## Technical specifications for X-ray Diffractometer (XRD) Machine

Supply, installation and performance demonstration floor mounted automatic X-ray diffraction systems along with all necessary hardware and software for XRD analysis of metallic and ceramic samples in the form of powder, solid and thin film (grazing incidence diffraction - GIXRD). Comprehensice XRD analysis includes identification of different phases, quantification, x-ray reflectrometry and grazing incidence diffraction of materials under different conditions used in LPSC programme. The detailed technical specifications of the equipment are given below:

| **Sl. No.** | **Specifications** | |
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| **1** | **Type of Instrument** | Fully Automated High Resolution X-Ray Diffractometer |
| **2** | **X-Ray Generator** | |
| i. | Power | 3 kW or higher |
| ii. | Tube Voltage | Operating range 20 - 60 kV or wider range with step of 1 kV |
| iii. | Tube Current | up to 5- 60 mA with step of 1 mA or wider |
| iv. | Stability | 0.01 % or better for high voltage and current with 10 % variation of main supply |
| v. | Focusing system | Line/point focus switch,<br>Easy and quick, without tooling/alignment with software controlled |
| vi. | Control | Alignment free, microprocessor controlled motorized switch of both primary and secondary optic avoiding misuse and malfunction |
| vii. | Compatability | X-ray Generator and optics should be capable for using with Cu and Co X-ray tubes. Seperate optics, if required in case of different anode material shall be provided. |
| **3** | **X-Ray Tube** | |
| i. | X- Ray Tube | Cu target tube, Co target tube with ceramic insulation |
| ii. | Focus | Point and line focus |
| iii. | Filters | Necessary secondary beta filters for Cu, Co tubes. |

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| iv. | Features | **a.** Tube shall be computer controlled and shall have automatic protection for voltage fluctuations and high voltage<br>**b.** Point focus at source with facility to rotate the tube from point focus to line focus and vice versa without any need for realignment and without disconnecting any utilities like high voltage cable, water connection or unscrewing the X-ray tubes (point focus creation at the source through blocking X-ray with slits is not acceptable)<br>**c.** Systems shall have user friendly, easy change over options for changing different tubes, as and when required.<br>**d.** Auto recognition facility for line focus and point focus.<br>**e.** Auto recognition facility of anode material type is mandatory.<br>**f.** Submit authentic documents from system manufacturer for all the tubes quoted for complete technical information. |
| v. | Operating power for X-ray tubes | 1.8 kW or more |
| **4** | **Goniometer** | |
| i. | Type of Goniometer | Automated high-resolution vertical with theta-theta geometry and provision for scanning in two theta mode. It should be suitable for phase analysis and phase quantification. |
| ii. | Goniometer Radius | 240 mm or better |
| iii. | Two theta range | -110 to 165 deg. or better |
| iv. | Smallest addressable increment | 0.0001º or better |
| v. | Angular reproducibility | ≤ 0.0002º |
| vi. | Scanning mode | Continuous scan, step scan, theta or 2 theta scan, fast scan, still scans for XRD analysis |
| vii. | 2 theta linearity over whole range | Equal or better than +/- 0.01º over full angular range. |
| viii. | Angular resolution | ≤ 0.026º (FWHM on NIST stanadard sample) |

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| ix. | Data acquisition Range | -110 º to 165 º |
| x. | Scan speed range | 0.001 to 1.25º/sec or wider |
| **5** | **Component Recognition** | The XRD system should be equipped with automatic component recognition features for conflict detection including X-ray tube, optics (both primary & secondary) sample stages and detector to be used. |
| **6** | **Detector** | |
| i. | Minimum 0D, 1 D and 2 D measurement modes must be possible, must not use any gas or liquid in its operation. Minimum number of pixel/channel/strip should be 190 or more in both X & Y Direction. | |
| ii. | The detector must be able to operate in both fixed and scanning mode and must not have any dead pixels. | |
| iii. | The detector must be able to work with Cu, Co X-ray tube. Dynamic range of the Count rate of $1x10^{10}$ CPS or higher without saturation. | |
| iv. | Resolution ≤ 75 micron | |
| v. | Necessary hardware & software must be in-built to reduce the fluorescence. | |
| vi. | Necessary application note/product details must be enclosed with the offer to support the requested facility in English version. | |
| **7** | **Sample Stages & Holders** | |
| 7.1 | **Sample Stages:** | |
| i. | Spinning sample stage for Reflection and transmission analysis:<br>Motorized sample stage, fully software controlled, with variable sample rotation speed. The sample stage should have a suitable motor for high precision sample positioning, enabling sample rotation (PHI) scans. | |
| ii. | a. Eulerian Cradle with the provision of x, y, z, φ, and χ movements should be offered<br>b. Sample size to be analyzed: Minimum: dia 60 mm, height 15 mm<br>c. Stage should be fully motorized for Z, Phi (ϕ) and Chi (χ) movement<br>d. Range for X and Y movement: ±12 mm or more, Z movement ±2 mm or more, with step size of 0.01 mm<br>e. Chi Tilt: -3 to 93º with step size of 0.01 º<br>f. Phi: 360 ºwith step size of 0.01 º | |

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| | g. Stage should able to use for XRR ( X-ray reflectivity) and GI-XRD analysis<br>h. Laser and camera based suitable stage alignment system shall be provided |
| **7.2** | **Sample Holders** |
| i. | Auto sampler (minimum sample 9 Nos) for spinning sample stage shall be provided, which should work in both reflection and transmission sample measurement in batch programming. It should able to accommodate the followings<br>a. At least 4 sample holders for metallic bulk sample of varying size (minimum) ϕ 5-30 mm x 4 mm thickness<br>b. At least 3 sample for holder powder samples<br>c. At least 2 transmission sample holder for thin films |
| ii. | At least 3 Air tight additional Sample holders with X-Ray Transparent Cover for air sensitive samples |
| iii. | 2 set of zero background sample holder (4 Nos). It is suitable to fit in auto sample changer. |
| iv. | A suitable holders (2 Nos) for small thin-films and irregular metals samples should be offred, which can be used for GIXRD and XRR, analysis |
| v. | Standard sample holders: (20 nos. each) or equivalent |
| **8** | **Microfocus : Specifc area investigation along with optical microscope**<br>Range: Minimum four microfocous collimeter for analysis of material with spot sizes of ~ 100, 300, 500 and 900 μm in the range of 100-1000 μm. |
| **9** | **Beam Optics** |
| **i.** | Incident & Diffracted Beam Optics for Powder Diffraction for getting best resolution |
| **ii.** | Facility to operate both in conventional Bragg-Brentano and parallel beam geometry essentially through computer control change over without any manual intervention. |
| **iii.** | The procedure for changing from Bragg-Brentano geometry to parallel beam geometry should not require any alignment. |
| **iv.** | Advanced multilayer parallel beam mirror optics should be provided for Reflectance, GI XRD and Transmittance measurements. |
| **v.** | Introduction of the Thin Film attachment and changeover to powder optics should be computer controlled and not manual. |
| **vi.** | The secondary optics should also be fully automated and should contain atleast one motorized anti-scatter slit, one equatorial soller slit for focusing and one long soller slit for parallel beam analysis. |

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| **vii.** | A polycapillary optics (to produce high-intensity point beam) suitable for all x-ray radiation should be offered | |
| **viii.** | Collimators of different sizes should be offered to meet microfocus analysis as per clause 8. The switchover of collimators should be easy | |
| **10** | **Chiller Unit** | |
| | Type of unit | Suitable compact indoor Chiller unit (coolant based) shall be provided and installed for XRD equipment. |
| **11** | **High Temperature Unit (Additional attachments- Price breakup shall be given seperately)** | |
| **i.** | Separate stage for high temperature with working temperature from RT to 1200 °C should be quoted with the system. | |
| **ii.** | Stage should be stable for minimum 30 minutes at any assigned temperature of the range. | |
| **iii.** | Heating rate minimum : 200 $^{o}$C/min | |
| **iv.** | Atmosphare : Vacuum , oxidative atmosphare and provision for inert atmosphare. The necessary attachment for same shall be provided. | |
| **v.** | Suitable optics and software should be provided | |
| **vi.** | It should not affect the functionallity of other attachments. | |
| **12** | **Software** | |
| i. | Type of Control | • Full instrument control<br>• Auto alignment for the XRD system along with automatic component recognition |
| ii. | A. The software shall have modules for the analysis/measurement of following as per the requirements/relevant standards:<br>a. Data acquisition<br>b. Processing<br>c. Search match<br>d. Rietveld analysis<br>e. Background subtraction<br>f. Kα2 Stripping<br>g. Smoothing<br>h. XRD system diagnostic facility<br>i. Line Profile analysis and Crystallite size<br>j. % Crystallinity determination | |

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| | k. Quantitative analysis with whole powder pattern fitting, RIR method<br>l. Pair distribution function analysis<br>m. Thin film analysis<br>n. Phase analysis<br>o. International Database such as COD, ICDD PDF-5 that can be integrated with analytical software to allow automatic search match and analysis as mentioned above.<br>B. Party should provide latest software and database for operation of machine and analysis . This software and database shall be supplied with two licences for operation of both the systems (online and offline) at LPSC. |
| **13** | **Computer:** PCs should be (i12) configured to run all analytical software and hardware of XRD with Operating Windows 11 Software or higher. Additional CD writer (HP/Dell/Lenovo) should be provided with the computers. |
| | i. Two Numbers of PC (reputed make such as HP/Dell/Lenovo) with latest generation Intel Core-i12 or better .<br>ii. Intel motherboard with at least 16 GB RAM<br>iii. 32" or bigger flat wide LED monitor with analogue and digital input<br>iv. RAID 1, Hot Swap, 2x1 TB SATA HDD, DVD/RW drive<br>v. nVidia Quadro K620 Graphics or better.<br>vi. Front and back USB ports, 2 serial RS-232 interfaces, standard keyboard and optical mouse.<br>vii. Preloaded with Microsoft Windows 11 or latest Windows OS. The recovery CD of OS along with license CD shall be provided.<br>viii. Software: Complete software package to run all analytical software and hardware of XRD machine, and compatible with operating system has to be supplied. License MS Office software shall be also be loaded on the PC.<br>ix. Software and database shall be avaialble for both the licence PC, so that data analysis can be done indpendently. |
| **14** | **UPS**<br>i. Required Power rating of UPS shall be provided to have power back up of at least 30 minute for the XRD equipment |

<table>
<tr><td>15</td><td>Operating Environment at installation site</td><td><table>
<tr><td>Power supply avilable</td><td>220 V±10% (Single Phase) OR<br>415 V ±10% (Three phase),<br>50 ± 2 Hz,</td></tr>
<tr><td>Ambient temperature</td><td>20-40 $^{o}$C</td></tr>
<tr><td>Operating Temperature</td><td>25±5 $^{o}$C</td></tr>
<tr><td>Relative Humidity</td><td>80% max.</td></tr>
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<tr><td>16</td><td colspan="2">Supply of System & PDI</td></tr>
<tr><td>i.</td><td colspan="2">Pre delivery inspection (PDI) shall be conducted at factory site. The schedule for PDI has to be communicated in advance to make necessary arrangements for participation in the PDI. The following tests need to be demonstrated during PDI.<br>a. XRD-Phase ID, GIXRD and other analysis listed in clause 12 (ii)<br>b. LPSC will provide specimens only<br>c. All the factory acceptance test certificates shall be submitted for verification. Calibration of equipment to be done after installation at LPSC.<br>d. Any modifications suggested (Within the scope of this specifications/purchase order) during PDI have to be incorporated during final supply.</td></tr>
<tr><td>17</td><td colspan="2">Accessories, Spares, Consumable, Safety features, Warranty and Annual Maintenance Contract (AMC)</td></tr>
<tr><td>i.</td><td colspan="2">Tools & Accessories</td></tr>
<tr><td></td><td colspan="2">a. All essential accessories, spares and consumables required for three years of continuous operation of the system should be quoted.<br>b. Necessary tools and tackles required for installation,commissioning and day to day operation of the system shall be supplied by the party.</td></tr>
<tr><td>ii.</td><td colspan="2">Safety</td></tr>
<tr><td></td><td colspan="2">a. Full Radiation protection chamber with failsafe open/close mechanism. Vendors should clearly declare Radiation level in terms of mirco-sievert / hour with X-Ray Tube of Cu and Co anode material. The quoted Model should have Type Approval from AERB, DAE, (Govt. of India) for the complete specification.<br>b. Construction of system with lead glass door or equivalent<br>c. X-ray ON warning feature</td></tr>
<tr><td>iii.</td><td colspan="2">Warranty</td></tr>
<tr><td></td><td colspan="2">a. The complete machine, accessories, software and hardware should be under comprehensive warranty for a period of Three year from the date of successful commissioning & demonstration of performance guarantee test at our site. During this period, any defects/malfunctions reported are to be attended within short time by the factory trained service personnel at our site for</td></tr>
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rectifying the defects, including free replacement of spares required. The LPSC will not pay anything extra on this account. Cost for additional extended warranty (after expiry of Three-year warranty) cost should be quoted separately.

b. During warranty period, it should have two numbers of preventive maintenance visit annually and breakdown visits as and when required (free of cost). The PM visit should be done on 6 monthly basis.

c. Party should have a strong service back-up in India with technically competent service engineers trained and certified by the factory. Proof of evidence has to be provided in the quotation.

**iv. AMC Support and Spare parts availability**

a. Non comprehensive AMC and onsite calibration has to be provided immediately after expiry of warranty for the full equipment including all sub-systems and AMC and calibration charges shall be indicated in the quotation separately for initial **five years (year wise cost)** after expiry of warranty. The AMC shall include 2 Nos of mandatory preventive maintenance visit annually and breakdown visits on chargeable basis (quoted separately) as on when required. LPSC has the right to include the cost of AMC to decide the lowest offer.

| **Description** | **Each Visit Charge** | **Charges for each additional day** |
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| Preventive maintenance | | |
| Breakdown Visitt | | |

b. Spares and guaranteed after-sales service support for 10 years has to be provided.

c. Detailed operational and service manuals in English including essential circuit diagrams for all systems have to be provided.

d. Calibration procedures and calibration certificates traceable to national/international standards have to be provided.

**v. Installation, Commissioning and Performance Guarantee Test**

a. The equipment must be installed, commissioned, calibrated and demonstrated with all features at our site.

b. Onsite verification of equipment shall be done with standard samples at customer's premises after installation and training.

c. In depth training shall be provided for operation and complete system including the attachments. Training period should be minimum of 15 working days after date of installation and commissioning and acceptance at LPSC. The training shall be given in batches as per mutually agreed schedule. The application training should be provided by expert in XRD for metallurgical applications for 15 days in batches.

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| | d. All the tests performed during PDI have to be performed during demonstration of the system. Necessary specimens will be provided by LPSC for this purpose. The system demonstration can be carried out by trained service engineer from OEMs or trained Indian service engineers. |
| **vi.** | **Other Conditions** |
| | a. Manufacturer/ Supplier submitting quotation for XRD machine should have at least 10 years of experience in India for supply, installation, commissioning and service & maintenance of XRD equipment as on date of submission of quotation. Party should also have executed at least 3 Nos of order in INDIA in the last 10 years. Parties not meeting this criterion may be summarily rejected. User names and references along with model number and year of supply should be provided along with the bid.<br>b. Equipment is tentatively planned to be installed on first floor, therefore party is requested to consider foot prints accordingly to have uniformly distributed load on the floor.<br>c. Party is requested to provide the overall weight and size of packaging used for transportation of equipment.<br>d. The overall weight of equipment, size of machine frame shall be provided along with quotation.<br>e. Detailed compliance matrix of our specification and supplier specification item by item in the format as specification mentioned one column and compliance to be mentioned in another column has to be filled and provided along with the quotation.<br>f. Description and sufficient drawing and/or illustrations to enable the equipment offered to be visualized and generally understood, including overall dimensions and weights of the separate units and safety features incorporated.<br>g. The party should submit technical brochures, catalogues for all the subsystems proposed (including bought out items, if any) with full features and capabilities.<br>h. No part quotation is permitted. Machine should be supplied as a whole with all the components/ systems indicated in the tender document.<br>i. The manufacturer should agree to supply 2 sets of manuals (printed hard copies) for operation, maintenance and application software in English for the system to be supplied.<br>j. Price break-up shall be indicated wherever possible.<br>k. Space requirement and other infrastructure requirements (like electrical, water, compressed air, space, erection civil requirements) for the entire systems have to be indicated in the quotation along with layout diagram.<br>l. Any software used for the system has to be supplied to LPSC in installable CD media, so that the software can be reinstalled at LPSC in case of a system crash. Any periodic update to the software to be provided free of cost during warranty. Pre-installation site visit has to be carried out by the company personnel for smooth installation of the equipment. |

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| | m. Indian Agents submitting the quotation on behalf of foreign suppliers must submit the authorization letter to submit the quotation, negotiation, after sales service, maintenance and repair. Such authorization letter must be valid till completion of installation of the equipment and training.<br>n. System has to be supplied within 8 months of placement of order/order acknowledgement. Party may submit their delivery schedule clearly in the quotation.<br>o. Party must indicate the actual specifications of the system offered in the compliance statement. The specification offered/ compliance statement must be linked to either the catalog or technical bid. Noncompliance of this requirement may call for rejection of the offer.<br>p. LPSC reserves the right to select the appropriate attachments / accessories among those quoted. |