Microwave Regeneration of Diesel Particulate Filter

Tae-Hoon Kim, Dan Rutman, Sameer Pallavkar, Jerry Lin, and Thomas Ho

Department of Chemical Engineering
Lamar University, P.O Box 10053, Beaumont, TX 77710

AIChE Annual Meeting

November 6, 2007

Introduction

- Diesel Engine Attributes
  - Excess Air Combustion
  - Better Fuel Economy Than Gasoline Engines – 30% Fuel Savings
  - Low Hydrocarbons and CO_2 Emissions

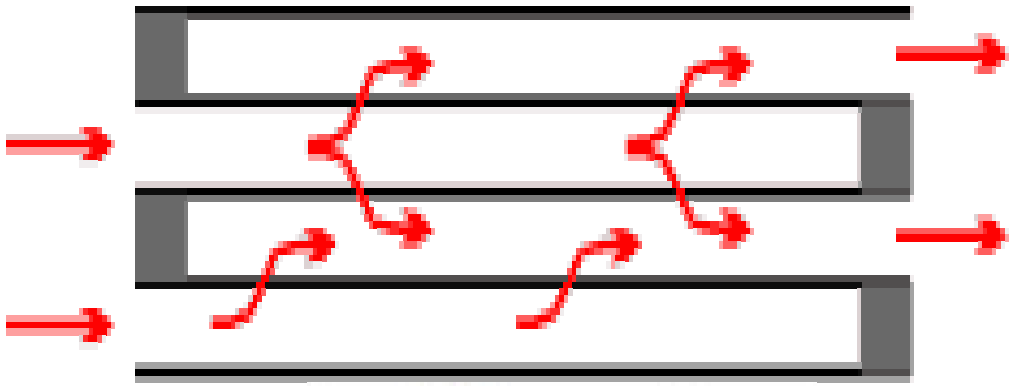
- Diesel Engine Emissions
  - High DPM (Diesel Particulate Matter) and NOx emissions
  - Chronic Environmental and Health Concern
  - Emission Standards Being Tighten Continuously
  - Efficient DPM control by Diesel Particulate Filter (DPF)
  - Regeneration of DPF required

- Current Study
  - Regeneration of DPF using Microwave

Wall-Flow Diesel Particulate Filter

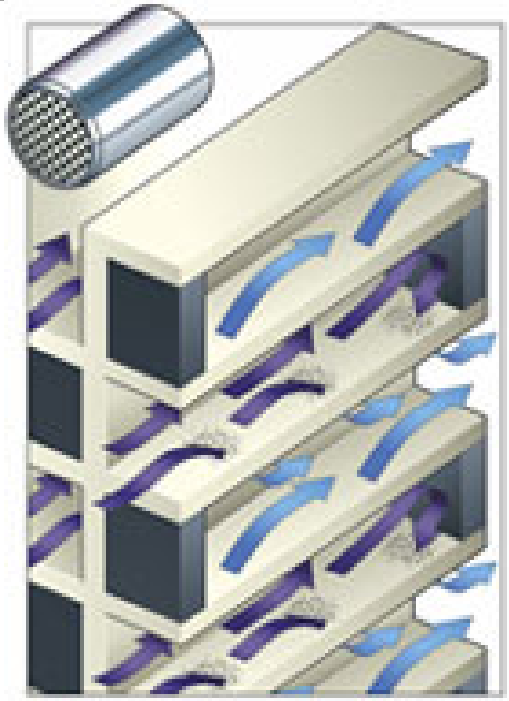
DPF

Exhaust Flow In



Exhaust Flow Out

(Dieselnet)



DPF Regeneration

Current Technologies

- Passive Regeneration with Diesel Oxidation Catalyst (DOC)
  - DOC upstream of DPF
  - $NO + ½\ O_2 \rightarrow NO_2$ (NO Oxidation)
  - $NO_2 + C \rightarrow NO + CO$
  - $NO_2 + C \rightarrow ½\ N_2 + CO_2$
- Active Regeneration (Supply Heat)
  - Additional Fuel Burning
  - Electrical Heating
  - Plasma Heating
  - Microwave Heating
    - Associated with thermal shocks and hot spots
    - Attributed with uneven regeneration

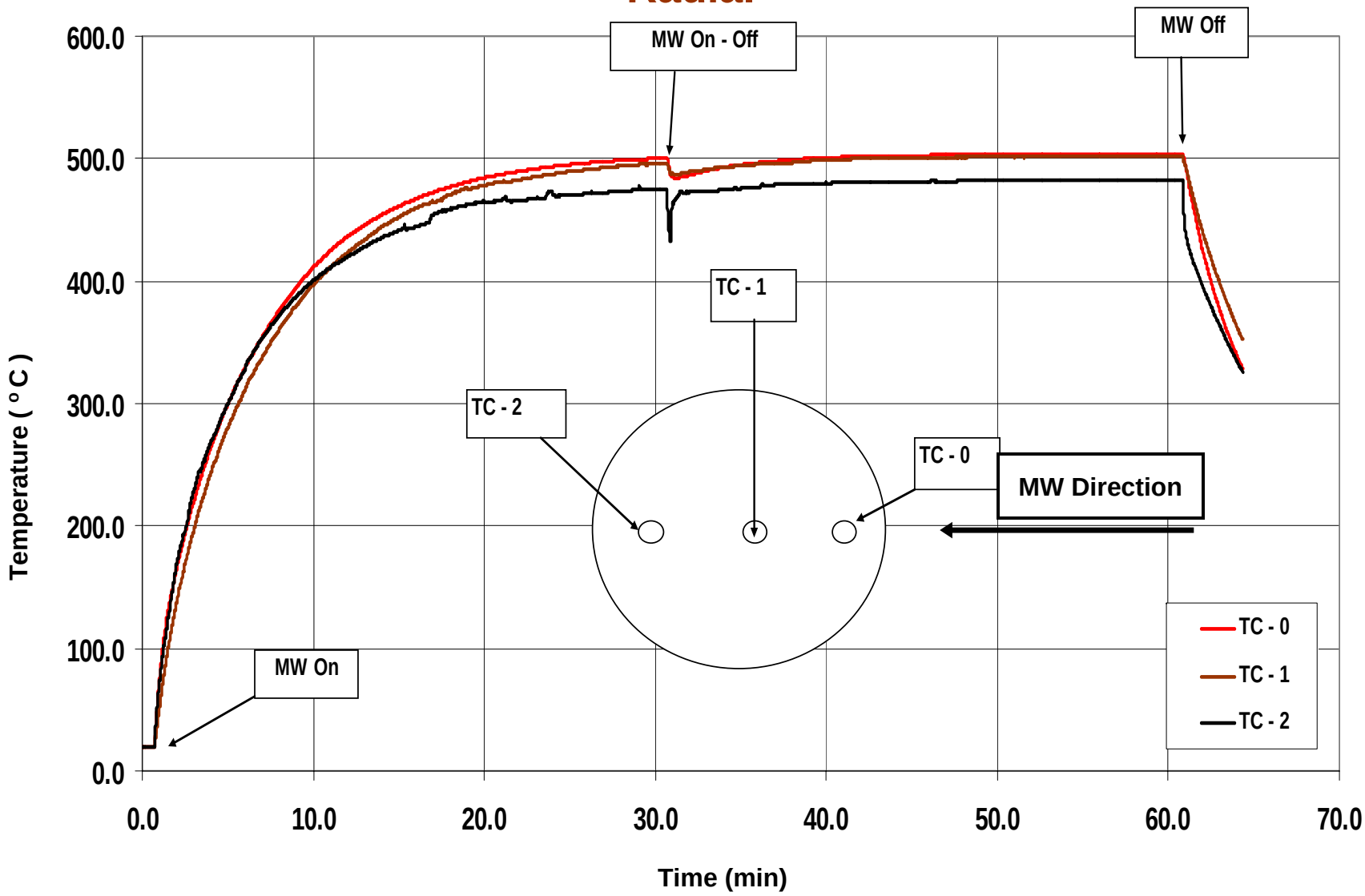
Objectives

- Characterization of Microwave Regeneration
  - Silicon Carbide Wall-Flow DPF
  - Microwave Regeneration Efficiency
  - Differential Pressure Drop, CO and Temperature

- Demonstration of Waveguide Design
  - Uniform Radial and Vertical Temperature Profiles
  - Elimination of Thermal Shocks and Hot Spots
  - Prevention of Physical Damages to the DPF

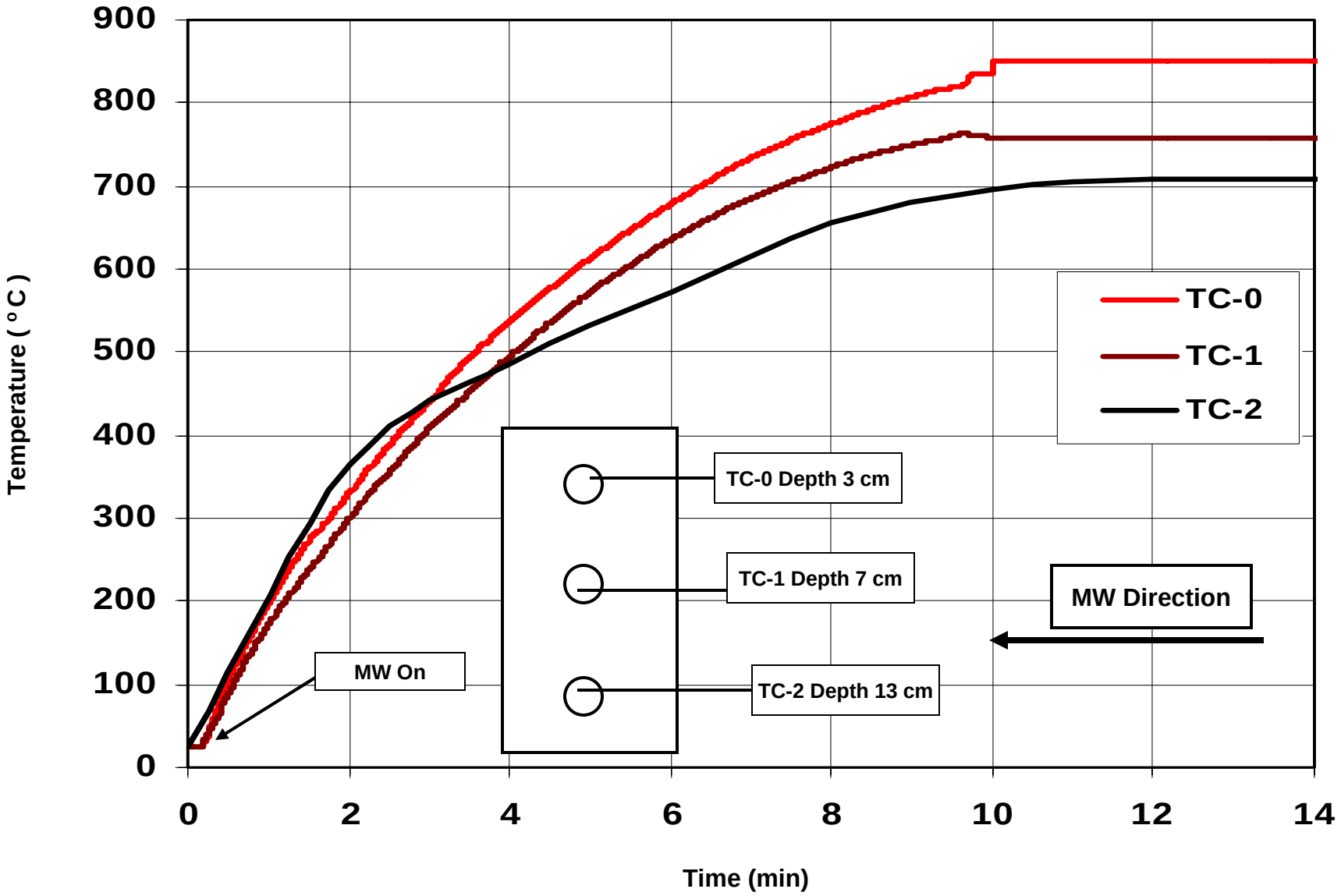
Temperature Profile

Radial

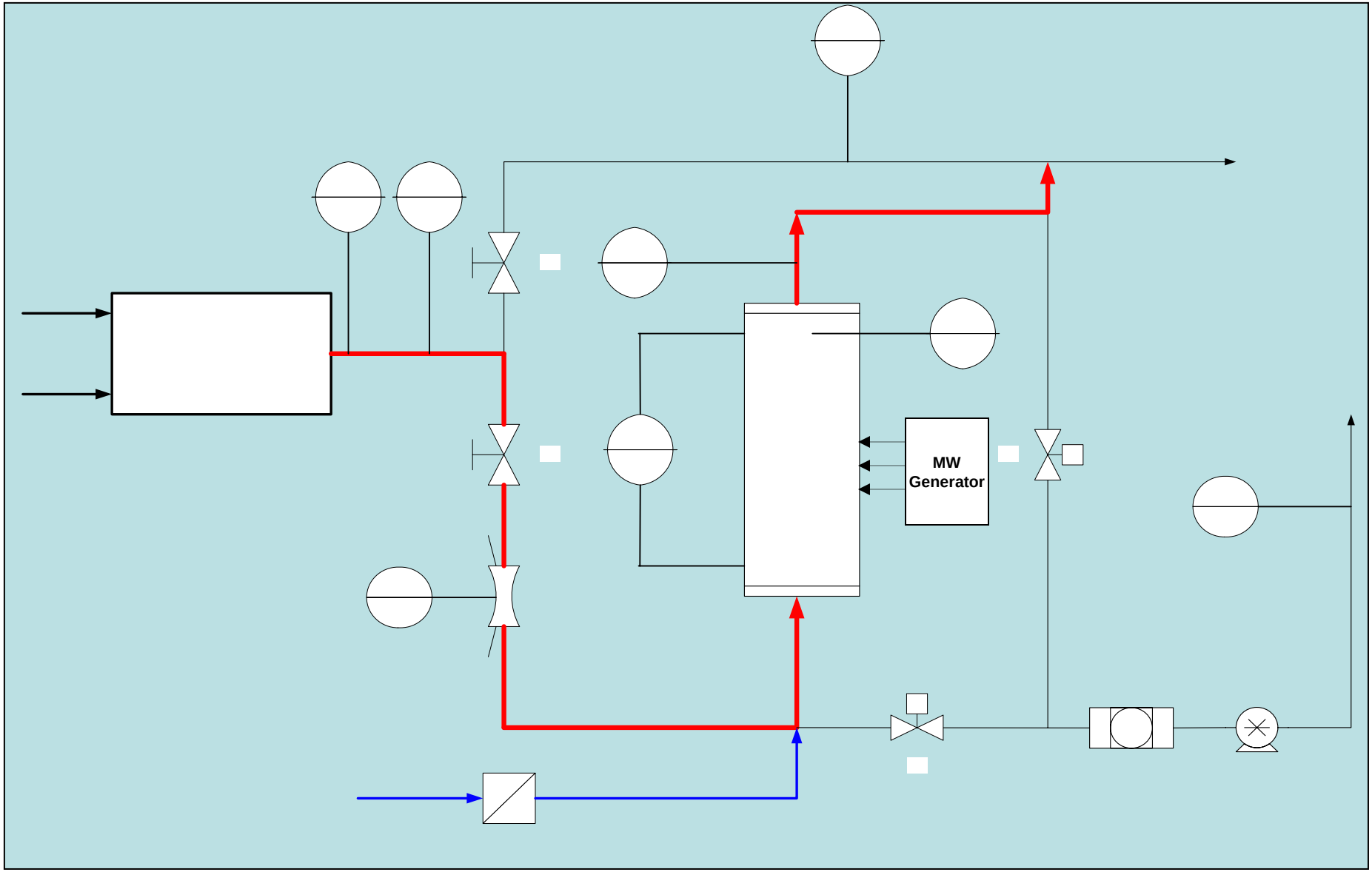


Temperature Profile

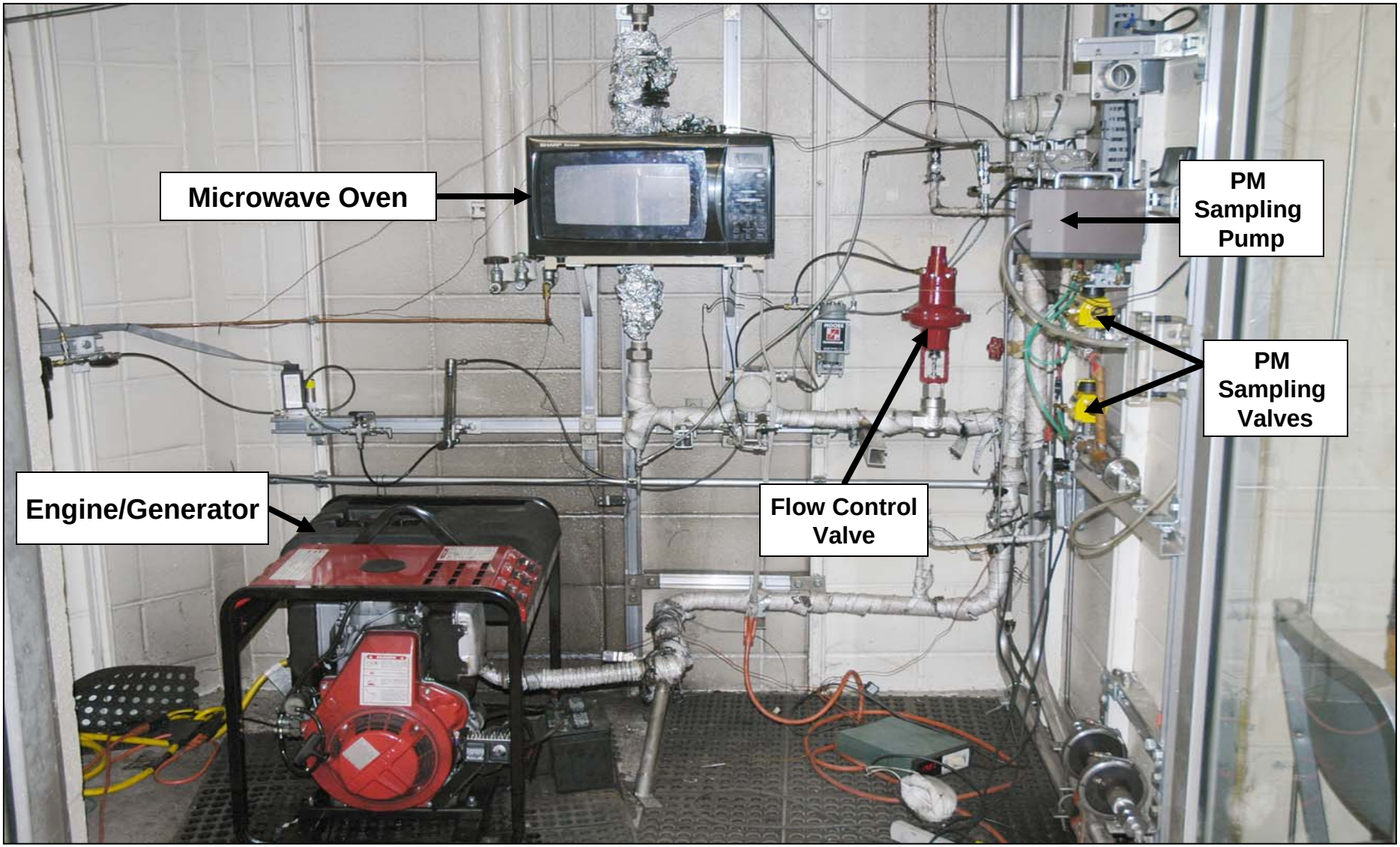
Vertical



Experimental Set-Up

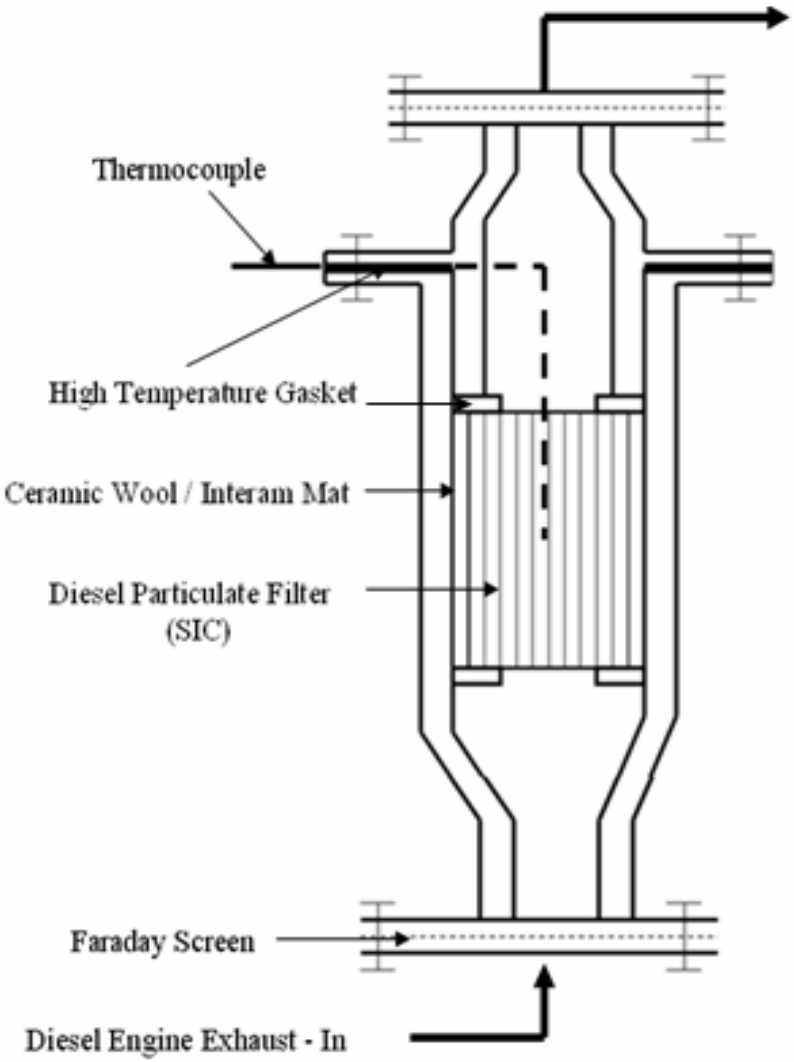


Experimental Set-Up



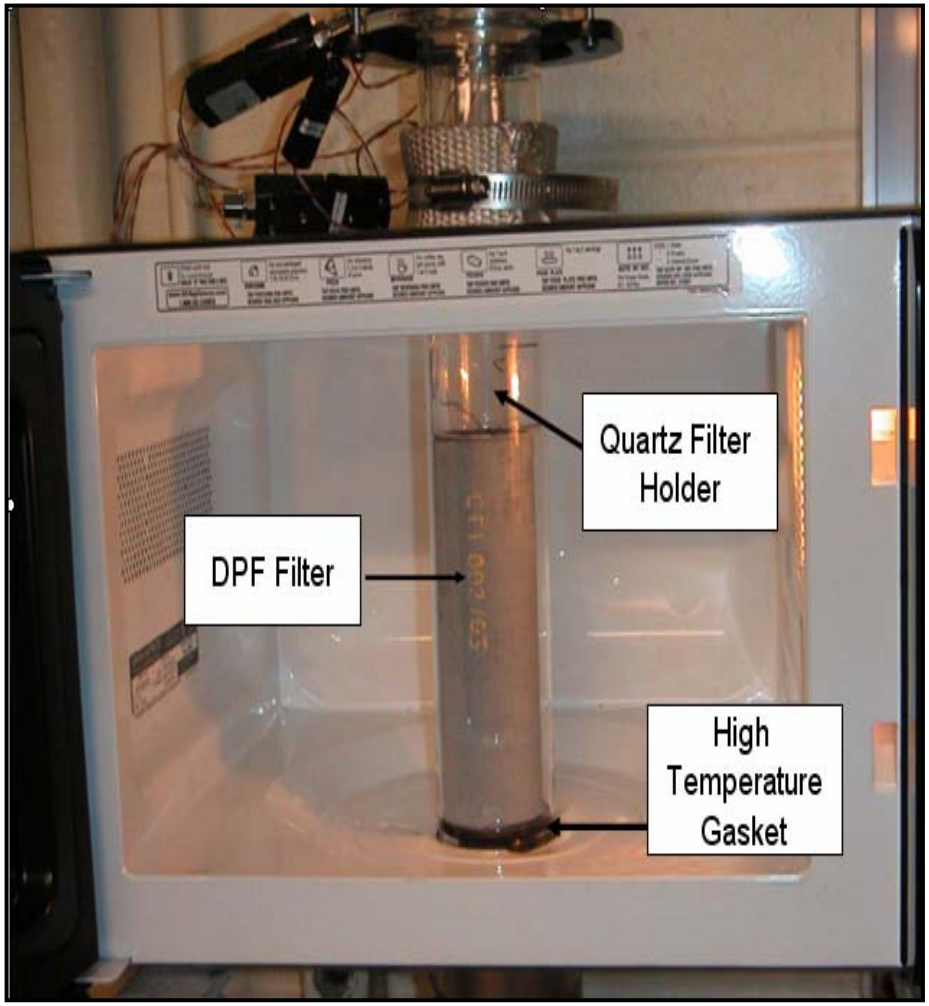
Experimental Set-Up

DPF Holder Schematic

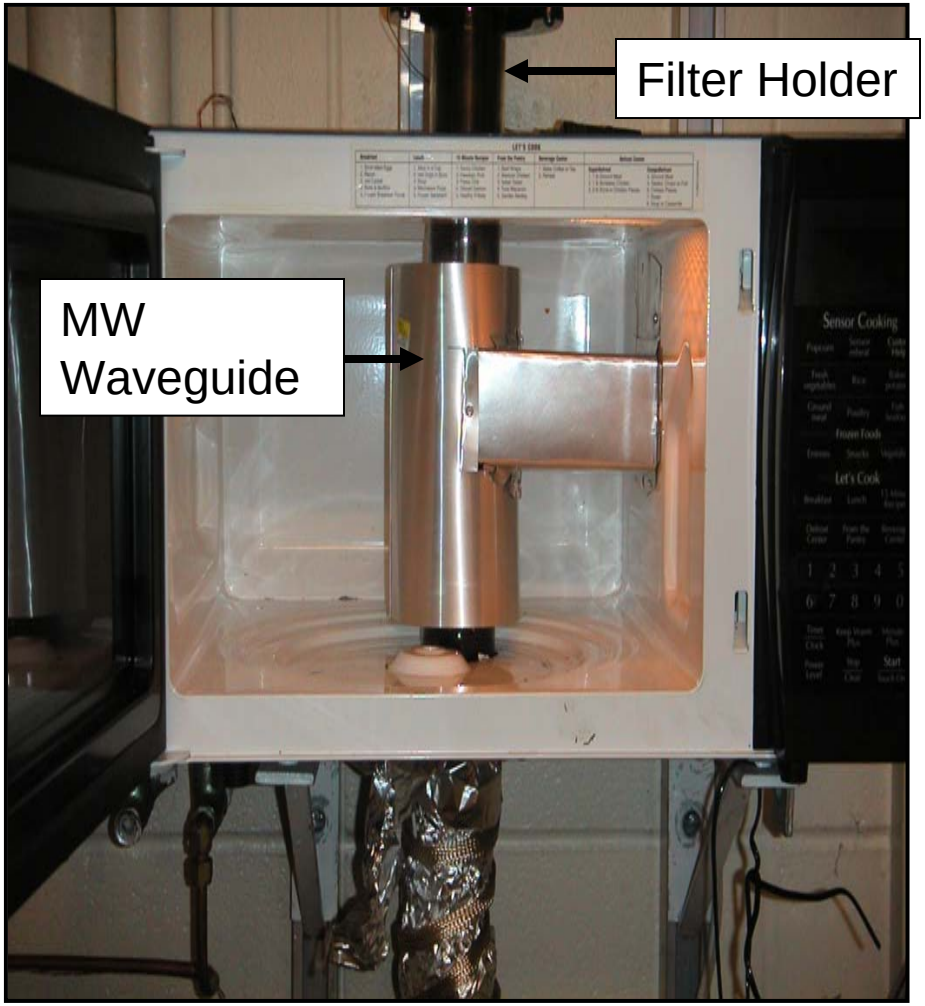


Material	100 % SiC
Cells / in^2	150
Cell size, wall width (mm)	1.6 X 1.6
Diameter (mm)	50
Length (mm)	150

Experimental Set-Up

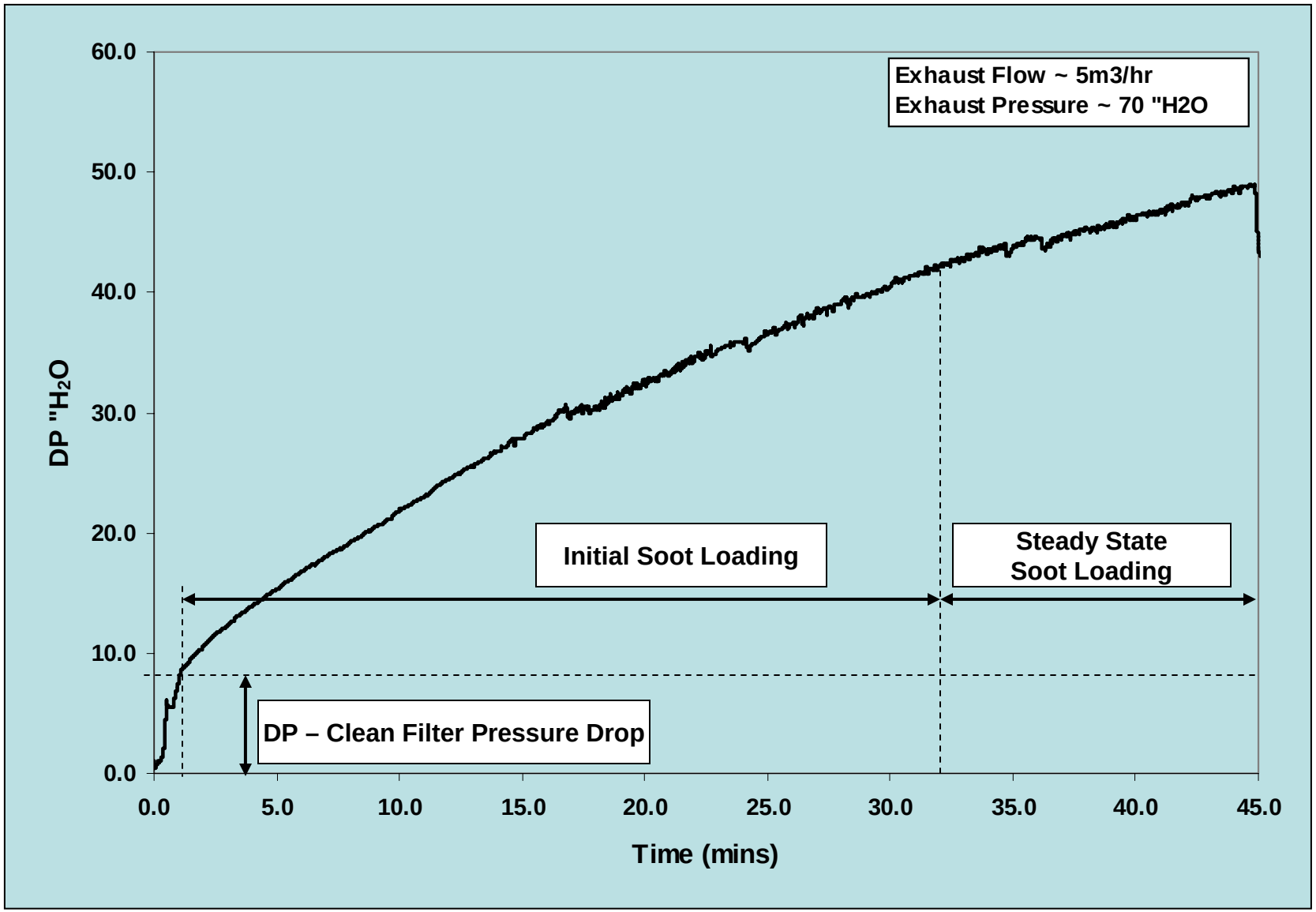


DPF Holder



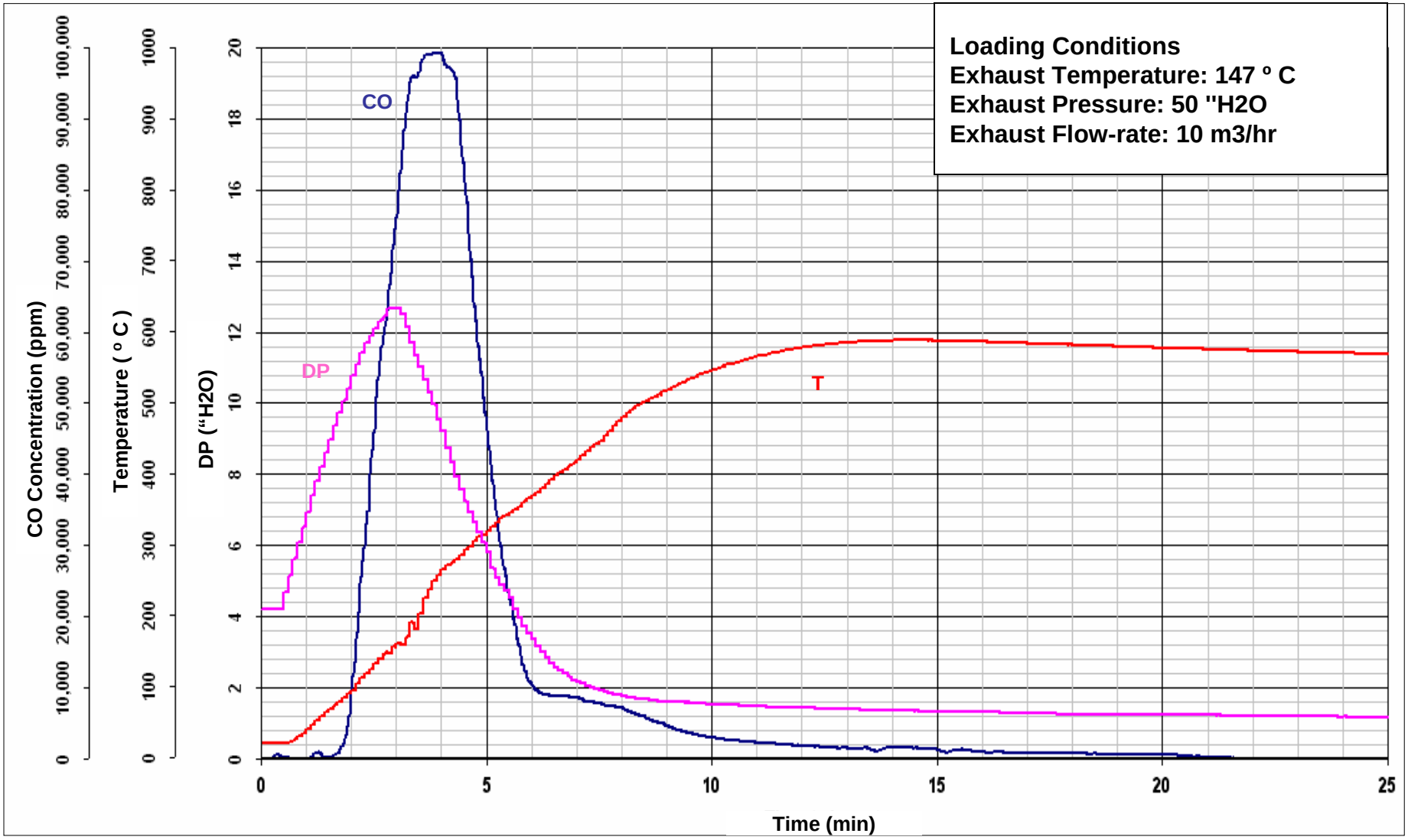
DPF with Waveguide

Soot Loading



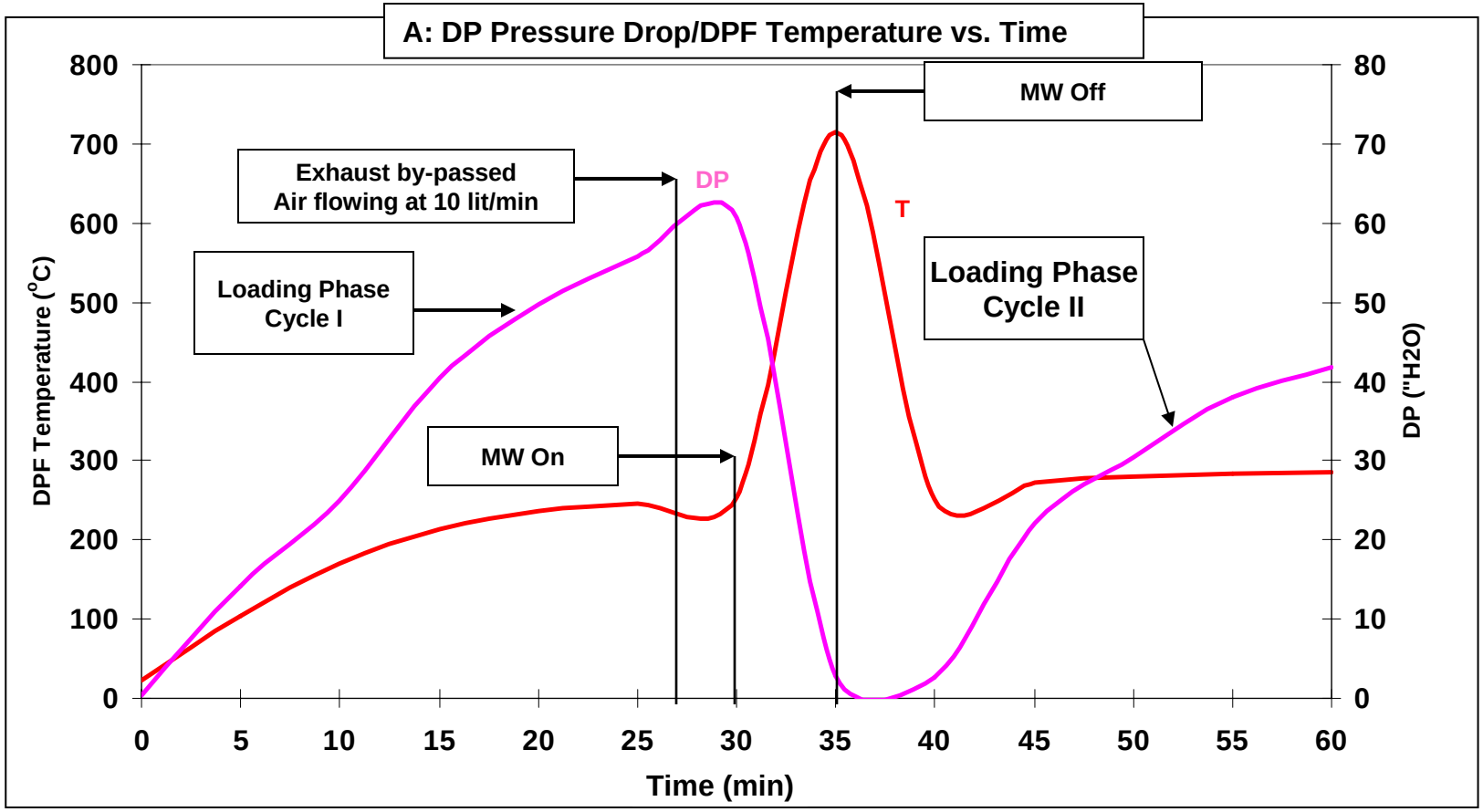
DPF Regeneration

Single-Cycle



DPF Regeneration

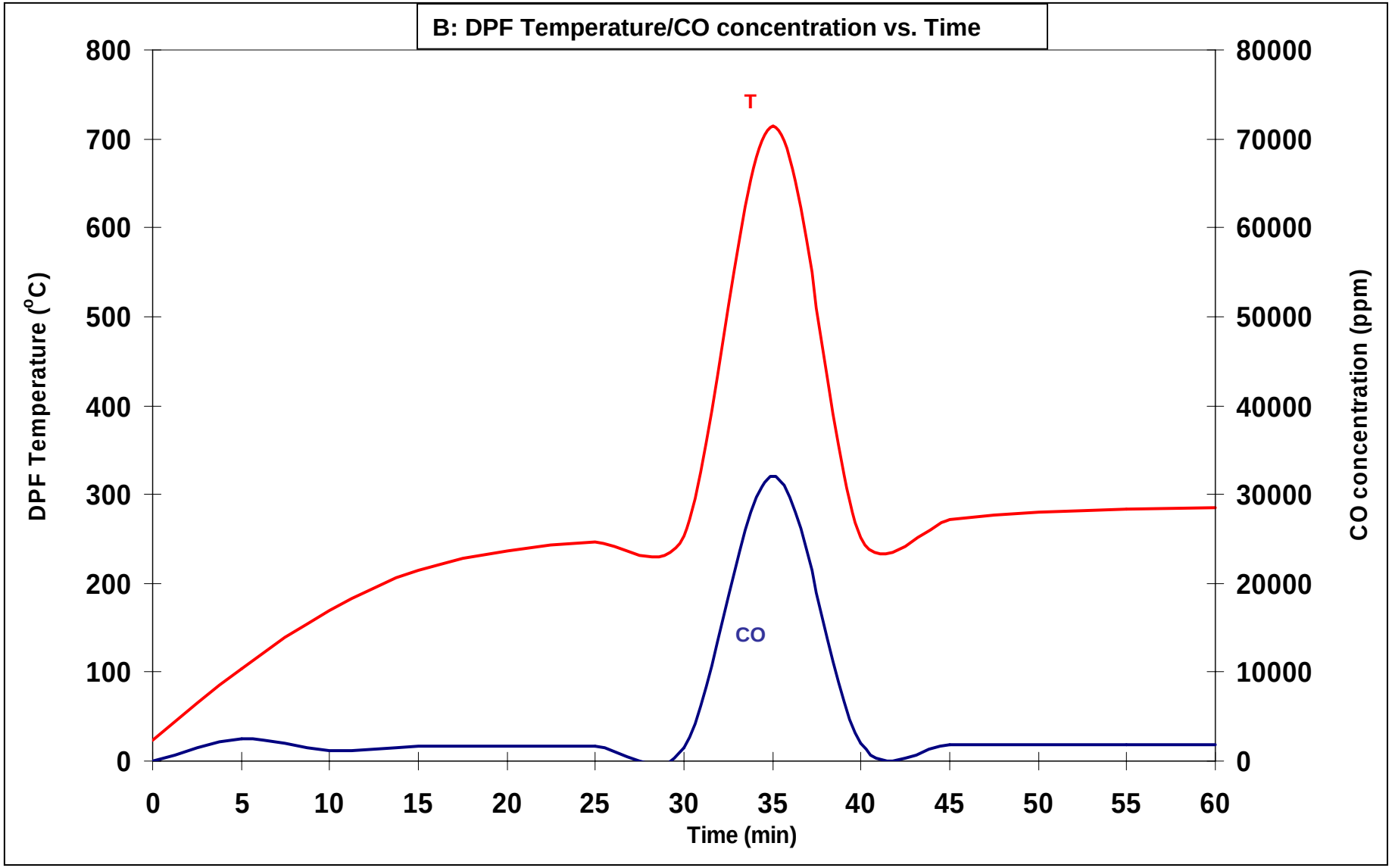
Offline Sequence



- Filter Loading at constant Exhaust flow rate of 5m3/hr
- Exhaust by-passed after the filter pressure drop reaches about 50 inches of water
- Air is then switched on at 10 liters/min
- Microwave is turned on for about 5 minutes

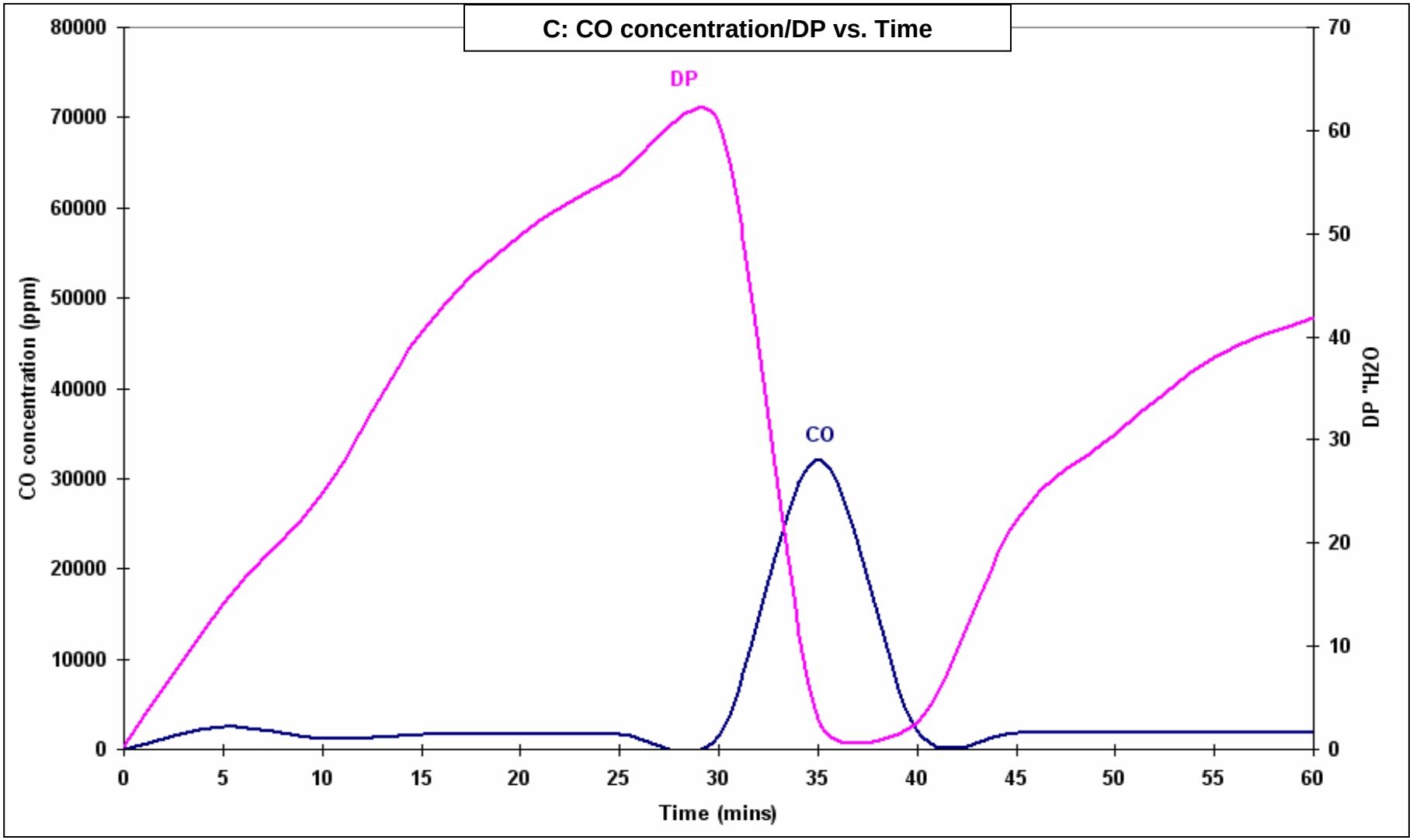
DPF Regeneration

Offline Sequence



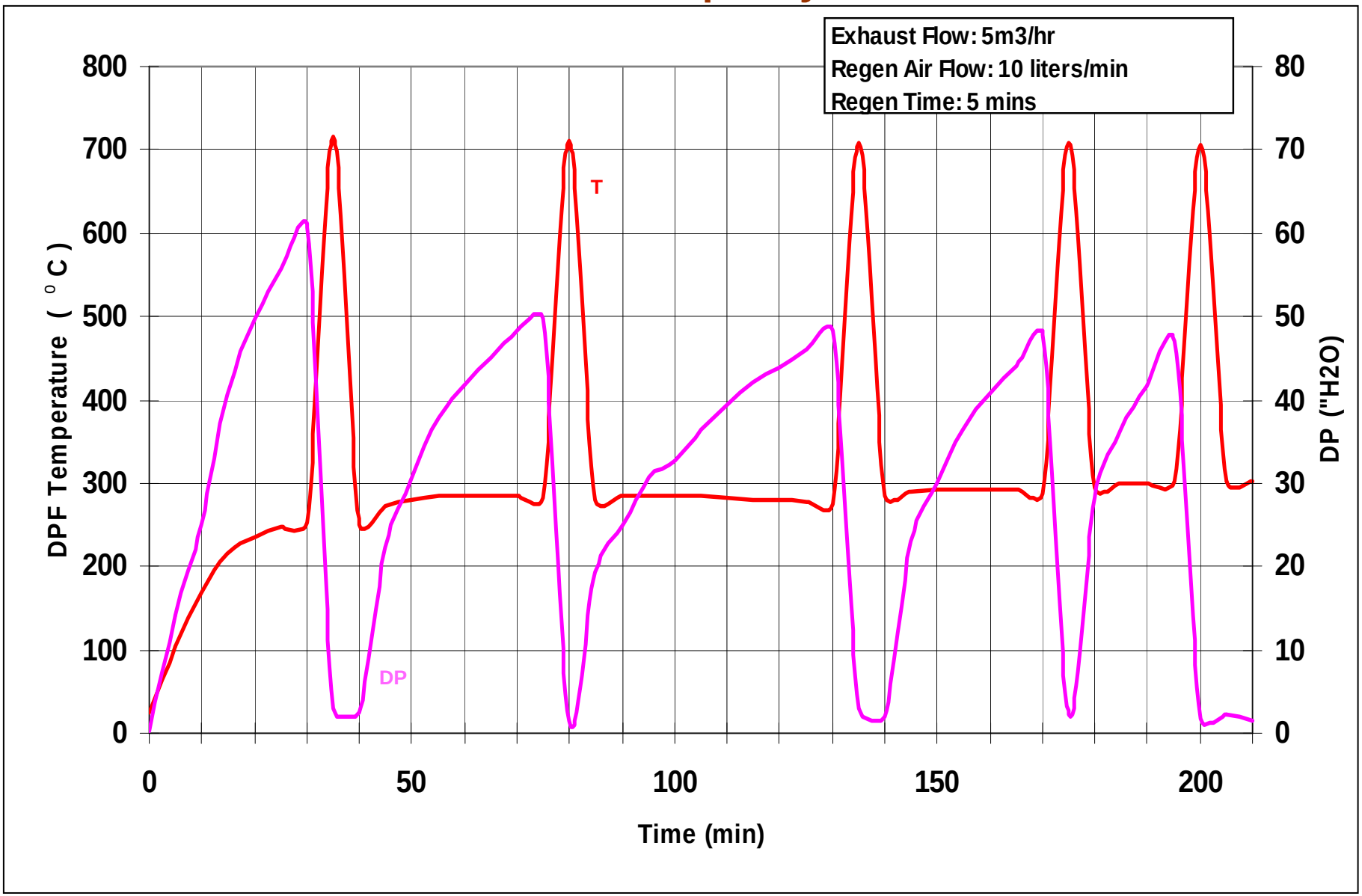
DPF Regeneration

Offline Sequence



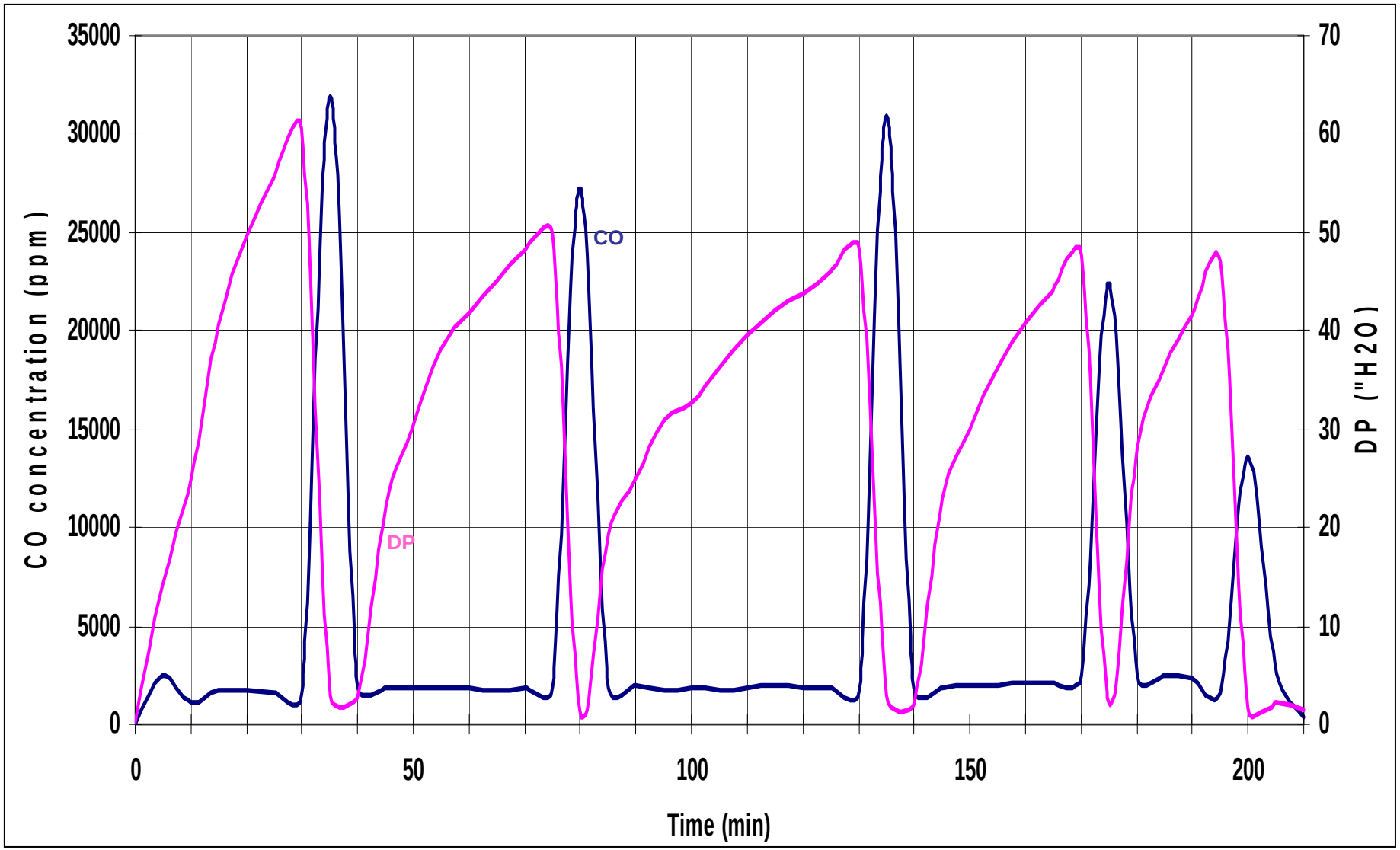
DPF Regeneration

Offline Multiple Cycle



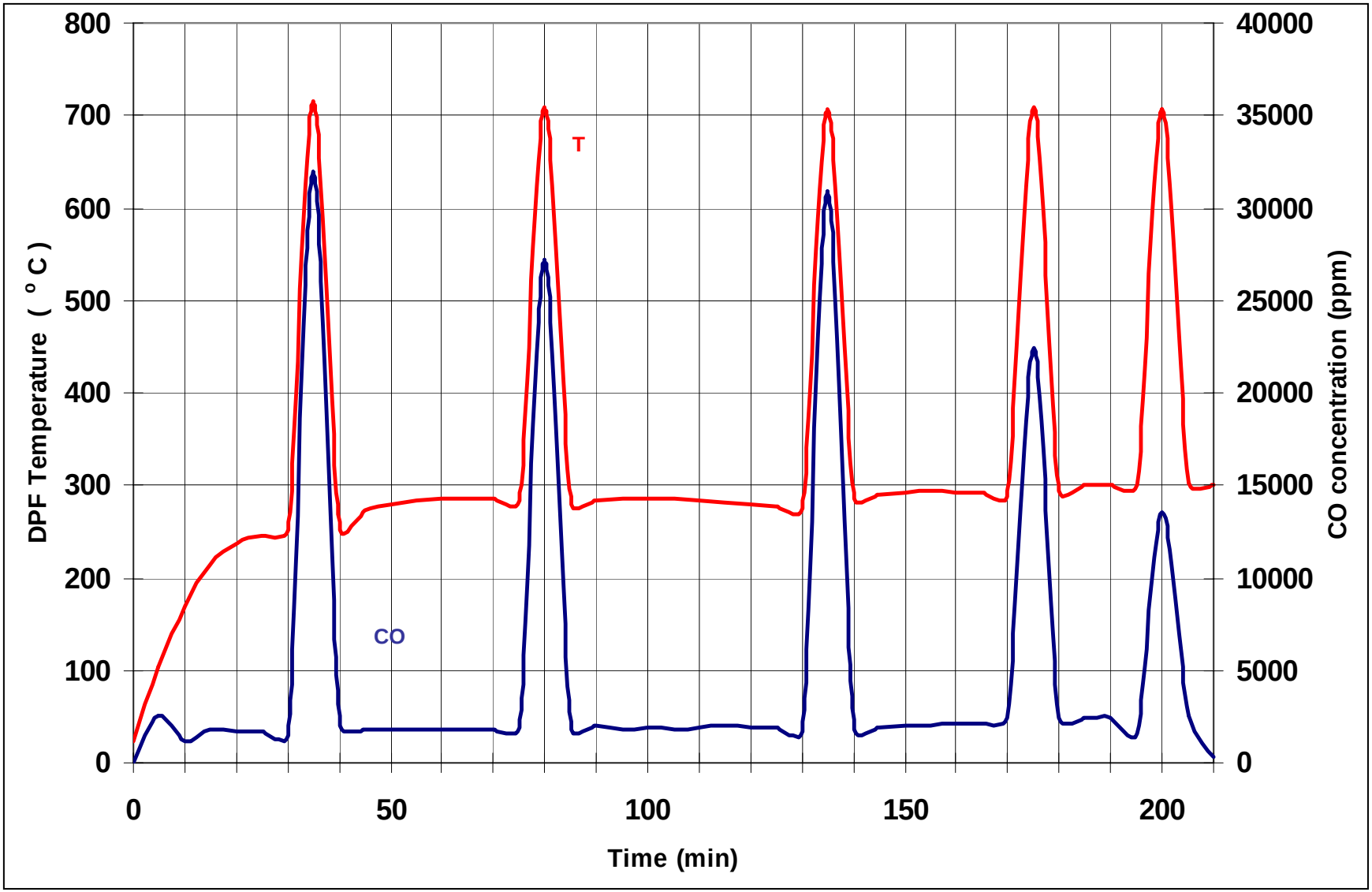
DPF Regeneration

Offline Multiple Cycle

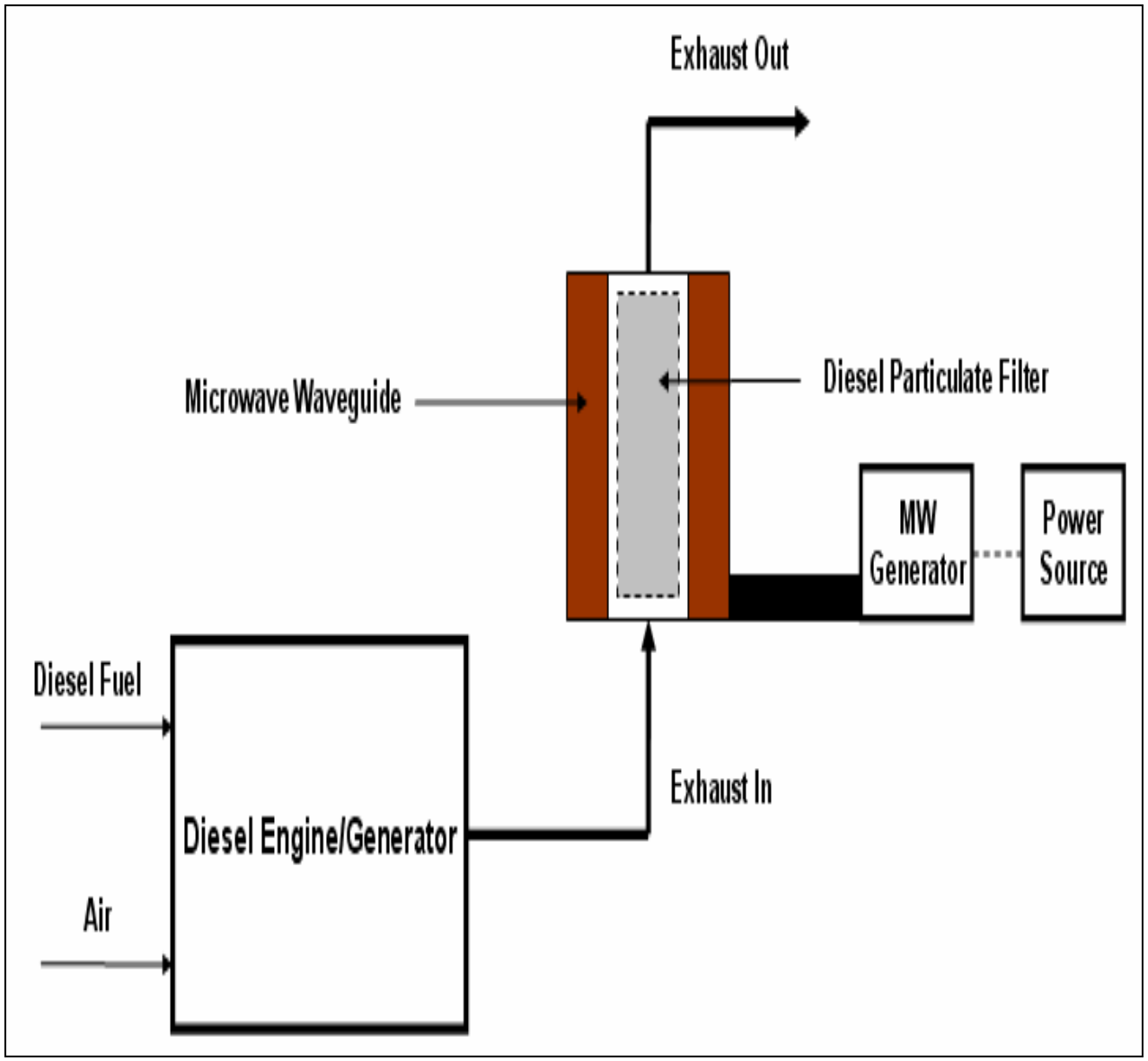


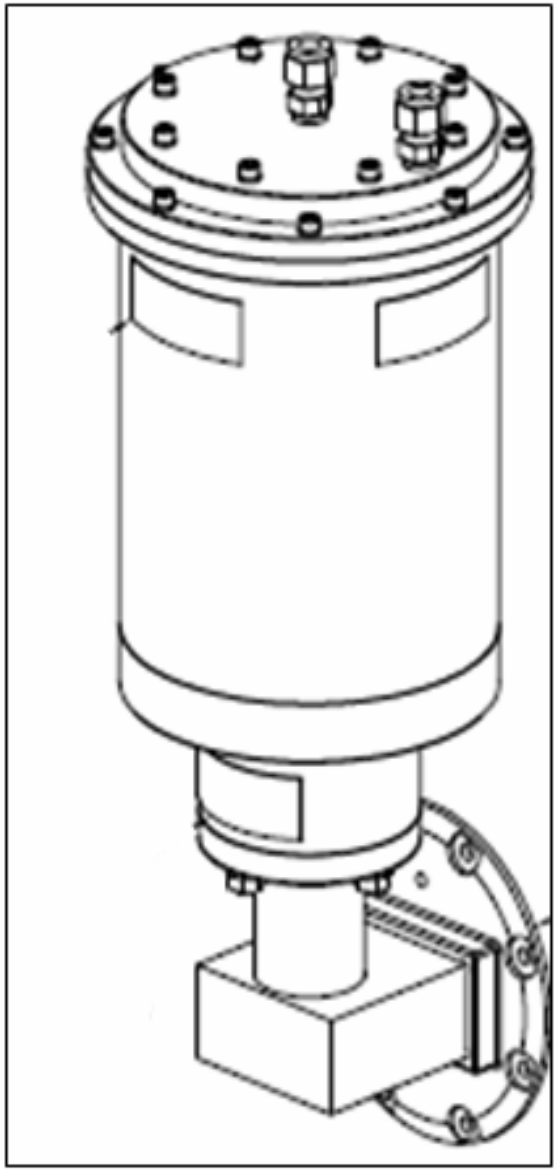
DPF Regeneration

Offline Multiple Cycle



Future Work


Exhaust Out
Microwave Waveguide
Diesel Particulate Filter
MW Generator
Power Source
Diesel Fuel
Diesel Engine/Generator
Exhaust In
Air



Concluding Remarks

➢ Microwave Regeneration Promising

- High Regeneration Efficiency (> 90%)
- High DPM Filtration Efficiency with Regenerated DPFs (> 90%)
- No Physical Damages Observed

➢ Waveguide Design Essential

- Uniform Temperature Profiles
- Hotspots Elimination
- Energy Efficiency

➢ Key Design/Operation Considerations

- Microwave Heating to the Ignition Temperature
- Oxygen Level Essential for Efficient Regeneration
- Monitoring of Differential Pressure Drop Necessary

Acknowledgements

This project was financially supported by the Texas Commission on Environmental Quality (TCEQ) through the 2005 New Technology Research and Development (NTRD) Program

Project No. 582-5-70807-0007