Specifications for the Single Cylinder Research Engine

Interdisciplinary Centre for Energy Research, Indian Institute of Science, Bangalore 560012

As a part of NCCRD, the objective of the SCRE would be to perform intensive research in the area of engines using conventional and alternate fuels, major focus on in-cylinder diagnostics coupled with emission performance. The entire engines system shall be installed on a turnkey basis and include erection of a suitable facility for the system.

The venue for all the meeting will be

Conference room,
ICER, Indian Institute of Science, Bangalore 560 012, India

Important dates

Sl.No	Item	Date
1	Pre-Bid meeting	17 August 2016 1530 hrs
2	Final Specifications	29 August 2016
3	Two bid tenders last date The tenderer should submit Technical and Financial Bid separately in sealed envelope super scribing the envelope as 'Technical Bid' and 'Financial Bid'. Both these envelopes should again be put in a single envelope suprscribed '**TENDER FOR .....**" should reach to the **....., Dept of....., Indian Institute of Science, Bengaluru 560 012 on or before 12 September 2016 by 3.30 pm**	03 October 2016 1530 hrs at **NCCRD, ICER, Indian Institute of Science, Bangalore 560 012, India**
4	Technical Bid opening date **The Financial bids of the short listed agencies, qualifying in the technical scrutiny** of the Committee set up by the Institute**, will be opened at a later date and will be intimated to qualifying bidders to attend the price bid opening.**	05 October 2016 1600 hrs At the same venue
	Validity of the quote.	

Research on alternate fuels and DI diesel / gasoline engine to study fuel properties, impact of different engine components (ignition & injection system, piston geometry), combustion procedures (variable valve timing), control strategies (injector timing, injection pressure) and influence of counter measures for reduction of misfire, knock, pre-ignition, combustion noise, torsional vibration and thermal load on mechanical components

The Single Cylinder Research Engines system should consist of the following:-

1. Single Cylinder Research Engine Specifications

The scope of supply should include a single cylinder research engine with a modification kit to convert the diesel engine into a GDI / MPFI engine. This shall allow easy switch from diesel engine to gasoline engine testing and vice versa. Provision for gaseous fuel injection to be provided in addition to the conventional liquid injection.

Diesel Engine mode

- Displacement approximately0.500 liters.
- Max. speed 4000 rpm
- Approximate engine power rating to be mentioned. [XX kW].
- Max. firing pressure 180 bar
- Compression ratio 15-22 (adjustable)

The Sub components to include but not limited to

- CR Fuel Injector, solenoid magnetic type,max.1800 bar
- High Pressure Fuel Pump, integrated into timing belt drive
- Fuel Rail with Pressure Sensor and Pressure Control Valve
- Safety Over pressure Valve
- Wiring harness and Sensors.
- Fully open electronic fuel injection system.
- Provision for creation and modification of load/speed maps via ECU application system interface.
- Control of fuel injection, rail pressure, ignition and cam phases should be supported. At least, up to 4 injection events per cycle e.g. two pre-injections, one main-injection and one post injection shall be possible.

Single Cylinder SI Engine:

- Displacement Volume approximately 0.5 liters
- Max. speed 6000 rpm
- Rated power: approx. 20 kW (natural aspirated)
- Low rotation inertia (less 0.75 kgm^2)
- Combustion concept Homogeneous; Lambda 1
- Cylinder Pressure PFP 120 bar
- Compression ratio (CR): approx. 9 – 16 (adjustable)

The Sub components to include but not limited to

- High pressure injection pump
- Fuel Rail
- Gasoline Direct Injector (solenoid, multi-hole type)
- Injector Driver
- Rail Pressure Control Valve

- Wiring Loom
- All mounting / un-mounting tools

The module must have a rigid structure to test the engine at its limits. Must have easy access into the crankcase for easy assembly/disassembly of the connecting rod and provide access to mass balancer system and oil sump. Cylinder block shall allow the replacement of the cylinder liner. The basic layout must be for natural aspirated operation with possibility of extension for boosted operation. Must support high tumble combustion concept suitable for homogeneous (lambda 1) and supercharged operation.

2. Sub-systems

- Active dyno with precise speed and load control (dyno control system)
- Automation system including open ECU with the possibility to modify engine maps and control algorithm (rapid prototyping functionality)
- Fuel measurement system including fuel conditioning for multi-fuel operation (gasoline, diesel, ethanol, bio diesel)
- General data acquisition including sensors and signal conditioning for speed, torque, temperature, ambient air pressure, temperature and humidity
- Buffer vessel/tank for stabilization of exhaust gas pulsations including back pressure valve
- Blow-by measurement system
- Gas analyzer for CO, CO2, O2, NOX, HC and Lambda
- Combustion analysis system
- System for high speed photography

3. Interfaces required.

Device Interfaces

The test bed control system (automation software) shall function as a test bed integration platform and it has to control and coordinate all devices delivered for the test bed operation and measurement.

ASAM Standard Interfaces

- Support for state-of-the-art interfaces which comply with the ASAM standard.
- The ASAP3 interface to link an ECU application system (APS) with the test bed control system.
- Access to ASAM-ODS server for data storage and management.
- Additional tools to allow the quick and convenient administration of parameters and results.

Media Control

- Reproducible ambient conditions on the test bed (coolant, oil, intake air, air humidity, fuel) to reduce the measured result scatter and, therefore, allow the precise comparability of measurements using PID controllers
- Test bed control used for the startup, shutdown, and control and monitoring of peripheral test bed equipment.

Local Parameter & Result Administration

- A database management toolbox for the easy administration of parameters and result data in the local test bed database.

Control and Automation Functions

- The functions should allow the user to operate the automation system in manual and automatic mode.

Measurement Data Acquisition & Storage

All quantities acquired in measurement requests and the derived results to be stored permanently in a well-managed way.

Result Presentation

Local, automatic printouts of measured results and system messages to be supported.

Multi-Level Safety Monitoring

A tool for multi-level safety monitoring is required to ensure the optimal safety of operator, unit under test and test bed in all operating states.

Formula Calculation

Formula calculations to be performed cyclically or on demand.

Test bed and engine controller

Suitable hardware and software for the control, manual and automatic operation of the combustion engine and dynamometer is to be included.
The system has to use proven and at commissioning fully tested algorithms to control the dynamometer. Further, it has to ensure bump less change of control modes. The dynamometer conditions are to be monitored continuously by the software with definable responses. The system shall supports control functions, such as control of ignition, preheating, start and stop.

Dynamometer specification	Active, water cooled AC dyno with power regeneration; including inverter unit and control cabinet
Torque	Min. 150 Nm (0 to 3000 rpm)
Power	Min. 50 kW (3000 to 7500 rpm)
Max Speed	7500 rpm
Testing mode	Steady state testing
Floor load	Max. 800 kg/m²
Protection class	IP54
Water supply limits	120 l/min @ 30 °C
Oil conditioning	Temperature control via set values on the console
Water conditioning	Temperature control via set values
Exhaust gas steadying vessel	
Max. allowable exhaust back pressure	3.5 bar absolute
Opening overpressure valve	4.0 bar absolute
Min. exhaust gas temperature	600 °C

Volume	40 Liters

List of sensors for general DAQ as per the engine requirements

Measurement point list for temperature
Oil Sump Temperature
Engine Coolant Temperature
Intake Air Manifold Temperature
Fuel Line Temperature
PMeasurement point list for pressure measurement
Oil Pressure
Intake Air Manifold Pressure
Fuel Line Pressure
Exhaust Manifold Pressure
Barometric Pressure Transducer
Measurement range
Humidity and Temperature Measuring
Relative humidity (RH) measuring range
Temperature measuring range

The accuracy of all sensors shall meet the requirements of research engine operation. This is 0.1 °K for temperature, 1 mV for voltages and 0.5% FS for low pressure measurement. For RH or RH 3% is required and for ambient air temperature 0.2 deg C. The sensors must be able to withstand the media temperatures of up to 300 °C for exhaust gas and – 30 ±120 °C for oil and water.

4. Data Acquisition hardware

For collection of general test bed data (analog voltages, digital I/O, pressure, temperature, humidity) a modular data acquisition system including sensors for high-precision data measurement is required. Signal conditioning by software should allow predefined configuration of all measurement channels and adaption for all sensor types to be used.
Following minimum channels must be available:

- 32 Analog input
- 16 digital I/O
- 8 analog out.
- 4 Frequency / Encoder Input

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6. Combustion analysis system:

- High speed data acquisition (8 channels, min. 600 kHz data through put rate per channel, 16 bit resolution)
- Software for thermodynamic analysis, knock analysis, combustion noise analysis, torsional vibration system, data and result value display, compiler or other means for programming of formulae, functions and algorithm for data evaluation
- Sensors for combustion pressure, intake and rail pressure (1 piece each)
- Accessories for sensor mounting
- Provision for optional sensor in exhaust
- Precision angle encoder with up to 0.1 deg CA resolution

- Signal conditioning for all sensors

Additional information

- 8 analog input channels
- Micro Amplifier with 4 piezo channels, installed in the device
- Micro Amplifier with 2 piezo channels and 2 multipurpose channels
- PC connection patch cable approximately, 10 m length
- Power supply cable
- 1 Power supply (200-240 V)
- 1 Analogue-in adaptor cable sub-d to 8 BNC
- Complete user manuals, English

Encoder details

High-precision optical-electronic encoder for angle related indicating measurements and rotary oscillation analyses in internal combustion engines. Mounting to a free shaft end or a belt pulley (standard version).

The angle information to be transmitted by light pulses from an encoder through an optical cable, length 2 m, to an emitter-receiver-electronic. The pulse multiplier should remain permanently in the test cell.

- 1st output, TTL-signals
- Angle marks: For engine indicating 0.5 deg. c.a. resolution from the 720 life-marks on the disk, other resolutions between 0.1 deg. c.a. and 1 deg. c.a. selectable by means of the integrated pulse multiplier.
- Trigger for TDC-correlation:1 Low-pulse (falling edge) per revolution, synchronized with the falling edge of an angle mark
- 2nd output TTL-signals, RS442-signal and LVDS
- Trigger and selectable: 720, 360, 180, 90, 60 or 36 square wave pulses per rev., e.g. for test stand applications
- Precise measurement up to 20000 rpm, even in dynamic operation
- Low inertia and material like titanium shaft for high tensile strength

The software should have the capabilities to address

- Detailed analysis of the combustion process: burn rate, fast heat release, peak value and position, indicated mean effective pressure (total IMEP, high pressure portion, low pressure portion), PV diagram, etc.
- Timing and angle position measurement of signals, e.g. injection timing
- Thermodynamic results: polytrophic coefficients for compression and expansion phase, start of combustion, center of gravity of heat release, mass burned fraction points, etc.
- Arithmetic functions: mean and integral values, high pass and low pass filter, first and second derivation, etc.
- Classification / distribution of result values
- Curve averaging and envelope curve display
- Statistics: minimum, maximum, mean value, standard deviation, standardized min./max. and coefficient of variance
- Fast Fourier transformation for frequency and order analysis
- Digital filters
- Rotary analysis
- Combustion noise analysis (third octave and narrow band analysis)

The pressure transducer should have the following specifications

Measurement range	0 to 300 bar
Sensitivity	19pC/bar nominal
Linearity	≤ ± 0.3% FSO
Thermal sensitivity shift	≤ ± 2% 20... 400°C ≤ 0.5% 250 ±100°C
Cyclic temperature drift *	≤ ± 0.7 bar
Thermo-shock-error ** Δp Δpmi ; Δpmax	≤ ± 0.4 bar ≤ 2% ≤ 1.5%
Thread	M5x0.5 Front sealing front sealing

7. High-speed photography system:

The system shall allow to provide fully digitized trigger able pictures for combustion research and development. Further, the minimum specification of the camera required is 800 X 600 pixel; 11.7 / 21.6 fps (12 / 24 MHz) with the control of camera operation synchronized with crank angle and combustion cycle. The system components shall be based on latest technology available for camera and PC.

The high speed photography system shall visualize and record images of injection and combustion processes, in addition mechanical motion of components shall be investigated in both diesel and gasoline engines. Proven endoscope technology shall be used to provide a high degree of flexibility for adaptation and easy optical access to almost all parts of the engine, without affecting engine operation.

- High speed camera (colour), PC with digital image processing and software for camera control
- Cooled endoscope for flame photography
- Endoscope with illumination for spray photography
- Software for recording, animation and image processing
- Software for thermography
- Conditioning of compressed air to be used in the endoscopy cooling application.

12. Services to be supplied on various aspects related to the installation:

Electrical Engineering:

- Electrical integration of all test system components at IISc test cell environment.
- The electrical engineering has to be carried out according to EN-60204-1 – Safety of machinery
  Electrical Equipment of machines
- All documents listed are to be provided.

Mechanical Engineering:

Mechanical / physical integration of the test system components at IISc test cell environment comprising of the following but not limited to:

- Creation of a 3D layout of the test cell, the operator area and –if applicable – the technical area. Note: Drawings of the concerned part of the building will be provided in a suitable digital format by IISc.
- Detailed Engineering and specification of specific components and subsystems as specified in the technical specifications.
- Arrangement of the equipment / components / devices to be supplied and incorporation of them into the 2D-layout.
- Design drawings are to be delivered.
- Fuel storage guidelines must be clearly specified for a variety of liquid and gaseous fuels along with safety aspects.

Mechanical Installation and Commissioning:

Ensuring correct erection of the mechanical parts of the system (according to the scope of supply) and to guarantee compliance to installation specifications prior to test system commissioning and productive operation.

- Positioning and mounting of all equipment in cooperation (if necessary with local subcontractor)
- Removal of protection coatings and transport locking device(s)
- Alignment of equipment at designated location
- Commissioning of mechanical system elements

Commissioning:

Well trained, qualified and certified engineers shall perform all required steps to get the single equipment and complete test system ready for the acceptance test as defined in the particular agreement.
Following activities are to be included:

- Check of power & media supply, data, measurement and sampling connections.
- Installation, configuration and parameterization of all software.
- Allocation and verification of used I/O and measurement channels according to engineering.
- Interfacing of peripheral equipment based on scope of supply.
- Commissioning work is carried out with one fully functional single cylinder research engine.
- Controller set-up and basic tuning for the given UUT/Load System combination as a preparation for the Final Acceptance Test

13. Turnkey arrangement

- Base frame / Isolated engine mounting plate with damper elements
- Dyno with suitable dyno controller for passive / active operation
- Dyno cooling unit
- Power Inverter Module
- Interfaces to dyno controller / testbed control software
- Mains Filter for Power Module
- Throttle actuator (for gasoline engine)
- Switch Box incl. main power switch and emergency stop button
- Drive shaft between engine and dyno for both engines (diesel and gasoline)
- Safety cover for drive shaft
- Torque flange 0.5kNm
- Sensors and signal conditioning for media pressure and temperature
- Lambda measurement
- Set signal cables and electrical quick connectors, cable length 30 m
- Exhaust gas control: exhaust steady vessel and back pressure valve

- For easy maintenance quick connectors for all electrical and signal cables and cooling water as well
- Special tools (if required for maintenance)
- all cables to be supplied in sufficient length (at least 25 m)

14. Documentation:

Includes a compilation of following documents digital format: User Manuals include typically

- Operating manual
- Maintenance instructions and schedules
- Spare and wear parts lists as well as a list of consumables, safety instructions and a troubleshooting guide.
- Emergency measures according to the safety matrix.
- Documentation of third party products (language as available).
- System engineering drawings.
- Description of the test bed layout and functionality
- Trouble shooting and emergency measures

Apart from the above technical specifications the standard requirements will be

- Complete integration and testing of all components as a turnkey responsibility
- Training courses and expert support over 3 years at least for all applied technologies (SCRE operation, combustions measurement, optical spray and flame analysis including wall wetting, knock, flame propagation and flame temperature investigations).
- Proof of suitability of equipment for industrial research is required, e.g. references for all technologies at leading OEM's in international automotive industry shall be available. Reference lists in India and any relevant documents from the client is a must.
- Single software package containing all tools for synchronized data evaluation of general engine data, combustion data (cylinder pressure, ignition/injection data, high speed photography pictures and flame luminosity)

The documentation shall be provided in English language.

Optional

1. Air, water and other oil conditioning systems.
2. Any upgrades/additions to emission equipment to have sufficient resolution/capability to measure emissions at Euro 6 levels.
3. Additional components for modular replacement of main engine to a 150-cc MPFI gasoline engine with all the facilities for instrumentation and measurement scheme. The 150 cc engine and any related components will be supplied by IISc. The supplier will have to provide the mounting for the smaller engine on the test bed. The endoscopy and other instrumentation sought shall remain common for both the 500 and 150 cc engine.

14. OTHER ITEMS

- The cost of the SERC system and that of each accessory to be quoted separately.
- The vendor must submit a signed compliance document mentioning whether theirequipment meets each and every specification detailed above.
- The award of the tender will be decided by the institute as per price of the complete system. All insurance charges shall be borne by the vendor.
- Technical and financial bids should be submitted separately.

- All prices of the SERC system and accessories should be quoted in currency of respective country of origin of the equipment.
- The specifications mentioned shall be understood to be the minimum required. Additional technical and research features suitable to our requirements shall be given due reference.
- Vendors that submit qualifying technical and financial bids are required to sendcompetent representatives from the sales and technical divisions for further negotiations.

All the communication in this regard should be addressed to:

The Chairman
ICER,
Indian Institute of Science
Bangalore 560 012
India

With attention to Prof. S Dasappa.

The email communication should be
office@icer.iisc.ernet.in and kala@icer.iisc.ernet.in

With a copy to dasappa@cgpl.iisc.ernet.in.

SPECIFIC TERMS AND CONDITIONS

The following requirements should be specifically adhered to by the vendor, and express Indication should be given regarding adherence.

1. GUARANTEE PERIOD

- The equipment should be guaranteed for a period of 12 months from the date of handing over the fully functional unit to the Institute, against manufacturing defects of material and workmanship.
- Separate list of spares desirable for an R and D lab along with costs to be provided separately with individual costs.

2. POST GUARANTEE ANNUAL MAINTENANCE CONTRACT(AMC)

Annual maintenance contract (AMC) for the complete system will be start after expiry of the warranty period as per agreed terms and conditions. The contract will also include the recommissioning of the system for what so ever reasons.

- Costs for the post-guarantee 3 years of annual maintenance contract for the complete system which includes all the accessories supplied during the installation. One annual visit by relevant subject expert(s) must be scheduled during the period of AMC.
- The amount due every year on account of the AMC will be paid at the beginning of theyear to the vendor.

3. WARRANTY

- The complete system is to be under warranty period of 36 months including free supply of spare parts, and labour from the date of functional installation, commissioning and acceptance.

- During the period of warranty the supplier is required to take full responsibility to recommissionthe system in the event of failure whatsoever reasons.

4. REPLACEMENT OF DEFECTIVES

Items found not acceptable or missing by the committee should be replaced by the supplier free of cost including the forwarding and Insurance expenses. Replacement of parts that become defective during installation and warranty should be arranged free of cost through the Indian associate of the supplier including all incidental charges.

5. DOCUMENTATION

- Two sets of operational/service/application manuals are to be provided along with the Equipment in English.
- Detailed documentation on various sequences, application software and evaluation software etc. are to be provided and the same must be updated regularly for next 10 years as and when these are released.
- Supplier is required to ensure mailing of product/research newsletters released from their R&D sites to the our site on a regular basis. This is to keep this centre abreast of the latest developments taking place in system technology and research techniques.
- The vendor is to provide a tender compliance sheet by giving all the necessary specifications, which should be supported by printed documentation sheets and certification of each item. In the absence of such documentation, a letter from the principals of the company should be provided.

6. SOFTWARE UPGRADATION

Software upgrades for the core system and all related applications for next 10 years to be provided free by the firm as a matter of routine as and when these are released, inclusive of
minor hardware changes.

7. RESEARCH COOPERATION (Optional)

- The vendor is required to provide work in progress packages to us for research trial as for their
- other research sites. The firm should provide an exhaustive list of performance of various engines which will help the research and cooperation.
- The vendor shouldextend demonstrated cooperation regarding design and implementation of novel hardware andsoftware inputs as required by the user, such as newer analysis techniques, emissions standards, post-processing,, synthesis ofdata.
- Specific proposal regarding research collaboration will be submittedsubsequently for consent and counter signatures of the principals on the research proposal.

8. DELIVERY, INSTALLATION & COMMISSIONING OF THE SYSTEM

The facility should be built and the SCRE system should be delivered, installed and functionally commissioned within 6 months from the date of receipt of confirmed supply order. The supply of the items will be considered as effected only on satisfactory commissioning and inspection of the system by the institute. After successful installation and inspection NCCRD, the date of taking over of the entire complete running of the SCRE system by the institute shall be taken as the start of the warranty period.

10. CUSTOM CLEARANCE

The Institute will furnish the necessary papers for the import of items into India, necessary custom duty exemption certificate and other supporting documents to facilitate the import of the items.

Note: Institute has got into an agreement with M/S FEI Cargo for custom clearance of all imported equipments to the Institute.

11. TRAINING

The supplier, at their expense, will arrange for an application specialist, immediately after the installation and commissioning of SCRE system, to demonstrate the capabilities/features of the system and also to impart training to staff members NCCRD. The supplier, at their expense, shall provide initial specialized training at our site by a research scientist and a research engineer from the supplier's international R&D Centre or from an internationally renowned centre; the training shall cover the state of art research application, together with system operation and first line maintenance of the system, system and application software, along with developmental aspects for modifications and development of user defined sequences, for various application purposes, etc. The travel, boarding and lodging expenses of the above personnel, scientist and engineer shall be borne by the vendor and this training should be completed before handing over the SCRE system to us.

12. MODE OF SHIPMENT

The consignment must be air-lifted, insured and transported to the installation site by the supplier.

13. PAYMENT TERMS

A confirmed irrevocable and divisible letter of credit will be opened with the bank designated by the vendor with 80% of the total cost payable against confirmed proof of dispatch and the remaining 20% balance on successful installation against a bank guarantee of 10% of the total cost for the 3 years warranty period.