not acceptable or sufficient for the equipment manufacturer, the manufacturer may propose alternative test conditions. These alternatives should be clearly documented and agreed upon by both parties to ensure a comprehensive and fair evaluation of the equipment.

Table 4: SAT (CEA site Acceptance Test) material deposition tests

N°	Test	Material	Sources involved	Target Thickness	Method of measurement	Acceptance Criteria
1	Thickness homogeneity	PbX ₂	A	Th=650 nm	SEM or ellipsometry	$(th_{max}-th_{min})/(th_{max}+th_{min})*100\% \leq 3\%$
2	Thickness homogeneity	CsX	B	Th=65 nm		$(th_{max}-th_{min})/(th_{max}+th_{min})*100\% \leq 3\%$
2	Thickness homogeneity	CsX	B	Th=65 nm		$(th_{max}-th_{min})/(th_{max}+th_{min})*100\% \leq 3\%$
3	Reproducibility	PbX ₂	A	Th=650 nm		$(th_{max}-th_{min})/(th_{max}+th_{min})*100\% \leq 3\%$ Comparison Th. values of test N°1 Less than 3% of difference
4	Compositional Homogeneity	1. PbX ₂ 2. CsX	2 co-deposition or sequential deposition	Th _{PbI₂} =650nm Th _{CsBr} =65 nm R= Pb / Cs	SEM or ellipsometry and SEM-EDX	$(th_{max}-th_{min})/(th_{max}+th_{min})*100\% \leq 3\%$ $(R_{max}-R_{min})/(R_{max}+R_{min})*100\% \leq 3\%$
5	Reproducibility	1. PbX ₂ 2. CsX	2 co-deposition or sequential deposition	Th _{PbI₂} =650nm Th _{CsBr} =65 nm R= Pb / Cs		$(th_1-th_2)/(th_1+th_2)*100\% \leq 3\%$ $(R_1-R_2)/(R_1+R_2)*100\% \leq 3\%$ Comparison Th. and R average values of test N°4 and N°5. Less than 3% of difference

Table 5: SAT operational and functionality tests

Test	Comment	Criteria
Carrier movement	Transport from glovebox to VDM	Transport from glovebox to VDM without mechanical or other issue
Pumping duration to reach the desirable pressure	Tests for all the chambers	<15 min for LL <1 hour for VDM
Load/unload the carrier and the substrates		User friendly process without mechanical or other issue
Substrate/carrier temperature		Accuracy: $\pm 1^\circ\text{C}$ Max carrier temperature during process <200°C Uniformity of the carrier temperature < 1°C of difference along a G12 wafer
Cycle duration: Loading→Deposition→Unloading	Cycle: Loading→ Deposition (650 nm of PbI ₂ and 65nm of CsBr)→ Unloading	< 30min

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Refilling of the source		Safe and user friendly
Masks to process different wafer sizes (see table 1)		Should be available and according to the sizes mentioned in table 1
Source temperature heating ramp and cooling down ramp		Check if there are any technical or electrical issues
Substrate temperature monitor		Check if there are any technical or electrical issues

During the SAT material deposition tests (previous table), operational and functionality tests will be also conducted.

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7.4.3. Measurement specifications (for characterization / measurement equipments)

A certificate of conformity for the measurement equipment is required for the acceptance of the equipment. This certificate must specify the traceability to standards accredited by the COFRAC (French Accreditation Committee).

7.4.4. Maintenance specifications

In its offer, the supplier will provide:

- Complete spare parts list, including datasheets.
- Complete list of recommended spare parts to have on-site (consumable and non-consumable) with part number and price, based on pareto list of replacement parts requests by other customers for same system
- A separate spares list for all safety devices components (leak detection, interlocks, safety relays...

If necessary, the supplier will provide a swap kit with all parts for which he recommends an external cleaning.

The Supplier will provide:

- Operation & Maintenance manual.
- Schematics of the entire tool (electrical schematics, diagrams of pneumatics and hydraulic circuits, interconnection schematics between sub-assemblies).
- Mechanical construction drawings i.e. exploded view with description and part number.
- For sub-assembly components, OEM operation & maintenance manual will be provided as well as software needed for maintenance purposes.
- Interlocks matrix.
- SECS/GEM PV2 implementation Manual.
- All the procedures to perform recommended preventive maintenance with list of parts to change and PM trigger (time, number of wafer, RF hours, thickness accumulation...).

Procedure to control all safety equipment items including:

- The list of items to be tested regularly (detailed subassembly list must be provided).
- The details of the test and control (as well as the expected result).
- The control tools.
- The control frequency.
- Procedure to calibrate all metrology inspection categories including calibration tools/instruments required and their calibration certificates
- Necessary number of technician, duration, and recommended equipment requalification for each procedure.
- The supplier will provide:

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- Every specific jigs or tools needed for maintenance purposes (main equipment, sub-assemblies...)
- Every calibration features, instruments, wafers... needed
- Cleaning recommendation (in situ clean, external cleaning) with best-known method

7.5. Computer specifications

7.5.1. Computer Control

The equipment is controlled from a computer workstation, preferably running the Windows operating system.

7.5.2. Network Connection

The equipment is connected to the CEA network through this PC via a dedicated Ethernet connection. The equipment supplier must ensure that an additional network card is installed in the workstation in case the equipment is connected to the sole available network port.

7.5.3. Instrumentation network cloud

The equipment is connected to a dedicated instrumentation IP network cloud. It follows the principle showed in the following figure:

Main Characteristics of the instrumentation network cloud:

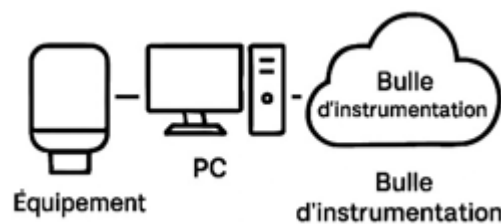


Figure 4 – CEA network connection diagram

- For IT security reasons, there is no internet access or email functionality.
- User session authentication is handled through a CEA Active Directory domain controller.
- Data is uploaded to a shared network storage system.
- Remote access is restricted to CEA's internal IT management service only.

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7.5.4. Connection prerequisites

Prior to network connection, CEA requests that the equipment supplier evaluate the feasibility of:

- Installing CEA's specified antivirus software on the PC (reference available upon request).
- Implementing a process for regular Windows updates with two options :
 - Complete system updates (including all updates).
 - Security-only updates (critical security patches only).

7.5.5. Documentation and procedure

The equipment supplier must document the IT configuration of the equipment for its connection to the CEA network (network interface configuration, protocols to be implemented, ports to be opened, data types, architecture diagram, etc.). The supplier will provide a network connection procedure.

7.5.6. Equipment Supplier IT Contact Availability

Availability of an IT contact from the equipment supplier is requested both prior to and during the network connection process.

7.5.7. Data Export

During operation, if the equipment serves as a data source, data should preferably be exported in flat file formats (TXT, CSV) or office document formats (XLSX, PDF) for deposit in the designated network storage (CEA infrastructure).

7.5.8. User Session Management

- Nominal phase:

The user session is either individual (named) or generic and authenticated through the CEA Active Directory domain controller.

- Maintenance phase:

The user session is local, has administrative privileges, and is named with the Equipment manager ID.

7.5.9. Hard Disk Drive Image

Subject to technical feasibility, CEA will create a disk image of the PC and store it on a network resource. In all cases, the equipment supplier must provide a complete system reinstallation procedure and all necessary source files or binary files (removable media, official download links, software licenses, etc.).

7.5.10. Administrator password

If the PC is running Windows, CEA requests that the equipment supplier provide the password for the ADMINISTRATOR account. This password will subsequently be managed by the IT service provider under CEA's outsourcing contract.

7.5.11. Remote maintenance

If requested by the equipment supplier and subject to technical feasibility, an external remote maintenance solution may be implemented based on CEA's service offering. For IT security reasons,

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consumer-grade remote maintenance software is not permitted. Remote maintenance sessions are scheduled and conducted under continuous supervision by CEA personnel. During these sessions, the equipment is physically disconnected from the instrumentation network cloud.

8. WORK ENVIRONMENT, INSTALLATION LOCATION, LIMITS OF SERVICE

8.1. Limits of services

The limits of Services between CEA and the supplier are the followings:

ITEM	CEA is responsible	Supplier is responsible
Metrology Equipments used for the SAT	x	
Installation and assembly of all materials on site		x
Electrical cabinet hook-up to the CEA power lines	x	
Cleaning, packing and conditioning according to clean room constraints		x
Transport	x	
Delivery of the equipment	x	
Handling and setting up the equipment in the clean room	x	
Leak tests on the tool		x
Starting up the tool		x
Declaration of conformity		x
Complete Layout of the tool		x
Complete technical datasheet and drawings		x
Operating instructions in English (French if possible)		x
Pneumatic and electrical diagrams		x
List of specific parts needed for maintenance operations (references and quantity)		x
Detail of preventive maintenance operations (frequency and operating mode)		x
Facilities Utility List (FUL)		x
Installation of gas detector linked to the distribution system	x	
Connecting the tool to the facilities	x	
Equipments used to perform the measurement during acceptance (SEM, EDX, Ellipsometry, profilometer)	x	

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Deposition materials & wafers/substrates used to perform the measurement during acceptance	x	
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8.2. Environment, Facilities

Specifications linked to facilities

	Cleanroom specifications	Specific comments
Acid-base rinsing effluent network	Material: HDPE	Reprocessed locally: Recycling of effluents into ultrapure water - mandatory limitation of the discharge temperature at the machine outlet → below 60 ° C
Ammonia effluent network	Material: HDPE	Storage (15 m³) – external reprocessing – mandatory limitation of the rejection temperature at the machine outlet → below 60°C
Concentrated acid-base effluent network	Material: HDPE	Reprocessed locally in the Ecureuil station: Recycling of effluents into ultrapure water. Mandatory limitation of the discharge temperature at the machine outlet → below 60 ° C
Organic effluent network (IPA, ALKATEX etc.)	Material: HDPE	Storage (15 m³) – outdoor reprocessing
Solvent effluent network	Material: galvanized steel	Collected in tanks 30 liters for off-site reprocessing
Wastewater network	Material: PVC	
General extractions	Material: PVC (locally stainless steel or galvanized)	Separate networks for solvent, acid and heat discharges.
	Pressure: from -250 to -600 Pa. depending on the location	"Booster" fans can be implanted locally to increase flow and depression

Specifications in regard to general fluid distribution:

	Cleanroom specifications	Specific comments
Cooling water	Material: Stainless steel One-way pressure: 5 bar Return pressure: 1.3 bar One-way temperature: 18 to 20°C Conductivity: less than 200 µS/cm pH: 7 Point-of-use filtration: 20 microns	Closed loop water circuits
Deionized water	Material: PVC or PVDF Pressure: 3 bar Temperature: ~18°C Resistivity: ~ 18 Mohm pH: 7 Point-of-use filtration: 0.1 or 0.2 microns	No EDI recycling at machine outputs CHU is in the scope of CEA INES.

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Tap water	Material: PVC or galvanized steel Pressure: 6 bar Temperature: 16°C Conductivity: 450 μ S/cm pH: 7.7 Hardness: Hard: 15°F<TH<30°F Point-of-use filtration: 20 microns	CEA INES accepts, that tap water does not comply with supplier requirements.
Process vacuum	Material: galvanized steel or stainless steel Relative pressure: ~ -700 mbar	
Nitrogen "process" gas	Material: stainless steel 316L Ra 0,4	
N2 Liquid	Relative pressure: 7.5 bar Quality: N5.0 O ₂ < 1 ppm CO + CO ₂ + CnHm < 2 PPM H ₂ O < 1 ppm H ₂ < 1 ppm	
Nitrogen "Service" gas	Same network than "process" nitrogen	"Service" nitrogen is used for everything related to the sweeping of gas pumps and burners
Compressed air "clean"	Material: stainless steel 316L Ra 0.8 Relative pressure: ~ 7 bar	
Argon	Material: stainless steel 316L Ra 0,4 Relative pressure: ~ 6 bar Quality: N5.0 O ₂ < 1 ppm H ₂ O < 2 ppm H ₂ < 1 ppm CO ₂ < 0.5 ppm CnHm < 0.5 ppm N ₂ < 1 ppm	
Oxygen	Material: stainless steel 316L Ra 0,4	
Liquid O2	Relative pressure: ~ 8 bar Quality: N4.5 H ₂ O < 5 ppm N ₂ < 10 ppm CO ₂ < 0.5 ppm CO < 0.5 ppm	
Helium network	nonexistent	
Hydrogen	Material: stainless steel 316L Ra 0,25 Relative pressure: ~ 4 bar Source quality: N5.0 H ₂ O < 2 ppm O ₂ < 0.5 ppm CO < 0.05 ppm CO ₂ < 0.05 ppm CH ₄ < 0.1 ppm N ₂ < 2 ppm	

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The supplier will submit with their offer the requirements for fluids, electrical power, and all other necessary interfaces, and will complete Appendix 2 provided with this specification document.

The **neutral grounding system** of the installation (e.g., TT, TN-S, IT) must be explicitly stated in this document. This information must be clearly and unambiguously presented to ensure equipment compatibility and compliance with electrical safety regulations. The neutral grounding system typically used at CEA Grenoble is TN-S.

Important note:

Completing Appendix 2 will enable CEA to create Piping and Instrumentation Diagrams (PIDs) for fluids as well as the PID for electrical power supply. These PIDs will then be validated by the equipment supplier before hook-up preparation work begins. For simpler equipment, PIDs may not necessarily be required.

Communication Between Equipment and Facilities:

When the equipment relies on certain facilities (such as cooling water, ventilation, compressed air, etc.) for safe operation, the supplier must provide CEA with the following during the design phase:

The conditions required for proper equipment functioning.

An analysis of criticality in case of parameter deviations.

This analysis may take the form of an FMECA (Failure Modes, Effects, and Criticality Analysis) or an equivalent method.

Loose of Facility Failure Analysis:

Every potential facility failure—whether isolated or combined with others—must be studied. If a risk is identified, a dedicated section must be included in the documentation.

Safety Signal Integration:

If certain facility parameters could impact:

The safety of the equipment's process,

Safe operational mode,

Overall installation safety,

The supplier must integrate the necessary signals into the safety loop or automation system to enable emergency shutdown or controlled shutdown based on criticality level.

Communication Protocol:

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Finally, if the equipment's operation could significantly disrupt the installation's facilities, the supplier must propose to CEA a communication protocol to anticipate and manage these impacts.

8.3. CEA on-site intervention rules

Access to the CEA site is strictly regulated. The applicable conditions are described in documents EQ/CS23-10 (Rules applicable for outside companies) and EQ/CS23-11 (Applicable rules for outside companies), provided with the bid documents. These terms also apply to the subcontractor of the supplier that will deliver the equipment.

Prevention plan:

CEA will establish, in collaboration with the supplier and any subcontractors, a comprehensive prevention plan for the installation and commissioning of the equipment.

Safety Equipment:

As CEA prohibits the lending of equipment, including safety equipment, the supplier and any subcontractors must provide all necessary safety materials to prevent risks specific to their intervention (PPE, collective protective equipment, etc.). They will ensure the replacement and repair of this equipment and, if applicable, will ensure their personnel are properly trained and aware of its use in accordance with regulations. This equipment must comply with current regulations and have a certificate of conformity.

Collective Safety Equipment:

The supplier and any subcontractors must provide all collective safety equipment aimed at preventing accidents related to the work, such as:

- Marking of work areas.
- Marking of circulation areas.
- Marking of handling areas.
- Marking and installation of barriers around pits and level differences.

They will ensure the installation and removal of this equipment as soon as the service no longer requires the presence of markings.

Specific Access for Deliveries:

Given the access constraints to the CEA site, the supplier must provide a restricted list of individuals authorized to access the CEA:

For EU residents, 10 calendar days before delivery.

For non-EU residents, 25 calendar days before delivery.

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8.4. Delivery

Delivery and Installation Organization

For the proper organization of delivery and installation at CEA, a packing list must be communicated to CEA at the kick-off meeting or at least 2 months before delivery. This list should include the following information:

- The total net weight of the shipment.
- The number of packages for transporting the equipment.
- The weight and dimensions (length × width × height) of each package.
- The number of support points (legs) and the weight supported by each.
- Any need for specific tools or a forklift for installation.
- The unloading plans.

Whenever unloading requires lifting equipment (forklifts, cranes, etc.), a safety protocol supplementing the prevention plan must be established before the unloading operation.

All delivered materials must bear the order reference and the recipient's name on each item in the packing list.

Supplier Presence

The supplier must arrange for all necessary measures to unload and install the equipment (unloading plan and installation plan). **The supplier must be present during the unloading of any equipment requiring special monitoring due to its size, value, or complexity.**

Installation Location

The equipment must be installed at the CEA-INES site in the Puma 2 building.

Commissariat à l'énergie atomique et aux énergies
alternatives 50 avenue du Lac Léman
F-73375 LE BOURGET-DU-LAC (Chambéry), France

Logistical Constraints

The supplier must consider logistical constraints related to equipment placement (maximum space, weight, access through doors, ramps, stairs, elevators, maximum height, etc.). These details are specified in Section 7.1. and in Appendix 1.

Packaging and Waste Disposal

The equipment and all its peripherals must be delivered clean and properly packaged. Transport platforms, pallets, and packaging crates must be suitable for the weight and volume of the items to ensure safe transport and avoid any disputes related to improper packaging.

All transport platforms, pallets, and packaging crates must be removed by the supplier (waste disposal from packaging is not handled by CEA).

Delivery Hours

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Deliveries will be made between 8:00 AM and 12:00 AM from Monday to Friday.

9. TIMELINE

The equipment will be installed on site and received within a desired timeframe of twelve (12) months from the date T_0 of notification of the order by the CEA.

To facilitate compliance with delivery and acceptance deadlines, the supplier must promptly transmit all Appendixes required for equipment installation (fluid requirements, electrical power supply, and any other necessary interfaces (Appendix 2), hazard identification sheet (Appendix 3), equipment consumption data, etc.) or any other necessary elements.

10. QUALITY

For all its activities, the supplier must comply with the requirements of the ISO 9001 standard.

Significant and/or repeated deviations from this specification will be notified to the supplier (via email-anomaly or Improvement Sheet) for corrective action within a specified timeframe. In case of deviations or unperformed corrective actions, penalties will be applied to the supplier in accordance with the contract.

CEA Grenoble reserves the right to verify the effective operation of the system at any time through quality audits, which may be conducted at the supplier's premises and on the CEA Grenoble site.

Any measurements performed by the supplier for acceptance testing must comply with the requirements of Section 7.4. of ISO 9001 (Resources for Monitoring and Measurement). If the supplier subcontracts these measurements, they must be accompanied by a certificate of conformity.

11. SAFETY AND COMPLIANCE

As required in CEA's general purchasing conditions, the supplier commits to treating safety as an absolute priority in the design, preparation, and execution of the services covered by the contract.

The supplier acknowledges and applies the "rules applicable to external companies at the Grenoble center" provided with the tender dossier.

The supplier, as well as any subcontractors at any level, must comply with all applicable legislative and regulatory provisions regarding safety and environmental protection.

The equipment must comply with current regulations.

The equipment will be CE certified, bear the "CE marking," and be accompanied by a CE Declaration of Conformity (see § 13 Documentation).

The supplier is requested to seek assistance from a French certification body to verify regulatory compliance from the equipment's design phase.

11.1. Hazard identification

CEA may request the supplier to provide a description of the equipment's residual hazards, including the following information:

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- Details about residual hazards for operators.
- Interactions between the equipment and its environment (gas or chemical emissions, electromagnetic fields, noise, etc....).

If hazard identification is required, CEA will make this request no later than during the market launch meeting. The supplier will base this analysis on Appendix 3 of the Technical Specification Document: Identification of Residual Hazards.

The supplier must submit this analysis to CEA during the design phase (cf. § 12.1 Documentation).

11.2. Hazards related to facilities

NA

11.3. Power supply disconnection and separation device

A power supply disconnection and separation device shall be provided on the equipment, for each source of energy of the machine.

11.4. Power supply lockout / tagout device

A power supply lockout / tagout device with dissipation of the residual energy shall be provided on the equipment, for each source of energy of the machine.

11.5. Emergency stop

Emergency stop buttons shall feature protection against unintentional operation. See the example on the side picture.



11.6. "Service" nitrogen or compressed air connection

When the equipment uses compressed air or nitrogen for controlling valves, actuators, and other systems, the machine must be equipped with a general shut-off valve.

This valve may be locked in the closed position using a padlock to allow for equipment isolation (maintenance).

There must be one or more purge devices to dissipate residual pneumatic energy stored in the machine after the main valve is closed. This dissipation must be performed without risk to exposed personnel.

11.7. Risks related to electricity

Generalities

The equipment shall comply with the regulations in force, in particular the following Directives:

- "Electrical Equipment" 2017/35/EU;
- "Electromagnetic compatibility" 2014/30/EU;
- "Restriction of the use of certain hazardous substances in electrical and electronic equipment" (2011/65/EU).

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11.8. Presence of an uninterruptible power supply (UPS)

If the whole equipment must be supplied by an uninterruptible power supply (UPS), then this power supply shall be provided by CEA.

The supplier shall give all the required information for product definition (voltage, power, battery life).

The supplier shall provide connection terminals on the equipment to connect the uninterruptible power supply.

In the event that only a portion of the equipment is powered by an internal UPS integrated by the manufacturer, the following rules shall be observed:

- An all-pole isolating device shall be installed downstream of the UPS in order to enable maintenance operations.
- If voltage still remains after the master switch of the machine has been turned off, such presence shall be indicated close to the switch.
- All circuits that remain live after switch off shall be marked in orange colour in accordance with standard 60-204.

11.9. Risks related to fire

The detectors integrated into the equipment will not be connected to the building's fire protection system by default, and will only act on the affected equipment and its associated peripherals, if applicable.

If the supplier deems it necessary to connect their fire protection system with the building's fire safety system, they must first consult with CEA to ensure the compatibility of the entire system.

11.10. Risks related to explosion

The equipment shall comply with the regulations in force, especially the "ATEX" Directive 2014/34/EU.

Whenever the equipment is likely to generate an explosive atmosphere, the supplier shall perform an ATEX risk assessment and substantiate the choice of the selected ATEX equipment. The ATEX zoning plan as well as the certificates of conformity of the ATEX items of equipment shall be supplied to CEA.

11.11. Risks related to Chemicals

When the equipment uses chemical products that pose health and safety risks to operators, the supplier must detail in the risk analysis the protective measures implemented during normal, degraded, or maintenance work phases.

- When chemical products (solid, gaseous, or liquid) are supplied by the supplier, they must provide the complete list of products, along with Material Safety Data Sheets in French (MSDS) for each product. CEA will be particularly vigilant about the content, pictograms, and classification used, as well as the provision of a version written in French.
- All equipment containing liquid chemicals must be organized to form a retention system to prevent the spread of these products outside the equipment without intentional action. These retention systems will be equipped with leak detectors reporting information to the equipment's control panel. The activation of a detector will interrupt the automatic power supply to the

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machine and the circulation of chemical fluids. The detectors will be tested before the equipment is put into operation.

- The operation of the equipment must be controlled by the proper functioning of the extraction system. The extraction level will be continuously monitored by one or more extraction controllers, which will trigger a visual alarm at the workstation (on the equipment, and if necessary on the affected peripherals).
- Note: For automated equipment, this "extraction" alarm may be combined with other types of alarms on the equipment's control panels. The following must be placed under extraction: trays, work surfaces, and generally any location where a leak could occur: presence of fittings, valves, pumps, storage capacities (even closed), canisters, etc.
- If the solution chosen by the supplier involves the installation of a buffer tank to allow cooling of these effluents, it must be under retention and equipped with an adjustable timing drain system, as mentioned above.
- For equipment with process chambers, the supplier must provide the list of expected by-products in case of chamber opening, to facilitate maintenance operations.
- The supplier will provide CEA with the technical data sheets and SDS for the thermal insulators used, prioritizing the least hazardous thermal insulating products (non-CMR). The use of CMR Category 1a and 1b is PROHIBITED. The use of thermal insulating products classified as CMR Category 2 must be justified by the supplier and validated by CEA in advance.
- The supplier will provide CEA with the list of refrigerants used in the equipment and the associated SDS.
- If the equipment is likely to contain materials subject to regulations related to perfluoroalkyl and polyfluoroalkyl substances (Decree of June 20, 2023) and "Substances of Very High Concern" (SVHC) (under Regulation (EC) No 1907/2006), the supplier will inform CEA during the design phase.

11.12. Risks related to handling

For those parts of the equipment requiring handling (pumping units, chamber lids, covers, etc.), in particular during maintenance or installation operations, suitable lifting means shall be provided and described in the safety instructions of the equipment.

Systems integrated into the equipment shall be given preference over removable systems.

11.13. Risks related to pressure vessels

The equipment and specifically the tanks/containers must comply with current regulations, including:

- Pressure Equipment Directive 2014/68/EU.
- The contract holder will provide the following elements with the supplied pressure equipment, at a minimum:
- The pressure equipment conformity declaration;
- The presence of a CE conformity plate on the affected equipment;
- The service instruction manual;

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- The maximum allowable pressure (PS) value;
- The maximum allowable temperature (TS) value;
- The useful volume for tanks;
- The diameters of the sections for pipelines, if applicable;
- The calibration certificates and safety accessories certificates.

11.14. Risks related to work at height

In the event that use, maintenance or installation operation of the equipment require access at height, the supplier shall give priority to the installation of collective protective equipment (e.g.: built-in work platform with handrail complying with the standards in force) or, failing that, provide personal protective equipment (e.g.: anchoring points or lifelines complying with the standards in force). In the latter case, the technical documents shall very clearly refer thereto, so that the associated regulatory checks can be implemented.

Where necessary, the associated personal protections may be required.

These shall have been validated by CEA.

11.15. Risks related to artificial optical radiation

NA

11.16. Risks related to noise

If the equipment falls under the definition of a machine, it must comply with current regulations, including Regulation EU 2023/1230.

11.17. Risks related to temperatures

If the equipment falls under the definition of a machine, it must comply with current regulations, including Regulation EU 2023/1230.

11.18. Signalling

If the equipment falls under the definition of a machine, it must comply with current regulations, including Regulation EU 2023/1230.

Residual risks shall be indicated on the machine by means of regulatory hazard pictograms (triangles with yellow background), accompanied by additional text when applicable. In this case, this text shall be written in French.

11.19. Regulatory Inspection

CEA shall have the necessary regulatory inspections carried out by an authorized organization of its choice, in order to verify that the supplied equipment complies with the regulations.

The Supplier shall remedy any non-conformity in the shortest time possible without being able to claim any compensation. Depending on the severity of the detected anomalies, CEA may decide to suspend

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the commissioning operations until the problems have been solved (refer to Article 30 of chapter 11 of the General Purchasing Conditions).

11.20. Inspection of the work equipment

The equipment must comply with current regulations, particularly Regulation EU 2023/1230. It must be accompanied by:

- The CE marking of the machine;
- The Declaration of Conformity;
- The instruction manual **in French**, including all necessary plans, diagrams, and documents for installation, commissioning, operation, adjustment, assembly, and disassembly.

CEA may arrange for a machine control inspection at the manufacturing site by a certification body of its choice. The report from this manufacturing site inspection must be free of any non-conformities. All remarks made by the certification body must be addressed by the contract holder, who will implement the necessary modifications without requesting any financial contribution from CEA.

In all cases, a second inspection must be conducted after the equipment is installed on-site.

If the equipment meets the definition of a machine, the design of the safety-related control systems must be carried out in accordance with the EN ISO 13849-1 standard. The contract holder must provide CEA with:

- The list of safety-related control systems (SRP/CS);
- The reasoning followed during the design (e.g., the faults considered, the faults excluded);
- The result of the required performance level (PLr);
- The achieved performance level (PL);
- The calculation tool used (e.g., SISStema)

11.21. Regulatory electrical inspection

CEA is attentive to the proper sizing of electrical supplies for equipment connected to its electrical network.

To facilitate proper sizing of the power supply, the supplier must provide CEA with all electrical information for the equipment, including cumulative power ratings determined by calculation (e.g., using the ELIE BT tool).

Once the equipment is installed on-site, CEA will arrange for a regulatory electrical inspection before first commissioning by an accredited certification body of its choice.

11.22. Safety concept against Pb (lead) contamination

As the considered tool will deal with a high quantity of lead and halogen containing materials collective and individual safety should be taken into account..

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- During the maintenance process (filling-up of the sources, replacement of any spare part related to the source's control, replacement of the shields, opening of the deposition chamber etc) the design and the handling of the tool should ensure the less possible contamination of the users and the surrounding area
- The design and the material used for the different parts of the tool should decrease as much as possible corrosion phenomena
- The design of the tool should minimize as much as possible operations that require to open the deposition chamber and generally the direct exposure of the user to the CMR powder
- Requirements to decrease as much as possible the CMR contamination in order to achieve the highest collective and individual protection
- CEA will be particularly attentive to the technical specifications proposed by the supplier regarding contamination risks.

12. ENVIRONMENTAL CLAUSES

As part of the "Sustainable Development" approach, CEA Grenoble works to improve its environmental performance, and wishes to be supported in this process by its Service Providers and Suppliers.

The equipment manufacturer will present in its offer the actions it has already implemented in its activity in favor of sustainable development and its proposals for improvements specific to this service. It will detail:

- In particular the efforts made to reduce:
 - Consumption of electrical and thermal energy and fluids
 - Extraction flow rates by a studied design of cowls and exhaust points,
 - Cooling water flow rates by an optimized calculation of the heat exchangers.
- The recycling of potential fluids proposed.

The equipment must be designed in such a way as to limit polluting emissions into the environment, in particular by the implementation of clean technologies, the segregation and treatment of effluents and waste according to their characteristics, and the reduction of the quantities released.

The equipment manufacturer will provide an assessment of the rejected flows:

- Concentration of vapors / gases and liquid (if any) active substances emitted
- Volume and masses discharged (active substances and if possible rate of pollutants entrained in the rinsing water).

12.1. Energy Performance/Standby Mode

The Contract Holder commits to implementing all the provisions described in their environmental proposal, which is an integral part of the contract.

In this context, and in accordance with these commitments, the Contract Holder implements all or part of the following environmental measures during the contract execution:

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- To communicate data related to the energy performance of the equipment under normal operating conditions (electricity consumption, water consumption, etc.); To communicate data related to the energy performance of the equipment under normal operating conditions (electricity consumption, water consumption, etc.); for this purpose the supplier must install an electricity meter in order to measure the power consumption of the tool while in standby mode.
- To propose equipment with a standby mode or equivalent device to limit energy consumption when the equipment is not in use or turned off;
- To propose equipment with an alert system to signal excessive energy consumption;
- To provide recommendations for the least energy-consuming modes of operation;
- To propose training on the use of the Equipment in line with the implementation of the clause.

The Contract Holder remains free to submit any alternative solution within the scope of this clause.

The Contract Holder must transmit recommendations to promote more sustainable use of the Equipment based on the usage data communicated during the contract execution by CEA.

12.2. Material Durability/Facilitating Equipment Maintainability

The Contract Holder commits to implementing all the provisions described in their environmental proposal, which is an integral part of the contract.

In this context, and in accordance with these commitments, the Contract Holder implements all or part of the following environmental measures during the contract execution:

- To design equipment with robust materials and extended lifespan;
- To propose equipment offering scalability or adaptability (e.g., by adding frames);
- To ensure that the components of the equipment are easily disassembled and repairable ;
- To propose training on the use of the Equipment in line with the implementation of the clause.

The Contract Holder remains free to submit any alternative solution within the scope of this clause.

The Contract Holder commits to providing recommendations to extend the lifespan of the Equipment during the contract execution.

12.3. Waste Management

The Contract Holder commits to implementing all the provisions described in their environmental proposal, which is an integral part of the contract.

In this context, and in accordance with these commitments, the Contract Holder implements all or part of the following environmental measures during the contract execution:

- To limit the production of waste and packaging ;
- To prioritize packaging that is precisely sized and reusable or recyclable solutions ;
- To prioritize, where possible, the consolidation of deliveries to reduce the carbon footprint associated with transportation ;
- To prioritize optimized transport design to reduce the volume transported.

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The Contract Holder remains free to submit any alternative solution within the scope of this clause.

The Contract Holder must provide all their practices regarding waste management during the contract execution.

13. EQUIPMENT DOCUMENTATION

The equipment supplier commits to providing, no later than before the Site Acceptance Test (SAT), all technical and administrative documentation related to the equipment (non-exhaustive list).

This documentation will include at least:

- The instruction manual written in French including the CE Declaration of Conformity (in accordance with Regulation EU 2023/1230).
- Identification of hazard sources (see Appendix 3) and safety instructions. These documents will enable the development of a risk analysis for the equipment, co-constructed between CEA and the equipment supplier (no later than before the SAT) (see section 11.1).
- If applicable, technical and installation manuals for all commercial devices, accompanied by their calibration certificates, particularly for measurement sensors.
- The list of spare parts and consumables for routine maintenance, with costs and procurement lead times.

If applicable to the type of machine considered (prototype or custom-built with more or less CEA Intellectual Property), the supplier must provide:

- Process plans and diagrams (assembly, piping, and instrumentation).
- The final design file of the equipment.
- Sources of automation and supervision programs, documented and unprotected.
- The diagram of the IT architecture.
- The nomenclature of inputs/outputs (with tag numbers reported on electrical diagrams).
- The manufacturer's file, TQC (Piping, Quality, Control) plans, as well as the electrical and control-command file (including functional analysis and plans).
- If applicable, the ATEX zoning plan of the equipment as well as the conformity certificates of ATEX materials.
- Any other documents required by applicable regulations.

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14. ACCEPTANCE CONDITIONS

14.1. Acceptance breakdown

14.1.1. FAT Phase - Factory Control and Testing

At the end of the FAT, a pre-acceptance proceedings record following CEA's formalism is drawn up and signed by both parties. This pre-acceptance proceedings record allows the acceptance of the factory control file and the listing of reservations.

14.1.2. SAT Phase - Controls and Testing on CEA Site

The tests to be carried out on the CEA site must be defined by CEA and validated by the supplier.

If remarks were made during the factory reception (FAT), it will be necessary to verify that the corrective actions implemented meet the safety requirements.

The acceptance tests must cover all the specifications detailed in chapter 7.

Each requirement must be evaluated (compliant/non-compliant/partially compliant), and the results must be recorded.

Before pronouncing the reception, the supplier must submit all the test and control reports carried out during the SAT.

14.2. Acceptance criteria

Acceptance will be granted if:

- The equipment complies with regulatory requirements (see § **Erreur ! Source du renvoi introuvable.**).
- The equipment meets all contractual technical requirements (see § 7).

When verification of an acceptance criterion requires measurement, the means used must be control, measurement, and test equipment (ECME), as defined by ISO 9001 (see chapter 10).

If CEA provides the measurement equipment: Verify the availability of suitable ECME with sufficient precision.

If the supplier provides the measurement equipment:

- Measurements must be performed using compliant ECME.
- The supplier must provide calibration certificates with COFRAC accreditation or equivalent.

14.3. Final Acceptance Pronouncement on Site

Final acceptance is pronounced when:

- The equipment has been delivered in full.
- Installation, commissioning and start-up are completed.
- Qualification controls and tests have been successfully passed.

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- Regulatory compliance has been approved. If applicable, machine compliance according to EU 2023/1230, as per a report issued by a CEA-accredited body, with no non-conformities.
- If applicable, compliance with specific risks (ATEX, pressure equipment, etc.) validated by an accredited body (see chapter 11).
- The complete equipment documentation has been delivered (see chapter 13).

A proceedings record following CEA's formalism is then drawn up and signed by both parties. This proceedings record allows the acceptance of the control file and, if necessary, the listing of reservations.

15. TRAINING

The supplier commits to provide the following training sessions. A training certificate will be issued by the supplier, listing the trained personnel and their level of intervention.

15.1. Equipment Operation Training

The supplier commits to provide training on the use of the Equipment for 5 people. The supplier will indicate in their offer the number of training days required.

This training will cover, among other topics, equipment operation, automation, and control system handling.

Hence, this training will include awareness on how to get started with the equipment as well as the software interface.

This training shall include:

- System overview (system components, options...)
- Safety (interlocks, safety hazard...)
- Equipment start/stop procedure
- Basic software operations and advanced operations including recipe modification database or log file analyses, and different level access
- Process procedures (including loading/unloading, deposition process, replacement of different parts...)
- Required calibration procedures
- Functional analysis

15.2. First-Level Maintenance Training

The supplier commits to providing first-level maintenance training for 5 people. The supplier will indicate in their offer the number of training days required.

This training shall include both maintenance and equipment safety awareness for basic non dangerous activities.

This training shall include:

- System overview (system components, options...)

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- Safety (interlocks, safety hazard, EMO, robot stops)
- Installation and facilities
- Advanced software operations including recipe modification, database or log file analyses, and different level access
- Functional analysis (tanks, components, etc...)

15.3. Advanced Maintenance Training

The supplier commits to providing first-level maintenance training for 5 people. The supplier will indicate in their offer the number of training days required.

This training shall include procedures and training on material loading and unloading on the equipment and all maintenance procedures that might present risk for the operator.

This training shall include:

- Advanced safety (MSDS, EMO loop, energy isolation lockout/tagout, etc...)
- Equipment start/stop procedure
- Required calibration procedures (pressure level, temperature, flow, weight, general inspection, etc...)
- Preventive maintenance procedures (parts to be changed, maintenance procedure etc)

16. WARRANTY

The equipment is contractually guaranteed for 2 year(s) from the date of acceptance against any defects in material, manufacturing, assembly, and operation, in compliance with the technical specifications of the tender document.

This warranty covers parts (excluding consumables), labor, transportation, and travel.

During the warranty period, the supplier commits to intervening for repairs within 48 hours following receipt of an email request for intervention from CEA. These services are performed every day from Monday to Friday, 8 AM to 5 PM.

In case of unavailability, the warranty period is extended by an equivalent duration to the equipment's downtime.

17. MAINTENANCE

17.1 Spare parts

17.1.1 List of spare parts:

In its bid, the Contractor shall include:

- A comprehensive list of spare parts;
- A comprehensive list of consumables needed to operate the equipment, with the functions, reference and price for each component.

These lists may be used as a basis for drawing up an agreement for the supply of spare parts and consumables.

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The Contractor shall specify the standard delivery timeframe as well as the timeframe for an emergency situation.

17.1.2 Process-kit:

The equipment must be delivered with an additional process-kit per chamber to allow continuity of service after maintenance.

17.1.3 Storage area

The Contractor must specify in appendix A the floor space necessary for the storage of specific maintenance materials supplied with the equipment, including spare parts, tools, handling means etc:

- 1- Floor space required during installation phase
- 2- Floor space required during normal use of the equipment

17.2 Maintenance contract

The Contractor undertakes to be able to provide preventive and corrective maintenance after the warranty period has expired and for a minimum period of 5 years.

The Contractor must include the following at least two types of maintenance in their commercial offer:

- Full service including preventive maintenance, unlimited corrective maintenance, and all necessary spare parts. The Contractor shall also undertake to guarantee a defined availability of the tool during this period.

Unless otherwise specified, the performance of the tool during the term of the full-service contract shall be as defined in the current "EQUIPMENT SPECIFICATIONS FORM."

- Preventive maintenance plus corrective maintenance on demand (hourly rates) in accordance with response and repair times.
- As a supplement, a "free" maintenance offers corresponding to its existing model

Following the adjustment of the CEA's maintenance requirements, the maintenance contract may be implemented after the warranty period has expired.

18. ELEMENTS TO PROVIDE IN RESPONSE TO THE CONSULTATION

- Comments from the Equipment Supplier on the Equipment Specification Document (named: "FOR_533_Appendix_1.xlsx").
- Completed characteristics of fluid requirements, electrical power supply, and all other necessary interfaces (named Appendix 2: "FOR_534_Appendix_2.xlsx").
- Hazard identification sheet (see § **Erreur ! Source du renvoi introuvable.** and Appendix 3: "FOR_535_Appendix_3.xlsx").
- The cost of preventive maintenance service must be specified

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- Duration and descriptions of planned training sessions.
- Separated Mandatory and non-Mandatory Option quotes
- A timeline proposition as illustrated at the table in Chapter 9

Mandatory and non-Mandatory Options:

- **Mandatory Option:** The supplier must obligatorily include an offer with the option, otherwise the offer will be considered irregular. CEA reserves the right to decide whether to exercise this option or not, but the price of the option must be clearly stated in the offer.
- **Non-mandatory type Option:** The supplier has the choice to propose or not propose the option. If the option is not proposed, the supplier will not necessarily be disqualified. CEA reserves the right to decide whether to exercise the option or not.

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APPENDIXES

FOR 533_Appendix_1.xlsx : Supplier's feedback on specifications document

FOR534_Appendix_2.xlsx : Specification Datasheet (GB spreadsheet) for tool installation

FOR535_Appendix_3.xlsx : Hazard Identification Sheet (GB Spreadsheet)