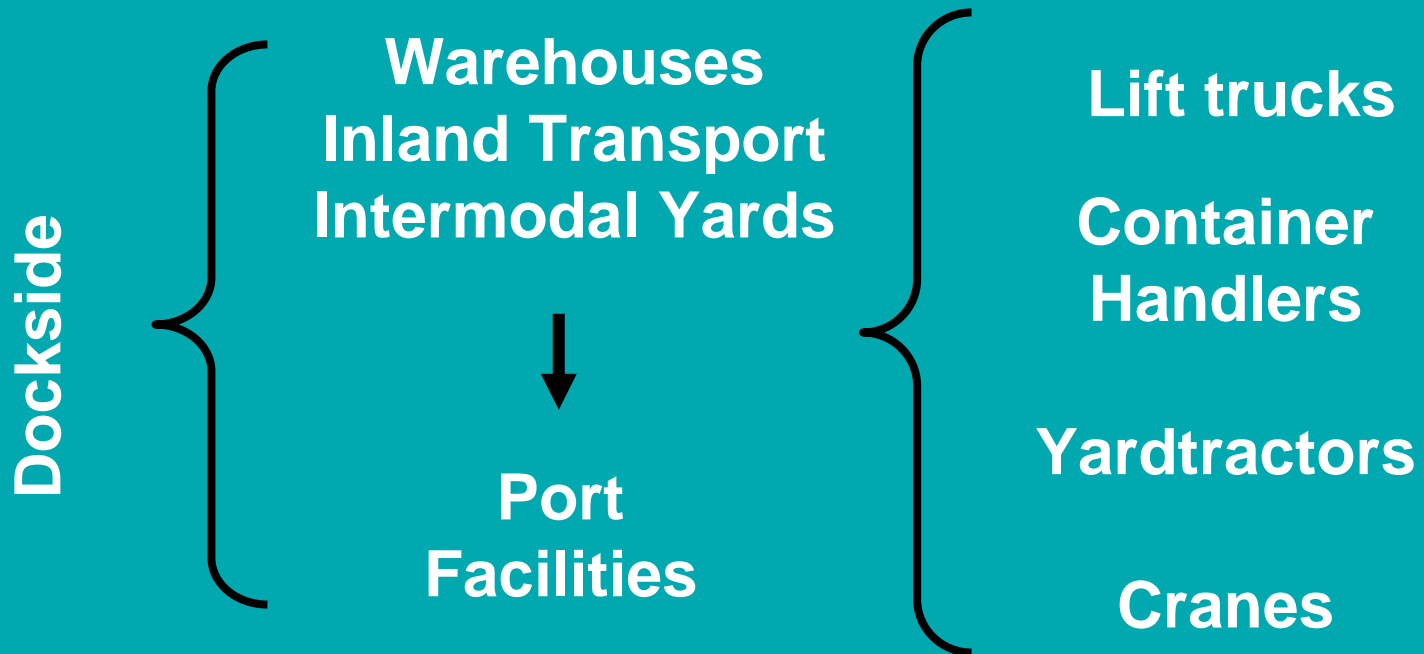


# Verified Emission Control Technologies for Port and Warehouse Equipment

June 2004

# Port Related Facilities and Equipment



# Verified Retrofit Technology Options

## PM Control

- Oxidation Catalysts
- Ox. Cats w' Crankcase Filters
- Fuel Emulsions
- Fuel Emulsions w' Ox. Cats
- Active Particulate Filters

## NOx Control

- Fuel Emulsions
- Fuel Emulsions w/ DOC
- SCR
  
- For SI engines
  - Closed loop 3-way catalyst systems

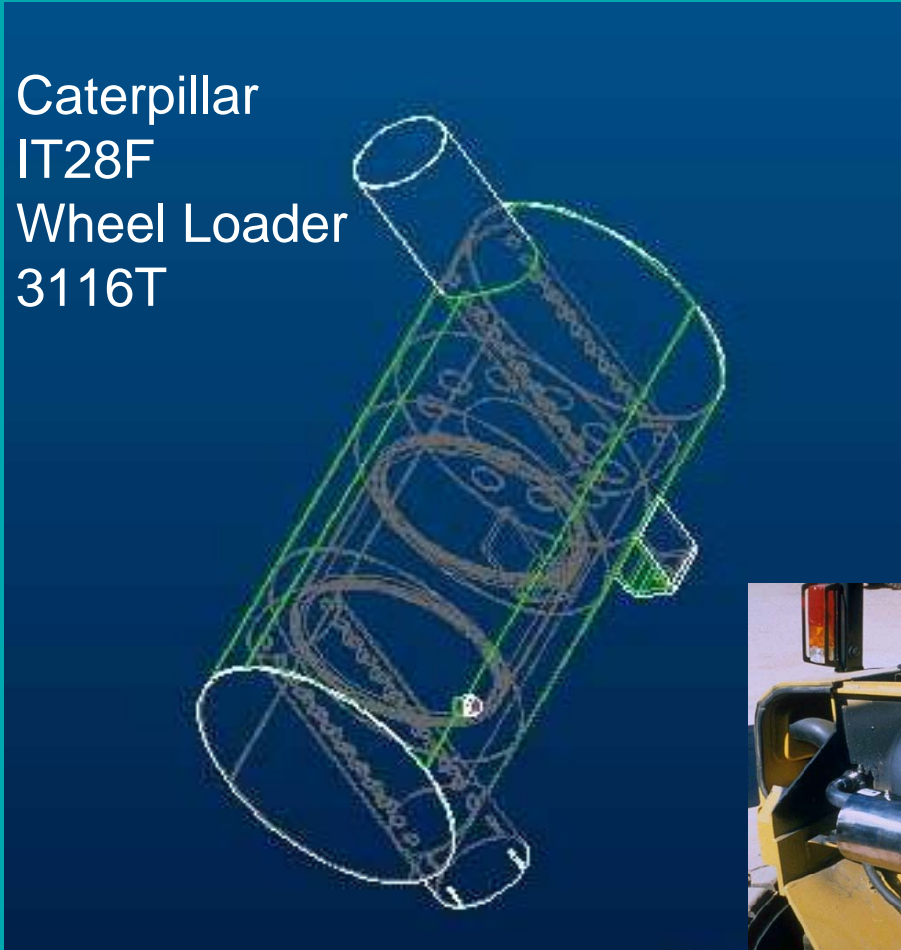
# Flexible DOC Design for Nonroad

- generic converter or converter muffler, modular design or integrated, or direct fit converter muffler
- need to deal with vibration
- need to deal with aspirator / venturi tubes, insulated muffler skins, spark arrestors
- prevent water entry into exhaust (i.e. raincaps)



# DOC Installation Examples for Nonroad

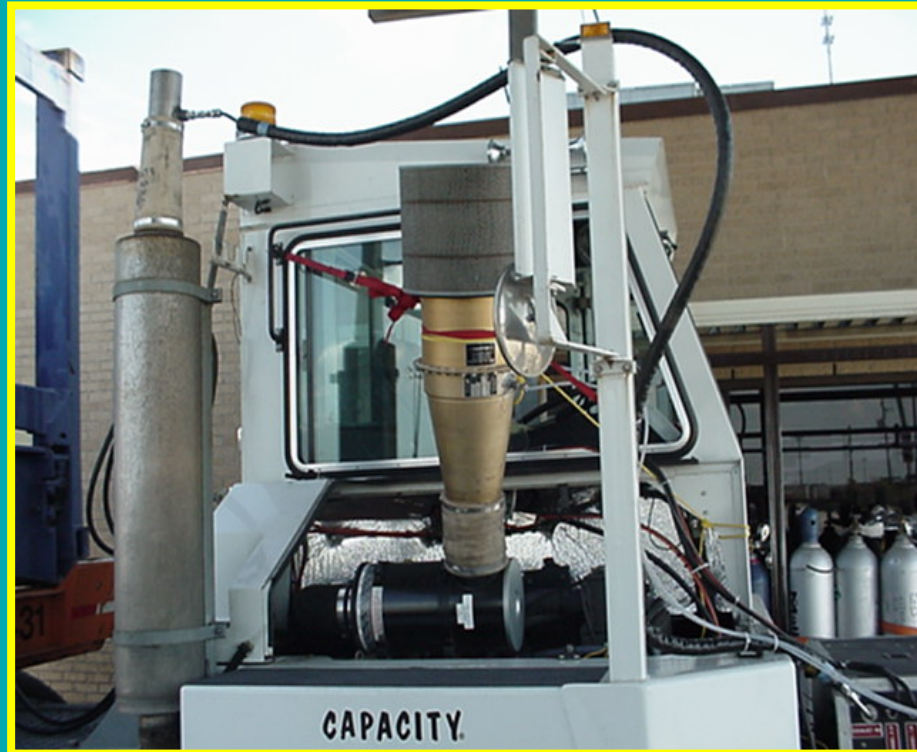
Caterpillar  
IT28F  
Wheel Loader  
3116T



# Yardtractor Retrofit

## Muffler

Vertical  
Nelson M86108  
length: 44"  
overall length: 53"  
Inlet / Outlet: 4"  
Diameter: 9"



## Converter muffler

Vertical  
ECS A17-0213  
length: 44"  
overall length: 53"  
Inlet / Outlet: 4"  
Diameter: 10"

Capacity Yardtractor w' Cummins 8.3L, 215 hp

# Port of Houston Testing

Capacity Yard Tractor  
with Tier 1 Cummins C engine  
Tested in-use- fully loaded condition  
Baseline: No. 2 off-road diesel



	HC	PM	NOx
PuriNOx™	18%	35%	23%
AZ Purimuffler™	48%	34%	0.5%
PuriNOx™ & Purimuffler™	43%	65%	30%
Purimuffler™ Reductions wrt PuriNOx as baseline	30%	45%	8%

# Combifilter™

Actively Regenerated DPF for Captive Fleet Use & Stationary Engines

- filter system which stores soot
- regeneration is done daily by connection to regeneration station
- thousands in Europe, commercial for > 20 years
- VERT approved- over 25,000 hours in-use – no NO<sub>2</sub> emissions
- can be used to extend the use of passive filter (Purifilter or Cattrap) to colder duty cycles



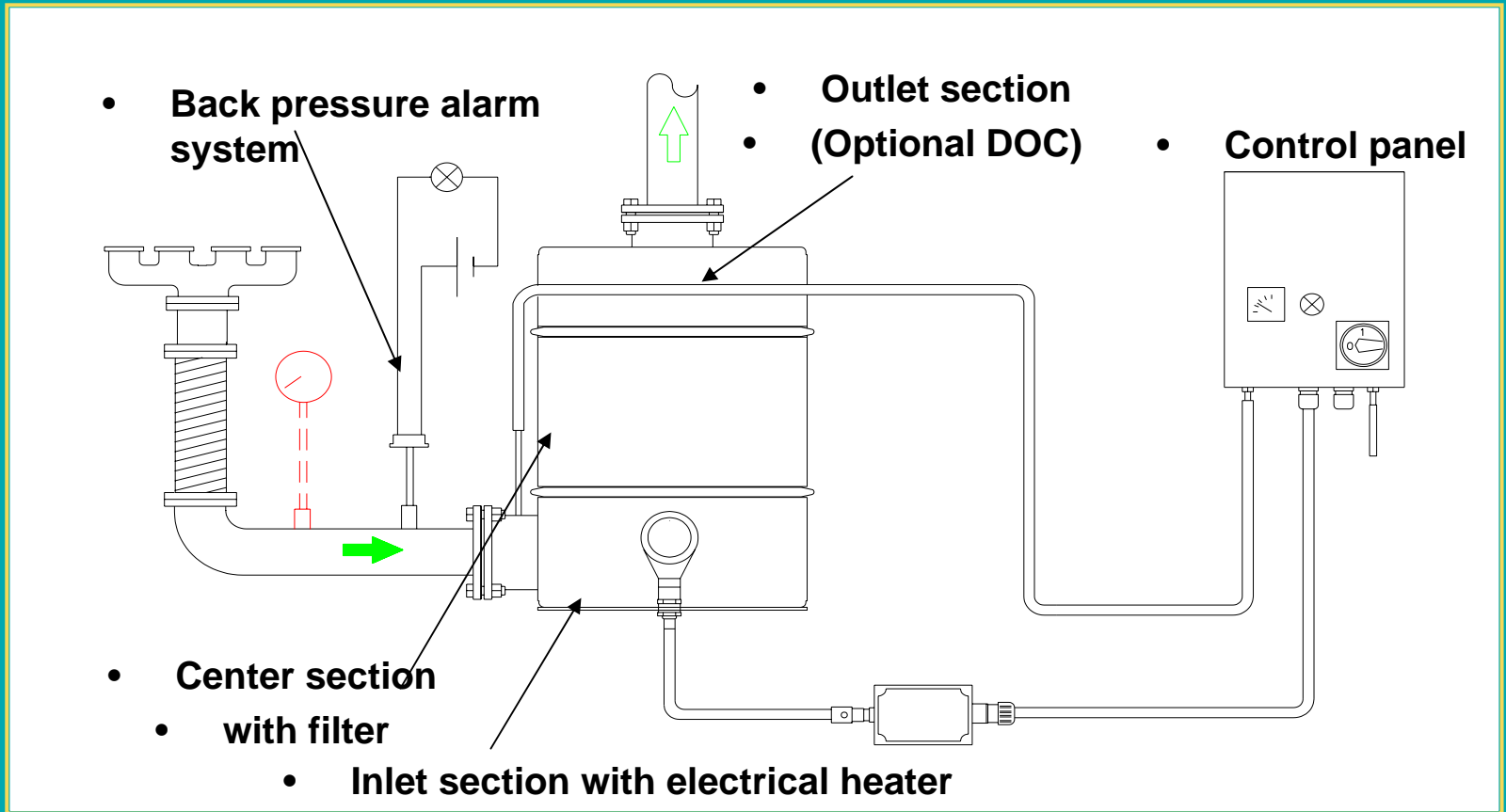
**Type K**  
8 hr regeneration



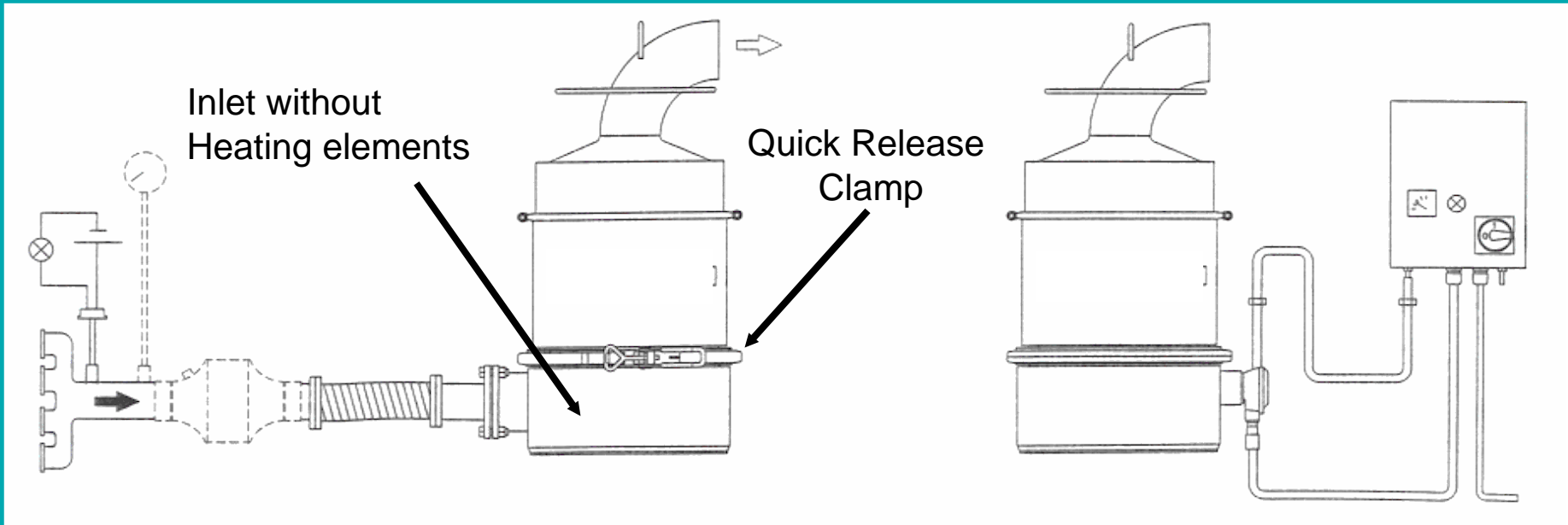
**Type S**  
1 hr regeneration



# On-board regeneration



# Off-board regeneration



- Filter is exchanged as required (usually once per shift)
- Filter exchange takes about two minutes
- Very common with lift trucks operating multiple shifts

# Active DPF's - Cargo Handling



# Combifilter Installation on a Yardtractor



# ARB Verification of TerminiNOx

- First ARB LSI verified product
- Closed loop fuel control & 3-way catalyst
- Reduces HC+NOx emissions to 1.0 g/hp-hr (>85% reduction)
- For 1L to 3L in-line configuration engines
- Verification for V configuration engines in progress.



# TerminOx™ Engine Upgrade Kits for off-road LPG / CNG engines

- **TerminOx consists of**
  - Electronic Control Module (ECM) with engine specific program, shielded wiring harness, oxygen sensor, fuel actuator valve and OE grade, 3-way catalytic converter or converter muffler
  - can be installed on open loop industrial engines with IMPCO, AISAN, NOLFF or Nikki carburetion
  - ECM is digitally programmable and allows for engine specific programming
  - ECM control results in reduced maintenance on fuel system and up to 20% fuel savings over open loop fuel systems



# TermiNOx Emissions Results

Engine Description	Test Description	HC + NOx (g/bhp-hr)	CO (g/bhp-hr)
1986 Toyota 5R	C1- de-greened	1.14	0.78
Nissan H20	C2- de-greened	0.37	0.90
	Transient- de-greened	0.26	1.34
1993 Mazda 4-121G, 2L, 34hp	C2- de-greened	0.58	1.59
	C2 aged 4,034 hrs	0.51	3.25
	Transient- aged 4,034 hrs	1.09	9.85
1992 GM 181, 3L, 40hp	C2- de-greened	0.25	0.28
	C2 aged 5,581 hrs	0.87	1.84
	Transient- de-greened	0.43	1.85
	Transient- aged 5,581 hrs	1.04	7.02

# Recommendations

## Non-road retrofit markets are still developing

- Typically Non-road verifications lag behind highway verifications
- When applicable, deal with companies with verified products for port applications or with an established reputation for obtaining verifications
- Insure that it is clear that you know what you are buying
  - Is it direct fit? Is it sized properly?
  - Does it include a quality installation?
  - Does it maintain all the current features in the exhaust system?
  - Does the product and vendor have an established reputation?



**Thank You**

**Engine Control Systems**

**165 Pony Drive**

**Newmarket ON L3Y 7V1**

**Customer Service: 800-661-9963**

**Fax: 905-853-5801**

**Email: [ecs@enginecontrolsystems.com](mailto:ecs@enginecontrolsystems.com)**

**[www.enginecontrolsystems.com](http://www.enginecontrolsystems.com)**