



TECHNOLOGY FOCUS

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Bimonthly S&T Magazine of DRDO

Vol. 25, No. 6, November-December 2017



TEST FACILITIES FOR ARMoured FIGHTING VEHICLES





From the Desk of Guest Editor

Dear Readers,

It is my honour and privilege to get back to this edition of Technology Focus since April 2014, an apt medium to ensure better connectivity and sharing of knowledge between DRDO labs all over India in the process of nation building. The above cited issue highlighted various Armoured Fighting Vehicles (AFVs), related technologies, sub-systems and their indigenous development. Nevertheless, testing, evaluation and proving of such indigenous developments are inevitable in this technology era and it is indeed a challenging task in the case of combat engineering and technologies. The current issue will focus on the state-of-the-art test facilities augmented at Combat Vehicles Research and Development Establishment (CVRDE), Chennai for major sub-systems of combat vehicles and aircrafts.

The legacy of CVRDE dates back to 1929 as a Central Inspectorate of Mechanical Transport Establishment at Chaklala (presently in Pakistan). After independence, a detachment of VRDE, Ahmednagar was set up at Avadi and became an independent R&D establishment, viz., CVRDE in the year 1975. Today, it has been transformed in to a full fledged premier establishment in the design and development of combat vehicles. To its credit, CVRDE has several success stories and many of the products worth of more than ₹ 100 billions developed, have already been inducted into the Services, and few of them are: Armoured Patrol Car, Armoured Recovery Vehicle, 130 mm SP Gun-catapult on Vijayanta, Carrier Mortar Tracked Vehicle and Carrier Command Post Tracked on BMP-II, Bridge Layer Tank (BLT-72), Combat

Improved Ajeya, Armoured Ambulance and Arjun MBT Mk-I. CVRDE has also developed unmanned ground vehicle based on BMP-II, Arjun MBT Mk-II, Arjun Catapult and Arjun ARRV, etc. Further, it is also engaged in design and development of Line Replacement Units (LRU) for LCA-Tejas and Rustom-II Unmanned Aerial Vehicle (UAV).

It is a pride for CVRDE that the development of above major combat systems and technologies have ensured the augmentation of various state-of-the-art test facilities for Engine and Transmission Sub-systems, Running Gear Systems of AFVs, EMI/EMC test facility, Environmental Test Facility, Training Simulators for Arjun MBT Drivers and Gunners, Testing and Evaluation of Mechanical Sub-systems, Evaluation of LRUs for LCA-Tejas and Rustom-II UAVs. CVRDE is also equipped with sophisticated instrumentation and data acquisition system that provides online monitoring-cum-recording of test data and post test analysis.

I believe that, this issue, providing an overview of CVRDE test facilities, will foster better collaborations in empowering the nation further.

Jai Hind !!

**Dr P. Sivakumar, FNAE
Distinguished Scientist & Director, CVRDE**

Test Facilities for Armoured Fighting Vehicles

Combat Vehicles Research and Development Establishment (CVRDE), is one of the premier establishment under Defence Research & Development Organisation (DRDO). It has its origin as Chief Inspectorate of Mechanical Transport Establishment (MTE), which was established in Chaklala (now in Pakistan) during World War II in 1929. After Independence of India, this establishment was moved to Ahmednagar to form Technical Development Establishment (TDE - Vehicles). It was later transformed into Vehicle Research & Development Establishment (VRDE), Ahmednagar. In 1965, when a decision was taken to manufacture Vijayanta tank in the country, the Heavy Vehicles Factory (HVF) was set up at Avadi.

To render R&D support to HVF, a detachment of VRDE was established as a nucleus at Avadi on 1st August 1965 and later it was made as an independent DRDO laboratory on 27 January 1969 with the name of 'VRDE, Avadi.' Subsequently it was re-designated as CVRDE on 26th March 1975. It is working with a mission, 'design, develop and lead to production of tracked armoured vehicles and specialist vehicles to meet the needs of the Services and to build technological capabilities in critical areas including test and evaluation of combat systems'. This issue of *Technology Focus* gives an overview of the test facilities available at CVRDE for Armoured Fighting Vehicles (AFVs) and also for aircraft projects.

Mechanical Systems Test Facilities

CVRDE is responsible for performance evaluation of automotive systems developed for AFVs. Various test facilities created in CVRDE helped in design verification of automotive systems in simulated field conditions. The performance of the mechanical systems is thoroughly validated by selective performance, endurance and acceptance tests before integration in AFVs for the field trials. CVRDE strives to complete the product development cycle of AFVs by achieving excellence in performance evaluation.

Facilities for performance evaluation of engine, transmission, bogie wheel, air cleaner, suspension and other hydraulic components were established during 1974 to 1983. Uprated Leyland L-60 engine, Grossol Hyperbar engine, Kirloskar Cummins KTA-1150 engine and Rolls Royce 750 TCA engine were tested in these facilities.

Subsequently, number of test facilities such as engine fan test rig, 300 hp variable speed drive test facility, 150 hp variable speed drive test facility were installed. Suspension test facility has provided performance evaluation service for more than 2500 hydrogas suspension units since its installation in 1983 and has enabled the indigenisation of high pressure piston seals of Hydrogas Suspension Unit (HSU) of Arjun MBT. Since 1984, testing of T-72 uprated engine, Arjun power pack, air cleaner, road wheels, top rollers, 150 hp automatic bus transmission, engine cooling fan, windmill generator was carried out. Also sub-assemblies such as hydraulic damper of HSU, fuel injection pump, retarder, engine lubrication oil pump, nozzle assembly, solenoid aggregate of automatic transmission and hydraulic steering unit were tested in CVRDE.

Since 2005, CVRDE is committed to creation of state-of-the-art AFV test facilities to meet future requirement. The new Engine Test House comprises of twin engine test cells; 1500 kW engine test facility equipped with hydraulic dynamometer and controller, and 870 kW engine test facility equipped with eddy current dynamometer. Regular running in and endurance tests

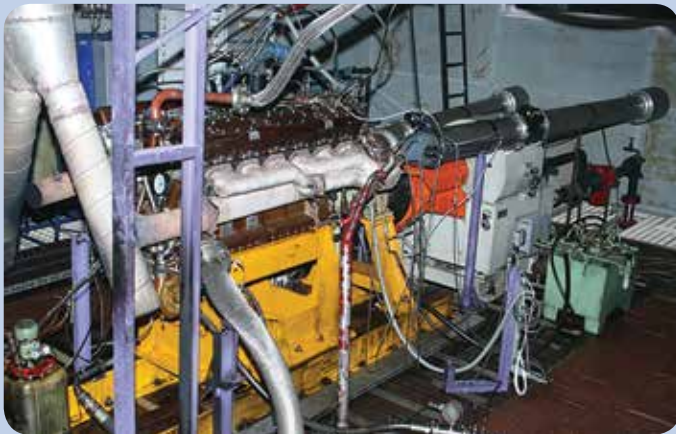
for various capacity engines can be performed. These facilities are equipped with latest test bed instrumentation of high accuracy. Wide range of engine performance parameters namely specific fuel consumption, exhaust smoke parameters, blow by estimation and combustion process data can be acquired. As a part of automation, data acquisition, monitoring and presentation are executed by an integrated software system.

The new facility also has test equipment HA 4500 installed to evaluate the performance of fuel injection pump for AFV engines. The high torque and high speed test facility has integral closed loop speed control system, digital display of rack measurement and delivery quantity of fuel. A new suspension test facility is also created to test HSU. This houses both single-axis and two-axes test rigs.

The sprung mass test rig is installed to enable testing of frequency response characteristics of AFV suspensions. The two-axes test rig is incorporated to simulate both terrain disturbances and steering load. Creation of a new 1500 kW transmission test facility in a new building is on the anvil.

870 kW Engine Test Facility

The engine test facility is extensively used for performance evaluation of engines up to 870 kW capacity. The facility consists of test equipment comprising eddy current dynamometer (Dyno), throttle actuator and dyno controller and the measuring equipment such as load and speed measurement system, fuel consumption meter, blow by meter, smoke meter, air mass flow meter and host of sensors for temperature, pressure and flow. The facility has been extensively used for validating the improvements carried out on the base engine V 46.6 of T-72 vehicle for power enhancement from 780 hp to 1000 hp. Also high coolant and lubricant temperature simulation testing is enabled through installation of three way control valves which contributed greatly in high temperature endurance test.



Engine test facility-870 kW



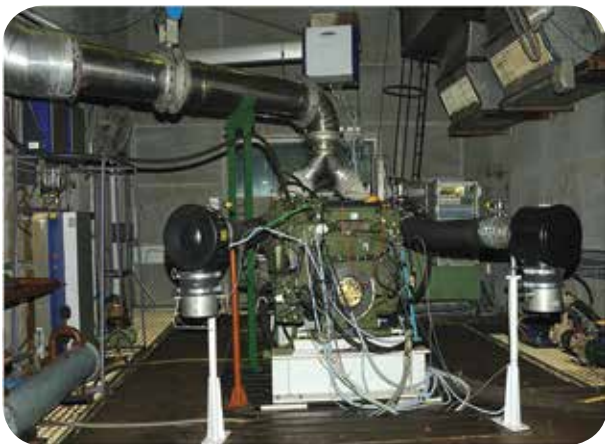
T-72 Engine uprated by CVRDE

SPECIFICATIONS	
Dynamometer	Eddy Current
Power	870 kW
Speed	6500 rpm
Torque	6000 Nm

1500 kW Engine Test Facility

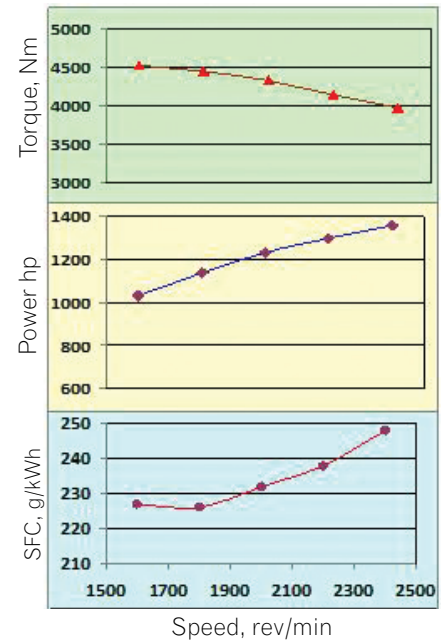
The 1500 kW engine test facility can be used for performance evaluation of engines of AFV. The facility consists of test equipment comprising hydraulic dynamometer, throttle actuator and dyno controller and measuring equipment such as load-cum-speed measurement system, fuel consumption meter, blow by meter, smoke meter, air mass flow meter and host of sensors for temperature, pressure and flow. Combustion phenomenon is studied by utilising high speed 16 channel indicating system

for crank angle and time-based measurements of combustion pressure, low pressure phenomenon at intake and exhaust manifolds. Injector needle lift sensor is also provided to correlate the combustion curve with injection timing and further performance analysis. The facility has been integrated with interfaces to carry out running-in and performance test of Arjun MBT, MB838, 1030 kW engine after overhaul for the first time in India.



1500 kW Engine test facility

SPECIFICATIONS	
Dynamometer	Hydraulic
Power	1500 kW
Speed	4800 rpm
Torque	9500 Nm



1400 hp Arjun MBT engine and its performance characteristics

Fuel Injection Pump Test Facility

The Fuel Injection Pump (FIP) test facility consists of dynamic measurement and analysis equipment, enabling performance testing and optimisation of fuel injection pumps. The 35 kW thyristor controlled drive powers the test pumps from 30 rpm to 3000 rpm speed.

Salient Features

- Pump with deliveries up to 650 mm³ per stroke can be tested
- Pump with twelve (12) injectors (max)
- Built-in video metering system
- Dynamic phasing
- Temperature controller
- High transient pressure measurement with reference to cam angle
- LVDT mounted injector assembly for measuring needle lift
- Software capability for acquisition-cum-post analysis of transient parameters



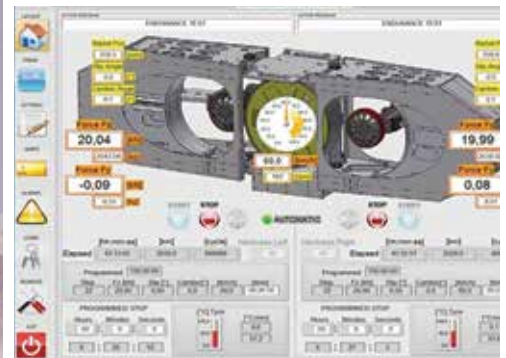
FIP of V46-6 engine (T-72 Tank), UTD 20 engine (BMP-II) and MB838 engine (Arjun) are tested in this facility. Injector testing and injection pressure setting of FIP for the uprated V46-6 engine are also carried out. The test facility is being equipped to evaluate common rail direct injection FIPs of future AFV engines.

Wheel Test Facility

This facility is used to evaluate rubberised wheels and top roller assemblies of AFVs for performance test and endurance test-96 hours (continuous) under simulated speed and load

condition with automated test cycle. Data logging facility is available to continuously measure and monitor load, temperature and speed during testing in both the wheel testing stations.

SPECIFICATIONS			
Central drum speed	100 kmph	Camber angle	$\pm 25^\circ$
Radial load	50 kN	Diameter of specimen	150 mm (min)-1000 mm (max)
Slip angle	$\pm 15^\circ$	Central drum diameter and width	1720 mm and 520 mm
		Data logging	measure and monitor load, temperature and speed



Components Tested in Wheel Test Facility



Arjun MBT Top roller



Arjun MBT road wheels



T-72 Road wheel

Variable Speed Drive Test Facility-220 kW

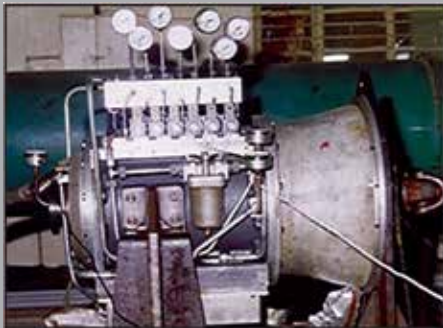
The 220 kW variable speed drive test facility is used to test rotating components of AFVs and commercial vehicles which can transmit power up to 220 kW. DC motor of capacity 220 kW (max speed 3000 rpm) is used as a prime mover with thyristor controller. Hydraulic dynamometer of loading capacity 1000 Nm

is used as a loading device. Instrumentation facility is available to monitor pressure, temperature, torque and speed during testing. This test facility can be used to test gear boxes, automatic transmissions, fluid couplings, final drive units and retarders.



SPECIFICATIONS	
Motor speed	3000 rpm (max)
Torque	2000 Nm (max)
Power	220 kW (max)
Dynamometer torque	1000 Nm (max)
Step up gear box	1:4 ratio
Instrumentation	Pressure, temperature, torque and speed

Components Tested in Variable Speed Drive Test Facility-220 kW



150 hp Automatic transmission unit



Arjun MBT final drive unit



T-72 Engine cooling fan



150 hp Torque converter



TVS Electromagnetic retarder

Components tested in variable speed drive test facility-220 kW

Variable Speed Drive Test Facility-110 kW

This test facility is extensively used for testing of engine cooling fans for AFVs in accordance with BS 848 test standard. DC motor of capacity 110 kW (max speed 6000 rpm with step-up gear box) is used as prime mover. The test facility is utilised to evaluate the performance of engine cooling fans of Arjun MBT, T-series tanks and indigenous fans along with the radiator assembly. Instrumentation facility is available to measure pressure, temperature, torque and speed during testing.



SPECIFICATIONS

Motor speed	1500 rpm
Torque transducer	500 Nm
Motor power	110 kW
Step up gear box	1:4 ratio
Instrumentation	Pressure, temperature, torque and speed

Components Tested in Variable Speed Drive Test Facility-110kW



Arjun MBT fan-MTU



Cast fan BLT T-72



LPDC Fan BLT T-72



Ring rolled fan BLT T-72



Riveted fan T-72



Imported cast fan-1000 hp

Air Cleaner Test Facility-37 kW



SPECIFICATIONS	
Speed	2800 rpm
Power	37 kW
Volume flow	1.56 m ³ /sec (3300 cfm)
Dust feed system	10 gm/min to 200 gm/min
Pressure	1000 mm of H ₂ O (max)
Instrumentation	Speed, temperature, pressure and air flow rate

The air cleaner test facility is extensively used for testing of air cleaners of both wet and dry types in accordance with BS 1701. Flow restriction characteristics (pressure drop test), air cleaner efficiency and dust retaining capacity can be measured. In this, 37 kW variable speed drive motor along with the blower is used as a prime mover. The facility has air compressor, dust feed assembly

to feed dust from 10 gm/min to 200 gm/min and a sensitive balance to weigh air cleaners up to 100 kg. The test facility can also be used to evaluate the pressure drop characteristics of radiator, oil cooler and louvres of AFVs. Instrumentation facility is available to measure the speed, temperature, pressure and air flow rate.

Components Tested in Air Cleaner Test Facility-37 kW



Air cleaner-Arjun MBT



Air cleaner- T-72



Air cleaner T-90



Dust Extraction Motor



Air cleaner 1000 hp



Armourec Louvre-MS



Side Radiator-Arjun MBT



Armoured louvre (Composite)

Pump Test Facility-11 kW

The pump test facility is extensively used for evaluation of engine coolant pumps with high temperature coolant (max 100 °C). This facility has the capability to evaluate the flow and pressure characteristics at variable speed mode and constant speed mode with simulated temperature condition. 11 kW

variable speed drive motor is used as a prime mover. The facility has flow meter to measure flow up to 1000 lpm. Instrumentation facility is available to measure the speed, torque, temperature, pressure and flow rate of the test specimen.



SPECIFICATIONS	
Prime mover	11 kW motor
Speed	3000 rpm
Flow rate	1000 lpm
Head	3 bar
Main tank	1000 l
Heater	18 kW
Instrumentation	Speed, torque, temperature, pressure and air flow rate

Components Tested in Pump Test Facility



T-72 Pump



BLT T-72 Pump (ind)





Imported pump 1000 hp



Engine cylinder block T-72

Two-axis Suspension Test Rig

This test facility is used to simulate road undulations with specific amplitudes and frequency. The frequencies and amplitudes are determined by speed of the vehicle and the track length in contact with successive peaks of test track. This test rig has both horizontal and vertical actuator systems that can individually and simultaneously simulate both road undulations and steering effects. This facility can be used for testing and evaluation of suspensions of armoured fighting vehicles, aircraft landing gear, bus strut, etc.

Salient Features

- Computer controlled test facility with 2500 Hz data acquisition rate
- Load reaction of test unit through load cell in both the axes
- System is controlled by digital controller with programmable input and 3-stage servo valve system and hydraulic control systems
- Simulation of terrain displacements as cyclic reciprocating

motions at different frequencies with the help of hydraulic actuator

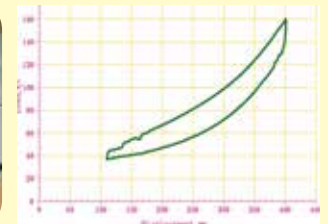
- Hydraulic power pack with 280 bar pressure and 1000 lpm flow rate
- Frequency : 0-5 Hz
- Vertical load (vertical axis) : 250 kN
- Side load (horizontal axis) : 100 kN
- Vertical displacement : 600 mm
- Horizontal displacement : 100 mm

Testing of Hydrogas Suspension Unit Hysteresis loop

The suspension test rig was modified to suit the landing gear adaptation. The limited qualification test and acceptance testing of main and nose landing gears of UAV were done at this test rig. The rig is capable of exerting necessary impact loads experienced during landing.



Testing of hydrogas suspension unit



Hysteresis loop

Sprung Mass Suspension Test Rig

In this test rig, simulation of the dynamic loads of sprung mass (e.g., turret and hull loads on the suspension system of AFV) aids to fine tune the damper systems for high frequency modes up to 15 Hz. This facility is used for testing and evaluation for damper tuning of suspensions of AFVs.

Salient Features

- Frequency : 0 - 15 Hz
- Vertical load (vertical axis) : 250 kN
- Vertical displacement : 600 mm
- Sprung mass : 20 kN to 50 kN with 5 kN increments
- Computer controlled test facility with 2500 Hz data acquisition rate
- Load reaction of test unit through load cell and measuring vibration using accelerometers
- System is digitally controlled with programmable input and 3-stage servo valve system and hydraulic control systems

- Simulation of terrain displacements as cyclic reciprocating motions at different frequencies with the help of hydraulic actuator
- Hydraulic power pack with 280 bar pressure and 1000 lpm



Environmental Test Centre

CVRDE has created an Environmental Test Centre (ETC) for AFVs with a mission to simulate adverse environmental conditions and to test AFVs as an integrated platform. The aim is to simulate the actual situation which will be prevailing in a battlefield scenario and the following tests can be carried out:

- High Temperature
- Low Temperature
- Humidity
- Solar Radiations and the specifications are as follows

Specifications

- Volume : 1890 m³ (18 m x 14 m x 7.5 m)
- Temperature range : - 40 °C to + 90 °C
- Humidity range : 20 % RH to 95 % RH
- Solar radiation : 600 to 1200 W/m²

The climatic walk-in-chamber will enable entry and positioning of AFVs, like Arjun MBT Mk-I, Mk-II, ARRV, Arjun Catapult, Armoured ambulance, BMP variants, etc.

AFVs can be tested with Engine ON static conditions. The entire operations can be programmed and automated using Programmable Logic Controller.



View of solar lamps and heat exchanger



Arjun MBT under solar radiation test

Climatic Walk-in-chamber

A special foundation is built to withstand the load up to 70 tons. The foundation has many special layers and the top layer consists of anti-skid stainless steel checker plate.

A solar radiation panel with 32 metal halide lamps are fitted on top of the chamber and it can be switched ON in such a way that a light intensity of 600 to 1200 w/m² can be focused on an area of 10 m x 4 m.

The walls of the chamber are made up of stainless steel sandwiched with 165 mm thick High Density Poly Urethane (HDPU) foam as thermal insulation to prevent heat transfer. Similarly under the flooring, pipes are routed to circulate warm water to avoid ice formation beneath the floor during low temperature testing.

Chamber is having heat exchanger integrated with 45 heating coils of 4 kW each which will produce total heat of 180 kW to simulate high temperature conditions.

Similarly low temperature is achieved by refrigeration system using eco-friendly R 404A refrigerant. Three numbers of screw compressors each capacity of 130 kW are used in refrigeration system.

There are five circulation fans with a capacity of each 20,000 m³ per hour to aid the heat exchange process. With this the uniformity of the chamber temperature can be maintained with a tolerance of ±1 °C. Relative Humidity can be achieved by means of de-humidifier and humidifier.



Heat exchanger



Compressors and PLC



Cooling tower/system



De-humidifier



Humidifier

Electro-dynamic Vibration System – 3000 kgf

All electrical and electronic sub-systems of AFV are subjected to vibration testing to ensure the ruggedness of the units to sustain vibration in battlefield and transportation. This facility is catered for vibration testing as per the standards, like, JSS 55555, MIL-STD and other industrial standards.

Principle of Operation of Shaker

Shaker is essentially an electro-dynamic assembly comprising a single/double fold electromagnetic circuit consisting of a stationary (field coil) and a moving coil (drive/armature), which is a part of Head that moves or vibrates.

Constant magnetic field/flux is generated by feeding DC power to the field coil from amplifier rack console. When power is fed to the Drive coil, the Head or in other way, moving platform vibrates exactly as per the nature power being fed to it, delivering force which follows the right hand rule.

The moving platform transfer the same vibration to the test specimen/object mounted on it. The drive coil suspension system utilises flexures design, which offers high lateral stiffness for heavier load and ensures low transverse motion.

SPECIFICATIONS(Model : DEV-3000 Force)	
Sine	3000 kgf (Peak)
Random	3000 kgf (rms)
Shock	6000 kgf (Peak)
Armature diameter	360 mm
Mass of armature	30 kg
Max. displacement	51 mm (p-p)
Max. velocity	1.6 m/s
Max. acceleration	100 g
Frequency range	5Hz to 2000 Hz



Electro-dynamic vibration system-3000 kgf

EMI/EMC Test Facility

EMI/EMC test facility has been established to enable compliance testing of electronic and electrical sub-systems of AFVs as per MIL STD 461 requirements. The facility includes a Semi-anechoic Chamber (SAC), a Sub-system Testing Anechoic Chamber (STAC) and common control rooms. Some of the salient features of the facility are:

- Completely self-supported and modular chambers
 - Support for testing platforms up to 70 tons
 - Vehicle smoke extraction system enabling continuous testing of platforms powered by engine generator
 - Turn table capable of withstanding 1.5 ton/m² distributed load for evaluating sub-systems
 - Simultaneous sub-system and platform level evaluation using common control rooms
 - Hybrid absorbers capable of withstanding 200 V/m fully lined on all the sides and ceiling
 - Movable floor absorbers to meet full anechoic chamber requirements
 - RF shielded sliding doors (SAC - 5 m x 6 m , STAC - 2.1 m x 1.8 m) with auto ramp for platform/ sub-system entry
 - Fully air-conditioned facility with humidity control to suit absorbers/ equipment needs
 - Waveguide vents and special interfaces to air-conditioning system
 - Lights with electrical lowering/ lifting system
 - Instant fire detection system
 - Safety interlocks to avoid exposure of high field to personnel
 - Remote audio/ video monitoring of chambers/ EUT
 - Ducts for concealed RF and power cable routing
- High performance from 10 kHz to 40 GHz with conformance to IEEE 299 for shielding effectiveness, field uniformity, normalised site attenuation and SVSWR as per ANSI C63.4 and CISPR 16-1-4
 - Automated test system capable of carrying out the following tests as per MIL STD 461 (Army, Navy and Air-force requirements)
 - * Radiated emissions - magnetic field from 30 Hz to 100 kHz (RE101)
 - * Radiated emissions - electric field from 10 kHz to 18 GHz (RE102)
 - * Radiated emissions, spurious and harmonic emissions up to 18 GHz (RE103)
 - * Conducted emissions on power leads from 30 Hz to 10 MHz (CE 101, CE 102)
 - * Conducted emissions from antenna terminals (CE 106)
 - * Radiated susceptibility - magnetic field from 30 Hz to 100 kHz (RS101)
 - * Radiated susceptibility - electric field from 2 MHz to 18 GHz (RS103)
 - * Conducted susceptibility at antenna ports to verify the effects of inter modulation, cross modulation and undesired signal effect (CS 103, CS 104 and CS 105)
 - * Conducted susceptibility, power leads (CS101, CS106)
 - * Conducted susceptibility, structure current (CS 109)
 - * Conducted susceptibility, bulk cable injection, 10 kHz to 200 MHz (CS114), impulse excitation (CS115), damped sinusoidal transients, cables and power leads, 10 kHz to 100 MHz (CS116)



Arjun MBT Mk-II inside EMI/EMC test facility



RF Sliding door for platform entry

Aircraft Sub-systems Test Facilities

CVRDE's expertise in AFV system design has contributed enormously in the realisation of maiden project on Aircraft Mounted Accessory Gearbox (AMAGB) programme for the LCA. This program was followed by development of aircraft filters, PTO shaft and 5 kW generator for LCA and landing gear for Rustom-II UAV. Later the development of indigenous aircraft bearings was also taken up.

The first flight test of LCA was carried out successfully in January 2001 equipping AMAGB and filters developed by CVRDE. The laboratory has created civil infrastructure to house all test facilities required to qualify the above products for airworthy certification.

Aircraft Mounted Accessory Gear Box

Since AMAGB is an airborne system, performance evaluation under all flight maneuvering conditions are to be simulated on ground, which is a biggest challenge for getting certification from airworthiness agencies. CVRDE has developed state-of-the-art test facilities namely endurance test rig, attitude test rig, altitude test rig, starting sequence test rig, etc., with a high end, full-fledged data acquisition systems facilitating safety interlocks and online diagnostics. They play a vital role to validate the gear box performance simulating all aircraft conditions on ground. Using these test rigs, CVRDE has validated the design of the gear box by carrying out stringent endurance and performance tests simulating flight maneuvers.

Subsequently, CVRDE also developed a naval variant of gear box to withstand corrosive environment and higher g load due to deck landing and got it validated by carrying out stringent tests. These gear boxes are fitted and flying in naval variant of LCA, undergoing flight trials.

Filter Development Centre

Extensive test facilities have been established at CVRDE as per International Standards of MIL-F-8815D such as bubble point test rig, multi-pass test rig, cold start test rig, collapse pressure test rig, impulse pressure test rig and proof pressure test rig. The technology involved in the design and development of filters for aircraft has been established.

Power Take-off Shaft

The endurance testing of PTO shaft is carried out using custom designed test rigs positioned at CVRDE. These endurance test is to be conducted on continuous basis for the acceptance and life extension of PTO shaft, attributed by Air Worthiness Certifying Authorities (AWCA). The PTO shaft is capable of negotiating high speed with the accommodation of centrifugal stresses, acceleration and higher torque transmission.

To validate the performance, proper testing of PTO shaft is

required. The back to back test rig is a state-of-the-art test rig used to conduct acceptance and qualification tests of PTO shafts.

Aircraft Bearings

CVRDE created design methodology for design and analysis of aircraft bearings with a commercially available dynamic analysis software to carry out design and analysis of dynamic behaviour of bearings. A dedicated dynamic analysis software Advanced Dynamics of Rolling Elements and Animated Graphics of Rolling Elements (ADORE and AGORE) is available for design and analysis of high speed bearings.

CVRDE established a 1000 class clean room for assembly and inspection of bearings. Also established a critical component level inspection set-up inside clean room. To carry out acceptance test and qualification test of indigenously developed bearings, test facilities such as vibration test rig, frictional torque test rig, static radial load test rig, endurance test rig, etc., are established.

5 kW Generator

CVRDE has established a generator endurance test rig to carry out endurance test cycles on the indigenous 5 kW generating system. The test rig comprises a variable speed motor with drive and an electrical load bank. High-end NI-based data acquisition system and vibration analyser accomplishes real-time monitoring of all test rig and generator parameters.

The test rig features automated pre-programming of speed and load for various test schedules and also a controller for various safety interlocks.

Retractable Landing Gear

CVRDE established inhouse test facilities to test the main landing gear and nose landing gear shock struts, hydraulic actuator, landing gear controller and wire harnesses of Rustom-II UAV. MLG and NLG spring curve testing, landing gear integration test facility, hydraulic actuator endurance test facility, wire harnesses endurance test facility and landing gear controller ATE test facility are utilised for validation.

Components Developed and Tested





LCA-Tejas hydraulic filters



Aircraft bearings



5 kW Generator



Landing gear for Rustom-II UAV

Back to Back Test Rig for PTO Shaft



Nomenclature	Back to Back Test Rig for PTO Shaft
Year of establishment	2004
Types of tests performed/capabilities	Power run test rig [endurance test] of PTO shaft
Unique characteristics/special features	Four square concept or Back to Back concept
Max speed	21,500 rpm
Max torque	110 Nm
Mis-alignment	5 mm (axial); 11.5 mm (lateral)
Test control parameters	Speed/torque/vibration/temperature/noise
Instrumentation	Torque/speed sensor/accelerometer/thermo couple/sound level meter
Data acquisition system	Lab View V 6.1
Milestones achieved	1800 hr of qualification testing completed on PTO shaft
Facilities utilised by	CVRDE, ADA and HAL, Bengaluru

Misalignment Cycle Test Rig



Nomenclature	Misalignment Cycle Test Rig for PTO Shaft
Year of establishment	2002
Types of tests performed/capabilities	Testing of diaphragm pack PTO shaft
Unique characteristics/special features	Specially made to test diaphragm pack of PTO shaft
Max speed	12,000 rpm
Mis-alignment	5 mm (axial); 11.5 mm (lateral)
Test control parameters	Speed/vibration/displacement
Instrumentation	Torque/speed sensors/accelerometer displacement sensors
Data acquisition system	RT Pro for vibration
Milestones achieved	150 hr of testing conducted in diaphragm pack with various misalignment
Facilities utilised by	CVRDE, ADA and HAL, Bengaluru

Static Thrust Test Rig



Nomenclature	Static Thrust Test Rig for PTO Shaft
Year of establishment	2002
Types of tests Performed/capabilities	Static thrust testing of PTO shafts
Unique characteristics/special features	Custom made rig
Distance between ends	510 mm
Max thrust/torque	10 mm displacement/300 kg (Thrust)
Test control parameters	Extension/compression of PTO shafts
Instrumentation	Load cell, displacement sensor
Milestones achieved	All PTO shafts acceptance tests were conducted in this test rig
Facilities utilised by	CVRDE and ADA

Static Torque Test Rig



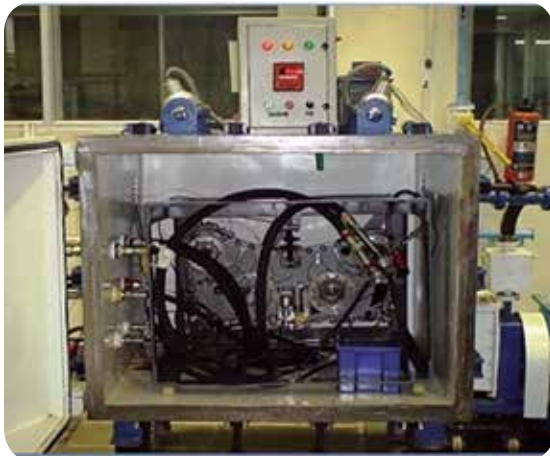
Nomenclature	Static Torque Test Rig for PTO Shaft
Year of establishment	2002
Types of tests Performed/capabilities	Static torque testing of PTO shafts and shear neck test
Unique characteristics/special features	Custom made test rig
Distance between ends	750 mm
Max thrust/torque	800 Nm (Torque)
Test control parameters	Acceptance test of PTO shafts
Instrumentation	Load cell
Milestones achieved	All PTO shafts tested using this test rig
Facilities utilised by	CVRDE and ADA

Torsional Fatigue Test Rig



Nomenclature	Torsional Fatigue Test Rig for PTO Shaft
Year of establishment	2003
Types of tests performed/capabilities	Torsional fatigue testing of PTO shafts
Unique characteristics/special features	Custom made rig for testing of PTO shafts
Max speed/oscillation	8 Hz
Max torque/max altitude simulation	105 Nm (Torque)
Test control parameters	Torque and no. of cycles
Instrumentation	Load cell, cycle counter
Milestones achieved	372 hr of torsional fatigue testing on PFD-03 shafts
Facilities utilised by	CVRDE, ADA and HAL, Bengaluru

Altitude Test Rig for AMAGB



Nomenclature	Altitude Test Rig for AMAGB
Year of establishment	2003
Types of tests performed/capabilities	For testing of aerostatic value in AMAGB under high altitude conditions
Unique characteristics/special features	Flight envelope of AMAGB test can be carried out
Max speed/oscillation	17,000 rpm
Max torque/max altitude simulation	16 km (Altitude)
Test control parameters	Absolute pressure AMAGB and chamber
Instrumentation	Vibration accelerometer, thermo couples, piezo resistive pressure sensors, magnetic pick up, turbine flow meter, etc.
Data acquisition system	50 Channel data acquisition system
Milestones achieved	16 km altitude simulation of AMAGB
Facilities utilised by	CVRDE, ADA and HAL, Bengaluru

Attitude Test Rig for AMAGB



Nomenclature	Attitude Test Rig for AMAGB
Year of establishment	1993
Types of tests performed/capabilities	To simulate gearbox pump performance under 19 steps of flight maneuver
Unique characteristics/special features	AMAGB tested with 15 kW load with 16810 rpm
Test control parameters	Lub oil flow, pressure, temperature and vibration
Instrumentation	Vibration accelerometer, thermo couples, piezo resistive sensors, magnetic pick up and turbine flow meter
Data acquisition system	50 channel data acquisition system
Milestones achieved	12 prototype, TOT and naval AMAGB Gear box successfully completed
Facilities utilised by	CVRDE, ADA and HAL, Bengaluru

Endurance test rig for AMAGB



Nomenclature	Endurance Test Rig for AMAGB
Year of establishment	1991
Types of tests performed/capabilities	To carry out Motoring Run Test, Performance Record Test, Starting Sequence Test, Machine Profile Test, Acceleration and Deceleration Test, Engine Acceptance Test, etc., for AMAGB
Unique characteristics/special features	Maximum power 250 kW at 18000 rpm
Test control parameters	Lub oil flow, pressure, temperature, vibration and noise level
Instrumentation	Vibration accelerometer, thermo couples, RTD piezo resistive pressure sensors, magnetic pick up, turbine flow meter and micro phone for sound level
Data acquisition system	100 channel data acquisition system
Milestones achieved	1000 hr endurance test successfully completed
Facilities utilised by	CVRDE, ADA and HAL, Bengaluru

Endurance Test Rig I for Rolling Element Bearings



Nomenclature	Endurance Test Rig I for Rolling Element Bearings
Year of establishment	2007
Types of tests performed/capabilities	To evaluate the performance and endurance life of roller/ball bearings at the specified speed and load conditions
Unique characteristics/special features	Bearing with ID and OD range of 20-50 mm and 45-90 mm respectively can be tested at the speed range of 5000-20000 rpm and radial load and axial load range of 0-25 kN and 0-2.5 kN respectively can be applied upon the bearing while testing
Test control parameters	Speed/radial load/axial load
Instrumentation	Temperature sensor/pressure sensor/vibration sensor/torque sensor/flow sensor/load cell
Data acquisition system	LabView software and Hardware of PXI-1031 chassis with PXI 8331 and PXI 6229 cards are used for acquiring test and monitoring data
Milestones achieved	More than 1500 hr of testing has been carried out on bearings
Facilities utilised by	CVRDE

Frictional Torque Test Rig for Rolling Element Bearings



Nomenclature	Frictional Torque Test Rig for Rolling Element Bearings
Year of establishment	2007
Types of tests performed/capabilities	To check and verify the rolling frictional torque of bearing
Unique characteristics/special features	Bearing with ID and OD range from 20-50 mm and 45-90 mm can be tested at the speed range of 2-2000 rpm with Radial load range of 0-30 N can be applied upon the bearing while testing
Test control parameters	Speed/radial load
Instrumentation	Load cell
Data acquisition system	LabView software, hardware of PXI-1031 chassis with PXI 8331 and PXI 6221. DAQ card is used for acquiring test and monitoring data
Milestones achieved	Tested and established different types of rolling element bearings
Facilities utilised by	CVRDE

Static Radial Load Test Rig – I for Bearings



Nomenclature	Static Radial Load Test Rig-I for Bearings
Year of establishment	2008
Types of tests performed/capabilities	To ensure and validate the static radial load capacity of bearing under the applied radial load
Unique characteristics/special features	Offers wide compression/tensile load range of 0-65 kN with stroke of 200 mm. Its hydraulic actuator has an accuracy of $\pm 0.1\%$
Test control parameters	Radial load
Instrumentation	Load cell
Data acquisition system	It is operated by programmable logic control system
Milestones achieved	More than 50 numbers of bearings has been tested
Facilities utilised by	CVRDE

Static Radial Load Test Rig – II for Bearings



Nomenclature	Static Radial Load Test Rig-II for Bearings
Year of establishment	2011
Types of tests performed/capabilities	To ensure and validate the static radial load capacity of larger diameter bearing under the applied radial load
Unique characteristics/special features	Offers wide radial load range of 0-250 kN with stroke of 500 mm, accuracy of $\pm 0.5\%$ and resolution $0.1\ \mu\text{m}$. Speed range is 0.005 mm/min to 500 mm/min, resolution 0.001 mm/min and accuracy $\pm 0.05\%$ of set speed
Test control parameters	Radial load and displacement
Instrumentation	Load cell, extensometer
Data acquisition system	Software DIONPRO and STAT and digital control system is PCS 5000
Milestones achieved	Tested engine main shaft bearings
Facilities utilised by	CVRDE

Vibration Test Rig-I for Rolling Element Bearings



Nomenclature	Vibration Test Rig-I for Rolling Element Bearings
Year of establishment	2010
Types of tests performed/capabilities	To check the vibration levels of bearings to find any presence of surface defect, form errors on the raceways
Unique characteristics/special features	Bearing OD range of 26 to 110 mm shall be tested at speed of $1800\ \text{rpm} \pm 2\%$ and vibration level up to $5000\ \mu\text{m/s}$ can be measured and shown in the frequency bands of 30-300 Hz, 300-1800 Hz and 1800-10000 Hz. Axial and Radial load that can be applied upon the Bearing are 30 N to 200 N and 50 N to 400 N respectively
Test control parameters	Radial load and axial load
Instrumentation	Velocity proportional sensor
Data acquisition system	FFT analyser and MEB 95/FPM Software
Facilities utilised by	CVRDE

Vibration Test Rig-II for Rolling Element Bearings



Nomenclature	Vibration Test Rig-II for Rolling Element Bearings
Year of establishment	2010
Types of tests performed/capabilities	To check the vibration levels of larger diameter size bearings to find any presence of surface defect, form errors on the raceways
Unique characteristics/special features	Bearing OD range of 80 to 200 mm shall be tested at speed of 700 rpm \pm 2 % and vibration level up to 5000 μ m/s can be measured and shown in the frequency bands of 20-120 Hz, 120-700 Hz and 700-4000 Hz.. Axial and Radial load that can be applied upon the bearing are 0 N to 900 N and 0 N to 400 N
Test control parameters	Radial load and Axial load
Instrumentation	Velocity proportional sensor
Data acquisition system	FFT analyzer and MEB 95/FPM Software
Facilities utilised by	CVRDE

Generator Endurance Test Rig



Nomenclature	Generator Endurance Test Rig for Testing DC Generators
Year of establishment	2016
Types of tests performed/capabilities	To test the generator at various speeds and loads and capture temperatures of machine and windings
Max speed Max power	14100 rpm 22.5 kW
Test control parameters	DC Generators of capacities up to 20 kW can be tested with the test rig. State-of-the-art DAS and safety interlocks are available with the rig. The test cycle can be automated with the built-in controllers. Vibration analyser is also available for monitoring the vibration
Instrumentation	Thermocouples, torque speed sensor, voltage and current sensors
Data acquisition system	NI-PXIe-based
Facilities utilised by	CVRDE and ADA

Multi-pass Test Rig for Hydraulic Oil Filters



Nomenclature	Multi-pass Test Rig for Hydraulic Oil Filters
Year of establishment	2002
Types of tests performed/capabilities	Unique test facility used for filtration efficiency test for hydraulic and lubrication filters, pressure drop across the filter, by-pass valve and relief valve functional test, and differential pressure indicator functional test
Pressure Flow	25 bar (Max) 180 lpm (Max)
Unique characteristics/special features	Filtration efficiency test for hydraulic and lubrication filters
Test control parameters	Pressure, flow, temperature and contamination injection
Instrumentation	Pressure transducers, turbine flow meter and thermocouple
Data acquisition system	UCC –LCM20 particle counter
Facilities utilised by	CVRDE, ADA, HAL and Naval HQrs

Impulse Pressure Test Rig



Nomenclature	Impulse Pressure Test Rig for Hydraulic Oil Filters
Year of establishment	2002
Types of tests performed/capabilities	Unique test facility used for filtration efficiency test for hydraulic and lubrication filters, pressure drop across the filter, by-pass valve and relief valve functional test, and differential pressure indicator functional test
Pressure flow	25 bar (Max); 180 lpm (Max)
Unique characteristics/special features	Filtration efficiency test for hydraulic and lubrication filters
Test control parameters	Pressure, flow, temperature and contamination injection
Instrumentation	Pressure transducers, turbine flow meter and thermocouple
Data acquisition system	UCC – LCM20 Particle counter
Facilities utilised by	CVRDE, ADA, HAL and Naval HQrs

Auto Shut Off Valve Test Rig



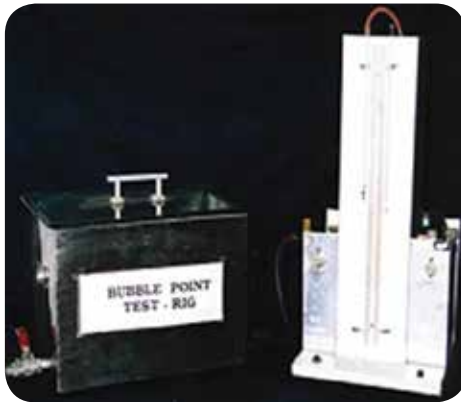
Nomenclature	Automatic Shut-off Valve Test Rig for Hydraulic Oil Filters
Year of establishment	1995
Types of tests performed/capabilities	Cycling testing for automatic shut-off valve
Pressure flow	25 bar (Max)
Unique characteristics/Special Features	This test rig is used for checking the function of automatic shut-off valve in the filter assemblies. The qualification cycling test for the structural stability of the threads on the bowl and head are also carried out
Test control parameters	Pressure, temperature and contamination injection
Instrumentation	Pressure transducer and thermocouple
Facilities utilised by	CVRDE, ADA, HAL and Naval HQrs

Collapse Pressure Test Rig



Nomenclature	Collapse Pressure Test Rig for Hydraulic Oil Filters
Year of establishment	2004
Types of Tests Performed/capabilities	Differential collapse pressure test
Pressure flow	280 bar (Max) ; 25 lpm (max)
Unique characteristics/special features	This test rig is used to check the structural strength of filter element at higher differential pressure due to clogging condition upto 250 bar with addition of test dust.
Test control parameters	Pressure, flow and temperature
Instrumentation	Pressure transducer, turbine flow meter and thermocouple
Facilities utilised by	CVRDE, ADA, HAL and Naval HQrs

Bubble Point Test Rig



Nomenclature	Bubble Point Test Rig for Hydraulic Oil Filters
Year of establishment	1995
Types of tests performed/capabilities	Test rig used to check the fabrication integrity of filter elements
Unique characteristics/special features	This test rig is used to check max pore value of the filter media
Test control parameters	Filtered and pressure controlled air
Instrumentation	Pressure transducer (Absolute) and U-tube manometer with water
Facilities utilised by	CVRDE, ADA, HAL and Naval HQrs

Proof Pressure Test Rig



Nomenclature	Proof Pressure Test Rig for Hydraulic Oil Filters
Year of establishment	1995
Types of tests performed/capabilities	Proof pressure and burst pressure test for filter housing
Pressure	700 bar (Max)
Unique characteristics/special features	Provided with safety bullet proof glass to view the test for any leakage. This test rig is used to test the filter assemblies for structural strength under proof and burst pressure upto 700 bar
Test control parameters	Pressure
Instrumentation	Thermocouples, torque speed sensor, voltage and current sensors, pressure transducer
Facilities utilised by	CVRDE, ADA, HAL and Naval HQrs

Cold Start Test Rig



Nomenclature	Cold Start Test Rig for Hydraulic Oil Filters
Year of establishment	2000
Types of tests performed/capabilities	Cold immersion test for 72 hr continuously and cold start test
Pressure flow	50 bar (max) 25 lpm (max)
Unique characteristics/special features	The filter elements are subjected to cold start test at - 40 °C with specially designed transfer cylinder arrangements. This is to check integrity at high viscous flow during low temperature start up conditions. The cold chamber is also used for cold immersion test with temperature upto - 54 °C.
Test control parameters	Pressure transducer, turbine flow meter and thermocouple
Instrumentation	Pressure transducers, turbine flow meter and thermocouple
Data acquisition system	Oscilloscope
Facilities utilised by	CVRDE, ADA, HAL and Naval HQrs



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Editors acknowledge the contribution of Dr S Muralidhar, Sc 'G' of Combat Vehicles Research & Development Establishment (CVRDE), Chennai in preparing this issue.

Technology Focus focuses on the technological developments in the organisation covering the products, processes and technologies.

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Published by DESIDOC

RNI No. 55787/93