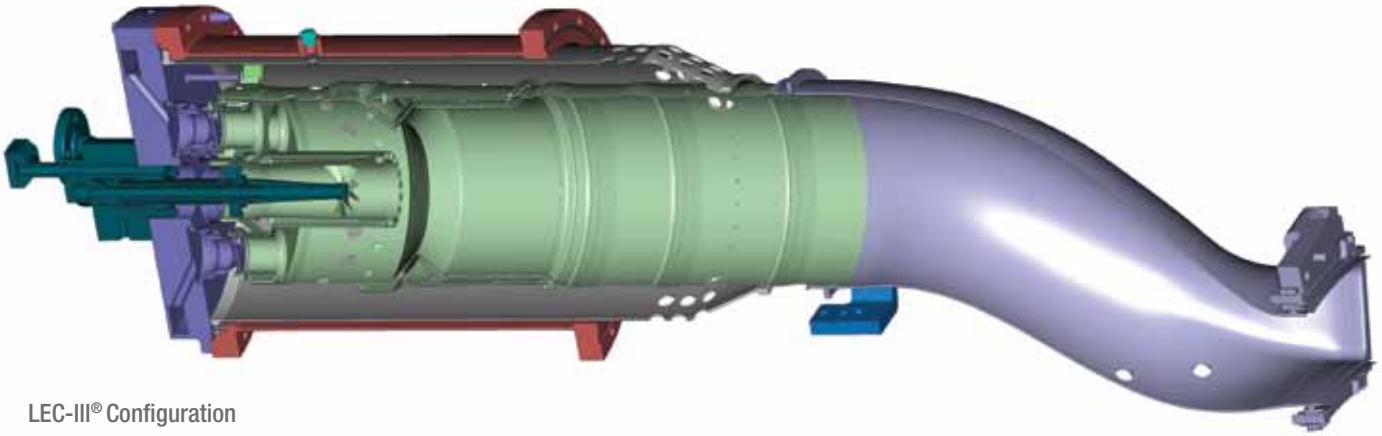
PSM
AN ALSTOM COMPANY ®

LEC-III® 3-5 PPM Emission Combustion Systems for E-Class Gas Turbines

Field Proven 3-5 PPM NOx

The patented LEC-III® combustion technology, developed, and manufactured by Power Systems Mfg., LLC (PSM), guarantees sub-5 parts-per-million (ppm) NOx emission levels when operated on natural gas over the entire premix operating range, from baseload down to 80% relative load (respectively 50%-60% with Inlet Bleed Heat system). CO emissions under these conditions are typically measured in the low single digits to meet customer requirements.



LEC-III® Configuration

Drop-In, Conversion, or Individual Parts Replacement

The LEC-III® system was developed for implementation in B & E-class gas turbines, including Frames 6B, 7B/EA, 9E, and W501B6/D5, either as drop-in replacements for existing OEM DLN1 systems, or as complete conversions from standard diffusion combustion systems. No changes to the control systems are needed for vintages Mark V and higher. Operators of DLN1 combustors also have the option to individually replace their OEM system components with PSM's LEC-III® parts.

Fuel Air Mixing is the Key

Thorough and efficient premixing of the fuel and air prior to the combustion process is the key to both low NOx and CO emissions in the PSM LEC-III® combustion system. Three key design features in the LEC-III® combustion system enable this improved process and fundamentally differentiate the LEC-III® from the OEM design: the forward flowing venturi, effusion cooling technology, and an advanced secondary fuel nozzle (SFN).

Summary of Design Features (Forward-Flowing Venturi Design)

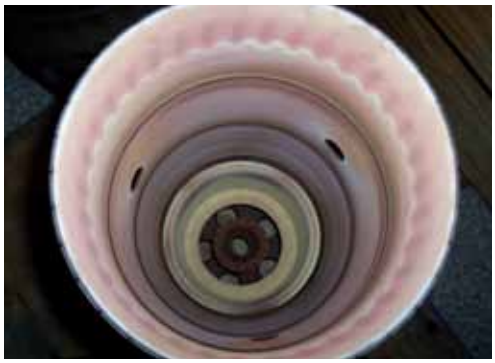
The venturi acts as the main flame anchor while the combustor is operating in premix mode. The OEM venturi design dumps spent cooling air at the aft end of the venturi to surround and mix with the reacting/combustion gases. This works to cool down local reaction temperatures which prevents CO from completely oxidizing to CO_2. PSM has taken a different approach.The PSM forward-flowing venturi design injects the cooling air at the downstream/aft end of the venturi, which flows toward the primary zone and eventually discharges into the premixer where it combines with the fuel and air mixture prior to combustion. This not only results in a leaner fuel-air mixture which produces less NOx, but significantly reduces CO levels.

Effusion Cooling Technology

Effusion cooling uses both conduction and convection and allows a more efficient use of available combustion air than the OEM configuration, which relies on a slot cooled impingement method. Because less air is used to cool the liner when compared to the OEM, more air can be mixed into the bulk fuel/air mixture via the premixer dilution holes, resulting in better mixing and a leaner combustion mixture which reduces NOx generation.

Advanced Secondary Fuel Nozzle Design

The patented Fin Mixer SFN design was developed to eliminate the nozzle tip pilot fuel, a requirement in the current OEM combustion design to control combustion dynamics. This has eliminated a small but very hot tip burning zone which is responsible for a disproportionate amount of NOx formation.



6B LEC-III® liner at 14kh

LEC-III® System Components

Liner & Flow Sleeve

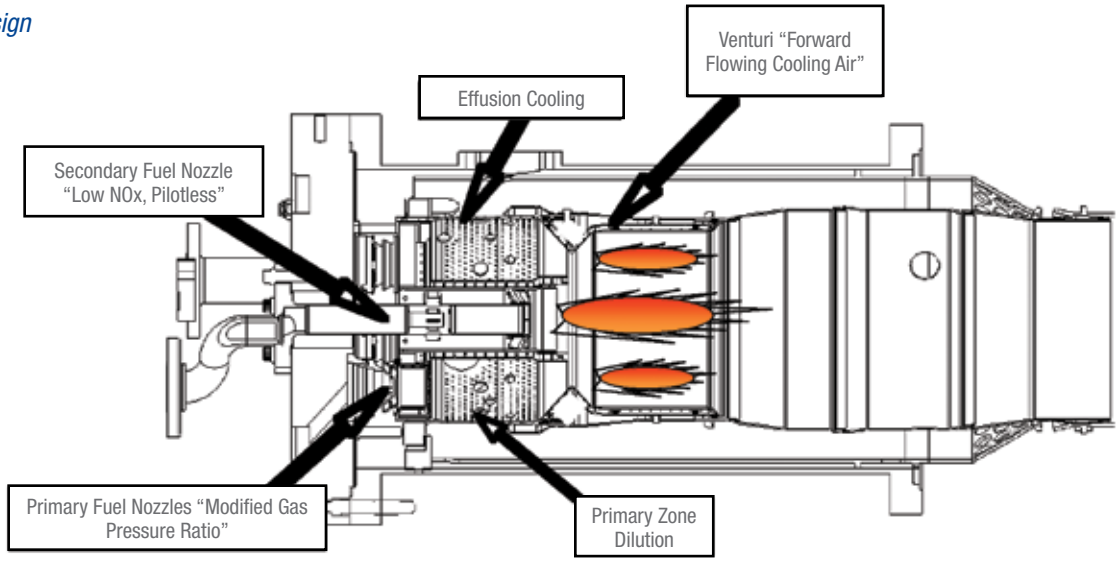
PSM's LEC-III® liner design has consistently demonstrated less than 5ppm NOx and less than 2ppm CO emissions in over 40 field installations (when installed as a complete system). The design incorporates improved manufacturing techniques and thus tighter manufacturing tolerances to reduce combustor dynamics, minimize liner-to-liner flow variation for minimal exhaust temperature spreads, improve assembly fit-ups, and improve overall system performance.

Design features & benefits:

- Advanced high-temperature alloys and manufacturing methods used
- Cast internal swirler (vs. brazed assembly) for reduced costs and increased durability and dimensional repeatability
- Thermal barrier coating standard on all hot gas path surfaces
- Anti-rotation feature incorporated to eliminate wear and fretting of PFN-to-liner interface
- Designed for repairability/maintainability: Modular construction and tight tolerance control on all interface components
- Aerospace tolerances held on critical dimensions to achieve ±0.25% flow variation
- Unique design minimizes flow variation and engine hot/cold streaks
- Exhaust temperature spreads reduced from <80°F typical to <50°F typical at base load

Liners are designed for maximum compatibility with the DLN1, and are available for Frames 6B, 7B/EA, 9E, and SW501B/D. Consult PSM for the specifics of your application.

Forward-Flowing Venturi Design



Designed for Extended Durability

PSM has also addressed all demonstrated areas of wear on the LEC-III® design. The design incorporates hard-facing and wear resistant materials/ coatings of critical interface components such as Hula Seal, Bullhorn Brackets, and T-lugs, which helps minimize wear and allows inspection intervals of 24,000 Hrs and beyond.

Primary Fuel Nozzle (PFN) Assembly

PSM's PFNs adhere to aerospace tolerance requirements. Fuel holes are specially processed to achieve ±0.25% flow variation when assembled. This results in reduced emissions and combustion dynamics, lower exhaust temperature spread, and enhanced turbine durability. Hard-face coating at the interface between the fuel nozzle and liner floating sleeve helps minimize wear and extends product life. A simple modification to the DLN1 end cover allows full compatibility with the PSM PFNs.

Design features & benefits:

- Chrome-plated threads provide anti-seize resistance
- Hard-faced coating at PFN-liner interface
- Ultra-tight aerospace tolerances on critical dimensions
- Spec sheets with flow data delivered with each nozzle
- Reduced sensitivity to flow variations, erosion, and fuel system deposits
- Combustion covers are manufactured to ±0.5% flow variation
- Improved seal design to eliminate leaks at PFN-cover interface

PFNs are fully compatible with the DLN1 through minor modification, and are available for Frames 6B, 7B/EA, 9E, and SW501B/D. Consult PSM for the specifics of your application.

Secondary Fuel Nozzle (SFN) Assembly

PSM's patented SFN design features a unique design for improved fuel distribution and mixing. SFN is 100% premixed for greatly reduced emissions while maintaining superior flash back/flame holding resistance. Improved dimensional tolerancing and wear resistant coatings have virtually eliminated wear against the liner. The unit comes standard with a replaceable fuel nozzle tip, greatly reducing maintenance costs.

Design features & benefits:

- Improved mixing for significantly reduced NOx emissions
- Integrated design approach for ease of manufacturing and repairability
- Aerospace tolerances on critical dimensions, with special emphasis placed on mating parts
- Cobalt wear coating applied to tip to resist wear with liner

Secondary Fuel Nozzles are designed to be fully compatible with the OEM.

Transition Piece

PSM's transition piece is constructed from advanced Nimonic alloy for improved high temperature strength. TBC is applied for improved durability and extended component life. Enhanced cooling has been included to further extend the useful life of the product by greatly reducing creep. All wear features and inserts are made of L605 material. The recently introduced transition piece design for Frame 7EA features a thermally free mounting system that significantly improves component durability. PSM's transition pieces are available for Frames 6B and 7B/EA and are designed to be fully compatible with the DLN1.

As of today, PSM has consistently demonstrated 3-5 ppm NOx at low single-digit CO levels in over 40 installations worldwide. Please contact PSM for installation references.

Component Compatibility	
Liner/Flow Sleeve	6B, 7B/EA, 9E
PFN/Cover Assembly	6B, 7B/EA, 9E
SFN Assembly	6B, 7B/EA, 9E
Transition Piece	6B, 7B/EA
System Compatibility	
LEC-III® Drop-In	6B, 7B/EA, 9E
LEC-III® Conversion	6B, 7B/EA, 9E, 501B/D

Outage/Maintenance Impacts

For "drop-in" conversions (existing DLN1), the LEC system is installed during a CI in the same way as a replacement/spare set would be installed. Installation procedures, tooling, lead-times, etc. are exactly the same. Additionally, for a drop-in, zero control changes are required. Refurbishment methods are consistent with current DLN1 processing with the exception of a required venturi flow. PSM provides maintenance and refurbishment documents along with parts delivery. Achieving low emissions cannot be easier.

LEC-III® – PSM's reponse to Ultra-Low Emission Needs

Since 1998, with the introduction of PSM's first LEC generation, PSM has continuously developed new combustion technology to drive emissions to ultra-low levels. These patented and innovative technologies have allowed the current LEC-III® systems to operate successfully to as low as <3ppm NOx operating on natural gas, with low single-digit CO, low combustion dynamics, and a large range of compliant turndown from base load conditions.

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