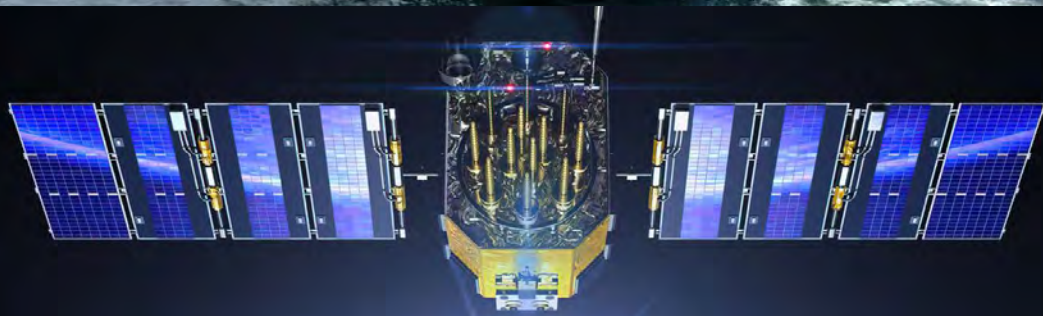


Defence & Aerospace



SERVING *our* SENTINELS





In Defence business
for more than three decades



Dedicated multidisciplinary manufacturing
facilities set up at major BHEL production
units, to ensure non-proliferation of
technologies & compliance to MoD's
standards of security and other safeguards



Various state of art equipment supplied/ in
production for Navy/ Army/ Air Force on a
long term basis



Contents

Who we are?	4
BHEL in Defence & Aerospace	5
Our Expertise in Defence Systems	6
SRGM 76/ 62 Upgraded	8
Integrated Platform Management System (IPMS)	9
Permanent Magnet Machines (PMM)	10
Our Expertise in Aerospace	12
Capabilites in Aerospace & Defence	14
Why Partner with BHEL	15
Collaboration with Industry/ Academia	16
BHEL Research Institutes/ Centres of Excellence (R&D)	16
Manufacturing/ Machining Capabilities	17
Testing Capabilities	18
Casting & Forging/ Electronics Manufacturing Capabilities	19
Clean Room Facility	19
Make in India with BHEL	20



Who We Are

BHEL is India's largest engineering and manufacturing enterprise in the energy and infrastructure sectors. Established in 1964, we are a leading power equipment manufacturer globally and one of the earliest and leading contributors towards building an Aatmanirbhar Bharat. We serve our customers with a comprehensive portfolio of products, systems and services to its customers in the areas of Power- Thermal, Hydro, Gas, Nuclear & Solar PV, Transmission, Transportation, Defence & Aerospace, Oil & Gas, and Water.

Right from developing country's power generation capacity to creating multiple capabilities in country's core industrial & strategic sectors, BHEL is deeply aligned to the vision of a self-reliant India.

BHEL is leveraging on its technological capabilities and committed workforce to transform itself. Asserting leadership in core business, diversifying the business mix, cost optimisation, efficiency optimisation & innovative technological solutions are the major enablers driving company's competitiveness in its businesses.



BHEL in Defence & Aerospace

BHEL has created a dedicated vertical '**Defence and Aerospace Business Group**' (DABG) at Delhi as a single point contact to the customers to harness the emerging opportunities and providing a boost to 'Make in India' initiative by promoting indigenous design, development and manufacturing of defence equipment, platforms, systems and sub-systems and to meet the growing national requirements of the Indian Space Programme along with the civil/military aviation and allied areas.

BHEL is present in Defence business since over three decades with proven track record of being competitive, adherence to quality, reliable supplies and life time product support. In field of aerospace, BHEL has long term association with key organizations viz. Armed forces, ISRO, HAL, ADA, NAL, DRDO, etc. for various projects.

BHEL has a long and admirable track record of supporting Defence Forces including critical equipment for the prestigious indigenous Aircraft Carrier and Strategic Naval Vessel programme to develop indigenous capability and achieve self-sufficiency in the field of Defence & Aerospace. During the development/ manufacturing of these equipment, BHEL has acquired the capability & experience in system design & integration, precision machining and fabrication of special materials like aluminium alloys, titanium alloys, INCONEL, maraging steel etc, qualification testing, type approval certifications etc. Currently, a number of Defence & Aerospace equipment are under development for Defence Forces, DARE, HAL, ISRO, ADA etc. BHEL is also setting up a dedicated end-to-end manufacturing facility for aluminium alloy tankages for launch vehicles of ISRO.



Our Expertise in Defence Systems



Naval Guns

76/62 SRGM
(Super Rapid Gun Mount)

76/62 SRGM -
Upgraded (Super
Rapid Gun Mount)



Naval Ships

Integrated Platform
Management
System (IPMS)

Marine Steam
Turbines

Alternators

A & P Bracket

Condensers



Naval Vessels

Power Generation
Equipment/
Systems
(Electrical/
Mechanical)



Armoured Vehicles

Turret Casting for Tanks

Thermo Pressed Components

Bridge Layer Tank Superstructure

Gun Control System



Simulators

Infantry Weapon Effects Simulation System (IWESS)

Simfire Vijayanta

Simfire T-72

Small Arms Training Simulator



Missile Systems

Trishul Missile Launcher

Mobile Autonomous Launcher for Brahmos Missile

Titanium Air Bottles for Aerospace applications

76/62 SRGM (Super Rapid Gun Mount) - Upgraded

The 76/62 Super Rapid Gun Mount (SRGM) is a light weight, rapid-fire naval gun providing unrivalled performance and flexibility in any air defence and anti surface role, particularly in anti-missile role. BHEL, a pioneer in heavy engineering and leading solution-enterprise in India, manufactures this state-of-the-art equipment at its Haridwar plant in Uttarakhand. BHEL is supplying SRGMs to Indian Navy since 1994.

SALIENT FEATURES

- Engineering, Manufacturing and Testing 76/62 caliber Naval Gun in collaboration with M/s Leonardo Italy.
- Providing in-house support for on-board installation and commissioning
- Lifetime product support including services, life-extension viz. major overhaul, health audit etc.
- Dedicated state of the art in-house production facility with wide variety of CNC machines and test equipment of various subsystems & Final assembly.
- Has successfully developed expertise in Technology absorption, assimilation & upgradation.

Features	Advantages
4AP-Fuse Programming	Capability to program fuse in 04 MODES – Proximity, Altimetry, Impact / Delayed Impact, Time
Multi-feeding System	Management of Multiple type of ammunition with capability for auto-selection of ammunition
Digital Console AC3	Handles requirement of MF System and Guided Ammunition Built in Black Box, Test Equipment, Manuals, Training Simulator
Fire Vulcano & DART Ammunition	Improved Effective range beyond the industry standard with the extra precision provided by VULCANO Technology DART guided projectile can change its trajectory and be re-vectorred towards the target during its flight.



Integrated Platform Management System (IPMS)

IPMS is designed to automate, control and monitor various critical and non-critical systems of naval ships. The underlying technology incorporates open architecture, digital, distributed control system designed to provide the integrated management i.e. control and monitoring of the ship machineries and systems from several control positions geographically distributed throughout the ship.

BHEL has successfully designed, supplied and commissioned Auxiliary Control System for P15A Destroyer Class of ships for MDL. We also provide technical assistance in Installation, connectorisation, channel checks, STW (Setting To Work), HAT (Harbour Acceptance Test) & SAT (Sea Acceptance Test).

The IPMS is composed of the following sub-systems:

- Propulsion control and Monitoring
- Automated Power Management System (APMS)
- Equipment Health Monitoring System (EHMS)
- Onboard Training System (OBTS)
- Close Circuit Television system (CCTV)
- Automatic Fire Detection System (AFDS)
- Auxiliaries control monitoring
- Battle Damage Control system (BDCS)
- Hull Auxiliaries
- Aviation Facility Control System (AFC)

Proud to be associated with the first 'Made in India' aircraft carrier INS VIKRANT-the largest & most complex Indian Warship designed & built by Indian Navy & Cochin Shipyard

INS Vikrant is equipped with BHEL-GE Avio supplied Integrated Platform Management Systems (IPMS)





Permanent Magnet Machines

Permanent Magnet Machines are rotating synchronous machines that have 3-phase stator winding and high-energy permanent magnets (PM) like samarium-cobalt (SmCo) and neodymium-iron-boron (NdFeB) field system, mounted on the rotor. The PM mounted on the rotor establishes flux, which crosses the air-gap and links with stator conductors. These machines are efficient and reliable as there are no field copper losses and rotating field winding. For some applications, the PM machines are designed with the field system on the outer rotating structure and

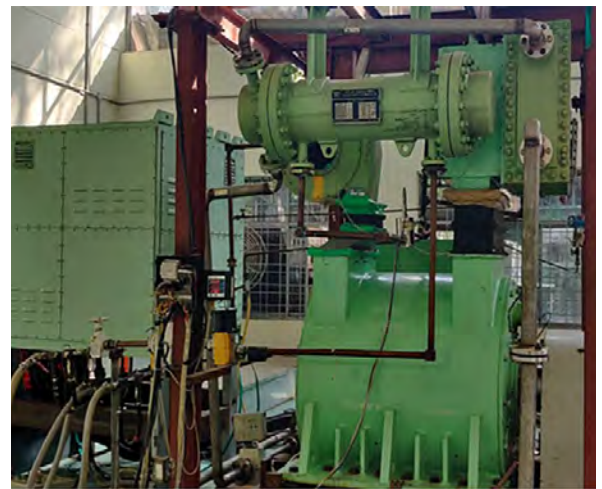
the 3-phase stator winding housed in the stationary armature. However, PM DC motors have field system on the stator and the rotor contains the armature winding. Elimination of field winding makes these machines compact.

BHEL has in-house end-to-end capability in design, engineering, prototyping, manufacturing & testing of permanent magnet machines which is supplemented by a dedicated Centre of Excellence at Corp R&D, Hyderabad.

Permanent Magnet Motor for Propulsion applications

SALIENT FEATURES

- Indigenously developed, first of its kind propulsion system
- Consists of Compact & high efficient PM Motor and IGBT based Inverter
- Operates from 175V – 325V Battery and converts into 3-ph Variable Voltage Variable Frequency to drive PM Motor
- DSP and FPGA based MIL grade hardware
- Compliance to NES, MIL461E and JSS55555 standards
- Successfully tested for applicable performance criteria and supplied to customer.



High speed Permanent Magnet Synchronous Motor



SALIENT FEATURES

- Liquid cooled Stator frame for high power density
- Interior permanent magnet rotor construction
- Max. Operating speed 10,000 rpm, Max. efficiency 96 %
- Coolant flow rate of 20-30 lpm at 2 bar pressure
- Certified as per AIS-041 Rev 01:2015

Permanent Magnet based Rotary Frequency Converter



SALIENT FEATURES

- Converts (a) 3Ø 415V 50 Hz supply into 3Ø 230V, 400 Hz supply (b) 175V – 325V DC into 3Ø 230V, 400 Hz supply
- Indigenously developed, first of its kind, consists of Compact & high efficient PM Motor–generator set and IGBT based Converter /Inverter
- Compliance to NES, MIL 461E and JSS 55555 Standards
- Successfully tested for applicable performance criteria and supplied to customer.
- Monoblock arrangement of motor and generator on common shaft and in single frame, avoiding mechanical coupling.
- Automatic detection and changeover to redundant supply, incase of failure of main input supply

Static Bidirectional Converter (SBC)

SALIENT FEATURES

- 1MW Static bi-directional Converter to supply critical loads in case of failure of main supply.
- Master /slave based configuration (4 x 250 kW) to have redundancy, flexible and higher efficient system
- Operates in grid synchronization mode when main supply available and charges the battery (AC-DC mode / Rectifier Mode)
- Operates in standalone mode from battery when main supply fails and feeds the critical AC loads with bump less change (DC-AC mode / Inverter Mode)
- Higher efficiency (>95%) and faster response in detection & change over to Inverter mode in case of failure of the mains
- Compliance to NES, MIL461E and JSS55555 standards
- Successfully tested for applicable performance criteria and supplied to customer.
- Compact in size and lower noise



Axial Flux based Permanent Magnet Synchronous Motor

SALIENT FEATURES

- State of the art technology based on axial flux principle
- Maximum Speed 3000 rpm
- Liquid cooled stator frame (Ethylene-glycol & DM water 50% by volume)
- Modular construction for building higher rating machines
- Compatible for accommodating where axial lengths are shorter

ADVANTAGES OF AXIAL FLUX OVER RADIAL FLUX PM MOTORS

- Compact in size & weight (35 to 40% reduction)
- Cost reduction of 25 to 30 % (with bulk manufacturing)



Our Expertise in Aerospace

Compact Heat Exchangers for Aircrafts, helicopters and pod-mounted applications

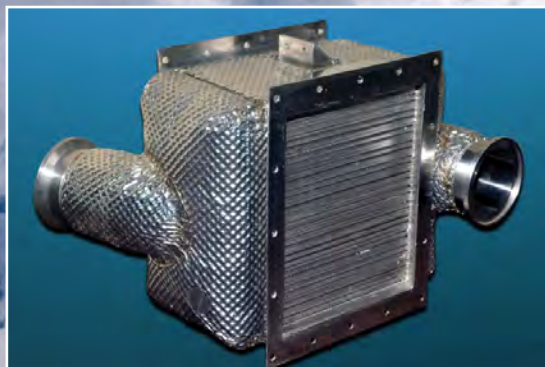
- LCA Tejas
- Sukhoi
- Advanced Light Helicopters (ALH)
- Light Utility Helicopters (LUH)
- Advanced Medium Combat Aircraft (AMCA)

Pump modules for Aerospace applications

- Airborne Pod applications
- Radar etc.



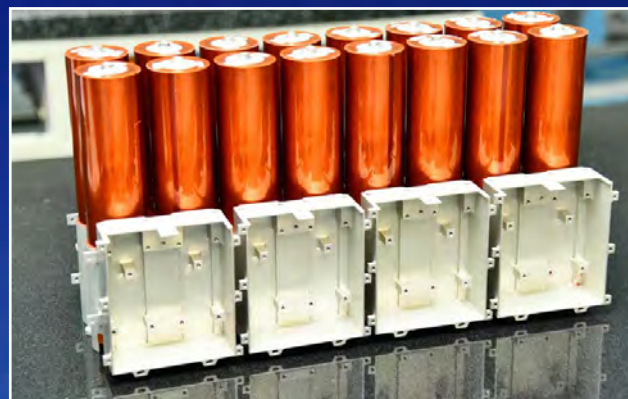
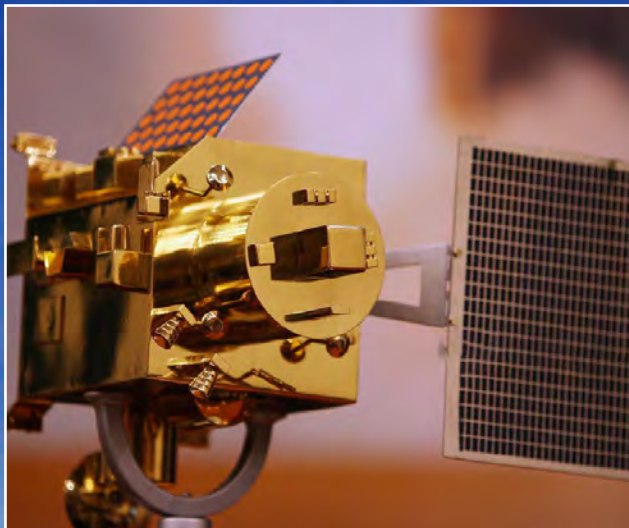
In-house capability for design development & manufacturing, testing & qualification



Heat Exchanger and pre-cooler for LCA Tejas, indigenously designed and manufactured by BHEL for HAL

Solar Panels & Propellant Tanks for Space Applications

- Space Grade Solar Panels for satellites
- Titanium domes & rings for Propellant tanks for Satellites



Lithium Ion Batteries

- Space Grade Lithium Ion batteries for aerospace application
- Dedicated Facility for Assembling & testing Li-Ion batteries in place.
- Full fledged Manufacturing facility of Li-ion cells



Capabilites in Aerospace & Defence

1. Concept Design
2. System Engineering
3. Technology Development
4. Computer Aided Design & Engineering
5. Prototyping
6. System Integration
7. Ruggedisation
8. Project Management
9. Kinematics & Dynamics
10. Hydrodynamics & CFD
11. Control Systems & Simulations
12. Real Time Operating System
13. Electrical Systems
14. Advanced Materials
15. Structures
16. Advanced Manufacturing



Why Partner with BHEL?

- Govt. of India MAHARATNA Company capable of fast Investment decisions in terms of infrastructure/ manpower.
- PAN India Presence - Product support at customer's door step.
- Vast infrastructure facilities including world-class manufacturing capability.
- Successfully working with world renowned OEM's for technology Transfer and quick assimilation of technology
- Ability to deliver Indigenous quality product with OEM specifications
- Competitive prices/ high quality/ timely delivery/ after sales support.
- Trained manpower & engineering knowledge gained through technology assimilation of various products/ systems
- Proven experience of dealing with Indian Ministry of Defence, Indian Defence Forces, Naval HQs, various user units, Quality groups of MOD and other agencies
- Ensuring non-proliferation of technology using safeguards
- Expertise in driving 100% indigenisation with available capabilities and association of domain experts



Collaboration with Industries/ Academia



BHEL Research Institutes

- Welding Research Institute (WRI), Trichy
- Ceramic Technological Institute (CTI), Bengaluru
- Centre for Electric Transportation (CET), Bhopal
- Amorphous Silicon Solar Cell Plant, Gurugram
- Pollution Control & Research Institute (PCRI), Haridwar

Centres of Excellence (R&D)

- Intelligent Machines & Robotics
- Machine Dynamics
- Compressors & Pumps
- Nano-technology
- UHV Laboratory
- Simulators
- Computational Fluid Dynamics
- Surface Engineering
- Permanent Magnet Machines
- Advanced Transmission Systems
- Power Electronics and IGBT & Controller Technology
- Centre of Excellence for Control and Instrumentation
- Coal Research Centre
- Advanced Fabrication Technology



Manufacturing Capabilities



Full range of Manufacturing Capabilities available at all Major Units

viz. Haridwar, Hyderabad, Bhopal, Trichy, Bengaluru, Vizag, Ranipet

- State-of-the-art Multi-axis CNC machine Centres for Precision Machining
- Fabrications including Special Grade Alloys Welding viz titanium, aluminium etc
- Non Destructive testing Facilities
- State of Art Forging and Casting Facilities
- State-of-the-art Electronics Manufacturing Facility including Surface Mount Technology Facility
- Established Capability wrt technology absorption, assimilation & system integration

Machining Capabilities



MACHINING

Precision machining center with wide variety of CNC machines -

- CNC Horizontal Boring Machines
- CNC Vertical Boring Machines
- Multi Axis multi spindle CNC machines
- CNC Horizontal milling / grinding Machines; Kopp Milling
- CNC Horizontal External Broaching Machine
- CNC Gun Drilling Machines for very thick plates
- Boring & Trepanning Machine
- CNC Creep Feed Grinding Machines

- Tube Finning Machines for Advance Class Steam Turbine Blades
- Modern Blade Shop

FABRICATION

- Cutting – Oxy-fuel cutting, Plasma Cutting, Shearing, Nibbling
- Forming - Bending, Rolling
- Special materials fabrication such as P-91, P92, Inconel, Titanium Alloys, Al. Alloys etc
- CNC Incremental Pipe Bending Machine for dia. up to 1200 mm
- CNC Gun Drilling Machines for very thick plates

Machining Capabilities (cont.)



WELDING CAPABILITY

- Welding - SMAW, MIG, TIG, SAW Processes
- Thin Section / pipe section welding
- Welding Manipulator capacity up to 15 ton
- Welding Overlay facility
- Experienced and Certified Welders
- 2 MW Nd-Yag Laser for Welding & Cutting
- Rack cutting
- EDM wire cutting of profiled components
- Robotics for material handling/ welding

SURFACE & HEAT TREATMENT

- Pre Weld and Post weld Stress relieving
- Metal Coating - Stellite, copper/ tin/ silver plating, etc
- Shot Blasting
- Processes like gas carburizing, nitriding, induction hardening, etc

Testing Capabilities

- Non-Destructive Testing:
 - 360 deg Panoramic X-ray
 - Digital X - Rays
 - DP, MPI, Ultrasound Testing
- CNC 3-D coordinate measuring machine
- Chemical analysis & mechanical testing
- Laser based gauge checking device
- Electrical insulation testing laboratory
- Electronics laboratory
- Dust Free Hydraulics laboratory
- Over Speed Balancing Tunnel for Turbine Rotors up to 1000MW unit size
- UHV Lab (750 kV) & Vapour Phase Plant for Transformers






Casting & Forging Capabilities

- 2650 T & 9000 T Forge Presses
- 10T, 30T & 70T Electric Arc Furnaces
- Ladle refining furnace – 12 T
- Vacuum Arc Degassing (VAD)/ Vacuum Oxygen Decarburizing (VOD) - 70 T
- Electro Slag Re-melting (ESR) -50 T
- Vertical Shaft & H. T. Furnaces upto 150 T
- Radiography facilities- Co-60 & Ir-192 Camera
- Optical emission spectrometer



Clean Room Facilities

- A cumulative area of 5200 sq. m. of clean room infrastructure present in Tiruchirappalli, Bengaluru and Bhopal units of BHEL to support production of defence and aerospace equipments & products
- Clean room of various classes are available viz. ISO Class 6/ Class 7/ Class 8
- Clean room sizes vary from 80 sq. m. to 2070 sq. m.
- Operating temperatures - 20 ± 2 deg C to 25 ± 2 deg C



Electronics Manufacturing Capabilities

- Complete manufacturing line for Surface Mount Technology (SMT) electronic sub assemblies with automatic optical inspection.
- Automatic functional test facilities and Burn in test facilities at sub-assembly level and system level.
- Large pool of qualified engineers in the areas of Hardware & software systems engineering
- Structured Technology absorption thro' TOT and Developments thro' in-house resources.
- Dust controlled building and facilities for assembly / manufacture of space grade solar panels. (Clean Room Standard: Class 10,000)
- General purpose and dedicated test equipment for electronic modules / sub-assemblies, components and harnesses.
- Facility for environmental testing with dry heat chamber, cold chamber and humidity chamber.
- Vibration test bed with sine & random vibration test.
- Air-conditioned CE Panel testing area for Integrated Testing of C&I Panels (SG, TG, BOP & HMI) with structured Networking for facilitating easy connectivity resulting in substantial reduction in testing cycle time.
- Air conditioned GTO Valve Assembly, GTO / IGBT / Thyristor Converters and Control Electronics Assembly & Testing facility

Dedicated Naval Gun Manufacturing Facility at Haridwar

- Endorsed by Indian Navy/MOD as nominated BHEL as **Sole Production Agency** for 30 mm Naval guns.
- Has dedicated Engineering, Manufacturing and Testing facility for manufacture of 76/ 62 caliber Naval Gun since 1994.
- Already Supplied 44 nos. Naval Guns to Indian Navy and complete on-board services and long term product support including maintenance/ overhaul is undertaken by BHEL.
- Dedicated state of art manufacturing facilities with wide variety of CNC machines and test equipment.
- Has capability of in-house production of various subsystems, Testing and Final assembly of Gun systems.
- Has successfully developed expertise in Technology absorption, assimilation & upgradation for variety of equipment and systems



**MAKE IN INDIA
with BHEL**

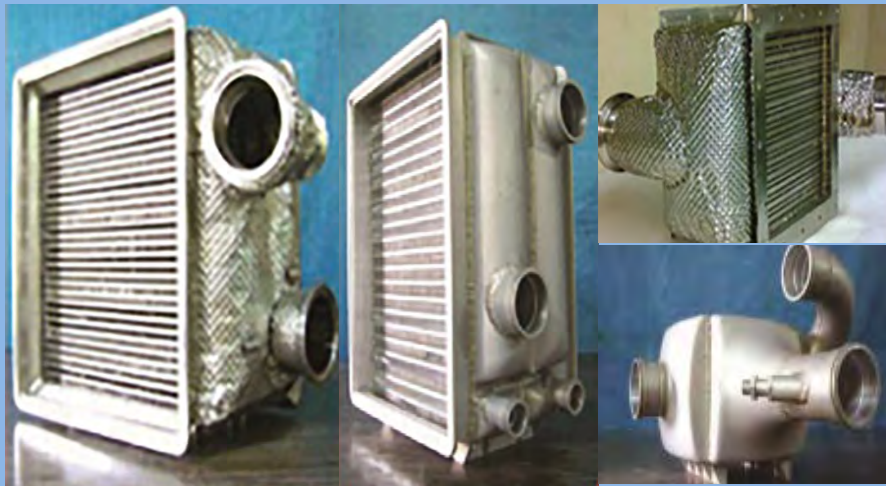




COMPACT HEAT EXCHANGERS for LCA Tejas at HPVP, Visakhapatnam

The R&D department of BHEL HPVP, Visakhapatnam has successfully developed 11 different types of compact & light-weight

Heat Exchangers for the Indian LCA 'Tejas'. These are:



1. Primary heat exchanger
2. Secondary heat exchanger
3. Regenerative heat exchange coolers
4. Reheater
5. Condenser
6. Liquid-air heat exchanger
7. Fuel cooled oil cooler (HE-1)
8. Fuel cooled oil cooler (HE-2)
9. Precooler
10. Air Cooled Fuel Cooler
11. Fadec Cooler

These heat exchangers perform the vital functions of maintaining the required environment for the pilot's cabin and prevent

the hydraulic & lube oils in the aircraft from excessive heating during flight.



**MAKE IN INDIA
with BHEL**

Heat Exchangers Capabilities at HPVP, Visakhapatnam

- Design, Development, Manufacturing, Testing
- Supply of Compact Plate Fin Heat Exchangers for Defence & Aerospace applications
- Tig Welding of Aluminium Alloys (Up to 10mm thickness)
- Vacuum Brazing of Aluminium Alloy Equipment (up to 600 mm X 600 mm X 1000 mm size)
- Vacuum Brazing of Stainless Steel Equipment. (up to 1000 mm X 1000 mm X 800 mm size)
- Clean room of size 42 m X 12.5 m X 10 m of ISO Class 8; Temperature : 22 ± 2 deg C and RH factor $\pm 5\%$
- Certified facility - AS9100D



SPACE GRADE PANELS & SATELLITE BATTERIES

EDN, Bengaluru

- BHEL & ISRO association in Satellite Batteries started with signing of Memorandum of Understanding (MoU) in year 2002.
- The association started with Ni-Cd and Ni-H₂ batteries.
- From 2010, BHEL is assembling and testing Li-Ion batteries for spacecrafts.
- 102 batteries have been supplied to ISRO as on date and used in Satellites.
- Presently fabricating batteries for all Gaganyaan Missions
- 350 sq. m. of class 1,00,000 clean room area.
- ISRO trained manpower for cells handling, battery assembly, wiring, welding, testing etc.
- Annual capacity of assembling and testing of 10 Spacecraft batteries.
- Equipment like High resistance meter, resistance welding machine, DMM, Cell testing systems, climatic chambers, electronic load, power supplies, data loggers, Automatic Battery testing systems (ABTS) available.

**MAKE IN INDIA
with BHEL**



Satellite Batteries



LARGE CAPACITY BATTERY

Capacity : 180 Ah/ 90 Ah
Nominal Voltage: 35 volts
Configuration: 4 (45Ah)/ 2 cells in parallel;
10 such modules in series
Protection: Cell Balancing cards /
By-pass switch



SMALL CAPACITY BATTERY

Capacity : 20 Ah
Nominal Voltage: 35 volts
Configuration: 10 cells in series and 8 such
strings in parallel
Protection: No need of Cell Balancing
cards and By-pass switch



Partners in India's Space Programme

BHEL is one of the long standing partners of Indian Space Research Organisation (ISRO), since 1992.

Most of the satellites launched by ISRO including GSAT 30, where a 500 sq. m. space grade solar panel was supplied and India's heaviest communication satellite GSAT11, among others, are powered by BHEL manufactured solar panels and Li-ion batteries. BHEL has also supplied space grade solar panels and batteries for Chandrayaan II.

Space Grade Solar Panels

**MAKE IN INDIA
with BHEL**



- BHEL & ISRO association in Space Solar Panels started with signing of MOU in year 1998.
- More than 600 sq. m. of space grade panels fabricated catering to more than 60 satellites
- Largest panel of 6.93 sq. m is fabricated for GSAT 20.
- Completed testing of 60,000 numbers of space grade solar cells for use in panels

Material	Multi junction & Advanced Triple Junction cells
Cell size	3 x 7 cm (1 watt) 8 x 8 cm (2 watt)
Panel size	Typically 1.8 m ² , 3.87 m ² , 5.32 m ² & 6.93 m ²
Voltage	48 V, 80 V



SOLAR PANEL FACILITY ELECTRONICS DIVISION, BENGALURU

Bonding Area 350 sq. m. facility

Temp. 23 ± 2 deg.cel. RH: 55+/-5%
10,000 class

Welding Area 200 sq. m. facility

Temp. 23 ± 2 deg.cel. RH: 55+/-5%
100,000 class



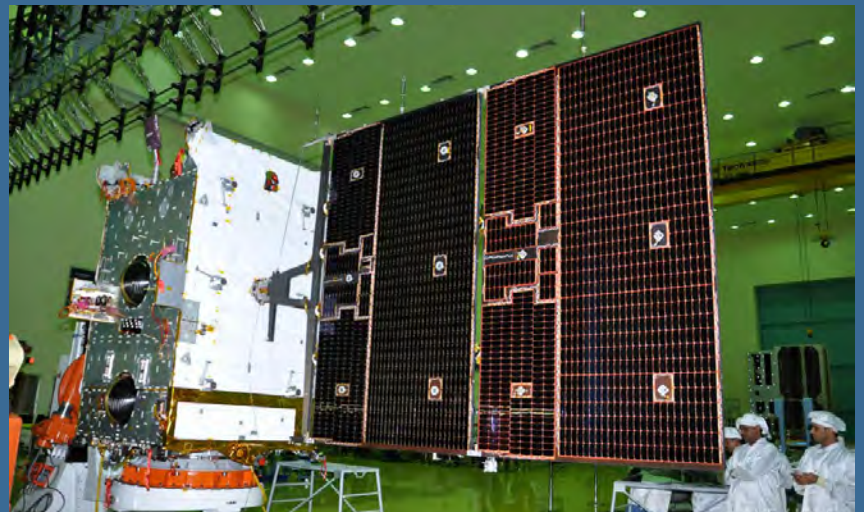
SPACE SOLAR PANEL TYPICAL

Panel area: 5.32 sq. m.

Power: 1kW
(EOL after 15 years)

1500 no of ATJ (Advanced
Triple Junction) Solar cells

Aluminum Honeycomb
substrate





Bharat Heavy Electricals Limited Defence & Aerospace Business Group

Integrated Office Complex, Lodhi Road, New Delhi 110003

www.bhel.com | dabg@bhel.in | +91-11-41793243

