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| भारतीय प्रौद्योगिकी संस्थान ततरुपतत Indian Institute of Technology Tirupati Settipalli, Renigunta Road Tirupati 517506 | दूरभाषसंख्या Phone no: 0877 – 2500331 ईमेल Email : govindak@iittp.ac.in |
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Prof. T.S. Natarajan
Registrar i/c

Ref: Mech. Engg. Labs at IIT Tirupati
Date: 16.10.2017

Public Tender No: IITT/MECH/08/2017/04

Due Date: 15.11.2017 at 3.30PM

Dear Sir/Madam,

On behalf of the **Indian Institute of Technology TIRUPATI**, sealed quotations are invited in two part bid system for supply of following mechanical equipment for **setting up of Mechanical Engg. Lab/Facilities at IIT Campus near Merlapaka Village, Venkatagiri Road, YERPEDU Mandalam, Chittoor District, Andhra Pradesh.**

- | | |
|--------------------------------------|-------|
| 1. 2- Axis CNC Turning Machine | 1 No. |
| 2. 3- Axis CNC Milling Machine | 1 No. |
| 3. Wire Cut EDM | 1 No. |
| 4. 3D Printer for Plastics | 1 No. |
| 5. 3D Scanner | 1 No. |
| 6. Coordinate measuring Machine | 1 No. |
| 7. Autocollimator | 1 No. |
| 8. Portable Surface Roughness Tester | 1 No. |
| 9. Metrology Kits & Hand tools | 1 No. |

The detailed specifications of the equipment are given in the Annexure "B" and the compliance statement of specifications as per format (Annexure "A") enclosed must be filled in item wise and signed with seal. The deviations, if any from the tendered specifications should be clearly brought out in the statement. Technical literature/leaflet showing the compliance of the specification may also be attached with the quotation.

Please ensure that the specifications are basic essence of the product. It must be ensured that the offers must be strictly as per our specifications. At the same time it must be kept in mind that merely copying our specifications in the quotation shall not make the parties eligible for consideration of the quotation. A quotation has to be supported with the printed technical leaflet/literature of the quoted model of the item by the quoting party/manufacturer and the specifications mentioned in the quotation must be reflected /supported by the printed technical leaflet/literature. Therefore the model quoted invariably be highlighted in the leaflet/literature enclosed with the quotation. Non-compliance of the above shall be treated as incomplete/ambiguous and the offer can be ignored without giving an opportunity for clarification/negotiation etc. to the bidder.

The eligibility criteria for participation in bid are mentioned below:

1. The Bidder must be an Original Equipment Manufacturer (OEM) or Original Software Developer (OSD) or his Authorized Dealer/Authorized Distributor/ Authorized Stockist/ Channel Partner having a Direct Purchase and Support agreement with the OEM. In case, if the Bidder is a Dealer/ Distributor, a valid LETTER OF AUTHORIZATION from the Two Similar completed works costing not less than Rupees 1.50 crore each
 - a) One similar completed work costing not less than Rupees 2.50 crore
2. The Bidder shall be required to present their capabilities to the Technical Committee, if required.
3. Vendor shall possess ISO 9000 certification for Quality System implementation. Required evidence shall be provided along with offer.
4. The technical bid shall be evaluated for acceptability by the technical committee and may call the tenderers for discussion. If necessary, the committee may modify the technical specification to suit the IIT Tirupati requirement. In such case the opportunity shall be given to the participating bidders for submitting the revised bid as per modified specifications, if any.
5. Bidder should be registered under **GST** Act with the relevant State Sales Tax Authorities. The bidder should furnish along with the bid document, the relevant **GST** Registration Document and PAN / TAN copies.
6. Copies of original documents defining the constitution or legal status, place of registration, and principal place of business of the bidding firm/entity; written power of attorney of the **signatory** of the Bid to commit the Bidder.
7. Should submit three years Income Tax returns and **GST/VAT/ CST** returns filed.
8. List of Present Clientele with contact addresses & telephone numbers.
9. **Documentation:** The Successful bidder shall provide three sets of the following documents in English (along with one set of soft copy):
 - a. Comprehensive Lecturer Guide and Student Guide including theory, experiments and sample results.
 - b. Setting/Programming Instruction Manual
 - c. Operator's Instruction Manual
 - d. Backup CD/DVD for total firmware, background software and the application software packages should be supplied.
 - e. Maintenance and spare parts manual for Mechanical, Electric servos and control system as applicable
 - f. Electric & Electronic circuit drawings for control system, DC/AC drives and interface for component level trouble shooting
 - g. Foundation drawings and installation instructions
 - h. Machine test charts
 - i. Calibration certificate for all measurable items including gauges – with periodicity.
 - j. Preventive maintenance check list, trouble shooting charts and guidelines.

The supplier should quote commercially proven model of equipment and/or control system.

The above mentioned basic eligibility conditions are broad guidelines for pre-qualification and the Director/Registrar, in-charge, IIT Tirupati, Tirupati hereby reserves the right to relax / alter / modify / add, any or all the conditions.

Pre-bid meeting:- The pre-bid meeting is scheduled to be held on Tuesday, 31.10.2017 at 11.00 AM in the 1st Floor Conference Room, Academic Block, IIT Tirupati, Chadalawada Nagar, Renigunta Road, Settipalli Post, Tirupati-517506. Non-attendance at the pre-bid meeting shall not be a cause for disqualification of a bidder. Bidders may avail the opportunity of pre-bid meeting to get first hand details of the proceedings in their own interest

Delivery schedule: The total system should be supplied within 6 months of order.

The interested bidders are advised to go through the conditions envisaged for eligible criteria for participation in the bidding

Instructions to the Bidder

- (i) **Preparation of Bids:** The bidders must ensure that bids are submitted in **two part bid system (i.e.) Technical bid and Financial bid in separate envelopes.**
- (ii) **Techno-commercial bid:** The technical bid should consist of all technical details/brochures along with commercial terms and conditions super-scribed as TECHNICAL BID with Tender No. and date and time of closing and the bidder's name and address. No prices should be included in technical bid.
- (iii) **Financial (Price) Bid** should indicate item-wise prices for the items with firm and fixed figures and words super-scribed with the Tender No. and date of closing of the Tender with name of supply/work and the bidder's Name and address. The price bid should not contain any conditional clauses. No price escalation for any reasons whatsoever is allowed. All prices should be given in Indian Rupees or USD or Euros only. The Indian bidders shall quote firm price fully in Indian currency only.
- (iv) The technical and the financial bids duly signed by the bidders or their authorised signatories with name and seal should be put in separate cover and sealed. Both sealed covers should be put into a bigger cover duly super-scribed with PT No. and due date/time with name of supply /work. **Technical bids must either be spiral bound / stapled together. No loose sheets will be accepted. All pages must be numbered.**
- (v) **Submission of the tender:** The complete sealed bids in all respects shall be sent to the following address well in advance either by post or by courier so as to reach this office before the due date and time specified in the Schedule. The bids received after closing date and time shall not be considered.

The Registrar I/C,
Indian Institute of Technology Tirupati,
Renigunta Road,
Settipalli Post,
Tirupati-517 506, Andhra Pradesh

While submitting the bids, the bidders must sign all the tender documents as a token of accepting of tender documents as well as terms and conditions stipulated therein. Tender documents without signature of bidders or their authorised signatories will be treated as invalid bids.

No conditional offer or terms and conditions will be entertained by the institute and such bids will be treated as invalid.

(vi) The tender documents can be down loaded from IIT Tirupati web site:<http://iittp.ac.in/tenders> on or after 23.10.2017.

(vii) Bid Security (EMD): *EMD either in the form of Bank Guarantee or Demand draft for a sum of Rs.3,00,000/- (Rupees three lakhs only) initially valid up-to 90 days drawn in favour of Indian Institute of Technology Tirupati payable at Tirupati must be sent along-with the technical bid only. The technical bid without EMD would be considered as UNSOLICITED and will be REJECTED. Photo/FAX copies of the Demand Draft/Banker's pay orders will not be accepted. No interest will be paid for the EMD and the EMD (Bid Security) will be refunded to the successful bidder on receipt of Performance Security (Security Deposit) and in case of unsuccessful bidders, the EMD will be refunded on finalisation of tender.*

(viii) Details of our Banker

| | |
|------------------------|-----------------------------------------------|
| Name of bank | State Bank of India |
| Address of bank branch | Settipalli Branch Renigunta Road, Tirupati |
| Bank Branch code | 006677 |
| IFS Code | SBIN0006677 |
| Bank Account Number | 35523338208 |

- (ix) Bid security be forfeited without any intimation in such cases as below:-
- If a bidder withdraws its bid during the period of bid validity
 - If a successful bidder fails to execute the awarded contract
 - If a successful bidder fails to provide performance guarantee

Modifications to bid:

- (x) The bidder shall make no modifications to the bids after the closing date unless specifically requested by IIT Tirupati. In case certain clarifications are sought by Institute after the opening of bid, then the reply of bidder should be restricted to the clarifications sought. Any bidder who modifies his bid having effect of altering the value of his offer after the closing date without specific reference by IIT Tirupati shall make himself liable to be debarred from this tender and forfeit the security bid amount.

xi) Modifications of specification:

The work to be performed by the contractor under this Purchase order can be modified or changed by the request from the IIT Tirupati provided that for such modifications or changes the parties shall first agree to possible addition or deduction in cost, the delivery date and such other terms and conditions occasioned by or resulting from such modification or change. Such agreement shall be effected either by way of exchange of letters duly signed by authorised representatives of the parties or by signed change order form or by minutes of meeting or similar signed by authorised representatives of the parties, which shall constitute the necessary amendments to the contract. Possible increase or decrease in the contact price shall be calculated in accordance with unit prices. The cost of such additional jobs should be reasonably fixed with reference to the quoted price for such or similar items.

(xii) Opening of the tender: The Technical Bids will be opened by the tender committee duly constituted in the presence of bidders or their authorised representatives on 15.11.2017 at 16.00 hours. **The technical bid without EMD will not be entertained and treated as invalid bid.** Then the bids will be evaluated by the Technical Evaluation Committee which will decide the suitability of the technical bids as per our requirement and terms and conditions. Once the technical evaluation is completed, the price Bids of only those bidders who are found technically acceptable will be opened in the presence of Authorized Representatives of such bidder(s), if any on a date and at a venue to be intimated by IIT Tirupati to the short listed bidders.

(xiii) The bidder shall note that any unsolicited post-tender reduction by them would disqualify them from participating from the bidding and forfeit the security bid.

(xiv) Incomplete bids are liable for rejection.

(xv) Prices: The price should be quoted on FOR: IIT, Tirupati basis and mentioned separately for the Item A. Electrical machines, related instrumentation and accessories , B. Civil works for mounting of machines, C. Electrical wiring including proper earthing for machines D. Installation and commissioning of machines, related instrumentation and accessories defined in the technical specifications. All packing and forwarding, freight charges and applicable taxes must be indicated separately for each item.

The bid should consist of basic price, P&F charges, freight, Installation and commissioning charges and applicable taxes and AMC charges separately for the equipments which come into force after expiry of warranty/guarantee periods and separate W.O will be issued by IIT Tirupati for AMC at its discretion in due course of time. For arriving at Lowest Bidder, the quoted price plus AMC charges will be taken into consideration. The percentage of tax & duties should be clearly indicated.

The total landed cost will be calculated from the information provided by the bidder in their price bids. The bid conforming to the lowest cost would then be considered for award of contract.

IIT Tirupati reserves the right to split and award item-wise contract to the lowest bidder.

The custom duty if any applicable must be shown separately. It may be noted that IIT Tirupati is exempted from payment of custom duty and duty at concessional rate against duty exemption will be paid.

In case of import supply, the price should be quoted on EX-WORKS/FOB/CIP basis indicating the mode of shipment.

Offer validity: The offer must be valid for 90 days from the closing date. If the validity of offers for acceptance is less than 90 days, the same will not be considered.

IIT Tirupati reserves the full right to accept / reject any tender or all tenderers at any stage without assigning any reason.

Yours sincerely,

Registrar, IIT Tirupati

SCHEDULE

Important Commercial terms and conditions:

- a) The due date for the submission of the tender is **15.11.2017 at 15.30 hours.**
- b) **Offer Validity:** Validity of Quotation shall not less than 90 days from the due date of tender.
- c) **Late offer:** The offers received after the due date and time of closing will not be considered. The Institute shall not be responsible for the late receipt of Tender on account of Postal, Courier or any other delay.
- d) **Performance Security (Security Deposit):** The successful bidder should submit Security Deposit for an amount of 5% of the value of Purchase Order/Work Order. The Security Deposit shall be furnished in the form of a Bank Guarantee with the validity up-to_____ issued by_____. The contractor undertakes to keep the Bank Guarantee valid and subsisting during the term of this contract until 60 days beyond the date of completion of all contractual obligations of the contractor. The performance Security Bond shall be claimed in the of the event of breach of any contractual obligation by the contractor such as non-delivery of the ordered material in time for any bad delivery performance.
- e) **Performance Bank Guarantee:** Performance Bank guarantee for 5% of Purchase order value should be produced in the form of B.G from the nationalised /scheduled Bank valid till the completion of warranty / guarantee period plus sixty days as claim period. Where-ever installation/commissioning is involved, the guarantee/warranty period shall be reckoned from the date of completion of installation/commission. Failure to render contracted service during the warranty/guarantee period by the contractor, the performance bank guarantee will be forfeited. No interest is payable on the performance Bank guarantee amount.

f) Evidence of supplies made:

The offer/bids should be quoted only for a standard machine that is available in the market and supplied to a number of customers. A list of customers in India and abroad with details must accompany the quotations. Quotations for a prototype machine will not be accepted.

Original catalogue (not any photocopy) of the quoted model duly signed by the principals must accompany the quotation in the Technical bid. No prices should ever be included in the Technical bid.

Documentary proof for the claimed position and repetition accuracies must be obtained from the principals and submitted along with the relevant pages of the standards.

- g) **Inspection Clause:** All major mechanical equipment will be inspected by a team of IIT Tirupati at Supplier's premises and after clearance in the form of report, the items shall be despatched to IIT Tirupati. Readiness of equipment shall need to be intimated well in advance for our inspection formalities.

- h) **Delivery Schedule:** Please note that delivery is the essence of the contract. In case there is any deviation in the delivery schedule, liquidated damages clause will be levied for the delayed supply period. Therefore, it should be ensured that all the ordered items should be supplied within 6 months from the date of receipt of Purchase Order on door delivery basis at our Institute as per Purchase order terms securely and sufficiently packed by following standard packing procedure to withstand transit damages. In case of import supply, the item should be delivered at the cost of supplier to our institution. The installation and commissioning should be completed as specified in our important terms and conditions.
- i) **Extension of time:** If the completion of stores is delayed due to reason of force majeure such as acts of God, acts of public enemy, acts of Government, fires, floods, epidemics, quarantine restriction, strikes etc., the contractor shall give notice within 15 days to Institute in writing of his claim for an extension of time. The Institute on receipt of such notice after verification, if necessary, may agree to extend the Contract delivery date as may be reasonable but without prejudice to other terms and conditions of the contract.
- j) **Liquidated damages:** If the Contractor fails to deliver the material within the time specified in the Contract or any extension thereof, the Institute shall recover from the Contractor as Liquidated Damages a sum of one-half of one per cent (0.5 per cent) of the Contract Price of the undelivered material for each calendar week of delay. The total liquidated damages shall not exceed ten per cent (10%) of the Contract price of the unit or units so delayed. Stores will be deemed to have been delivered only when all their component parts are also delivered.
- k) **Guarantee/Warranty:** The Contractor shall guarantee that the material supplied shall comply fully with the specifications laid down, for material, workmanship and performance after acceptance of the material. The tenderer should clearly mention in the bid the period of guarantee/warranty offered by him. If any defects are discovered therein or any defects therein found to have developed under proper use arising from faulty stores design or workmanship, the Contractor shall remedy / replace such defective items at his own cost.

In case any extended warranty/guarantee offered, the cost for the same must be shown separately. A separate commercial quote for Comprehensive Annual Maintenance of machines/equipment after expiry of warranty/guarantee period shall also be submitted with full details about free replacement of spares/accessories during the currency of AMC and no. of break down calls shall be attended within 48 hours from the breakdown time reported during the warranty period. The details of essential spares required to be supplied on chargeable basis also to be mentioned separately.

The Bidder should clearly categorize the Basic/Standard features as well as optional features of the system in order to have a clear cost comparison. Essential spares if any for maintenance to be quoted separately. The bidder should ensure continued supply of spares throughout the useful life of the equipment.

- l) **Insurance:** IIT Tirupati being a Central autonomous body under Ministry of HRD, Government of India, we will not insure our goods. However, to safe guard the ordered material from probable transit damage while in transportation the contractor may insure the goods at his risk and cost.

- m) **Payment terms:** No Advance payment will be made for Indigenous purchase. Our normal payment terms are 100% within 30 days after receipt of complete supply at our site and acceptance. However in case of high value Purchase Orders, as a special case, payment of 90% of Order value will be made based on pre-inspection of material at your site and against delivery of goods at our site. Balance 10% of PO value after installation and acceptance. For making payment original tax invoice in triplicate, Delivery Challan's, material test certificate, pre-inspection of material at factory, guarantee/warranty certificates must be sent along with material.

In case of import supplies the payment will be made only through 100% Letter of Credit i.e. (90% payment will be released against proof of shipping documents and 10% after successful installation wherever the installation is involved.)

- n) **Advance Payment:** No advance payment to indigenous supplies will be made. However in case of import goods, specific percentage of advance payment will be agreed upon for which, the Foreign Vendor has to submit a Bank Guarantee equal to the amount of advance payment and it should be routed through the Beneficiary Bank to the end user Bank. Otherwise, the Indian Agent of the foreign vendor has to submit a Bank Guarantee through a Nationalized Bank of India.

If an Indian agent is involved, the following documents must be enclosed:

Foreign principal's proforma invoice indicating the commission payable to the Indian Agent and nature of after-sales service to be rendered by the Indian Agent.

Copy of the agency agreement concluded with the foreign principal and the precise relationship between them and their mutual interest in the business.

The enlistment of Indian agent with Director General of Supplies & Disposals under the Compulsory Registration Scheme of Ministry of Finance.

- o) **Agency Commission:** Agency commission, if any, will be paid to the Indian agents in Rupees on receipt of the equipment and after satisfactory installation. Agency Commission will not be paid in foreign currency under any circumstances. The details should be explicitly shown in Tender even in the case of 'Nil' commission. The tenderer should indicate the percentage of agency commission to be paid to the Indian agent. The foreign Principal should indicate about the percentage of payment and it should be included in the originally quoted basic price, if any. This payment will be released to the Indian Agent immediately after customs clearance of the goods in India.
- p) **On-site erection and commissioning:** It is the responsibility of the Contractor to install and commission the equipment or machinery supplied by them within 15 - 20 days from the date of receipt of the item at site of IIT Tirupati and demonstrate the performance of the system to the satisfaction of the users/concerned faculty members/committee in-charge at IIT Tirupati. In case the Contractor fails to carry out the erection as and when called upon to do so within the specified period by the Institute, the Institute shall have the right to get the erection work done through any source of his choice. In such an event, the Contractor shall be liable to bear any additional expenditure that the Institute is liable to incur towards erection.

- q) **Training of End user:** The successful bidder shall provide comprehensive training at IIT Tirupati to IIT personnel on operation, programming, and maintenance at free of cost on all the items installed to the satisfaction of the IIT personnel. The expenses related to travel (to and fro) including local travel, stay, food and per diem and training have to be completely borne by the vendor.
- r) **Do not quote the optional items or additional items unless otherwise mentioned in the tender documents / specifications.**
- s) **ARBITRATION CLAUSE:** Arbitration in the event of any dispute or difference arising under these terms & conditions or any Condition contained in the Purchase Order or in connection with this contract (except as to any matter the decision of which is specially provided for by these conditions), the same shall be referred to the sole arbitration of the Registrar, IIT, Tirupati or of some other person appointed by him, and the dispute further processed in terms of the Arbitration & Conciliation Act, 1996. There will be no objection that the arbitrator is a Government Servant that he deal with matter which the Contract relates to or that in the course of his duties as Government Servant has expressed views on all or any of the matters in dispute or difference. The award of the arbitrator shall be final and binding on the parties of this Contract.

If the arbitrator is the Registrar, IIT, Tirupati

- i. In the event of his being transferred or vacating his office by resignation or otherwise, it shall be lawful for his successor in office either to proceed with the reference himself or to appoint another person as arbitrator, or
- ii. In the event of his being unwilling or unable to act for any reason, it shall be lawful for the Registrar, IIT, Tirupati to appoint another person as arbitrator.

If the arbitrator is a person appointed by the Registrar, IIT, Tirupati – In the event of his denying or neglecting or refusing to act, or resigning or being unable to act, for any reason, shall be lawful for the Registrar, IIT, Tirupati to proceed with the reference himself or to appoint another person as arbitrator in place of the outgoing arbitrator subject, as aforesaid, to the Arbitration & Conciliation Act, 1996, and the rules there-under and any statutory modifications thereof for the time being in force shall be deemed to apply to the arbitration proceeding under the clause. The Arbitrator shall have the power to extend with the consent of the purchaser and the contractor the time for making and publishing the award. The venue of Arbitration shall be the place as the purchaser in his absolute discretion may determine work under the Contract shall, if reasonably possible, continue during Arbitration Proceedings.

All amendments, time extension, clarifications etc., if any will be uploaded in the website only and will not be published in newspapers. Bidders should regularly visit the above website to keep themselves updated. No extension in the bid due date/ time shall be considered on account of delay in receipt of any document by mail.

- t) **Acknowledgement:** It is hereby acknowledged that the tenderer has gone through all the conditions mentioned above and agrees to abide by them.

**SIGNATURE OF TENDERER
ALONG WITH SEAL OF THE
COMPANY WITH DATE**

ANNEXURE A**FORMAT OF COMPLIANCE STATEMENT OF SPECIFICATIONS**

| S.No. | Name of specifications/ part / Accessories of tender enquiry | Specifications of quoted model/Item | Compliance whether "YES" or "NO" (Values wherever necessary) | Deviation, if any, to be indicated in unambiguous terms | Whether the compliance/ deviation is clearly mentioned in technical leaflet/ literature |
|-------|--------------------------------------------------------------|-------------------------------------|--------------------------------------------------------------|---------------------------------------------------------|-----------------------------------------------------------------------------------------|
| 1 | 2 | 3 | 4 | 5 | 6 |
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1. CNC LATHE

| S. No. | Description | | Specification |
|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|---------------|
| | Machine Description | | |
| | A 2 axis CNC Milling Machine with servo motor, Industrial control panel. | | |
| | CNC lathe with LM guideways inclined bed 45 degree with Siemens control to be offered. Machine should be FEM analysed, suitable for machining components made of aluminium alloys, steel alloys, titanium. etc., Machine built with rigid construction that offers good static and dynamic rigidity. | | |
| | | | |
| 1 | WORKING CAPACITY | | |
| 1.1 | Bed Type | Type | Inclined 45° |
| 1.2 | Swing Over Bed | mm | 550 or more |
| 1.3 | Swing Over Cross Slide | mm | 350 or more |
| 1.4 | Turning Diameter Between Centers | mm | 300 or more |
| 1.5 | Turning Length | mm | 500 or more |
| | | | |
| 2 | SPINDLE & CHUCK | | |
| 2.1 | Nose | Std | A2-6/A2-8 |
| 2.2 | Power (Cont.) | Kw | 11 |
| 2.3 | Torque (cont.) | Nm | 112 |
| 2.4 | Speed (Minimum) | rpm | 10 |
| | Speed (Maximum) | rpm | 5000 or more |
| 2.5 | Hole through the Spindle | mm | 70 Φ or more |
| 2.6 | Chuck diameter | mm | 210 / 250 |
| | | | |
| | | | |
| 3 | SERVO TURRET | | |
| 3.1 | Bi-directional Servo driven tool turret | No. | 12 Station |
| 3.2 | Tool Size (Cross section) | | 20X20/25X25 |
| 3.3 | Maximum Boring Bar Dia. | mm | 50 |
| | | | |
| 4 | FEED RATE | - | |
| 4.1 | Cross slide travel (X-axis) | mm | 240 |
| 4.2 | Saddle travel (Z-axis) | mm | 550 |
| 4.3 | Rapid traverse Rate (X-axis) | m/min | 30 |
| 4.4 | Rapid traverse Rate (Z-axis) | m/min | 30 |
| | | | |

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|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----------------|
| 5 | PROGRAMMABLE TAIL STOCK (Hydraulic Body Movement) | | |
| 5.1 | Quill dia. | mm | 85 or more |
| 5.2 | Quill stroke | mm | 100 or more |
| 5.3 | Thrust (adjustable) | Kgf | 400 or more |
| | | | |
| 6 | ACCURACIES- ACCORDING TO NORM VDI/DGQ 3441 FOR FULL LENGTH | - | |
| 6.1 | Positioning Uncertainty X-axis | mm | 0.008 or better |
| 6.2 | Positioning Uncertainty Z-axis | mm | 0.008 or better |
| 6.3 | Repeatability X-axis | mm | 0.008 or better |
| 6.4 | Repeatability Z-axis | mm | 0.008 or better |
| | | | |
| 7 | STANDARD ACCESSORIES TO BE SUPPLIED WITH BASIC MACHINE | | |
| | Along with the machine Programming/Training Software Sinutrain 840D Operate V4.7 Mill & Turn - 18 users to be provided | | |
| 7.1 | Self-centering 3-jaw Hydraulic Power Chuck of Ø200 mm with 1 Set of Hard and Soft Jaws, Hydraulic Cylinder for Power Chuck with draw bar and matching elements. | | |
| 7.2 | Hydraulic Power Pack | | |
| 7.3 | Centralized Lubrication Unit | | |
| 7.4 | In built Coolant Tank with pump and motor | | |
| 7.5 | Coolant Guards | | |
| 7.6 | Auto and Manual Coolant System | | |
| 7.7 | Maintenance Tool Kit | | |
| 7.8 | Foundation Bolts, Leveling Screws and Leveling Pads | | |
| 7.9 | Basic tools - Turning, Threading (Internal & External), Parting and drilling operation tool holders with 10 number of each operation inserts to be provided, to be quoted separately | | |
| 7.10 | Machine Lamp and Tower Lamp | | |
| 7.11 | Manual Pulse Generator | | |
| 7.12 | Data communication through Ethernet, USB to be provided | | |
| 7.13 | Machine Operator Panel with horizontal and vertical swivel for easy operation | | |
| 7.14 | AC Unit for System and Drive Cabinet | | |
| 7.15 | English Manuals 03 Sets in hard copy for operation, programming and maintenance | | |
| 7.16 | Isolation transformer / Servo controlled voltage stabiliser (35 KVA) for input power supply (3 Phase). For smooth running of the equipment - To be quoted separately | | |
| 7.17 | Machine Layout drawing | | |
| | | | |
| 8 | CNC CONTROL | | |
| 8.1 | The machine should be equipped with CNC control Siemens having flexibility to change the parameters. System suitable to drive 2 axes machine (X, Z), spindle, With 3D control technology | | |

| | |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| 8.2 | Control cabinet should be totally enclosed and should be suitable for ambient condition of 10 degree to 45 degree C and relative humidity up to 95 %. |
| 8.3 | Control should have minimum memory of 2GB, 256 MB RAM . |
| 8.4 | Should display machine position, block number, active command data, absolute position of axes, distance to go position of the axes, speed, and tool. |
| 8.5 | Manual pulse generator for X, Z axes and indexing head. Minimum resolution of 1 micron, 10 micron and 100 micron. |
| 8.6 | Block search and rewind |
| 8.7 | Feed override 5 % to 12 % |
| 8.8 | Rapid traverse over ride. |
| 8.9 | Speed over ride |
| 8.10 | Feed hold for axis and spindle stop during auto mode. When released spindle to start and axis to move . |
| 8.11 | System lock - With different user level control |
| 8.12 | Locking of parameters |
| 8.13 | Easily programmable canned cycles (Technological cycles for turning cycle) |
| 8.14 | Temporary origin fixing |
| 8.15 | Absolute programming and incremental programming |
| 8.16 | USB drive. Latest version of USB port drives for part programme & PLC program loading |
| 8.17 | Decimal point programming |
| 8.18 | Tool wear compensation |
| 8.19 | Operators Panel and Manual Data Input via Key Board |
| 8.20 | Data input like tool offsets/work offsets |
| 8.21 | EIA/ISO coding |
| 8.22 | Diameter / Radius Programming |
| 8.23 | Built-in geometric calculation |
| 8.24 | Direct feed rate programming in mm/min and mm/rev |
| 8.25 | Datum offset and datum search |
| 8.26 | Display of NC, PLC Messages and Internal PLC Status & Alarms in English |
| 8.27 | 19" multi touch display Monitor for operator panel. |
| 8.28 | Color Graphics |
| 8.29 | Measuring System: Encoder |
| 8.30 | UPS for Control System |
| 8.31 | Machine bed should be made of high quality cast iron , fully stress relieved and adequately ribbed to be provided for maximum stiffness and rigidity |
| 8.32 | Machine shall be capable to taking higher cutting parameters even with hard turning materials with linear motion guide ways |
| 8.33 | Independent AC servo motors and digital drives for X & Z axes and spindle. |
| 8.34 | The machine should have adequate safety interlocks for safe operation. |
| 8.35 | Backlash elimination to be provided for all the axes. |

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| 8.36 | All electrical insulation to be tropicalised. |
| 8.37 | Coolant system : for providing coolant flow near tool point. The system should be designed in such a way that the coolant should be collected from the table in a collection tank |
| 8.38 | Machine to be provided with adequate protection guards. |
| 9 | INSPECTION AND ACCEPTANCE |
| 9.1 | Standard accuracy test performed as per protocol to be provided along with the machine |
| | The machine should be CE certified |
| 10 | Constructional Features |
| | Ergonomic design |
| | The machine must be built using high quality stress relieved closed grain Cast Iron, rigid in construction to with-stand heavy cutting loads |
| | Roller guide ways for all the axes |
| | Recirculating ball screws and servo motor for all axes |
| | Direct measuring system with air purge for all the axes |
| | Status light beacon |
| | Electronic hand wheel |
| 11 | Axes Drives |
| | All axes to be provided with directly coupled AC servo motors |
| | Telescopic covers to be provided for each axes |
| 12 | CNC control system |
| | a) Control system reputed make and latest model like Siemens 840D with 3D control technology |
| | b) Electrical wired-up panel to conform to IP54/ IP55 norms. |
| | c) The electrical / control cabinet shall be provided with panel A/C |
| | d) System lock - with different user level control |
| 13 | Control features |
| | I. Main control features should be as following: |
| | a) Display: 19" color display in English Language |
| | b) Simultaneously controllable axes : 2 axes |
| | c) Minimum input increment : 0.001 mm |
| | d) Spindle speed override: 50%-120% (in steps of 10%) |
| | e) Feed override : 150% (in steps of 10 %) |
| | II. Other CNC functions should be as following: |
| | a) Absolute / Incremental programming |

| | |
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| | b) Canned cycles : drilling, reaming, pecking, boring, tapping, roughing and finishing of circular pockets, linear and circular hole patterns, internal and external threads |
| | c) Work piece co-ordinate system |
| | d) Tool compensation |
| | e) Scaling , Mirroring |
| | f) Polar co-ordinate |
| | g) Metric & inch input. |
| | h) Background editing and programming. |
| | i) Pitch error and backlash compensation. |
| | j) Alarm & error display and diagnostic features. |
| | k) Program repetition and Macro Programming. |
| | l) External interface: RS232 (1 No) / Ethernet interface facilities |
| | m) Multi program storage with programme identification. |
| | n) Temporary origin fixing. |
| | o) Automatic repositioning after cycle interruption |
| | p) Decimal point programming. |
| | q) Display of remaining cycle during execution of repetitive cycle/subroutine. |
| | r) Manual Pulse Generator |
| | s) Graphics simulation during real-time machining |
| | t) ISO programming to be offered for turning application |
| | |
| 14 | Display features |
| | a) Machine position. |
| | b) Program under execution. |
| | c) Block no. |
| | d) Active command block. |
| | e) Spindle speed & feed rate- actual & program value. |
| | f) Absolute position. |
| | g) Off-set no. |
| | h) Error message if any. |
| | i) Mode of operation. |
| | j) Relative position. |
| | k) Part program & tool file library. |
| | l) Work zero. |
| | |
| 15 | Operator panel – With flexibility for horizontal & Vertical swivel |
| | a) Manual pulse generator with axes selector X1, X10, X100 of Detachable type. |
| | b) Manual ON/OFF for Control System, Coolant, Spindle. |

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| | c) Spindle neutral position for dialing. |
| | d) Operating modes: Jog, reference point, MDI, Single block, Auto. |
| | e) Manual tool loading. |
| | f) Feed hold. |
| | g) Emergency stop. |
| | h) Machine lock & programme lock. |
| | i) Block search & skip. |
| | j) Test run / dry run. |
| | k) Cycle start & stop. |
| | l) Part programme edit selector. |
| | m) Cycle stop indication. |
| | n) Manual reference point return |
| | |
| 16 | Coolant system |
| | a. Suitable Coolant system must be provided for the part being machined, with delivery nozzles. |
| | b. Coolant spray gun for the manual cleaning area |
| | |
| 17 | Chip Conveyor: |
| | A suitable chip conveyor along with the machine to be provided |
| | |
| 18 | Power Supply |
| | The machine should be able to operate under following power supply conditions: 415 V \pm 10%, 3 phase, 50 \pm 2 Hz. |
| | Requirement of AC voltage stabilizer 35 kVA / isolation transformer to be quoted separately |
| | Electrical insulation shall be fully tropicalized. AC panel for electrical cabinet to be provided. |
| | |
| 19 | Basic Tools - To be quoted separately |
| | Basic tools - Suitable Turning, Threading (Internal & External), Parting and drilling operation tool holders with 10 number of each operation inserts to be provided, to be quoted separately |
| | |
| 20 | Air Pressure |
| | Operating air pressure: 5 - 6 bar. |
| | Suitable air compressor if required for operating the equipment to be quoted separately |
| | |
| 21 | Lubrication |
| | Centralized lubrication system with automatic lubrication cycle shall be provided for spindle, axes ball screws and guide ways |
| | |
| 22 | Working condition |

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| | The machine and its accessories should be tropicalized. |
| | |
| 23 | Acceptance test and inspection |
| | a) Inspection schedule for acceptance covering all the relevant international standards should be enclosed along with the quotation. |
| | b) The test charts /methods adopted for confirming the geometrical accuracies of the machines are to be furnished by the Supplier along with quotation |
| | The Machine should be CE certified |
| | |
| 25 | Spares |
| | i. Essential spares if any for maintenance to be quoted separately |
| | ii. The supplier should ensure continued supply of spares throughout the useful life of the machine. |
| | |
| 26 | Safety |
| | a) The machine should be provided with all safety features to protect the machine, control and the operator, while in operation, from possible damages/injury. (Some special operations & maintenance activities needs the door to be kept open, & provision to be made for the same) |
| | b) Working area of the machine should have safety enclosure with Plexi glass windows. |
| | c) Automatic machine shut off in the event of Lubrication failure with warning and warning in the event of coolant failure must be provided. |
| | d) Over temperature protection |
| | e) The equipment should be so designed that in the event of power failure there should not be any over shooting in any of the axes which could cause damage leading to rejection of the components. |
| | f) A suitable safety package for the power failure with overload limiter, under-voltage monitoring with fast deceleration control shall be quoted separately. |
| | g) Over travel limit for all the axes, parity check, spindle drive failure warning etc should be provided. |
| | h) Automatic shut off of the machine in case of major spikes in the incoming supply which affects the control system and the machine functions. |
| | i) The machine should work satisfactorily to the ambient conditions up to 45°C and 95% humidity (maximum). |
| | |
| 27 | Installation & Commissioning. |
| | i. Foundation kit like vibro mounts, bolts etc., required for the foundation should be supplied by the party. |
| | ii. Layout drawing of the machine to be provided indicating: |
| | a. Size and weight of the equipment. |
| | b. Total area required for the equipment |
| | c. Type of foundation required. |
| | d. Detailed drawing of foundation indicating necessary details to be supplied |
| | e. Requirements of water and compressed air lines to be specified. |
| | iii. Special requirements like isolation, vibration criteria, Air conditioning, dust free atmosphere and flooring to be specified. |

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| | v. Party should co-ordinate for installing the equipment and commission the equipment within the stipulated time from the receipt of the machine at IIT Tirupati site |
| | vii. The machine shall be accepted after satisfactory commissioning, tests and prove out of NAS component as per international standard |
| | |
| 28 | Training |
| | During commissioning visit, supplier's engineer should provide training in the following areas: |
| | a) Operation and Programming |
| | b) Mechanical Maintenance |
| | c) Electrical and CNC maintenance |
| | d) CNC Control System |
| | |
| 29 | Documentation |
| | Three sets of the following documents in English (along with one set of soft copy) are required to be supplied: |
| | i) Setting/Programming Instruction Manual |
| | ii) Operators Instruction Manual |
| | iii) Maintenance and spare parts manual for Mechanical, Electric servos and control system |
| | iv) Electric & Electronic circuit drawings for control system, DC/AC drives and interface for component level trouble shooting |
| | v) Foundation drawings and installation instructions |
| | vi) Machine test charts |
| | vii) Calibration certificate for all measurable items including gauges – with periodicity. |
| | viii) Preventive maintenance check list, trouble shooting charts and guidelines. |

2. CNC MILLING MACHINE

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| 1. Machine Description |
| A 3 axis CNC Milling Machine with servo motor, Industrial control panel. |
| The machine construction should be on a C Frame design with Table integrated in X axis and a well thought out robust cast construction. The high quality of the machine base allows whole lifetime permanent high quality and cutting capacity. Constant mass in Y and Z axis to allow a positive influence on the heavy cutting loads with roller guideways. Dual Support Y axis for maximized stability. FEM analyzed and appropriate webbing and ribs in all main parts to ensure high rigidity, torsional strength and thermal stability with anti-friction guideways and recirculating ball screws on all axis. To have better dynamic rigidity, machine should be designed without overlapping axis on table. |
| 2. Traverse |
| a) Longitudinal travel (X-axis): 600 mm |
| b) Cross travel (Y- axis): 550 mm |
| c) Vertical travel (Z-axis): 500 mm |
| 3. Table |
| a) Clamping area : 900 x 550 mm |
| b) No. of T-Slots : 5 |
| c) Distance from table to spindle face : 120 - 630 mm |
| d) Workpiece weight : up to 500 Kg |
| 4. Positional Accuracy (As per VDI / DGQ3441)/Linear scale feedback |
| Axes X, Y, & Z : 0.006 mm |
| 5. Repeatability (As per VDI / DGQ3441) |
| Axes X, Y, & Z : 0.004 mm |
| 6. Feed rates |
| a) Feed rate - X, Y & Z axes : 10- 30000 mm/min |
| b) Feed force - X, Y & Z axes : 5 kN |
| 7. Rapid traverse |
| a) X, Y & Z axes : 30000 mm/min |
| 8. Spindle Details |
| a) Spindle power : 9 kW @ 100 % ED |
| b) Spindle speed : 20 to 12000 rpm (infinitely variable) |
| c) Spindle run-out : 0.003 mm |
| d) Spindle taper : BT40 /SK40 |
| e) Good lubrication and coolant system shall be provided for the spindle |
| 9. Tool Magazine: |
| (i) Double gripper : 30 tools |
| (ii) Tool change time : 4 seconds |
| (iii) Max. Tool diameter : 75 mm |
| (iv) Max. Tool length : 300 mm from spindle nose |

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| 10. STANDARD ACCESSORIES TO BE SUPPLIED WITH BASIC MACHINE |
| Along with the machine Programming / Training Software Sinutrain 840D Operate V4.7 Mill&Turn - 18 users to be provided |
| Centralized Lubrication Unit |
| In built Coolant Tank with pump and motor |
| Coolant Guards |
| Auto and Manual Coolant System |
| Maintenance Tool Kit |
| Foundation Bolts, Leveling Screws and Leveling Pads |
| Machine Lamp and Tower Lamp |
| Manual Pulse Generator |
| Data communication through Ethernet, USB to be provided |
| Machine Operator Panel with horizontal and vertical swivel for easy operation |
| AC Unit for System and Drive Cabinet |
| English Manuals 03 Sets in hard copy for operation, programming and maintenance |
| Isolation transformer / Servo controlled voltage stabilizer (35 KVA) for input power supply (3 Phase). For smooth running of the equipment - To be quoted separately |
| Machine Layout drawing |

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| 11. Constructional Features: |
| Ergonomic design |
| The machine must be built using high quality stress relieved closed grain Cast Iron, rigid in construction to with-stand heavy cutting loads |
| Roller guide ways for all the axes |
| Recirculating ball screws and servo motor for all axes |
| Direct measuring system with air purge for all the axes |
| Status light beacon |
| Electronic hand wheel |
| |
| 12. Axes Drives: |
| All axes to be provided with directly coupled AC servo motors |
| Counter balance system shall be provided for the vertical axis |
| Telescopic covers to be provided for each axis |
| |
| 13. CNC control system |
| a) Latest model Siemens 840D Control system with 3D control technology |
| b) Electrical wired-up panel to conform to IP54/ IP55 norms. |
| c) The electrical / control cabinet shall be provided with panel A/C |
| d) System lock - with different user level control |
| |
| 14. Control features |
| I. Main control features should be as following: |
| a) Display : 19 inch color display in English Language |
| b) Simultaneously controllable axes : 3 axes |
| c) Minimum input increment : 0.001 mm |
| d) Spindle speed override : 50 %-120 % (in steps of 10 %) |
| e) Feed override : 150 % (in steps of 10 %) |
| II. Other CNC functions should be as following: |

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| a) Linear, circular and helical interpolation. |
| b) Absolute & Incremental programming |
| c) Canned cycles : drilling, reaming, pecking, boring, tapping, roughing and finishing of rectangular and circular pockets, linear and circular hole patterns, internal and external threads |
| d) Workpiece co-ordinate system |
| e) Tool compensation |
| f) Scaling , Mirroring |
| g) Polar co-ordinate |
| h) Metric & inch input |
| i) Background editing and programming |
| j) Pitch error and backlash compensation |
| k) Alarm & error display and diagnostic features |
| l) Program repetition and Macro Programming |
| m) External interface: RS232 (1 No) / Ethernet interface facilities |
| n) Multi program storage with programme identification |
| o) Temporary origin fixing |
| p) Automatic repositioning after cycle interruption |
| q) Decimal point programming |
| r) Display of remaining cycle during execution of repetitive cycle/subroutine |
| s) Manual Pulse Generator |
| t) Graphics simulation during real-time machining |
| u) ISO programming to be offered for milling application |
| |
| 15. Display features |
| a) Machine position |
| b) Program under execution |
| c) Block no |
| d) Active command block |
| e) Spindle speed & feed rate- actual & program value |
| f) Absolute position |
| g) Off-set no |
| h) Error message if any |
| i) Mode of operation |
| j) Relative position |
| k) Part program & tool file library |
| l) Work zero |
| |
| 16. Operator panel – With flexibility for horizontal & Vertical swivel |
| a) Manual pulse generator with axes selector X1, X10, X100 of Detachable type. |
| b) Manual ON/OFF for Control System, Coolant, Spindle. |
| c) Spindle neutral position for dialing. |
| d) Operating modes: Jog, reference point, MDI, Single block, Auto. |
| e) Manual tool loading. |
| f) Feed hold. |
| g) Emergency stop. |
| h) Machine lock & programme lock. |
| i) Block search & skip. |
| j) Test run / dry run. |

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| k) Cycle start & stop. |
| l) Part programme edit selector. |
| m) Cycle stop indication. |
| n) Manual reference point return |
| |
| 17. Coolant system |
| a. Suitable Coolant system must be provided for the part being machined, with delivery nozzles. |
| b. Standard chip tank with three nozzles for external coolant supply (20 litre/min, 4 bar, 120 litre coolant tank capacity- approx.) |
| c. Coolant spray gun for the manual cleaning area to be quoted separately. |
| |
| 18. Chip Conveyor: |
| A suitable chip conveyor along with the machine to be provided |
| |
| 19. Power Supply |
| The machine should be able to operate under following power supply conditions: |
| 415 V \pm 10 %, 3 phase, 50 \pm 2 Hz. |
| Requirement of AC voltage stabilizer 35 kva / isolation transformer to be quoted separately |
| Electrical insulation shall be fully tropicalized. AC panel for electrical cabinet to be provided. |
| |
| 20. Basic Tools - To be quoted separately |
| Face milling cutter dia. 63 mm with holder - 1 No, Suitable insert - 10 nos |
| Shoulder milling cutter dia 40 mm with holder - 1 No, Suitable insert - 10 nos |
| Chamfer tool with holder - 1 No |
| End mill dia 16 mm with holder - 1 No, suitable insert - 10 Nos |
| Dia. 8.5 mm drill - 1 No |
| Collet & Collet chuck - 2 Nos each, M 10 Tap - 1 No |
| Suitable pull studs - 4 Nos |
| |
| 21. Air Pressure |
| Operating air pressure: 5 - 6 bar. |
| Suitable air compressor for operating the equipment to be quoted separately |
| |
| 22. Lubrication |
| Centralised lubrication system with automatic lubrication cycle shall be provided for spindle, axes ball screws and guide ways |
| |
| 23. Working condition |
| The machine and its accessories should be tropicalized. |
| |
| 24. Acceptance test and inspection |
| a) Inspection schedule for acceptance covering all the relevant international standards should be enclosed along with the quotation. |
| b) The test charts /methods adopted for confirming the geometrical accuracies of the machines are to be furnished by the Supplier along with quotation |
| c) The Machine should be CE certified |
| |
| 25. Warranty |

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| a) Entire machine inclusive of all systems/ accessories should be warranted for 12 months from the date of installation / commissioning against all the design, material or manufacturing defects. |
| b) Supplier to indicate the useful life of the machine on 2 shift per day basis. |
| c) Breakdown calls shall be attended within 48 hours from the breakdown time reported during the warranty period. |
| |
| 26. Spares |
| i. A kit of spares for maintenance of the machine and control system, for a daily 2 shift operation, to be quoted separately |
| ii. The supplier should ensure continued supply of spares throughout the useful life of the machine. |
| |
| 27. Safety |
| a) The machine should be provided with all safety features to protect the machine, controller and the operator, while in operation, from possible damages/injury. (Some special operations & maintenance activities needs the door to be kept open, & provision to be made for the same) |
| b) Working area of the machine should have safety enclosure with Plexi glass windows. |
| c) Automatic machine shut off in the event of lubrication failure with warning and warning in the event of coolant failure must be provided. |
| d) Over temperature protection |
| e) The equipment should be so designed that in the event of power failure there should not be any over shooting in any of the axes which could cause damage leading to rejection of the components. |
| f) A suitable safety package for the power failure with overload limiter, under voltage monitoring with fast deceleration control shall be quoted separately. |
| g) Over travel limit for all the axes, parity check, spindle drive failure warning etc should be provided. |
| h) Automatic shut off of the machine in case of major spikes in the incoming supply which affects the control system and the machine functions. |
| i) The machine should work satisfactorily to the ambient conditions up to 45°C and 95 % humidity (maximum). |
| |
| 28. Installation & Commissioning. |
| i. Foundation kit like vibro mounts, bolts etc., required for the foundation should be supplied by the party. |
| ii. Layout drawing of the machine to be provided indicating: |
| a. Size and weight of the equipment. |
| b. Total area required for the equipment |
| c. Type of foundation required. |
| d. Detailed drawing of foundation indicating necessary details to be supplied |
| e. Requirements of water and compressed air lines to be specified. |
| iii. Special requirements like isolation, vibration criteria, Air conditioning, dust free atmosphere and flooring to be specified. |
| v. Party should co-ordinate for installing the equipment and commission the equipment within the stipulated time from the receipt of the machine at IIT TP site |
| vii. The machine shall be accepted after satisfactory commissioning, tests and prove out of NAS component as per international standard |
| |
| 29. Training |
| During commissioning visit, supplier's engineer should provide training in the following areas:- |
| a) Operation and Programming |

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| b) Mechanical Maintenance |
| c) Electrical and CNC maintenance |
| d) CNC Control system |
| |
| 30. Documentation |
| Three sets of the following documents in English (along with one set of soft copy) are required to be supplied: |
| i) Setting/Programming Instruction Manual |
| ii) Operators Instruction Manual |
| iii) Maintenance and spare parts manual for Mechanical, Electric servos and control system |
| iv) Electric & Electronic circuit drawings for control system, DC/AC drives and interface for component level trouble shooting |
| v) Foundation drawings and installation instructions |
| vi) Machine test charts |
| vii) Calibration certificate for all measurable items including gauges – with periodicity. |
| viii) Preventive maintenance check list, trouble shooting charts and guidelines. |

3. Wire-Cut EDM Machine

| Clause No. | Technical Specifications of CNC Wire-Cut EDM Machine | Specification Value / Remarks |
|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| A | Machine description and application: The CNC Wire-cut EDM machine is intended for complex profile cutting and thin wall cutting with high aspect ratio on aerospace materials like Titanium alloys, Aluminum alloys, super alloys, High Strength Steels Graphite, Carbides, CBN, PCD etc. This machine shall have 5 axes simultaneous control for X, Y, U & V Linear Axes and Horizontal rotary axis. The machine shall be equipped with state-of-the-art CNC control system, drives and generator. | Party shall comply |
| B | Technical features of the machine: | |
| | 1 Submerged wire cutting type | Essential feature |
| | 2 Polymer concrete machine body base | Essential feature |
| | 3 LM Guide ways for linear axes. | Essential feature |
| | 4 Linear motion with ball screw | Essential feature |
| | 5 Centralized automatic lubrication system | Essential feature |
| | 6 Direct feedback system with Heidenhain make linear glass scales with 0.1 Microns resolutions | Essential feature |
| | 7 Inbuilt safety feature (Mechanical anti-collision system) to avoid collision & damage. In the event of crash , there should be a mechanism to absorb the impact force and should not cause damage to machine or part. Operator must be able to clear the Alarm and restore to | Essential feature |

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| | | normal working condition with reset button. | |
| C | | Technical specifications: | |
| | | Axis travel (nominal) | |
| | | X-axis (mm) | 350 (Minimum) |
| | | Y-axis (mm) | 250 (Minimum) |
| | | Z-axis (mm) | 250 (Minimum) |
| | | U-axis (mm) | 90 (Minimum) |
| | | V-axis (mm) | 00 (Minimum) |
| | | Maximum taper angle | ± 25° (Minimum) for 80 mm part height. |
| | | Work Area: | |
| | | Nominal job envelop L x W x H (mm) | 800 x 650 x 250 |
| | | Maximum work piece weight without bath (Kg) | 400 or more |
| | | Maximum work piece weight with bath (Kg) | Party to specify |
| | | Standard (Round Diamond Guides) wire diameter kit | 0.1 mm to 0.3 mm |
| | | Automatic dielectric level control provision | Essential feature |
| | | Light for work area & Warning Light system | Essential feature |
| | | Accuracies (As per ISO 230 -2 (97) for full traverse: | |
| | | Positional Accuracy (A) for X,Y,U,V axis (mm) | 0.005 or better |
| | | Bi-Directional Positioning Repeatability (R) for X,Y,U,V axis (mm) | 0.005 or better |
| | | Reversal Value (B) | 0.003 or better |
| | | Feed & feedback system: | |
| | | Type of drive | AC digital servo drives |
| | | Drive element | Preloaded backlash free ball screws |
| | | Type of feedback | Closed loop |

| | | | |
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| | | Traverse feed rates: | |
| | | Rapid traverse of linear axes X,Y,U,V (m/min) | 3 m/min (Minimum) |
| | | Generator: | |
| | | The generator shall be of latest version having Preloaded features/technologies for cutting Titanium alloys, Aluminum alloys, Super alloys, High Strength Steels, Graphite, Carbides, CBN, PCD etc. | Essential feature |
| | | It shall be of digital generator | Essential feature |
| | | It shall have anti-electrolysis feature | Essential feature |
| | | It shall have tested/proven technologies for common user and aerospace material. | Essential feature |
| | | Machining current | 50 A (Minimum) |
| | | Maximum cutting speed with 0.3 mm diameter copper or brass wire and Steel workpiece (mm ² /min) | 300 (Minimum) |
| | | Surface roughness Ra (µm) on steel | 0.2 (or less) |
| | | Control feature to control influences of wire wear and flushing pressure | Essential feature |
| | | Dynamic path optimization and process adaptation in the radii | Essential feature |
| | | Real time detection and correction of the wire bending | Essential feature |
| | | Dynamic corner control | Essential feature |
| | | Automatic power optimization | Essential feature |
| | | Wire threading system: | |
| | | Automatic & Programmable wire threading system | Essential feature |
| | | Programmable wire tension (daN) | 0.3 to 3 |
| | | Wire tension meter | Essential feature |
| | | Wire alignment tool | Essential feature |
| | | Maximum weight of wire spool (kg) | 8 Kg (Minimum) |
| | | Wire disposal / cutting System | Chopper type |

| | | | |
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| | | Die-electric conditioning unit: | |
| | | Integrated dielectric conditioning unit | Essential feature |
| | | Dielectric capacity (liters) | 750 |
| | | Filter cartridges | Party to specify nos. of filters etc. |
| | | Filtrate quality | 5 μ m |
| | | Programmable flushing pressure Essential feature | Essential feature |
| | | Chiller unit for cooling dielectric | Essential feature |
| | | CNC system and programming: | |
| | | Remote control with all setup functions with LCD display | Essential feature |
| | | Operating system | Windows / Linux |
| | | Servo controlled axes X,Y,Z,U,V | Essential feature |
| | | Simultaneously controlled axes X,Y,U,V | Essential feature |
| | | Resolution (μ m) | 0.1 (or less) |
| | | Collision protection for all axes X,Y,U,V and Z axes | Essential feature |
| | | Automatic restart after power failure | Essential feature |
| | | Hard disk capacity | 40 GB (Minimum) |
| | | RAM capacity | 512 MB (Minimum) |
| | | Network connection; Ethernet port and USB | Essential feature |
| | | Network protocol | IP Based |
| | | CD/DVD ROM drive | Essential feature. |
| | | 2D/3D Machining simulation | Essential feature. Party shall provide details |
| | | Incremental or absolute programming | Essential feature |
| | | Wire radius compensation | Essential feature |

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| | | Canned cycle for wire alignment | Essential feature |
| | | ISO programming in metric & inch | Essential feature |
| | | Cartesian, polar programming | Essential feature |
| | | Parametric programming | Essential feature |
| | | Mathematical functions, logical operators | Essential feature |
| | | Coordinate transformation, linear transformation | Essential feature |
| | | Rotation in the machining plane | Essential feature |
| | | Mirror image | Essential feature |
| | | Scaling | Essential feature |
| | | Copy function | Essential feature |
| | | Automatic corner rounding | Essential feature |
| | | Sub programs | Essential feature |
| | | Background programming | Essential feature |
| | | Onboard documentation for error message list, maintenance book, consumable list & machining Recommendation | Essential feature |
| | | Human Machine Interface: | |
| | | Display with touch screen | 19" (Minimum) TFT |
| | | Key for start point return | Essential feature |
| | | Key for hold point return | Essential feature |
| | | Key for filling and draining the tank | Essential feature |
| | | Compensation: | |
| | | Pitch error compensation | Essential feature |
| | | Quadrant error compensation | Essential feature |
| | | Backlash compensation | Essential feature |

| | | | |
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| | | Machine Guarding: | |
| | | All moving parts/guide way/ball screws shall be protected against dust incursion by providing suitable cover/bellows | Essential feature |
| | | Machine shall be provided with adequate guarding & doors | Essential feature |
| | | Control system elements shall be enclosed in a dustproof cabin with air conditioning | Essential feature |
| | | Electrical specifications: | |
| | | Voltage (V) | 415±10% AC, 3 phase |
| | | Frequency (Hz) | 50 ± 1% |
| | | Maximum power consumption (15 kVA) | Party shall specify |
| | | ESSENTIAL SPARES: | |
| | | Mechanical, electrical & electronics spare parts & wear parts for two years operation of the machine | Essential & party shall offer with detailed list and cost breakup |
| | | ESSENTIAL CONSUMABLES | |
| | | Filter (3 to 5 Micron) Quantity: 48 Nos. | Party shall offer |
| | | Resins Quantity: | Party shall offer |
| | | Wire diameter 0.25 mm (100 Kg) | Party shall offer |
| | | OPTIONAL ACCESSARIES (with cost break-up) to suit the offered machine model: | Party shall offer with detailed list and cost break up |
| | | UPS system for CNC control unit to provide power back-up for safe shut-down of machine in the event of power failure. | Party shall offer |
| | | Technical Documentation (two sets each & one set in CD) | |
| | | Operator's manual | Party shall provide |
| | | Programming manual | Party shall provide |
| | | Programming manual | Party shall provide |
| | | Maintenance manual for mechanical, hydraulic, pneumatic and electronics | Party shall provide |
| | | Foundation drawings | Party shall provide |

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| | | Electrical wiring diagram | Party shall provide |
| | | Preventive maintenance checklist, troubleshooting charts & guidelines | Party shall provide |
| | | Machine test charts | Party shall provide |
| | | Inspection: | |
| | | The machine shall be inspected as per ISO 230 -2 (97) standard for positional and geometrical accuracies | Party shall comply |
| | | Installation & commissioning: | |
| | | The machine shall be installed and commissioned at end user site, India by a company specialist and suitable trials & demonstration shall be carried out | party shall comply |
| | | Delivery period: | |
| | | Ex Works ,Minimum 22 to 24 weeks from the date of Down payment and Clear LC | party shall comply |
| | | PRE-DISPATCH INSPECTION : | |
| | | Pre-delivery inspection (PDI) will be carried out at manufacturer's works in presence of buyer's Engineer(s) for geometrical accuracy of the machine positioning accuracy of the machine as per ISO 230 -2 (97) standards. Dispatch clearance will be provided by buyer representatives based on the satisfactory Pre-despatch inspection and testing at Manufacturer's works. | party shall comply |
| | | INSTALLATION & COMMISSIONING At Buyer | |
| | | Erection, installation and commissioning of the specified machine shall be carried out at Purchaser's site Buyer's site in India | party shall comply |
| | | Assembly / integration tools, instruments etc required for machine installation & commissioning of the machine at purchaser site is under party's scope. | party shall comply |
| | | MACHINE ACCEPTANCE: | |
| | | The final acceptance of the machine shall be only on satisfactory installation, commissioning & inspection of the machine as per manufacturer's test plan at purchaser's site. | party shall comply |
| | | TRAINING AT END USER SITE: | |
| | | One week training on operation and maintenance aspects of the machine shall be given to End user personnel at Buyer's, after commissioning and acceptance of the machine. | party shall comply |

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| | | Warranty | |
| | | Minimum one year from the date of commissioning. | party shall comply |
| | | Annual Maintenance Contract: | |
| | | Party shall undertake Non-Comprehensive Annual Maintenance Contract (AMC) for the offered machine for 3 years after completion of warranty period. AMC shall include two preventive maintenance visits in one year and unlimited number of breakdown calls during the contract period. Preventive maintenance shall be carried out by the Indian service provider of the original equipment manufacturer. The quote shall be in Indian Rupees and shall be valid till expiry of warranty The AMC contract shall be placed on the Indian service provider after expiry of warranty. For the breakdown maintenance the cost shall be offered on all-inclusive per man-day basis. This shall include the cost for boarding, lodging and internal travel, to and fro cost for air fare shall be paid at actuals on production of documentary proof as applicable | Essential |
| | | After sales service & spares support shall be provided by the party for a minimum period of 10 years from date of machine acceptance. | Party shall comply |
| | | Details of customers including contact details & email ids of similar manufacturing industries to which similar machines have been supplied in India (minimum 5 machines). | Party shall provide |
| | | Delivery terms: | |
| | | Packing of machine is under party's scope. | Party shall comply |
| | | All items ordered shall be supplied in ONE LOT without any party / short shipment, before the expiry of delivery period. | Party shall comply |
| | | All commercial terms like FOB, payment terms etc shall be clearly mentioned. | Party shall comply |
| | | In case of an order the party shall submit performance bank guarantee for 10% of purchase order value till the expiry of warranty period. | Party shall comply |
| | | Technical Documentation (to be submitted along with technical bid): | |
| | | Technical leaflet and write-up of the equipment must be furnished along with quotation | Party shall comply |
| | | Quotation shall be prepared and signed by the original machine manufacturer only | Party shall comply |
| | | The bidders should have manufactured and supplied similar machines during last 5 years to similar Industries | Party shall confirm |

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| | | Template of the quote should be provided without pricing in part I : Technical and commercial bid | Party shall provide |
| | | Please specify the requirement of Export License and provide format for the same, if any. | Party shall provide |
| | | Please attach positional & geometric accuracies test report with actual test value for same model of the offered machine | Party shall comply |
| | | Instructions for submitting the offers: | |
| | | The party shall submit their offers in two parts as under: Part-I: Technical and commercial bid Part-II : Price bid | Party shall comply |
| | | The price bid shall include the following: | Party shall comply |
| | | Basic price of full complement of the machine as per specification and scope of work of tender document | |
| | | Price of essential spares with list & cost breakup | |
| | | Price for installation & commissioning of the machine at purchasers site. | |
| | | Price for AMC for 3 years. | |
| | | Price for essential consumables & optional items with cost breakup. | |
| | | Compliance matrix showing each & every tender specification [Clause No. A to C (33.3)] with 'CONFORMS' & 'NON*-CONFORMS' shall be indicated by the party | Party shall comply |
| | | Basis for price comparison: | |
| | | The price comparison will be made for the cost of the basic machine as per specification, essential spares for two years operation, Annual maintenance contract for 3 years and scope of work as defined in the tender. | Party shall note & comply |

4. 3D Printer

1.0 Purpose and Application:

3D printer based on FDM Technology with temperature controlled enclosed chamber capable of producing Physical Models & assemblies to check fitment, form, ergonomics & visualization, jigs and fixtures in multiple engineering grade thermoplastics such as ABS-M30, ASA, PLA etc... Specific test certificate to be submitted for whichever material applicable along with the bid. Ability to use different Engineering grade thermoplastic materials for specific & multiple applications.

2.0 Scope of Supply:

- a) 3D Printer Machine
- b) Support Software
- c) Consumable materials to carryout printing works

3.0 Technical Specifications:

| S. No. | Item/Parameters | SPECIFICATION |
|---------------|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.1 | Technology | <ul style="list-style-type: none"> • Material Extrusion-based Additive Manufacturing technology for printing thermoplastic 3D parts in a Closed Chamber Temperature controlled environment. • Three-dimensional objects in a heated build chamber by dispensing modeling material from a dispensing head onto a base in a pattern determined by control signals from a controller. • Thermal isolation of the motion control components from the build chamber allows the chamber to be maintained at a high temperature. |
| 1.2 | Input file format | STL file format and all CAD native file from Solid 3D modeling software. |
| 2.1 | 3D printed parts to be used as | Prototypes. |
| 2.2 | | Functional prototypes. |
| 2.3 | | Honeycomb type lattice structure. |
| 2.4 | | Patterns for casting applications. |
| 3 | Machine Parameters | |
| 3.1 | Build Size in mm | X: 250 to 255. Y: 250 to 255, Z: 250 to 255 |
| 3.2 | Layer thickness (mm) | Range : 0.1 - 0.255mm |
| 3.3 | Printing Envelope | Closed Temperature Controlled Oven Chamber |
| 3.4 | Accuracy on printed part | Parts are produced with an accuracy of +/- .200 mm (.008 in), or +/- .002 mm/mm (.002 in/in), whichever is greater. |

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| 3.5 | Network connectivity | Machine should be available with both options: Wired: TCP/IP protocols at 100 Mbps minimum 100 base T, Ethernet protocol, RJ45 connector Wireless: IEEE 802.11n, g, or b; Authentication: WPA2-PSK, 802.1x EAP; Encryption: CCMP, TKIP; Direct USB option |
| 4 | Software | |
| 4.1 | Software Capability | Cloud-based platform software, access through web/desktop/mobile devices, advanced algorithms, efficient user interface, easily print, monitor and manage print jobs, imported directly from CAD. Built-in camera to monitor parts printing through GCP or own application |
| 4.2 | Software features | The necessary software required for running the printer should be supplied on CD/DVD media with perpetual licenses. |
| 4.3 | | Preprocessing software should be capable to take native files from CAD softwares. |
| 4.4 | | Automatic pre-processing including slicing |
| 4.5 | | Automatic Support generation |
| 4.6 | | Part packing and nesting |
| 4.7 | | Computing Part build time and material consumption details |
| 4.8 | | Option for automatic generation of honeycomb like lattice structure from a solid as input. |
| 4.9 | | OS Support - Microsoft Windows7 and higher |
| 5 | Materials that can be processed | |
| 5.1 | Build Material | The machine should have multiple thermoplastic material processing capability including ABS-M30, ASA, PLA. |
| 5.2 | UV-stable material | Printed parts should be resist fading during prolonged UV exposure. Properties should match to below figures. ELONGATION AT BREAK = 9%, TENSILE STRENGTH = 4,720 psi (33 MPa), UNNOTCHED IMPACT = 6 ft-lb/in (321 J/m), Z-STRENGTH RATIO = 91 %. It should also support soluble material. |
| 5.3 | | Provide the list of materials as mentioned in 5.1 & 5.2 along with data sheets. |
| 5.4 | | Test reports on Co-efficient of Thermal Expansion, out- gassing properties and strength from an accredited laboratory has to be submitted. |

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| 5.5 | Material Handling | Material handling system should be part of the printer with Automatic material loading, feeding and storage management system. |
| | | Material to be supplied in sealed contamination- free packing |
| | | E-Prom Enabled Cartridges to Read |
| | | a) Type of Material |
| | | b) Quantity of Material in Cu in3 |
| 5.6 | Operator Attendance | Limited attendance for job start and stop required. |
| 5.7 | Noise Specification | 46 dB maximum during build, 35 dB when idle |
| 6 | Power Supply | |
| 6.1 | Power Supply | Indian Standard - 100–132V/15A or 200–240V/7A. 50/60 Hz |
| 7 | Safety | |
| 7.1 | Machine Enclosure | Operations of machine should be in closed chamber with necessary safety measures like door interlocks and should have non-hazardous environment. |
| 7.2 | CE Certification | CE certification or equivalent is mandatory. |
| 7.3 | Regulatory Compliance | FCC, EAC, EMC (low-voltage directive), TUV, FCC, RC, RCM, RoHs, WEEE, Reach |
| 8 | Specify Following Parameters | |
| 8.0 | Machine Parameters | |
| 8.1 | Printer Make | Specify |
| 8.2 | Model Name | Specify |
| 8.5 | Electrical Power Rating | Specify |
| 9 | Support Material | |
| 9.1 | Support Material requirement if any and removal process | Specify |
| 10 | Safety | |
| 10.1 | Toxicity of Process | Specify |
| 10.2 | If Toxic, then any special arrangements or Precaution | Specify |

11.0 MATERIAL and APPLICATIONS REQUIREMENTS:

1. Materials should be strong and durable thermoplastics for fit form and functional testing.
2. Should be capable of producing complex assemblies.
3. Materials should come in multiple colour options.

4. Parts have to be capable of being used as patterns for vacuum, sand and investment casting patterns.
5. Durable materials which can withstand the wind tunnel testing for subsonic wind tunnel testing.
6. Regulatory Certified Materials which can be used for manufacturing and End use applications in automotive industry.
7. Materials capable of withstanding maximum temperatures of around 96 deg. C.
8. Materials to have a shelf life of at least 36 months from the date of supply.
9. Eprom enabled & Sealed material canisters.
10. Minimum One canister bays each for model and support material.
11. Support material should be soluble/breakaway.
12. Support and Model should be different material.

12.0 SOFTWARE and PROCESS:

1. Software should be capable of :
 - a. Automatic pre-processing with slicing
 - b. Support generation
 - c. Part packing and nesting
2. Machine and the process has to be clean and which can be installed in a design office setup.
3. The process has to be safe and should not emit harmful radiation, hazardous lasers or toxic fumes.
4. The model materials has to be eco-friendly and recyclable.
5. Operator intervention to be minimal and has to be unattended lights out operation.
6. Hands free Support material removal thru water soluble technology.

5. 3D SCANNER

| S. No. | Specification | Description | | | | | | |
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| 1 | Type of Instrument, Sensor Head | Optical Blue LED fringe projection measuring system with sensor head, mono camera system. Projector should use Digital Fringe Projection technology. The sensor head should consist of a high quality projector and single industrial grade high resolution camera. | | | | | | |
| 2 | Lenses / Measurement Volumes | System should be modular with possibilities of adding multiple measuring volumes in future, based on application. Should have options for 45 mm ³ to 500 mm ³ measuring volumes. No additional settings should be required while using alternate measuring volumes. <table border="1"> <thead> <tr> <th>FOV</th> <th>Measurement volume</th> <th>3D Point Distance</th> </tr> </thead> <tbody> <tr> <td>100 mm FOV</td> <td>118 x 98 x 60 mm³</td> <td>48 microns</td> </tr> </tbody> </table> | FOV | Measurement volume | 3D Point Distance | 100 mm FOV | 118 x 98 x 60 mm ³ | 48 microns |
| FOV | Measurement volume | 3D Point Distance | | | | | | |
| 100 mm FOV | 118 x 98 x 60 mm ³ | 48 microns | | | | | | |
| | a) Camera Resolution | 5 Mega Pixels or better 2448 X 2050 or better | | | | | | |
| | b) Volumetric Accuracy | 10 µm or better. | | | | | | |
| | c) Scanning Speed | 5 million points per measurement in less than 1 second. | | | | | | |
| | d) Standoff distance | Single setup and a fixed standoff distance for all measurement volumes. Should equip with laser guided pointers for visualizing the optimum measuring distance. | | | | | | |
| | e) Triangulation angle | Fixed triangulation angle of 20° to ensure efficient and accurate measurements. | | | | | | |
| | f) Setting of focus of lenses | No manual setting of focus either at projector or cameras. | | | | | | |
| | g) Scanner weight | Less than 6 Kg & Portable. | | | | | | |
| | h) Set Up | Easy and simple to setup with the ability to change only the measurement lenses for adapting for different sizes of parts (ex. Small dental implants to entire car) | | | | | | |
| | i) Life of light source | Minimum 25,000 hours | | | | | | |
| 3 | Power Supply | Power pack with wide operating voltage range : 90 to 240 V at 50 Hz. | | | | | | |
| 4 | Calibration | <ul style="list-style-type: none"> Completely automated calibration process. Artifacts required for calibration should be provided. Ability to calibrate for the entire measurement volume within 9 positions of artifact. The sensor head should be stable while calibrating, with the ability to just move or reposition only the calibration artifact only to ensure high accuracy and repeatability. Each calibration plate should be supplied with a calibration report which is as per VDI 2634 procedures for the scanning volume. System should not require calibration every time the machine is switched on. Procedure and details of calibration need to be submitted with scanner and demo should be covered in training. | | | | | | |
| | a) System Certification | System accuracy should be certified as per VDI 2634 Part 3. | | | | | | |

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| | b) Local Calibration and support | Supplier should be an OEM with capability to handle local calibration activities. |
| 5 | Completely Automated Rotary Table | Automated rotary table towards fully automated single directional measurement of parts, with weight capacity of up to 150 Kg. o Maximum load: 150 kg o Resolution: 0,05° o Rotation speed: max. 10°/sec |
| | a) Optional upgrade of automated rotary | An optional upgrade to dual axis or higher weight capacity automated rotary should be available. |
| 6 | Tripod | Professional, high quality and light weight tripod with wheels and the gear head which supports all positions of inclinations of the sensor. |
| 7 | Cables and data transfer | Ethernet data connection between sensor and computer via CAN bus and Gigabit for fast data transmission. Real-time sync mode capability for faster data acquisition. |
| | a) Sensor Cable length | Minimum 5 meters |
| 8 | Operating Temperature range | 10 ⁰ to 40 ⁰ C |
| 9 | Optional Targets or Markers | Should be capable of measuring without the need for external targets or markers. Scanning with rotary should be possible without any targets or markers. |
| 10 | Scanning Software | Single software for both scanning and inspections. |
| | a) Mesh Generation | <ul style="list-style-type: none"> • Mesh generation algorithm, triangles aligned along the curvature should be included in the software. • The software should be capable of generating application based STL viz Design, Reverse Engineering, Quality Control, Custom mode. |
| | b) Import formats | <ul style="list-style-type: none"> • Import of common CAD data formats: Catia V4 / V5, Pro/E, Unigraphics , SolidWorks, XT Parasolid, JtOpen • Import of pointclouds and polygons: OBC , ASC, PTS, TXT, STL, AC, PLY |
| | c) Export Formats | <ul style="list-style-type: none"> • Export of pointclouds and polygons: ACS, PTS, TXT, STL, SBT, SBP, AC, PLY • Data export to statistics programs: qs-STAT, CSV |
| 11 | Inspection software | Universal geometric measuring program for the following measuring functions <ul style="list-style-type: none"> • Geometric Elements • Form & Position Tolerance measurements • Measurement of conic sections • Alignment facility • Auto recognition of standard Geometrical elements. • Possibility to import CAD model for making off-line programming. • Auto decisions during Alignment and Geometry measurements through intelligent interface. • Complete graphics user interface. |

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| | | <ul style="list-style-type: none"> • Intermediate results shall be possible with graphical assistance in CAD window. • Simplified and optimized evaluation routines. • Digitizing of unknown 2D Curves & 3D Curves (Reverse Engineering). • Collection of point data by measurement from unknown curves. Output of the measured curve as surface data by compensating the probe diameter. • Measurement of 2D Curves & 3D Curves against nominal data: The nominal data of the curve can be input manually by keying in the data from the table given in the drawing or from the CAD files. Then the measurement is done against this data. • Software should have point cloud to CAD alignment option. • Standard CAD Interface software IGES and DXF should be provided • Programming capability for multipart inspections. • Deviation calculation from nominal & measured curves: The difference between the nominal and the measured data in the normal vector direction is calculated as deviation. • Interactive and auto editing of triangle meshes (hole filling, cutting, smoothing, decimating) • 3-2-1 alignment of coordinate system • Best fit alignment of measurement object to reference data (CAD) • Automatic post processing (conversion of point-clouds into triangle meshes, decimation and optimization in one automatic tolerance-based process) • Interactive and automatic calculation of cross sections • Graphical presentation of nominal curves , measured curves & deviations. • Automatic measurement of adapters • Calculation of the deviation for surface data, planar sections, borderlines, fold points • Display of deviation via freely scalable color display • Display of needle diagrams for comparison of border lines and intersections • Visualization of the results by freely definable flyers (GD&T information, object features, deviations and spatial position) • Software should have macro function for repetitive measurement tasks. • Should be PTB certified. • Should be able to create a measurement plan from Product and Manufacturing Information (PMI) automatically |
| 12 | Transport Case / PELI TM case | Compact, rugged carry case with rollers and form cut padding for easy transport to any location. |

6. Coordinate Measuring Machine

| S. No. | Technical Specifications |
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| 1 | <u>Scope of Supply</u> |
| | The specification should cover supply, erection and commissioning of a computer numerically controlled, 3D Coordinate Measuring Machine with Continuous Scanning feature, complete in all respects, ready for use. |
| 2 | Technical Data: |
| | <u>2.1 Measuring range :</u> X axis: 700 mm or more Y axis : 700 mm or more Z axis: 600 mm or more |
| | <u>2.2 Measuring uncertainty independent of the position of the Spindle :</u> |
| | As per ISO 10360-2 MPE_E = 2 + L/300 μm or Better MPE_P = 2 μm or Better |
| | <u>As per ISO 10360-4</u> MPE_THP = 3.S in 68 sec. or better MPE_RONt = 2 μm or better |
| | <u>2.3 Job Weight:</u> Maximum part weight carrying capacity should be 550 kg or more |
| | <u>2.4 Clamping area:</u> Granite surface plate with suitable size with threaded holes for clamping purpose |
| | 2.5 Scale Resolution for X, Y, Z axes : 0.2 μm or better |
| | a) Length of the probe used to measure the above measuring uncertainties to be specified. Also specify in detail how the accuracies will be checked. The gauges used for proving accuracy should be traceable to national/international standard. Linear, Volumetric Scanning accuracies to be proved with the same probe head. |
| | b) Scanning accuracy should be checked in XV ,XZ , YZ plane by scanning certified ring gauge of 50 mm. |
| | c) All the accuracies are to be provided with the same probe |
| | 2.6 Accuracy should be guaranteed in the following Operating temperature gradients |
| | a. Ambient temperature : 18 - 26 deg C. |
| | b. Variation per hour : 1.0 K |
| | c. Variation per day : 1.5 K |
| | d. Variation per meter : 1.0 K |
| | <u>2.7 Control:</u> |
| | a) Manual control with joystick operation |
| | b) Microprocessor based CNC control with vector control. |
| | c) Machine/system should be equipped with minimum 1 automatic electronics temperature sensors for acquiring temperature of workpiece integrated with the Controller for automatic temperature correction . |

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| | 2.8 Computer system/operating system: Windows -10 based software with Networking facility. |
| 3 | <p><u>Machine Capabilities:</u></p> <p>3.1 The machine should be capable of complete automatic inspection of precision components. It should be able to perform inspection of all parameters on five faces of a component from start to finish without the operators' intervention in between.</p> <p>3.2 It should be possible to carry out the inspection without physical alignment of the workpiece.</p> <p>3.3 The system should be capable of measurement in point to point as well as in continuous scanning mode.</p> <p>3.4 For each individual job the machine should produce a printout detailing all actual dimensions as inspected. Dimensions deviating from the laid out tolerances are to be indicated specifically, with the magnitude of deviations, including tolerance band utilization.</p> |
| 4 | <p><u>Main Features:</u></p> <p>4.1 The machine should have rigid traveling bridge, stationary table of type of construction with wrap around Y- guideway to provide high torsional rigidity during bridge movement</p> <p>4.2 Bridge & Z axis material should be ceramic for better stiffness</p> <p>4.3 Air bearings in all axes.</p> <p>4.4 Motorized movement in all axes by joystick and CNC programmed measuring traverse for automatic measurements.</p> <p>4.5 Drive system movements should be motorized, all moving parts should slide on wear-proof guide to achieve minimum stick-slip ratio and long life. It should be possible to vary the speed of movement of the axes from 0 to 70 mm per second in manual mode. CNC speed up to 250 mm/sec along each axis and 500 mm/sec in vectorial direction should be possible.</p> <p><u>4.6 Operating Panel:</u></p> <p>a) Portable operating panel with 3 independent joystick and function keys should be provided for motorized manual movement in all axes</p> <p>b) Should be possible to call all the important functions of the operating software from the panel.</p> <p><u>4.7 Measuring system :</u></p> <p>1) High Precision Glass ceramic scales of reflected light system with near Zero Temperature expansion coefficient</p> <p>2) The scale should not be directly fixed on the Guide</p> <p>All important items such as probe head I controller / air bearings / software etc should be supplied from the same manufacturer</p> |
| 5 | <p><u>Probe head : INDEXING MECHANISM WITH SACNNING SENSOR</u></p> <p>Sensors with Indexing Mechanism</p> <p>Indexing Mechanism :</p> |

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| | <p>The machine should also have facility to use INDEXING mechanism with a step of 2.50 and should be able to rotate +/- 180 degrees in A & B axes. Suitable catalogue should be attached for the same.</p> |
| | <p>Scanning Sensors:</p> |
| | <p>1. The sensor should be capable of single point measurement and Continuous Scanning.</p> |
| | <p>2. Should have minimum probe deflection range of + 1 mm.</p> |
| | <p>3. The said sensor should be able to carry Styli from up to 150 mm length and Minimum diameter of styli to be used should be 0.3 mm .</p> |
| | <p>4. Sensor should have manual magnetic probe changer, allowing operator to change the probe without calibration.</p> |
| | <p>5. Compatible probe kit to be offered. Please give details of the probe kit.</p> |
| | <p>6. (Optional) Probe head must have manual/automatic probe change facility enabling the operator to use different probe configurations without recalibration. Supplier to quote for the necessary accessories allowing user to use minimum 3 probe configuration in one CNC Run.</p> |
| | |
| 6 | <p><u>Application Softwares :</u></p> <p>8.1 Universal geometric measuring program for both manual and CNC operation, including component misalignment compensation in plane and space, form and position tolerance calculations, MMC provision, self teach capability, batch component position programming, probe tip calibration etc.</p> |
| | <p>Should be able to measure minimum following elements :</p> |
| | <ul style="list-style-type: none"> • All the standard Geometric Elements |
| | <ul style="list-style-type: none"> • Should recognize the standard elements automatically. |
| | <ul style="list-style-type: none"> • Different elements linking should be possible. |
| | <ul style="list-style-type: none"> • Form & Position Tolerance measurements according to DIN 7184/ISO R 1101 |
| | <ul style="list-style-type: none"> • Measurement of conic sections |
| | <ul style="list-style-type: none"> • Alignment facility |
| | <ul style="list-style-type: none"> • Self teaching facility CNC program preparation |
| | <ul style="list-style-type: none"> • Apart from standard reports it should be possible to give measured results in Excel & PDF format. |
| | <p>Following features should be included :</p> |
| | <ul style="list-style-type: none"> • Auto recognition of standard geometrical elements. |
| | <ul style="list-style-type: none"> • Possibility to import CAD model for making off-line programming |
| | <ul style="list-style-type: none"> • Automatic generation of probe path and measuring parameters for CNC program from the CAD model. SAT interface STD for import of the CAD models . |
| | <ul style="list-style-type: none"> • Auto decisions during Alignment and Geometry measurements through intelligent interface. |
| | <ul style="list-style-type: none"> • Complete graphics user interface. |
| | <ul style="list-style-type: none"> • CNC program and parameters for CNC runs shall be automatically generated during measurement. |
| | <ul style="list-style-type: none"> • Movement of the machine shall be possible in workpiece co-ordinate system . It will be very useful in case of inspection of inclined bores. |
| | <ul style="list-style-type: none"> • Intermediate results shall be possible with graphical assistance in CAD window. |
| | <ul style="list-style-type: none"> • Simplified and optimized evaluation routines, result calculation shall be faster |

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| | <ul style="list-style-type: none"> • Possibility to connect CMM computer to our existing Network through LAN. <p>It should have possibility to apply the temperature correction for the range of specified temperature and different materials .</p> |
| | |
| 7 | <p><u>Standard Accessories</u></p> <p>9.1 Calibration sphere should be provided for calibration of probe tips.</p> <p>9.2. Damping devices should be available to protect the machine from low frequency oscillations.</p> <p>9.3 In addition, any other item considered essential for smooth and interruption-free running of the machine should also be quoted separately.</p> |
| 8 | Power / Air Requirements : To be specified by the supplier. |
| 9 | Reference list of machines installed in India should be provided |
| 10 | Detailed compliance statement for all the technical points to be submitted along with the offer |
| 11 | <p>Details of local Aftersales service support in India should be provided covering the following points;</p> <p>a) Installation Experience.</p> <p>b) Application training.</p> <p>c) Part programming capabilities .</p> <p>d) After sales Maintenance .</p> |
| 12 | If installation and commissioning will not be done by the supplier, please indicate your authorized organization in India who will be responsible for installation, commissioning, application training and after sales service. They may submit the quotation for their charges in local currency. However, the manufacturer should take full responsibility of all the activities they will be carrying out. |
| 13 | If demanded the supplier should be in a position to organize a demo on same model in India. |
| 14 | Vendor to provide the complete technical details of the air quality requirement and also the complete technical details about the air compressor, filter, air dryer required for operating the CMM |
| 15 | Vendors to provide the complete technical details about the power requirement for the CMM and also the technical details of the UPS . |
| 16 | Vendors to provide the technical details of the complete CMM room requirement |
| 17 | Warranty shall be indicated along with calibration certificate for 1 year. |
| | |
| The following accessories shall be quoted separately | |
| | 1) CNC curve dongle base software with license |
| | 2) IGES IN/OUT Dongle base software with license |
| | 3) Multi sensor rack |
| | 4) Styles holder |
| | 5) Probe socket with 3-slots for probe holder |

7. Autocollimator

| | |
|--------------------------|------------------------------------------|
| Source | : 6V 2 Watts Lamp or better |
| Number of measuring axes | : 2-Axes |
| Measuring range | : ± 900 Sec in (X) and (Y) or better |
| Accuracy | : 1 Sec or Better |
| Accuracy over full range | : 1 Sec or better |
| Acquisition range, Sec | : Equal to the measuring range |
| Max. Working Distance | : 1 m or Better. |
| Range in eyepiece | : 2, 800 Sec |
| Direct reading to | : 0.5 Sec or better |
| Display | : Micrometer & reticule |
| Power supply | : 230 V, 50 Hz |
| Computer interface | : RS-232 / USB |

Software: Windows XP/7 based user-friendly, menu driven software with capabilities of:

- Single axis or simultaneous 2-axes measurement.
- Numerical & graphical display of measured data.
- Optional full screen camera window (for visual alignment).
- Comprehensive data reporting functions.
- ASCII Data export.

Built-in standard electro-optics applications package

8. PORTABLE SURFACE ROUGHNESS TESTER

| Item | Specification |
|---------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Gauge Range Minimum | 400 um |
| Resolution | 50 nm or better |
| Display Size Minimum | 100 mm X 50 mm |
| Noise floor (Ra) | 150 nm or Better |
| Repeatability (Ra) | 1 % of value + noise 0.5 % |
| Gauge force | 150 - 300 mg or less |
| Stylus tip radius | 5 µm or better |
| Stylus length Minimum | 60 mm |
| Measurement type | Skidded |
| Calibration Process | Automated software calibration routine |
| | Standards able to calibrate to ISO 4287 roughness standards |
| X axis range | 25 mm or above |
| Measuring speed | 1 mm / sec or better |
| Returning speed | 1.5 mm / sec or better |
| Pickup lift mechanism | Minimum 50 mm to adjust the pickup without any additional stand or better |
| Parameters Standards ISO 4287, ISO 13565-1, ISO 13565-2, ASME 46.1, JIS 0601, N31007 | |
| - ISO basic Ra, Rv, Rp, Rz, Rt, Rq, Rsk, Rmr, Rdq, Rpc, RSm, Rzlmax | |
| - ISO advanced Optional Rk, A1, A2, Mr1, Mr2, Rpk, Rvk | |
| - ASME Ra, Rv, Rp, Rz, Rt, Rq, Rsk, Rdq, RSm, Rpm, Rda | |
| - JIS Ra, Rv, Rp, Rz, Rt, Rq, Rsk, Rmr, Rdq, RSm, RzJIS, Rc, Rku, Rdc | |
| - Others R3z | |
| ISO Primary Pa, Pv, Pp, Pz, Pt, Pq, Psk, Pmr, Pdq, Ppc, PSm, Pzlmax | |
| | |

| |
|---------------------------------------------------------------------------------------------------------|
| Units: μm |
| PC Connection - Full data analysis with supported software |
| Data storage – Minimum Internal 100 measurement results |
| USB -(4 GB to be supplied) > 39,000 raw profiles, up to 100,000 results per batch (> 70 batches) |

Software capabilities:

| |
|--------------------------------|
| Multi-language support |
| EN, FR, DE, ES, IT, PL, CN, KR |
| Levelling |
| Symmetries |
| Zoom |
| ISO 4287 |
| Material Ratio Curve |
| Area of a hole / peak |
| Profile parameters & curves |
| Roughness & waviness curves |
| Distance measurement |
| Multiple file format reports |
| Report printing |
| Tolerance limits (pass/fail) |
| Data file explorer |
| ISO 13565 Automotive |
| Interactive MR curve |
| Step height measurement |
| Form removal |
| Filtering by FFT |
| Thresholding |

| |
|------------------------|
| Frequency spectrum |
| Power spectrum density |
| Retouch profile point |
| Rk parameters |
| Rk parameters curves |
| ISO 12085 R&W motifs |

Scope of Supply :

1. The Instrument with above specified specification
2. Ra Master with certificate
3. Software analysis as mentioned in the specification sheet
4. Data Acquisition System (Suitable for the instrument and software)
5. Installation and training – FOC

9. Metrology Kits

Training kit 1

Measurement exercises with steel ruler and vernier calliper gauge; ten stainless steel test pieces

Features

- tried and tested dimensional metrology exercises
- several test aids and 10 test pieces
- comprehensive and well-structured instructional material

Learning objectives/experiments

- familiarisation with steel ruler and vernier caliper gauge
- measurement of pre-determined lengths:
 - with the steel ruler and an auxiliary stop
 - with the vernier caliper gauge
- keeping a measurement log
- estimating measurement variations
- identifying typical errors

Specification

- [1] practice kit for dimensional metrology in the metalworking trades
- [2] measurement exercises on a stainless steel spacer plate
- [3] instructional kit complete with test pieces and measuring aids
- [4] 10 test pieces, each of different dimensions
- [5] plastic storage system to house all parts
- [6] detailed instructional material

Technical data

Test pieces: 13 lengths measurable

Vernier caliper gauge: 200mm

Steel ruler: 300mm

Set square: 90°, LxW: 100x70mm

LxWxH: 500x350x110mm (storage system)

Weight: approx. 5kg

Training kit 2

Measurement exercises on a bearing plate with vernier calliper gauge and external micrometer

Features

- tried and tested dimensional metrology exercises
- several test aids and 10 test pieces
- comprehensive and well-structured instructional material

Learning objectives/experiments

- familiarisation with vernier caliper gauge, depth caliper gauge, external micrometer and depth micrometer
- measurement of pre-determined lengths, depths and diameters
- keeping a measurement log
- estimating measurement variations
- identifying typical errors

Specification

- [1] training kit for dimensional metrology in the metalworking trades
- [2] measurement exercises on a stainless steel bearing plate
- [3] instructional kit complete with test pieces and measuring aids
- [4] 10 test pieces, each of different dimensions
- [5] plastic storage system to house all parts
- [6] detailed instructional material

Technical data

Test pieces: 9 lengths, 4 depths, 4 diameters measurable

Vernier caliper gauge: 0...200mm

Pocket caliper gauge: 0...150mm

Depth caliper gauge: 0...150mm

External micrometer: 0...25mm, resolution: 0,01mm

Depth micrometer: 0...25mm

LxWxH: 500x350x110mm (storage system)

Weight: approx. 7kg

Training kit 3

Measurement exercises on a bush with vernier calliper gauge, micrometer and calliper

Features

- tried and tested dimensional metrology exercises
- several test aids and 10 test pieces
- comprehensive and well structured instructional material

Learning objectives/experiments

- familiarisation with the various measuring devices
- measurement of pre-determined lengths and diameters
- using an inside spring caliper as gauge
- keeping a measurement log
- estimating measurement variations
- identifying typical errors

Specification

- [1] practice kit for dimensional metrology in the metalworking trades
- [2] measurement exercises on a stainless steel bush
- [3] instructional kit complete with test pieces and measuring aids
- [4] 10 test pieces, each of different dimensions
- [5] plastic storage system to house all parts
- [6] detailed instructional material

Technical data

Test pieces: 6 lengths, 9 diameters measurable

Vernier caliper gauge: 0...200mm

Pocket caliper gauge: 0...150mm

Depth caliper gauge: 0...150mm

Three-point internal micrometer: d12...d16mm

Internal micrometer: 25...50mm

Inside quick caliper: 10...30mm

Inside spring caliper: 125mm long

LxWxH: 500x350x110mm (storage system)

Weight: approx. 7kg

Training kit 4

Angle measurement exercises with universal goniometer; ten stainless steel test pieces

Features

- tried and tested dimensional metrology exercises
- several test aids and 10 test pieces
- comprehensive and well-structured instructional material

Learning objectives/experiments

- familiarisation with a universal goniometer and its function
- measurement of pre-determined angles
- calculation of angles
- keeping a measurement log
- estimating measurement variations
- identifying typical errors

Specification

- [1] practice kit for dimensional metrology in the metalworking trades
- [2] measurement exercises on a stainless steel angle piece
- [3] instructional kit complete with test pieces and measuring aids
- [4] 10 test pieces, each of different dimensions
- [5] plastic storage system to house all parts
- [6] detailed instructional material

Technical data

Test pieces: 6 angles measurable

Universal goniometer

- track length: 150mm

- adjustable to any angle

LxWxH: 500x350x110mm (storage system)

Weight: approx. 5kg

Training kit 5

Measurement exercises on a shaft: lengths and radii

Features

- tried and tested dimensional metrology exercises
- several test aids and 10 test pieces
- comprehensive and well-structured instructional material

Learning objectives/experiments

- familiarisation with the various measuring devices
- measurement of pre-determined lengths
- measurement of pre-determined diameters
- measurement of pre-determined radii
- dimensional checking with block gauges
- keeping a measurement log
- estimating measurement variations
- identifying typical errors

Specification

- [1] practice kit for dimensional metrology in the metalworking trades
- [2] measurement exercises on a stainless steel shaft
- [3] instructional kit complete with test pieces and measuring aids
- [4] 10 test pieces, each of different dimensions
- [5] plastic storage system to house all parts
- [6] detailed instructional material

Technical data

Test pieces

- 6 lengths
- 7 diameters and radii measurable

Vernier caliper gauge: 0...200mm

Depth caliper gauge: 0...150mm

External micrometer

- 0...25mm
- 25...50mm

Radius gauges: 1...7mm concave and convex

Block gauges

- 10mm
- 50mm
- 90mm
- accuracy to DIN 861/2

LxWxH: 500x350x110mm (storage system)

Weight: approx. 7kg

Training kit 6

Measurement exercises on a shaft: lengths, angles, radii; ten stainless steel test pieces

Features

- tried and tested dimensional metrology exercises
- several test aids and 10 test pieces
- comprehensive and well-structured instructional material

Learning objectives/experiments

- familiarisation with the various measuring and testing devices
- measurement of pre-determined dimensions
- keeping a measurement log
- estimating measurement variations
- identifying typical errors

Specification

- [1] practice kit for dimensional metrology in the metalworking trades
- [2] measurement exercises on a stainless steel shaft
- [3] instructional kit complete with test pieces and measuring aids
- [4] 10 test pieces, each of different dimensions
- [5] plastic storage system to house all parts
- [6] detailed instructional material

Technical data

Test pieces: 9 lengths and angles, 7 diameters and radii measurable

Vernier caliper gauge: 0...200mm

Depth caliper gauge: 0...150mm

Radius gauges: 1...7mm concave and convex

Universal goniometer

- track length: 150mm

- adjustable to any angle

LxWxH: 500x350x110mm (storage system)

Weight: approx. 6kg

Training kit 7

Measurement exercises on a shaft with groove: key-way vernier calliper, block gauges

Features

- tried and tested dimensional metrology exercises
- several test aids and six test pieces
- comprehensive and well-structured instructional material

Learning objectives/experiments

- checking shaft slots
- width and depth
- parallelism
- keeping a measurement log
- estimating measurement variations

Specification

- [1] practice kit for dimensional metrology in the metalworking trades
- [2] measurement exercises on a stainless steel shaft
- [3] instructional kit complete with test pieces and measuring aids
- [4] 6 test pieces, each of different dimensions
- [5] box of 32 block gauges, DIN EN ISO 3650
- [6] plastic storage system to house all parts
- [7] detailed instructional material

Technical data

Test pieces: 4 dimensions measurable

Pocket caliper gauge: 0...150mm

Depth micrometer: 0...75mm

Dial gauge

- 0...1mm, graduations: 0,001mm

Key-way vernier caliper: D=5...80mm

V-Block: indent 90°

LxWxH: 500x350x110mm (storage system)

Weight: approx. 12kg

Training kit 8

Testing external and inner tapers; eight stainless steel test pieces

Features

- tried and tested dimensional metrology exercises
- several test aids and eight test pieces
- comprehensive and well-structured instructional material

Learning objectives/experiments

- checking tapers:
 - checking an external taper with the taper ring gauge
 - checking an internal taper with the taper plug gauge
- keeping a measurement log
- estimating measurement variations

Specification

- [1] practice kit for dimensional metrology in the metalworking trades
- [2] measurement exercises on an external and internal taper
- [3] instructional kit complete with test pieces and measuring aids
- [4] 8 stainless steel test pieces, each of different dimensions
- [5] plastic storage system to house all parts
- [6] detailed instructional material

Technical data

Test pieces: 3 dimensions measurable

Taper ring gauge MK 3

Taper plug gauge MK 3

Depth caliper gauge: 0...150mm

LxWxH: 500x350x110mm (storage system)

Weight: approx. 4kg

10. Metrology Hand Tools

| S. No. | Item and Specifications |
|--------|--------------------------------------------------------------------|
| 10.1 | Height Measuring Instrument |
| | 2D operating & display unit with Calibration Certificate |
| | Spherical probe of ball dia. 6 mm & shaft length 24.2 mm |
| | Setting Block |
| | Carrier for probe |
| | Operating Manual, Adaptor 230 V |
| | Measuring Range: 600 mm |
| | Application Range: 770 mm |
| | Perpendicularity error: frontal $\leq 6 \mu\text{m}$ |
| | Resolution: 0.01 / 0.005 / 0.001 / 0.0005 / 0.0001 mm (Selectable) |
| | Measuring error (L in mm): $(1.8 + L/600) \mu\text{m}$ or better |
| | Measuring force: $1.0 \pm 0.2 \text{ N}$ |
| | |
| 10.2 | Gauge Block set (Steel) |
| | Size: 1.0005 to 100 mm |
| | Blocks per set 122 pcs |
| | Normal Size : 1.0005 , 1 nos |
| | Normal Size : 1.001-1.009 mm, 9 nos |
| | Normal Size : 1.01-1.49 mm, 49 nos |
| | Normal Size : 0.5-24.5 mm, 49 nos |
| | Normal Size : 25-100 mm, 4 nos |
| | |
| 10.3 | Granite Surface Plate Grade 0 |
| | Size: 400 x 400 |
| | Flatness error: ≤ 5 micron as per IS 7327-2003 |