

TRANSIENT DYNAMOMETER FOR TESTING OF SI AND CI ENGINES FOR COMBUSTION AND EMISSION RESEARCH

IITM intends to set up a transient engine dynamometer test facility for conducting performance and emission studies on multi-cylinder automotive engines. The facility shall allow engines to be subjected to transient tests as per details given below and provide capability to measure in-cylinder combustion pressure and pollutant emissions.

Essential Details:

- The vendor must have supplied and commissioned at least 1 transient dynamometer system with in India and at least 10 transient dynamometer systems worldwide with **identical**
 - 1 Transient dynamometer controller
 - 2 Automation system
 - 3 Software for control (subject to upward change in version)
 - 4 Type of transient dynamometer wherein the only difference if any could be the maximum torque / power rating.

These supplies should have been in reputed research and development laboratories of government funded institutions or research and development divisions of leading automobile industries during the past 3 years. The vendor should provide the details of such organizations where such systems have been installed and are operating satisfactorily for at least 1 year. The details must include name and address of the organization along with the brief specifications of the supplied dynamometer.

- **The vendor should be the manufacturer of the transient dynamometer, automation system, software and the controller of the system that is to be supplied.** The vendor should have their Service Centre in India and trained personnel for after-sales service. Vendor has to submit the complete details of service set up.
- The two bid system is to be followed (technical bid and a commercial bid). The technical and commercial bids should be in separate sealed envelopes. **The commercial bid should also include the charges for comprehensive AMC for a period of 3 years after the warranty period.**
- Vendor should provide the list of utilities along with their capacity required to satisfactorily run the test facility along with the technical offer. The required civil work/ modifications will be carried out by IITM. Vendor should provide the drawings, data and manuals as per actual installation of the equipment within a month from the date of placement of the order.

Scope of Supply

The proposed facility shall consist of the following major equipment:

- a) Transient dynamometer capable of measuring a maximum power of about 200 kW but not lower and a nominal continuous braking torque greater than 450 Nm from 0 to 4000 rpm and capable of operating up to a maximum speed greater than or equal to 10,000 rpm. Along with the dynamometer a digital controller which can allow it to work in both loading and motoring modes as per transient test cycles is to be supplied.
- b) Test cell Automation system with all the required software and hardware modules which will allow the user to program and execute test cycles of any nature for testing diesel, gasoline and gas engines as per Euro IV, ETC, ELR, NEDC cycles and current Indian standards requiring transient tests for emission certification. The above system should have the required hardware

for simulating road load transient conditions in the test bed. It should be possible to add/upgrade the software without any additional hardware for performing the above mentioned road load simulation.

- c) The controller /automation system should have the capability to accept external analog inputs generated as a function of time in order to vary the torque, throttle position and speed as required.
- d) The sampling rate of the data acquisition system for control and automation should not be less than 1 kHz.
- e) Base plate, air cushion suspension, Engine support/mounting system, coupling shaft along with necessary couplings and shaft guard as per the specifications given.
- f) Torque measurement using a torque flange of high sensitivity along with the calibration check system.
- g) Encapsulated speed encoder should be a part of the supply.
- h) Throttle actuator
- i) Ambient Temperature, Pressure and Humidity measurement systems
- j) Engine temperature and Pressure measurement system.
- k) Design and details of necessary foundation for the Engine dynamometer installation to be given.
- l) The power supply system should be able to seamlessly and automatically connect with the power grid at IIT Madras during its generator/motor modes without any manual intervention of the user.
- m) Transducer box over the engine with boom.

Detailed Specifications

Specification	Requirement
Capacity of Engine Dynamometer	
Maximum Speed	Greater than or equal to 10000 rpm
Maximum rotor inertia	Less than 0.4 kgm ²
Nominal continuous power braking	Greater than 200 kW
Nominal continuous torque braking	Greater than 470 Nm from 0 to 4000 rpm
Power during motoring mode	10% lower than the generating mode
Torque during motoring mode	10% lower than the generating mode
Overload Capability	Greater than or equal to 20% of nominal values for at least 60s in every 10 minutes
Nominal vibration level of the system during uncoupled operation	<3.0 mm/s
Operating Condition	The system should work in the temperature range of +5°C to +40°C and at high Relative Humidity of 90-95%
AC Motor	
Motor type	Four quadrant operable asynchronous/synchronous motor with necessary IGBT bridges and integrated power modules for engine testing under steady state and transient conditions according to European/Indian test cycles
Power factor	0.98 0.85 or better with less than 3% harmonic

	distortion
Dynamic torque response	Less than 5.0 ms
Bearing lifetime	At least 20,000 hours when used in the allowed operating conditions.
Torque Measurement	
Torque measurement	Torque measurement shall be by means of a Torque flange. The torque flange shall be capable of meeting the dynamic responses of the dynamometer's AC motor and the demands of the specified test cycles.
Torque flange range	Up to 100 kW
Torque flange Nominal Torque	Capable of measuring torque in the range 0-500 Nm and also withstanding the torque spikes that will occur during transient testing of a 100 kW automotive diesel engine.
Class of accuracy	0.05
Temperature effect per 10K on output signals	≤ 0.05 %
Temperature effect per 10K on zero signals	≤ 0.05 %
Linearity deviation including hysteresis related to the nominal sensitivity	≤ 0.05 %
Relative standard deviation of reproducibility by reference to variation of the output signal (according to DIN 1319)	< +/- 0.03%
Speed Measurement	
Speed Encoder	Inbuilt / encapsulated encoder type with direction identification
Minimum resolution	1000 / 512 pulses/revolution
Dynamometer Controller	
Controller type	Digital
Dynamometer Control modes	Idle, Speed throttle position, Torque throttle position, speed torque, torque speed, user definable speed and torque modes shall be definable via software and via the operating panel
Torque control accuracy	0.4%
Speed control accuracy	+/- 1 RPM
Features	Controller should allow different steady/transient test cycles to be programmed by user and provide data output for demand and measured values. It should be possible to measure up to 16 digital inputs with definable delay time and response time
Safety	Safety against over speed, over torque, over current and over temperature.
PID Controller update rate	Greater than or equal to 500 Hz
Drive Shaft	
Quantity	One shaft for coupling with Mahindra mHawk120 automotive engine.
Shaft Guard	
Feature	Guard should have removable cover and quick

	release mechanical lock.
Safety	Safety contact switch has to be provided which prevents test run starting with open shaft guard.
Base Plate	
Type	Cast iron base plate with T-Slots and oil drain. The engine and dynamometer to be mounted on the same base plate
Isolation	Air dampers with automatic levelling and control unit
Natural frequency of system with engine running	Less than 3 Hz
Engine Mounting System	
Type	Engine mounting frame of welded steel structure/screw jacks
Degrees of Freedom	System should have flexibility in the X,Y and Z directions
Cable Boom	
Cable boom with swinging arm and transducer box	Yes
I/O modules	The unit should have an industry standard interface with 16 bit A/D converter built in. This bus shall enable the connection of one module to the other and also to the automation system. All necessary interfaces and cabling from the wall box to the control panel are to be provided.
Throttle Actuator	
Actuator Type	Linear Motion Type, suitable for transient application. In addition facility for analogue output representing throttle position which can be given to the ECU directly is to be provided. In such a case also the automation system should ensure that the necessary safety limits are not exceeded.
Control Features	Suitable digital controller capable of operating under transient European and Indian cycles.
Shifting travel	100 mm
Max. actuation force	100 N
Positioning accuracy	<0.4 mm
Test Cell Automation System	
Type	PC based and user configurable. Test cell Automation system should have all the required software and hardware modules which will allow the user to program and execute test cycles of any nature for testing diesel, gasoline and gas engines as per Euro IV, ETC, ELR, NEDC cycles and current Indian standards requiring transient tests for emission certification. Software libraries for running the above mentioned standard cycles should be available. The above system should have the required hardware for simulating road load transient conditions in the test bed. It should be possible to add/upgrade the software without any additional hardware for performing the above

	mentioned road load simulation
Safety	Different user levels with password protection
Software	<p>Software interface modules should be able to communicate with all supplied equipment. Standard Analog/Digital interfaces should be available to connect with other systems like air and fuel measurement systems (at least 16 analogue and 16 digital). It should be possible to start, set, shut down, control and monitor the following sub-systems.</p> <ul style="list-style-type: none"> • Dynamometer control system • Temperature and pressure measurement systems • Automation system should have interface to link with raw exhaust gas analysers. The emission test results should be displayed in different units like ppm, g/kW-hr, etc. <p>The software should be compatible with Microsoft Windows 7.</p>
Functionalities	User definable graphical user interface necessary to monitor and control the testing process.
Cabinet	
Type	19" rack
Safety	Necessary safety features complying to relevant standards to be provided
Pressure and Temperature Measurement System	
Universal Channels	At least 16 standard universal measurement channels for measurement of voltages, currents and resistances.
Thermocouple	At least 24 channels for measurement of thermocouples of type B, E, J, K, N,R, S and T.
Resistance Temperature Detectors	At least 8 channels
Pressure measurement	At least 8 channels for piezo resistive transducers
Digital I/O	At least 16 channels
Frequency Input	At least 2 channels
Analog Output	At least 4 channels
Sampling Rate and Resolution	At least 1000 Hz with minimum 16 bits resolution
Features	Analog input has to be at least 16 bit ADC.
Temperature Measurement	
Sensors	12 Nos. for temperature measurement (PT100) of 0-200 °C 6 no. for temperature measurement of 0-1000 °C
Pressure Measurement	
Sensors	2 sensors for pressure of -1 to 1.6 bar 2 sensors for pressure of 0 to 2 bar 2 sensors for pressure of 0 to 6 bar 2 sensors for pressure of max. 10 bar
Measurement of Test Cell Temperature, Pressure and Humidity	
Feature	A separate system indicating test cell ambient conditions such as Temperature, Pressure and

	relative humidity shall be offered which can be integrated with standard test cell automation system.
Ambient pressure measurement range with accuracy	Range 85 to 110 kPa, accuracy +/-0.1 kPa absolute
Relative humidity measurement range with accuracy	Range 10 to 90%, system accuracy +/-3% absolute
Temperature measurement range with accuracy	range 5 to 50 C, accuracy +/- 1 °C absolute

Outputs of transducers:

The outputs of all the amplifiers used for temperature, pressure and torque measurement should be available in a form that can be read by other standard data acquisition / readout systems preferably in the analog form.

Electrical Connections:

Standard electrical connections/connectors will be provided for the dynamometer and controller by IIT Madras. The vendor will be responsible for connections to the dynamometer from this standard electrical connector which will be at a maximum distance of 8 m.

Documentation:

Vendor should provide at least one CD of instruction manuals for operating and maintenance of the system in English language. All the documents/floppies/ CDs related to the system should be provided. This will include the descriptions and drawings required for operation and control of the equipment supplied.

Time Schedule:

The system should be supplied, installed and commissioned within 8 months after acceptance of Purchase Order.

Training:

IIT Madras may depute its two representatives for training on the transient test bed at a relevant location. Travel and stay will be taken care of by IIT Madras.

Warranty:

The vendor should provide a warranty for at least 12 months from the date of commissioning of the setup.

After Sales Support:

The vendor should have well trained engineers for after sales support in India to service the installation at IIT Madras.

Software upgrades inclusive of libraries relevant to the purchased hardware should provided as and when available free of cost.