



Packaged Engine Test Solutions



Packaged Engine Test Solutions

Sierra–CP has a comprehensive range of AC, Eddy Current and Hydraulic Dynamometers to meet the complete spectrum of test requirements for engine, transmission and powertrain applications including solutions specifically designed for E-Motor and Hybrid testing.

We designed and installed our first AC Dynamometer in the mid 90's and have subsequently installed systems throughout the world. Our solutions always incorporate the latest proven technologies for motor, inverter design and torque measurement, and are backed up by Global Customer Support.

Sierra-CP have designed a number of standard testing solutions, for educational or research and development applications to offer a complete packaged system at an affordable price. CP are able to supply these systems complete with single or multi-cylinder engines as required.

CP are able to offer upgrade services to existing test cell controllers, to implement CADET V14 control, automation and datalogging software on existing testing hardware. CP are able to replace inverter drives or dynamometers whilst maintaining existing functional test cell hardware.





CP Engineering





Transient Educational

Testbed

CP Engineering



Introduction

CP Engineering have designed and developed a complete transient test bed, with AC dynamometer, AC drive and engine all supplied as a single package.

CP Engineering's aim was to generate a design that would have all the functionality of a larger transient dynamometer system for users who do not need the specific power output of a larger system. This was achieved by selecting a small yet dynamic petrol engine, permitting a smaller AC Dynamometer and Drive solution.

By using a smaller engine, as a basis for the test bed, all associated services such as electrical, mechanical, thermal and acoustic requirements are also reduced both physically and financially.

The result is a fully integrated enginedynamometer package with control of ignition and injection parameters together with combustion pressure analysis.



The supplied components and systems selected for the test bed; provide a very flexible overall facility. Numerous and varied experiments can be written around the supplied equipment making it an ideal tool for engine mapping and optimisation or combustion analysis research. The system can be upgraded to include automated mapping using the CP ICAM software package either at time of order or as an option later. The CP engine test system is called CADET V14. This incorporates Direct Digital Control (DDC), to provide absolute real-time operation on a Windows XP platform, through a dedicated Input/ Output called CP128. CADET V14 will enable personnel to easily compile test programs, automatically protect the bed against out of limits operation, record data during the test and analyse the data during or at the completion of the test. CADET V14 hardware has been designed specifically for engine testing and structured to be located within a standard 19" modular format installed into a cabinet.

Benefits and Features

- Single Source Supply
- High Performance to Cost Ratio
- Research Project or Under Graduate Teaching



Applications

- Emissions Certification Work
- Transient Test Cycles
- Drive Cycles
- Vehicle Simulation Work
- Educational Demonstrations
- Engine Mapping

When operating with CP Engineering's CADET V14 test systems all machines are suitable to generate the dynamic test requirements for Federal and European emissions tests.

Customer Responsibilities

The customer should make available or prepare the following services:

- 3 and 1 Phase Power, with Regen' Capability on 3 Phase
 - Consider G59 regulations for electrical regeneration
- Cooling Water Supply for Cooling Systems
- Clean Compressed Air

These will be confirmed and discussed during the project phase.

Educational Rig – 3.2



General Description

AC Dynamometer and Drive

The AC Dynamometer has been built into a torque reacted swing frame design, this system uses a stock load cell for torque measurement. Should engine seizure or other incident occur, damage should be limited to the load cell which is cheaper to replace than an in-line torque-meter.

Dynamometer speed is measured with an optical encoder and also a multiple toothed wheel with inductive pickup. The toothed wheel is linked to the safety system and the encoder used for speed feed back to the Drive cabinet and Combustion Analysis System.



- 45kW Dynamometer
- Accessories included
 - Cal arm
 - Load cell, to reduce on-costs of possible Torque-meter damage
 - Swing-frame Design, helps demonstrate reaction forces of system
- Mounting system
- Encoder and Toothed wheel
- Shaft breakage detection

CP Engineering

Educational Rig – 3.2



Engine

The engine selected for use on the educational test bed is from a 'smart' car, this is a small water-cooled, petrol engine with fuel injection. There is also a turbo charger fitted to the engine, this can be run at various boost pressures

under the control of CADET V14. The engine operates with a twin spark ignition system, CP run this engine using just a single spark plug per cylinder, this makes it ideal for iCAS (CP's integrated Combustion Analysis System) by replacing the second set of plugs with either high speed pressure transducers, or blank plugs. Using the second set of spark plug tappings eliminates the need for machining the head of the engine in order to position the pressure transducer.



Specification

- 3 Cylinder 700cc 4 Stroke petrol engine
- Water cooled, petrol, fuel injection
- Turbo-charged, OHC, twin spark



Features

- Small capacity keeps power and torque figures low
- Custom throttle body
- Custom built air filter, allows connection to installation conditioned air supply and inlet temp measurement
- Custom intercooler
- AT12 throttle control
- PID control of Boost Pressure

Engine and Dynamometer Control and Datalogging System

The educational test bed is supplied with a full CADET V14 control and datalogging system. CADET V14 has been developed to create a single source integrated solution for engine testing research and evaluation. When used in conjunction with the various other products from the CP range, it provides an excellent basis for educational needs from basic mechanical or thermodynamic demonstrations through to innovative research projects. The system can also be expanded to include integration to emissions equipment or third party monitoring systems.

Further details about CADET V14 and its capabilities and features can be found in the relevant datasheet.

Sensors Pack (supplied fitted to the engine)

CP will supply the following sensors fitted to the engine and setup on the CADET V14 system for control and datalogging purposes.

Some of the sensors are for control whilst others could deal with potential experiments such as Air Fuel ratio variation.

- Water and Oil temperature
- Exhaust temperature post Turbo
- Air inlet temperature pre Turbo
- Water temperature pre and post Intercooler
- Water and Oil pressure
- Lambda Sensor
- Exhaust outlet and temp measurement
- Toothed wheel speed pickup for safety
- Encoder speed pickup for CAS system

Educational Rig – 3.2



Test Bed Features

The test bed is built upon a single frame, the frame is derived from a CP design used for mounting the engine on many of our existing test systems. For this application the frame has been used to mount both the dyno and the engine. The top rails of the frame are tee-slotted, this adds extra flexibility to the test bed, allowing the easy addition of ancillaries or other equipment.

- Dyno and Engine mounted on a single frame
 - Ease of shipment to site and installation on site
 - Dyno and Engine alignment simplified
 - Compact package to ship and manoeuvre
 - Bowman Heat exchanger linked into engine water circuit
- Teeslots, easy to mount equipment
- Feet of frame, allow various

Ancillary Equipment

- Transducer Box, sensor patch panel
- Engine Electrics Box, low voltage switching
- Fuel Filter and Pump box
- Flexible Element Drive Shaft
- Shaft Guard
- Drip Tray
- Engine loom terminal box

EMaCS Ignition and Injector Control

By installing EMaCS onto the engine and test bed, the user via CADET V14 can have full control of the Ignition and Injection systems. This allows engine maps to be modified manually, with ignition and injection set points being selected depending upon the state of various engine parameters. Using EMaCS also

eliminates the need for the manufacturers ECU to be used, this can introduce problems when the engine is not installed in the vehicle, because the ECU is checking for ABS or Anti-Theft hardware that is not present.

- Control of engine without an ECU
- Optimisation of settings/ maps
- Control of air/ fuel ratio, Lambda sensor
- Control of Ignition and Injection timing/ duration





CP Engineering





Transient Single Cylinder Test Cell Systems



Introduction

CP engineering have developed a complete range of test cell equipment specially tailored towards single cylinder engine research and development. CP offer a standard transient AC dynamometer with regenerative drive to allow both motoring and absorbing of a single cylinder engine. The engine and dynamometer mounted on a common test frame.

CP offer a range of complimentary sub systems to enhance the testing of single cylinder engines. CP can offer:

- Oil conditioning circuits
- Coolant conditioning circuits
- Boost simulation systems
- Exhaust Back Pressure Simulation
- Fuel measurement and conditioning circuits

CP are able to provide a boost rig which will allow simulation of turbo pressures of up to 5 bar with temperature conditioning. This allows research to be carried out into the effect of high boosting turbo and super chargers on engines. Exhaust back pressure simulation can also be offered with this to give complete control of the airflow through the engine.

All the systems are controlled by a single central CADET V14 control and datalogging system. This system is specially designed for engine and vehicle testing applications and as such has both software and software independent safety systems embedded. The CADET software and hardware offers control over dynamometer and throttle demand as well as all systems within the test cell. The CADET system offers true real time control and aligned data capture on up to 1000 physical channels.

As will all CP systems, the designs are flexible and CP is able to modify any of the systems mentioned to cater for a customer's specific testing requirements such as extended conditioning ranges, specific software modifications or specific datalogging requirements and channel counts.



Benefits and Features

- Flexible system design allows many test parameters to be changed and investigated
- Single source supply
- All major parameters can be altered individually

Applications

- Research and development
- Component testing
- Educational demonstrations
- Transient test cycles
- Emissions research
- Turbo charger research

When operating with CP Engineering's CADET V14 test systems all machines are suitable to generate the dynamic test requirements for Federal and European emissions tests. Additional analysers are required.

Customer Responsibilities

The Customer should make available or prepare the following services, depending

- 3 phase power with regenerative capability
 - Consider G59 regulations for electrical regeneration
- Single phase power
- High volume compressed air
- Oil free dry compressed air
- Bed water supply
- Chilled water supply 1°C supply
- Cable trays and trunking
- Civil work



AC Dynamometer and Drive

CP Engineering offer AC Dynamometers and a 4 quadrant regenerative Drives system suitable for Motoring and Absorption. When in Absorption mode the Drive cabinet will regenerate the electrical power back into the main electrical supply. This is deemed the 'cleanest non-heating' method of absorbing the energy from the engine.

The photo shows an AC dyno ready to be connected up to the test engine.

Systems include the following:

- o Swing Frame Air Cooled Electric Motor
- o Loadcell Torque measurement system
- o Speed Encoder
- o Calibration arms and weight pans (weights excluded)
- o Dynamometer and Engine mounting frame

Dynamometer Performance:

Standard 45kW, 60kW and 75kW dynamometer and drive specification which CP can offer is shown below. CP can offer custom dynamometer and Drive solutions to suit the specific engine test requirements such as increased power or speed requirements.

Dynamometer	45kW	60kW	75kW
Speed	0 / 3300 / 6000 rpm	0 / 3200 / 6000 rpm	0 / 3200 / 6000 rpm
Power	0 / 45 / 45 kW	0/60/60 kW	0 / 75 / 75 kW
Torque	140 / 140 / 83 Nm	180 / 180 / 95 Nm	220 / 220 / 120 Nm
Accuracy	Speed < ±1rpm, Torque < ±0.25% fsd		
Drive			
Power	45kW 4 Quadrant	60kW 4 Quadrant	75 kW 4 Quadrant
Capability	Drive	Drive	Drive
Overload	110% for 30 seconds in 5 minutes		
Сараршту			
Power	3ph, 120A 380-415V	3ph, 160A, 380-415V	3ph 200A, 380-415V
Requirement			
Size H x W x D	2130 x 430 x 646mm	2130 x 430 x 646mm	2130 x 630 x 646mm





Engine and AC Dynamometer Mounting System

CP recommends that the engine is mounted on the same frame as the dynamometer. This aids alignment and transportation issues. For single cylinder applications an isolating seismic mass can be positioned under the engine, on the test frame, as an option.

With a standard dynamometer and mounting frame CP will supply a dynamometer and engine mounting frame built to a required dimensions needed for the specific engines. Tee slotted rail mounts will be attached for mounting the dynamometer and engine/seismic mass (seismic mass usually excluded).

A split tube shaft guard will be provided with the dynamometer and frame setup which will either connect to the engine or to a manufactured bracket attached to the frame. CP can also provide a suitable drive shaft for the installation if required.



A common engine and dynamometer frame design has the following advantages:

- o The system can be tested at CP before shipment
- o Shipment can be of the assembled system
- o Installation is minimised
- o Future alignment issues are reduced



Control and Datalogging System

The single cylinder test bed is supplied with a full CADET V14 control and datalogging system. CADET V14 has been developed to create a single source integrated, flexible solution for engine test research and development. When used in conjunction with other products from the CP range it provides an excellent basis for the specific needs of single cylinder engine testing and research.

The system can also be expanded to include the integration of emissions equipment, emissions analysis software or third part monitoring systems. Additional control of CP equipment can also be added such as ventilation systems or fuel systems. The system can be expanded at any time to incorporate additional control and datalogging channels.

CP can offer the following control and datalogging expansions:

- Analogue inputs: 0-10V, 0-20mA, 4-20mA
- Analogue outputs: 0-10V, 0-20mA, 4-20mA
- Digital inputs
- Digital outputs
- Thermocouples
- PRTs
- PTX pressure transducers with excitation
- Frequency inputs
- Frequency outputs
- CAN interfaces
- OBD interfaces
- Ethernet interfaces
- Serial interfaces

CADET V14 Software

CADET V14 is specifically designed for engine test applications. The software is provided on a specially selected industrial, rack mountable system controller PC running Windows XP. The software offers the following features as standard for engine testing:

- Programming capability
- Bed protection using stage selectable high and low alarm and shutdown levels
- o Automatic and Manual Control modes
- o Data logging
- CP Trace V14, multiple y-axis, real-time display and analysis software
- o Bumpless transfer between Auto and Manual control
- Bumpless mode transfer
- Form based Calibration Mode
- Instrument Interfaces
- Speed, Torque and Direct/% control modes for Dyno and Throttle control



CADET Integrated Safety Features

CADET and CP128 hardware has been specifically designed for engine and vehicle testing purposes. As such it has many safety features built into the hardware and the software to protect the test bed, dynamometer and the engine under test. The system does not simply use a 3rd party datalogging system with computer monitored protection, CP offer dedicated protection for key channels and systems on the test bed.

Hardware Protection Card

This eight-channel computer independent shutdown system will be configured to critical channels. Including over speed, low engine oil pressure and high engine water temperature being driven from the CP128 Control and Monitoring System cards. Other channels usually include software failure, fire and cell services failure. The remaining channels are spare to be specified by the customer. The Hardware Protection Card operates independently of the PC, but with annunciation on the monitor.

Software Protection System

Each channel can be set with its own Low / High Alarm and Shutdown levels. These can either be default values or on a Stage by Stage basis. Typical safety channels include the following and others as required:

- o Overspeed, Engine and Dyno and Differential (to detect shaft break!)
- o Oil Pressure monitoring
- o Oil Temperature monitoring
- o Coolant Temperature monitoring
- o Dynamometer Supply Services, water or electrical
- o Dynamometer Status, temperature
- o Exhaust and Ventilation systems functioning
- o System Controller PC
- o Emergency Stop Button
- o Test Cell Door

Operator Interface

CADET V14 is designed for Automatic, unattended and manual operation. The following equipment is the only interface required between the test system and the operator.

CADET offers multi screen capability so additional monitors can be used with the system allowing additional channels and information to be viewed simultaneously.

- CP 'winged keyboard'. This is a pre-formed, alloy tray supporting
 - 102-Key English (UK) keyboard
 - Encoders for dynamometer and throttle manual control set-points
 - Engine/ test bed emergency-stop 'mushroom' type push-button
 - o Bed 'Alarm Accept', and 'Reset' push-buttons
- 2off 19" flat screen colour displays
- PS2 mouse

CP Engineering



AT12 Throttle Actuator

The AT12 is an enclosed DC motor driven Throttle Actuator that forms part of the CADET Dynamometer and Throttle control system.

- o Permanent Magnet DC Motor
- o Servo Potentiometer
- o 150 N Pull Capability
- o Response time for typical application 120 msec
- o 0-180 Deg in 250 milliseconds

An OM22 closed loop power module for the AT12 is mounted in the engine electrics box.

Alternatively CAN throttle or opposed voltage throttle control options are available.

Engine Electrics Box

This Engine Electrics Box provides a marshalling point for the in-cell low voltage electrical systems. There are four relay switched 12V/24V DC terminals, which switch from a common power source connection such as an in-cell power supply or Battery. These can be switched on or off with the associated Digital Output during tests. They are typically linked to ECU, Fuel, Glowplugs and Ignition.



Datalogging

As standard CADET provides datalogging channels for in cell safety equipment and all dynamometer control aspects. The CADET system will be provided with suitable channels for controlling all CP supplied equipment. For a standard single cylinder test system CP will provide the following datalogging channels available to the user:

- 7off K type thermocouple connections
- 2off PRT connections
- 10off analogue inputs channels
- 8off analogue output channels

Customer specific channel counts are available on request; please contact CP for further information.

Analogue input channels can also be used for 4-20mA pressure transducers.



Transducer Box

A Transducer box will be provided in cell, with suitable datalogging panels installed. Additional blank panels will be supplied to allow future expansion of the system. Panel sizes and looms are common across CADET systems allowing for panels to be swapped or upgraded with minimal effort.

Transducer panels supplied as standard:



Cabinet

The CADET cabinet for a standard single cylinder system is a 19" 16U cabinet built onto castors. The cabinet houses two CP i/o racks and also the rack mounted system controller PC.

The cabinet includes all the termination for the control, safety and data-logging sub-systems such as the Engine Protection Panel.

Any wiring associated with in-cell equipment is terminated into modules within the cabinet that provide a multi-way connection for onward connection using the supplied looms. The looms are soldered to multi-way connectors at each end, these are then connected to the corresponding connector in the cabinet and also the connector in the in-cell enclosures.





Oil and Coolant Conditioning System

Most single cylinder engines do not have oil or coolant conditioning and circulating abilities as standard, CP have developed an oil and coolant conditioning unit.

The cooling system allows the temperature of both coolant and oil to be conditioned to either heating or cooling the circulating fluids. Oil pressure control on the circuits supply lines can be included as an option. This is achieved by having a bleed valve installed in the supply pipework. These valves can either be manually settable or electropneumatically actuated to allow transient pressure variation.

Typically control temperatures of between 80°C and 100°C are possible, however as with all CP products, flexibility is inherent in the design to allow an amount of adaptation should requirements change. The temperature is controlled using PID channels provided in the CADET system. The temperature of the oil and water/glycol can be set constant, or varied during a test as necessary. The system can also be used for conditioning of the engine prior to testing. The 'EVENTS' feature in CADET can be set to optimise the warm up time for the engine.







Standard Supply, for the coolant conditioning unit

- o Heater for heating mode
- o Heat exchanger for cooling mode
- o Control box for CCU
- o Flexible hoses to connect to the engine and heat exchanger
- o Circulating pump for coolant circuit
- o Level and temperature and pressure monitoring
- o Sump, aeration tank
- o 3way control valve for cooling circuit

Standard Supply, for the oil conditioning unit

- o Oil Conditioner to produce conditioned loop
- o Heat exchanger for cooling mode
- o Control box for OCU
- o Flexible hoses to connect to the engine and heat exchanger
- o Circulating pump for oil circuit
- o Sump, aeration tank
- o Level and temperature monitoring
- o 3way control valve for cooling circuit

Cooling system specifications

Max Oil Flow Rate	5 l/min
Max Coolant Flow Rate	35 l/min
Typical Oil Supply Pressure	4 bar gauge
Typical Coolant Supply Pressure	1 bar gauge
Suggested Coolant Temperature Out	90°c
Coolant Temperature In	86 °c at rated power
Oil Inlet temperature	90 °c
Maximum Heat Rejection in Coolant	35kW
Maximum Heat rejection in Oil	5kW

In order to allow cooling of the oil and the coolant a customer supplied bed water circuit is required. This should consist of a feed and return line complete with the necessary pumps. The connections should be provided to a location discussed with CP during the project phase.

CP Engineering



High Pressure Boost Rig

CP are able to provide a boost rig that will allow dynamic control of pressure and steady state control of temperature of the engine supply air, to simulate turbo charger conditions. High pressure air is supplied by a compressor unit (not included), the boost rig conditions the temperature of this air, either heating or cooling as required. The pressure of the air is then reduced to the desired level, using a fast acting dump valve.

All of the air for the system is temperature conditioned, the air not used by the engine is dumped, fast acting valves on the dump line and on the supply line allow transient pressure regulation.

The TOTAL intake flow rate is measured on the rig intake using a venturi style flow meter – this Total flow meter IS included. Engine Flow consumption can be achieved by putting an additional flow meter on the dump line (located at atmospheric pressure) and using a totalising calculation within the CADET system. This dump line meter is NOT included as standard. A cooling heat exchanger can also be installed in the dump line to provide a stable temperature for the dump line air mass meter. This cooling heat exchanger is NOT included as standard.



An additional rack with the required input and output cards will be provided with the CADET control and automation system. A dedicated tab in the operating system will be added that will allow control of the entire boost rig. This additional rack may cause the height of the CADET cabinet to increase.



Delivery Conditions

Delivery Pressure	1.2 – 5 bar Absolute* ±0.5%
Maximum Flow Rate	700 kg/hr*
Temperature Range	6°C - 60°C ±1°C

* Compressor supply dependant

Customer responsibilities

The customer should provide the following in cell services required for the operation of the boost rig:

- High volume, compressed air supply
 - Oil Free air
 - At least 800kg/hr continuous air flow
 - 5.5+ bar absolute supply pressure
- Instrumentation oil free, dry air compressed air supply for valve actuation
- 12kW chilled supply with a 1°C supply temperature
- Dump line air meter
- Suitable flexible ductwork to the engine



Exhaust Back Pressure Simulation

The 50mm Exhaust Back Pressure Valve is a fast acting ALL Stainless Steel Butterfly Valve, controlled by a cable driven electronic actuator. It is used for adjusting and simulating the effective back pressure of the test bed exhaust system. The monitoring signal for the control loop is provided by a pressure transducer (not supplied). This pressure signal is read by one of CADET V14's fast analogue channels and then the valve position is adjusted using PID control within CADET. A high pressure insert for precision control at lower airflow volumes is available on request.



Additional Test Cell Services

CP can provide additional test cell equipment which will complement the single cylinder test equipment. Further information and the relevant datasheets are available on request.

Ventilation Systems

CP can supply bespoke ventilation systems for existing and new test cells. Ventilation systems can include heating and cooling coils, for test cell conditioning as well as test cell pressure regulation by using inverter driven fans. A recirculation system can also be installed.

Fuel Conditioning Units

CP have a number of systems to condition the temperature and/or pressure of an engine fuel supply. All parts are stainless steel so any fuels can be used.

Fuel Measurement Systems

CP offer a range of fuel measurement units which use either gravimetric or transient fuel measurement techniques. All systems deliver fuel at ambient pressure and have capabilities for engine spillback.

Emissions Analysis Equipment

CP can provide emissions analysis equipment which interfaces with CADET V14. CP can offer TLS software which allows emissions regulatoray test cycles to be run and analysed.

Turnkey Solutions

CP specialise in bespoke and turnkey test cell installation if required.

Chiller Units and Blast Coolers

CP are able to supply a variety of chiller units and blast coolers to provide chilled water and bed water loops required for various equipment.

CP Engineering





Versatile Test Bed

VTB