Industrial Gas Turbine Aftermarket Parts, Repairs and Services
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About **PW Power Systems**

PW Power Systems, Inc. (PWPS) is a world leader in developing and manufacturing energy solutions for power generation, offering products for aero-derivative and industrial gas turbines. PWPS offers a full range of maintenance, overhaul, repair and spare parts for other manufacturers’ gas turbines with specific concentration on the high-temperature “F” class industrial machines. PWPS also offers quick turnaround for parts and repair services utilizing the latest in component repair technology licensed from Pratt & Whitney®.

PWPS is committed to providing high-quality solutions for the distributed energy market that increase energy productivity, energy reliability, and operational savings for its customers.
Industrial Gas Turbine New Parts

PWPS has surpassed 3 million hours of accumulated run-time on its hot gas path and combustion new parts.
Production of the highest quality gas turbine parts requires a deep knowledge of operational and equipment performance. PWPS designs and manufactures alternatives to OEM-sourced, large-frame industrial gas turbine (IGT) components. Proven by engine-run hardware, years of experience in component repair and aerospace technology allow PWPS to design new parts that incorporate performance improvements not often considered by the OEMs. In many cases, PWPS prolongs service intervals and even offers guarantees of extended part life.

PWPS develops enhanced product solutions by conducting full analyses and applying reengineered improvements to the design and manufacturing effort. The PWPS approach results in patented innovation and the delivery of product upgrades tailored to customer’s requirements. The design criteria and quality control are derived from standards applied to aerospace engine development. PWPS considers the performance, durability, and reliability of every design feature and apply proprietary alloys and coatings licensed from Pratt & Whitney® to deliver new IGT parts that exceed customer expectations.

PW Power Systems maintains customer satisfaction and confidence that is unparalleled in the industry. Supporting this confidence in PWPS components is the accumulation of over three million hours of trouble-free service in the field.

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**Industrial Gas Turbine Enhanced New Parts**

**Advanced Proprietary Technology Includes:**
- High-temperature technology
- Proprietary alloys
- Metallic coatings
- Ceramic coatings
- Film cooling
- Tip clearance material systems
- Advanced computational modeling techniques

**60 Hertz Portfolio Offerings:**
- Frame 7FA.03 1st, 2nd, and 3rd stage buckets, nozzles, and shroud blocks
- Frame 7FA.03 DLN 2.6 transition pieces, liners, flow sleeves, liner end cap assemblies, and fuel nozzles
- Frame 7EA 1st, 2nd, and 3rd stage buckets

**50 Hertz Portfolio Offerings:**
- High-temperature-class hardware
- STGS-4000F (V94.3Ax) HGP components
  - 1st, 2nd, 3rd, 4th stage blades and vanes
  - 1st and 4th stage turbine guide ring segments

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**Engineering Standard Work**

**The Foundation for Quality**

- **OEM Part**
- **New PWPS Part**
- **Final Definition**
- **Design/Analysis**
- **Systems and Aero Analysis**
Product Development Process

Robust Intellectual Property (IP) Strategy Integrated into Reengineering Design

Product Launch → Metrology → Preliminary Design → Detailed Design → Production

- Engineering Analysis
- Features List
- Prelim IP Assessment
- IP Risk Identification
- IP Due Diligence Process
- Final Clearance
PWPS Experience and Technology
Differentiating from the Competition

Copying vs. Redesigning

Market Data and Source for Parts
Reverse Engineer Existing Parts and Engine Equipment
Enhance Design and System Integration
Manufacturing Development
Validation
Manufacturing and Sourcing

CMM Technology
Optical Technology
Wax Molding
Analysis
IP Risk Analysis

Computational Fluid Dynamics
Durability Analysis
Structural Analysis
Finite Element Heat Distribution Analysis
Materials and Coatings

Production Qualification Processing
Testing and Producibility
Production

Design Toolbox:
- Multi-disciplinary optimization allows for extensive exploration of design options while monitoring many design constraints
- Iterations maximize effectiveness
Industrial Gas Turbine Repairs

PWPS has successfully repaired over 1000 sets of 50 Hz and 60 Hz “F” class components.
PW Power Systems IGT repair activities are directed to our San Antonio Service Center. At this facility, PWPS characteristic level of rigor and competency is extended to the efficient repair of industrial gas turbine components. Each component repair is driven by documented repair procedures, process controls, and inspection methods ensuring the highest quality levels.

A significant investment in equipment and facility improvements has been made over the last several years as PWPS transformed this facility into a dedicated industrial gas turbine facility. These investments in the facility will continue to expand capabilities and help PWPS to retain the best technical talent in the industry.

The vast majority of all repair processing is performed in-house with minimal vendor supported operations. This helps ensure the highest levels of quality and schedule control. On-site process capabilities include, but are not limited to:

- Elevated temperature weld
- Manual TIG weld
- Laser weld
- Vacuum heat treat
- Braze crack repair
- CNC shot peen
- Robotic HVOF plasma coat
- Robotic APS coat
- Grit blast
- Blending
- Airflow
- Water flow
- Digital 450 kV X-ray
- Heat tint
- FPI
- CMM
- Bridgeport machining
- EDM plunge and hole drill
- Submerged ultra sonic inspection system
- Frequency Scanning Eddy Current Test (F-SECT) System
- 5-axis CNC grinding

The technical expertise required to develop and execute advanced IGT repairs resides on-site at PWPS San Antonio Service Center, fortified by the depth and technical resources of over 90 years of turbine engine expertise.
Gated Repair Process

PWPS has successfully repaired over 1000 sets of 50 Hz and 60 Hz “F” class components.

**Strip and Inspect Process Steps:**
- Mark ID and Incoming VIS
- Incoming Photo Document
- Metallurgical Assessment
- Disassembly
- X-ray
- Airflow
- Removal of External Coat
- Chemical or Waterjet Strip
- Heat Tint
- Blend Residual Coating
- Dimensional FPI
- Post Strip Photo Document
- Generate Report
- Customer Review Gate

**Repair Process Steps:**
- Machine and Rout Defects
- Solution Vacuum Heat Treat
- FPI
- Weld Repair
- Blend Repair
- Hot Isostatic Press (HIP)
- Machine and CNC
- Vacuum Heat Treat
- EDM Cooling Holes
- Blend and Deburr
- Grit Blast Clean
- FPI
- Heat Tint
- X-ray
- Airflow
- Water Flow
- Dimensional
- Pre-coat VIS
- Customer Review Gate

**Coat and Finish:**
- Heat Tint
- Internal Aluminum Coat
- Mask for Coat
- HVOF
- Diffusion Vacuum HT
- APS TBC Coat
- Diffusion and Age Vacuum HT
- Deburr Cooling Holes
- Heat Tint
- Shot Peen
- Rail Coat
- Cosmetic Clean
- Airflow
- Water Flow
- X-ray
- Dimensional Inspection
- Final Visual Inspection
- Moment Weigh and Sequence
- Customer Review Gate
Standardized Repair Methodology

TRP – Technical Repair Package:
• Technical requirements
• Defines key characteristics

Router (Traveler):
• Sequenced operational process steps
• Piece-by-piece traceability

Work Instructions:
• Instructions for performing a specific type of operation (blending, welding, moment weight, airflow, etc.)

Technique Sheet:
• Detailed parameters and specific instructions within a work instruction group unique to a specific operation or part

Repair Experience

Engine Types:
• Frame 6B
• Frame 6FA
• Frame 7EA
• Frame 7FA
• Frame 9FA
• Frame 9E
• V84.2
• V84.3A
• V94.2
• V94.3A2/A4
Coatings

State-of-the-art Coatings Extend Part Life

PWPS creates advanced coating systems to refurbish hot section components, provide oxidation and hot-gas corrosion protection, and aid temperature reduction through the use of advanced coating ceramics.

These coatings represent state-of-the-art proprietary materials tailored to meet the unique challenges of industrial gas turbine environments.

Metallic Coatings

<table>
<thead>
<tr>
<th>Oxidation Resistance</th>
<th>Improved Survivability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proprietary Coating</td>
<td>GT29 (baseline)</td>
</tr>
<tr>
<td>PIAI</td>
<td>GT29 Plus</td>
</tr>
<tr>
<td>GT33 Plus</td>
<td></td>
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TMF Cracking Resistance

<table>
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</tbody>
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Relative Durability of TBC Systems

Proprietary Thermal Barrier Coatings (TBC) Offer More Design Flexibility
Industrial Gas Turbine Aftermarket Services

Through its world-class partnerships, PW Power Systems provides these specialized field services.
PWPS provides complete project management, overhaul, and reconditioning of heavy rotating equipment worldwide to support planned and unplanned maintenance activities. The service teams of project managers, technical directors, shop personnel, and consulting engineers enable PWPS to provide true turnkey outage management.

Services provided by our Gas Turbine Aftermarket Services team include:

• Combustion, HGP and major inspections
• Generator inspection and repair
• New and used capital, and consumable parts
• HGP, combustion and compressor repairs
• Technical direction, consultation, and controls engineers
• Labor and supervision
• Control system upgrades
• Full suite of specialty services

Fleet Support for:

7EA, 7FA, 9FA, V94
Compressor Solutions

Compressor Rocking and Shim Migration Issues

The PWPS compressor vane and shim pinning process prevents wear and tear that can lead to costly power plant gas turbine compressor failure.

Compressor Field Issues Observed on Frame 7EA / 7FA / 9E / 9FA:

- Compressor casing groove wear
- Compressor vane shank wear which causes rocking
- Shim migration/ protruding shims which may lead to damage downstream

Compressor Vane Pinning, A Simple and Economical Solution:

- The compressor vanes are clustered together through the pinning technique and re-installed into the case
- Shims, as required to maintain drop dimensions, are held in place with pins, preventing liberation into gas path
- Hook fits and casing groove are inspected

Compressor Vane Pinning Industry Experience:

- Over 200+ gas turbines running with pinned vanes
- Over 100,000 pinned vanes in operation on Frame 7EA, 9E, 7FA and 9FA gas turbines
- 4.5 million fleet hours
- Multiple lead to fleet sets have completed major inspections (50,000 factored fired hours)