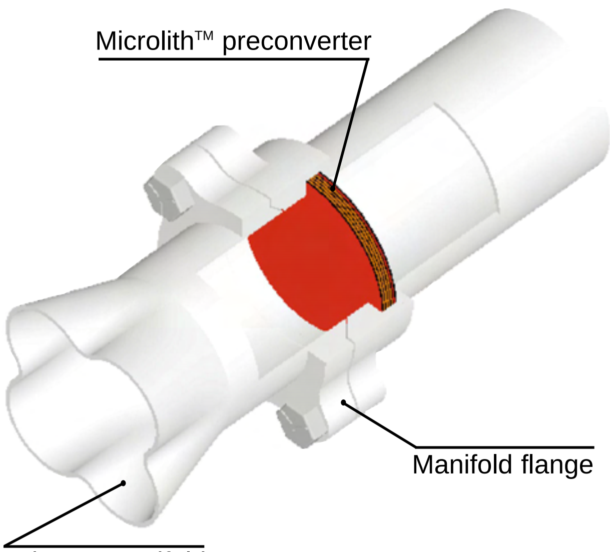
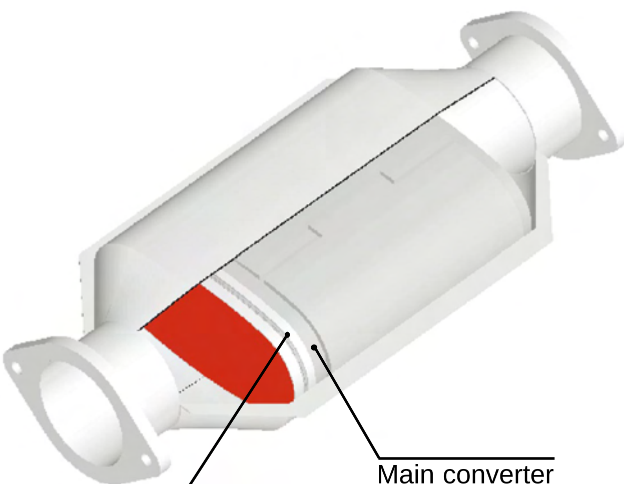
Configurations





The small size of the coated metallic substrate allows design flexibility in positioning and mounting the preconverter.

The Practical Solution

- Retains simplicity of exhaust system - no energy addition required
- Adapts readily with existing systems - hardware modifications minimized
- Reduces total converter size and catalyst use
- Minimizes pressure drop penalty
- Metallic substrate facilitates mounting design options
- 50,000 mile durability and ULEV performance demonstrated

Microlith™
A Division of Precision Combustion, Inc.

Clean power solutions for the 21st Century.

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Microlith™

Automotive preconverters for LEV/ULEV

RAPID LIGHTOFF

Low thermal mass
High heat transfer coefficient

HIGH CONVERSION EFFICIENCY

High geometric surface area
High mass transfer coefficient

RUGGED, COMPACT DESIGN

Passive system
Shock resistant, high temperature metal substrate

Precision Combustion, Inc. (PCI) has developed a lightweight, high-efficiency catalytic converter based upon a novel reactor engineering design. The advantages of the preconverter are derived from an atypical substrate structure and the use of a novel catalyst coating process. This passive preconverter in conjunction with a conventional main converter offers a simple yet elegant solution to reducing cold start emissions and achieving LEV/ULEV goals.

Physical Characteristics

The converter substrate consists of an assembly of multiple Microlith™ elements each with extremely short channel lengths and high cell density, resulting in high geometric surface area. Comparison with conventional substrates is presented here. (1)

CHARACTERISTICS	***Microlith™ Substrate***	***Ceramic Substrate***	***Metal Substrate***
Cell Density (cpsi)	2500	350	400
Wall Thickness (mm)	0.076	0.14	0.05
Hydraulic Diameter (mm)	0.14	0.304	---
Open Frontal Area (%)	72	80	91
Specific Heat Capacity (J/gK)	0.47	0.76	0.42
Geometric Surface Area (m^2/L)	6.30	2.64	3.46
Channel Length (cm)	0.005-0.02	5-15	5-15

Auto Emissions Test Summary

FTP tests were conducted on a 1.9L Ford Escort at Ford APTL. The prototype assembly consisted of a small Microlith™ preconverter and a ceramic main converter. Aging was performed as per the Ford 4-mode aging cycle at 950°C inlet temperature. ULEV was demonstrated with and without secondary air (1). Data from 50,000 mile dynamometer aged prototypes are summarized here.

EMISSIONS	***NMHC gms/mi***	***CO gms/mi***	***NO_x gms/mi***
With secondary air	0.024	0.36	0.094
Without secondary air	0.038	0.554	0.068
STANDARDS			
ULEV - 0-50k	0.04	1.7	0.2
ULEV - 100k	0.055	2.1	0.3

Advanced Technology Catalytic Converter

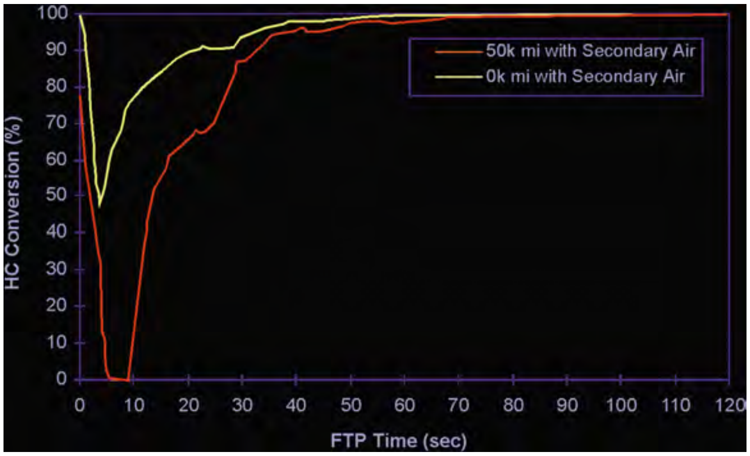
[1] SAE Paper 971023

14 February 1997

Test Results

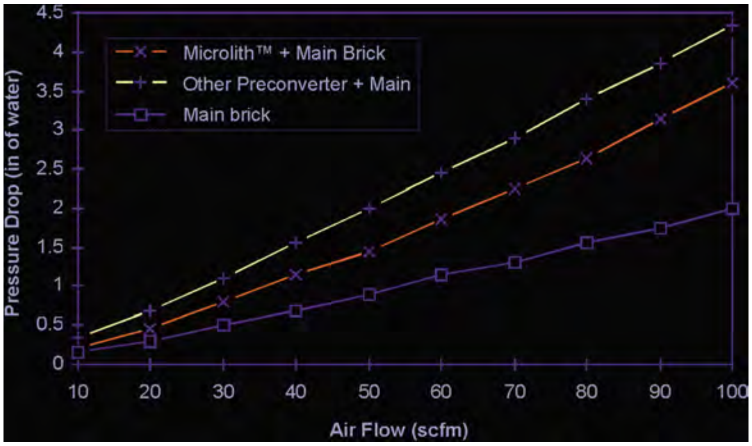
Rapid Thermal Response

Temperature profile after 50k miles of aging shows that the preconverter closely tracks the inlet gas temperature due to its low mass and enhanced heat transfer characteristics.



Fast Lightoff

Hydrocarbon (HC) conversion efficiency curves for fresh stabilized and 50,000 mile dynamometer aged prototypes show lightoff within 15 seconds.



Low Pressure Drop

Cold flow pressure drop data indicate minimized pressure drop penalty. Automotive tests confirm these results.

Durability and High Temperature Capability

The substrate is made from a high temperature alloy capable of continuous operation at 1050°C and periodic excursions to 1200°C. Multiple 50,000 mile engine aging tests have been performed to evaluate aging effects and demonstrate durability. ULEV performance after aging have been achieved with low deterioration factors. Preliminary hot vibration testing indicated no substrate or mounting deterioration.

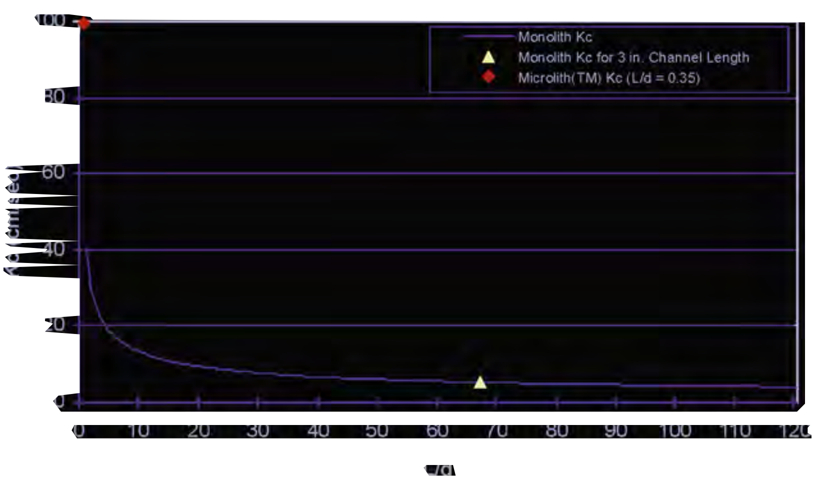
The Techology

High Mass Transfer Rate Results in High Conversion and Small Size

Conversion rates of conventional monolithic reactors after lightoff are inhibited by the growth of a boundary layer along the walls of the monolith channels, which limits the mass transfer rate. This boundary layer growth results in a rapid decrease of the mass transfer coefficient (kc) along the length of the channel. 10mm into a 400cpsi monolith the mass transfer coeffient is almost 10 fold lower than that for Microlith™ (see graph below). This means that the rate of catalyst-pollutant interaction, which is vital for pollutant conversion, is severely suppressed in the long path length channels in conventional substrates. *The Microlith™ substrate, with channel lengths of ~0.1mm and over twice the geometric surface area, achieves an order of magnitude improvement in catalyst-pollutant interaction.* This is also beneficial due to the reduced potential of breakthrough emissions at high converter space velocities, such as during US-06 operation and hard acceleration. Comparative laboratory tests between monolith and Microlith™ substrates have shown that with a 20-fold reduction in converter volume, the Microlith™ delivers equivalent mass transfer-limited conversion.

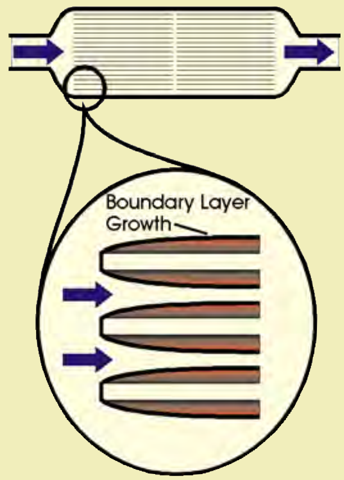
High Heat Transfer and Low Thermal Mass Results in Rapid Lightoff

The heat-up of a catalytic converter during cold start of an engine occurs first through heat transfer from the warm exhaust gas and then, as the catalyst becomes active, through heat generated in the exothermic reactions at the surface. *The reduced boundary layer on the Microlith™ substrate and the higher unit geometric surface area (2500 cells/in^2) causes an order of magnitude increase in the convective heat transfer coefficient resulting in rapid heat up.* Additionally, because a smaller size is needed to achieve the same conversion under mass transfer-limited conditions, there is a much smaller thermal mass to heat up before the catalyst becomes active. Another advantage of this new substrate is derived from being segmented, resulting in a much reduced rate of axial heat conduction compared to a monolith. Therefore, the first element heats up both from the warm exhaust gas and by the exothermic catalytic reactions without being "weighted down" by the thermal sink of the downstream catalyst. *In this way each element can lightoff independently of those downstream, thereby creating a cascading effect.* This results in significantly improved lightoff times.



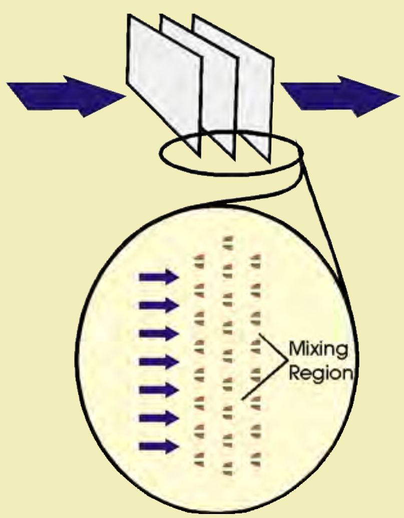
Conventional Substrates

Boundary layer growth inside channels limits conversion in conventional monolithic converters.



Microlith™ Substrate

Multiple, low thermal mass, short metal monolith (Microlith™) substrates with enhanced heat and mass transfer, inter-element mixing and boundary layer breakup - improves lightoff and conversion efficiency.



Mass Transfer Coefficient

The short channel length and the higher geometric surface area of the Microlith™ allows a 10 fold increase in catalyst-pollutant interaction.