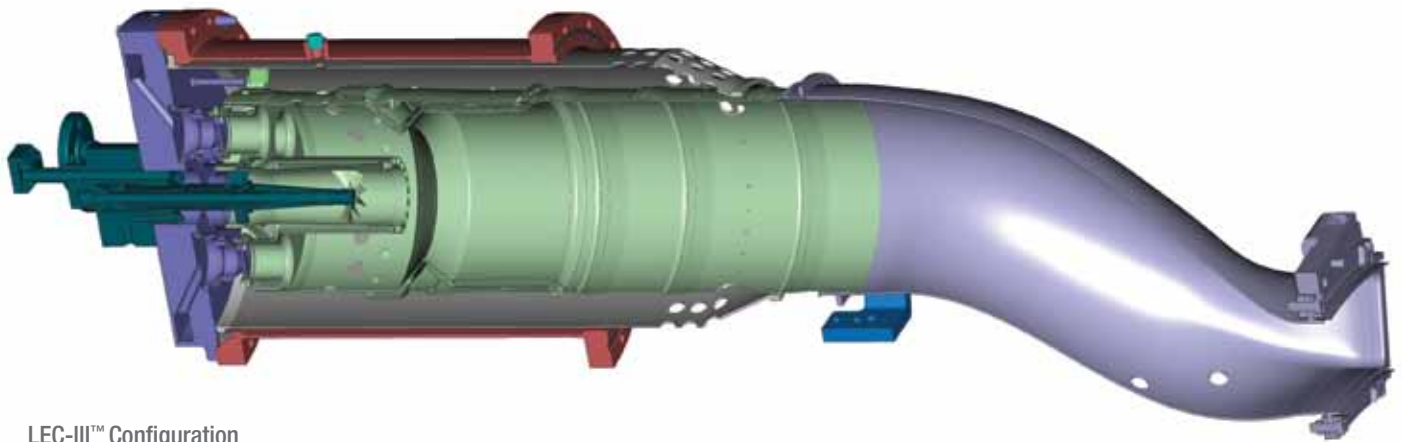


LEC-III™ 3-5 PPM EMISSION COMBUSTION SYSTEMS FOR E-CLASS GAS TURBINES

Field Proven 3-5 PPM NOx

The patented LEC-III™ combustion technology, developed and manufactured by 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 an 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 gradually replace their OEM system 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:

- + Forward flowing venturi
- + Effusion cooling technology
- + Advanced secondary fuel nozzle (SFN)

Main Features and Technical Concepts

Design Features

Forward-Flowing Venturi Design

The venturi acts as the main flame anchor while the combustor is operating in premix mode. While the OEM venturi design dumps spent cooling air directly into the core combustion gas flow to mix with the hot combustion gases and prevent CO from completely oxidizing to CO₂ in the available residence time, PSM has taken a different approach. The PSM forward-flowing venturi design injects the cooling air at the downstream end of the venturi, flowing toward the primary zone and then releasing it into the premixer where it joins with the fuel and air mixture prior to combustion. This not only results in a leaner fuel-air mixture which produces less NO_x, but also prevents chilling the combustion gases as they exit the premix combustion zone, significantly reducing the formation of CO at lower load operation.

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 of this air can be mixed into the bulk fuel/air mixture via the premixer dilution holes, affording better mixing and allowing the combustion mixture to burn leaner which reduces NO_x 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, thus eliminating the relatively small tip burning zone which is responsible for a disproportionate amount of NO_x.



6B LEC-III™ liner at 14kFFH (Factored Firing Hours)

LEC-III™ System Components

Liner & Flow Sleeve

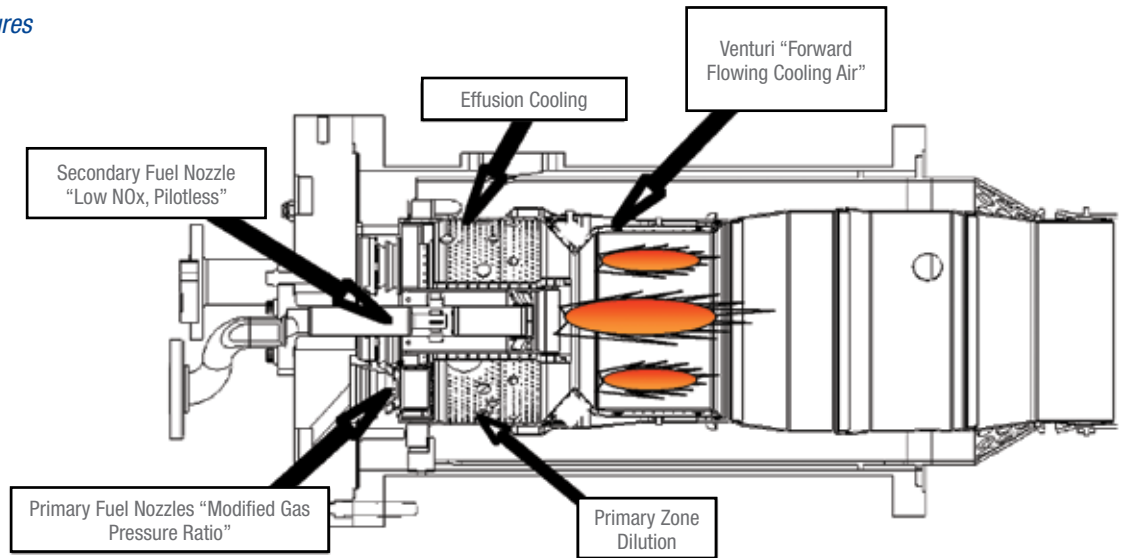
PSM's LEC-III™ liner design has consistently demonstrated less than 5ppm NO_x and less than 2ppm CO emissions in over 40 field installations (when installed as a complete system). The design incorporates improved manufacturing techniques and thus tighter manufacturing tolerances to reduce combustor dynamics, minimize liner-to-liner flow variation for minimal exhaust temperature spreads, improve assembly fit-ups, and 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 reparability/maintainability: Modular construction and tight tolerance control on all interface components
- + Aerospace tolerances held on critical dimensions, e.g. cooling holes are drilled to $\pm 0.002''/50\mu\text{m}$ tolerance to achieve $\pm 0.25\%$ flow variation
- + Unique design minimizes flow variation and engine hot streaks
- + Exhaust temperature spreads reduced from $<70^\circ\text{F}/<39^\circ\text{C}$ typical to $<50^\circ\text{F}/<28^\circ\text{C}$ typical at base load

Liners are designed for maximum compatibility with the DLN1, and are available for Frames 6B, 7B/EA, 9E, and W501B/D. Consult PSM for the specifics of your application.

LEC-III™ Technology Features



Designed for Extended Durability

PSM has also addressed all demonstrated areas of wear on the LEC-III™. The design incorporates hard-facing of critical interface components such as Hula Seal, Bullhorn Brackets, and T-lugs, which helps minimize wear and allows inspection intervals of up to 24kFFH and beyond.

Primary Fuel Nozzle (PFN) Assembly

PSM's PFNs adhere to aerospace tolerance requirements. Fuel holes are specially processed to $\pm 0.001"/25\mu\text{m}$ and achieve $\pm 0.25\%$ 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
- + All holes configured for reduced sensitivity and longer life
- + Reduced sensitivity to flow variations, erosion, and fuel system deposits
- + Combustion covers are manufactured to $\pm 0.5\%$ 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 W501B/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 axial/radial/circumferential fuel distribution and mixing, resulting in a 25% reduction in fuel/air mixing distance for optimized fuel distribution,

reduced emissions, and improved flash back/flame holding resistance. Improved dimensional tolerancing eliminates interference and wear against the liner. The unit comes standard with a replaceable fuel nozzle tip, drastically reducing maintenance costs.

Design features & benefits:

- + Improved mixing for better flash back resistance and reduced NOx emissions
- + Designed for reduced internal mach numbers to eliminate fuel coking in nozzle body
- + Integrated design approach for ease of manufacturing and reparability
- + Aerospace tolerances on critical dimensions, with special emphasis placed on mating parts

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. Cooling augmentation has been included to further extend the useful life of the product. PSM's transition piece features L605 wear inserts and has been designed with a thicker wall for resistance to creep and bulging. 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 close to 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

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, combustion dynamics, and turndown from base load conditions. In the United States, governmental regulations force most new base load gas turbine based power plants to have NOx emissions levels no greater than 2.0 to 2.5ppm. This has forced the industry to install devices such as SCRs as their existing gas turbine combustion technology cannot operate even close to these levels. PSM recognizes that significant power plant life cycle costs can be realized if SCRs are not required to achieve these emission levels and has developed its Emissions Reduction Roadmap to drive to NOx levels below 2ppm with LEC-III™ technology.

In cases where a liquid fuel capability is required as back-up, PSM can offer a dual-fuel design of the LEC-III™. Further, the LEC-III™ combined with other upgrades like power augmentation (with steam or water) and Inlet Bleed Heat (IBH) system.

Power Systems Mfg., LLC 60Hz Market

1440 W. Indiantown Rd. P +1-561-354-1100
 Jupiter, FL 33458 USA F +1-561-354-1199
www.psm.com

50Hz Market

c/o Alstom (Switzerland) Ltd P +41 56 205 7222
 Brown Boveri Strasse 7 F +41 56 205 9580
 5401 Baden, Switzerland

