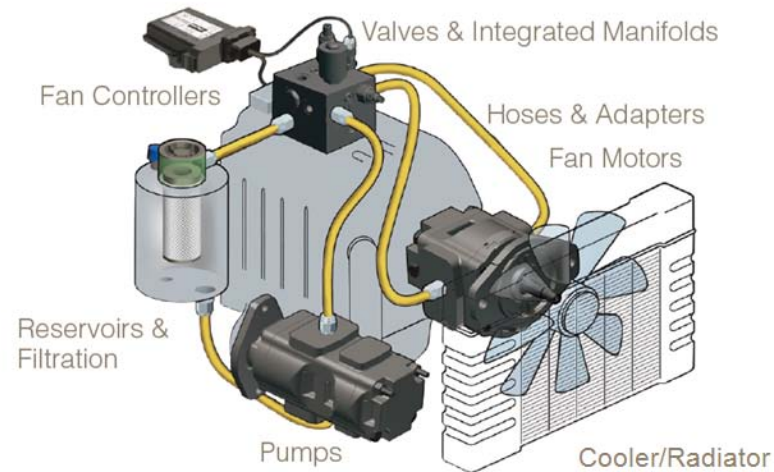


# Parker Fan Drive & Cooling Systems

## PHtruck Web Training Session



ENGINEERING YOUR SUCCESS.

# Diesel Emissions Regulations



## Legislation to Reduce:

### Nox – Nitrogen Oxide Gases

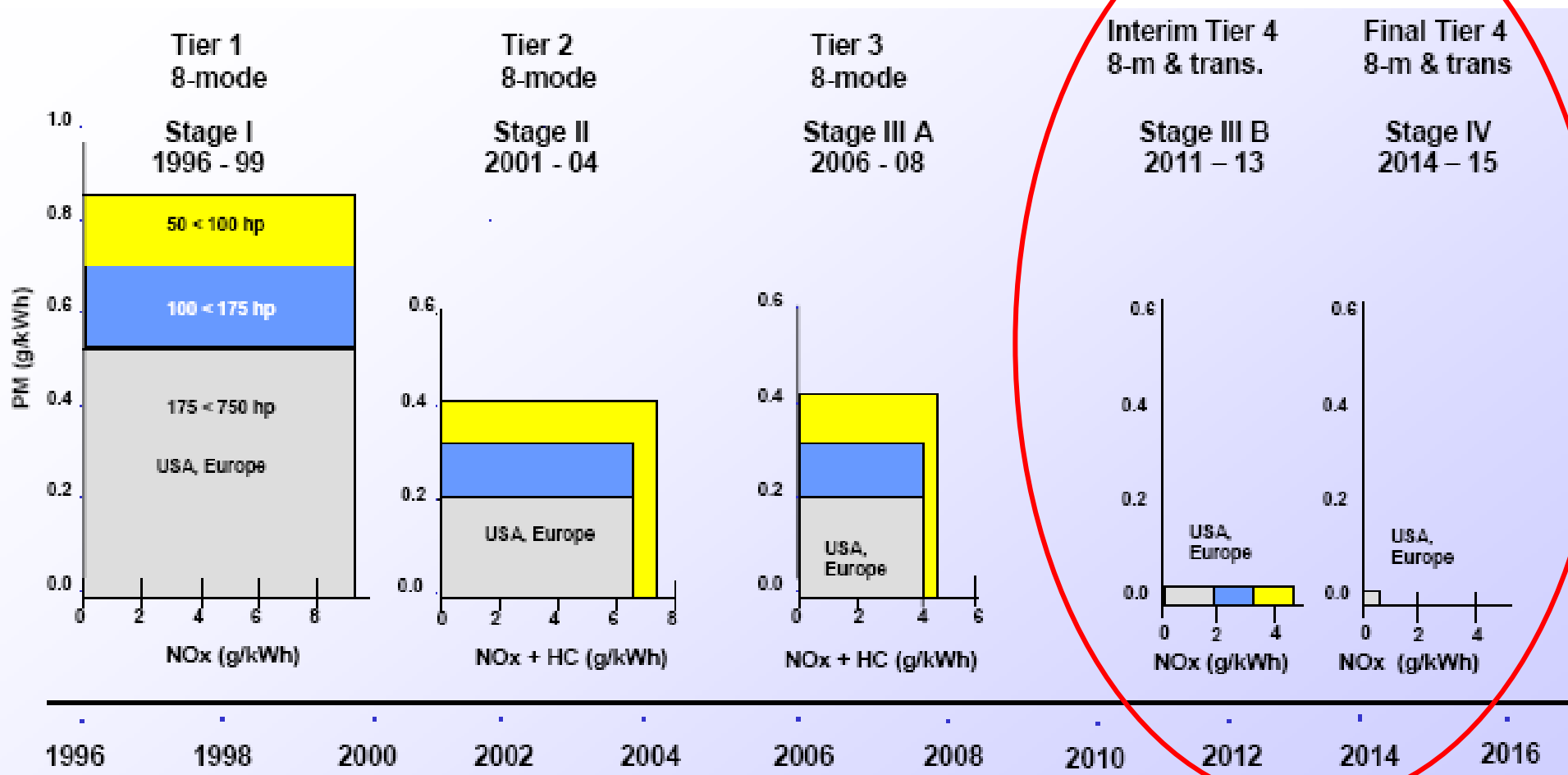
- Combination of gases nitric oxide (**NO**) and Nitrogen Dioxide (**NO<sub>2</sub>**).

### DPM – Diesel Particle Matter.

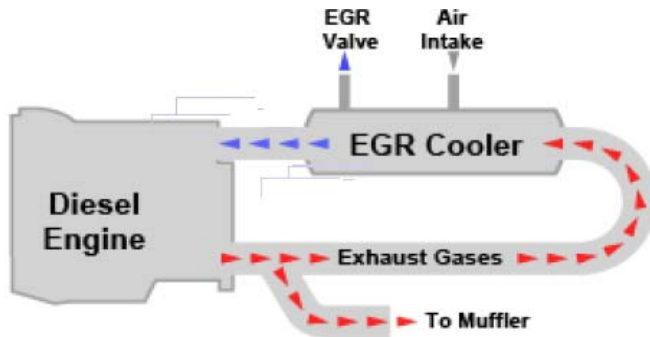
- Soot, inorganic Oxides primarily sulfates

# EPA Emission Regulations

US "Tiers" Europe "Stages"

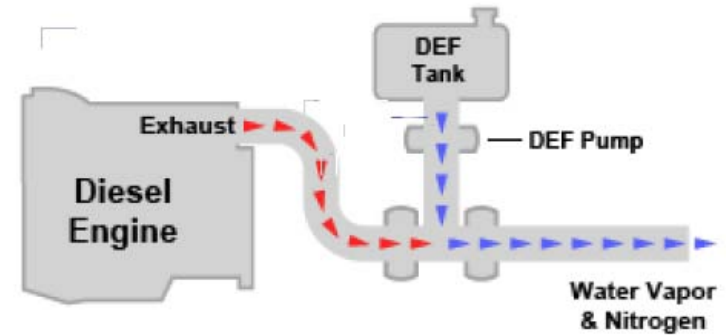


# Main Emission Reduction Technologies



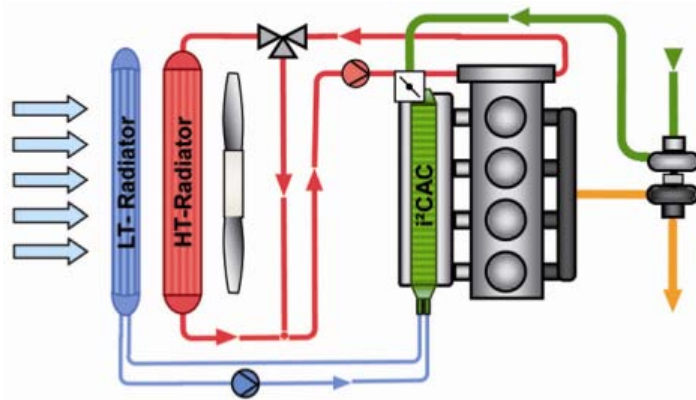
## EGR

Exhaust Gas Recirculation



## SCR

Selective Catalytic Reduction



## CAC

Charge Air Cooling



## DOC/DPF

Diesel Oxidation Catalyst  
Diesel Particle Filter



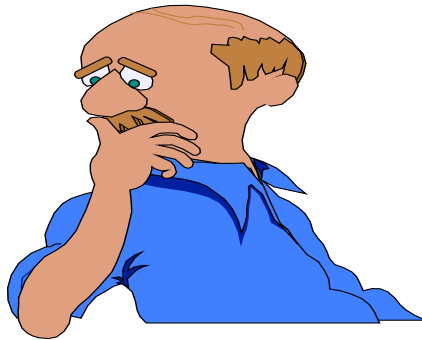
# The Customer's Design Challenge:



More engine power  
diverted to cooling  
(+30% Tier 3 to 4i)  
(+10% Tier 4i to 4)

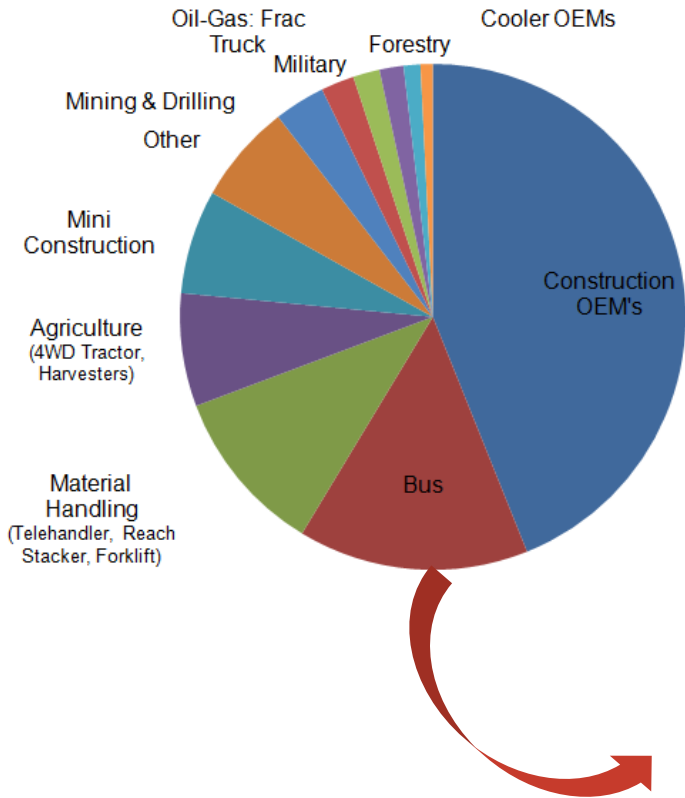
More precise  
Engine temperature control

Less space



- Fuel Efficiency
- Space Constraints
- Comfort
- Reliability

# Global Fan Drive Market



## North America – Fan Drive + Cooler

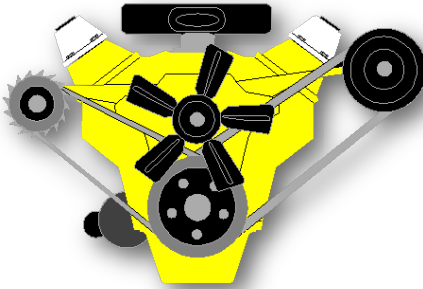
<b>Top 10</b>			
<b>N.A. Transit Fleets:</b>	<b>Fleet Size &gt;35Ft</b>	<b>Articulated</b>	<b>Annual Repowers</b>
MTA New York City Transit	3872	621	749
Metro Los Angeles	2272	388	443
Pace Suburban Bus	422	0	70
New Jersey Transit Corp.	2215	85	383
Toronto Transit	1800	0	300
Chicago Transit Auth	1528	208	289
Montreal Urban Transit	1572	108	280
Washington Metro	1319	90	235
Southeastern PA Transit	1201	155	226
King County Metro	484	669	192
<b>Total:</b>	<b>16,685</b>	<b>2,324</b>	<b>3,168</b>

Assumptions:  
 Repower every 6 years covers mix of Transit and Motorcoach buses.

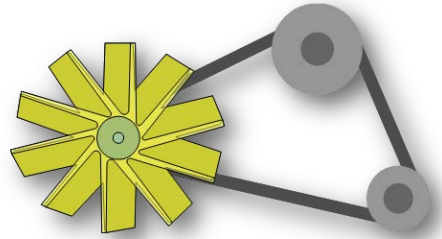


# Fan Drive Solutions:

**Fixed**



**Direct Engine Drive**



**Pulley & Belt Drive**

**Variable**



**On/Off Clutch**

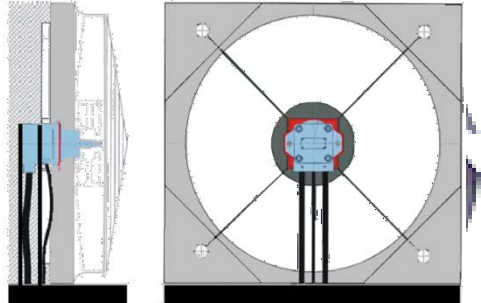


**Viscous Clutch**

**Variable &  
Remote**



**Electric Motor Drive**

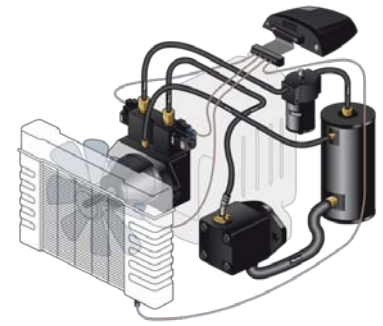


**Hydraulic Motor Drive**



# Why Hydraulic Fan Drives?

## 3 main reasons...



### *Enables emissions reduction...*

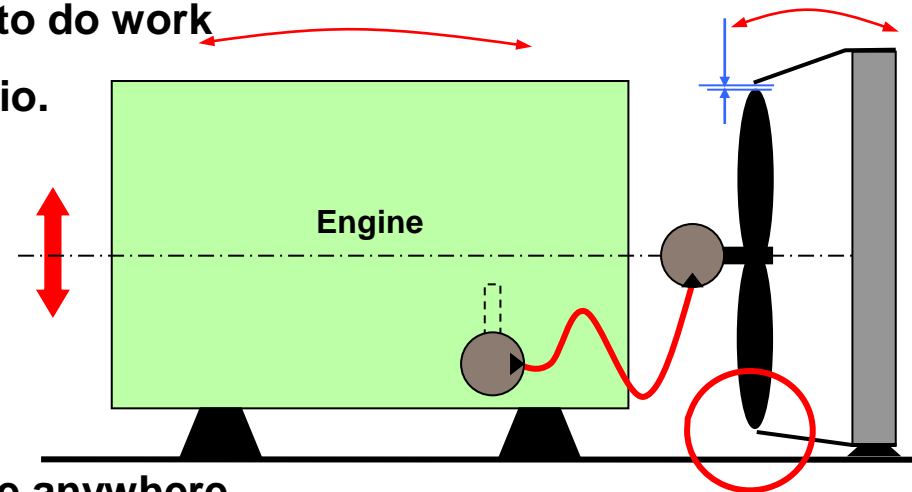
- ▼ Appropriate Cooling at any engine RPM

### *Efficiency....*

- ▼ 70-90% Efficient. Frees up Horsepower to do work
- ▼ Fuel savings. High Power to Weight Ratio.

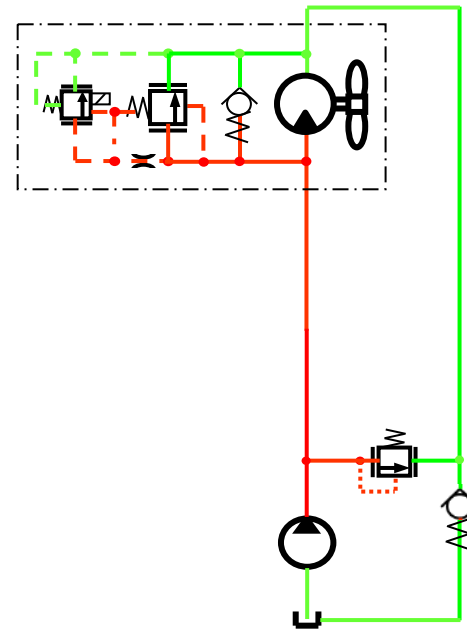
### *Design advantages...*

- ▼ Often utilizes existing hydraulic system
- ▼ Reversible - Clear clogged radiators
- ▼ Installation Flexibility: Small Size, Locate anywhere
- ▼ Fixed tip Clearance = 10-15% more cooling efficiency



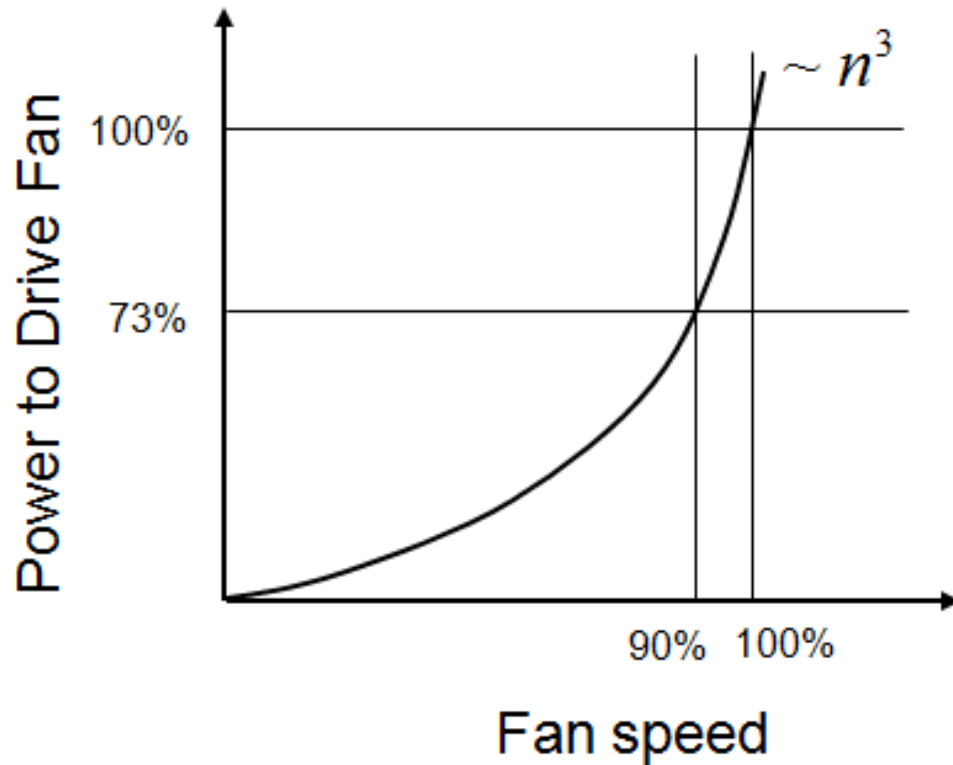


# Hydraulic Solutions & Components



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# Fan Drive Power

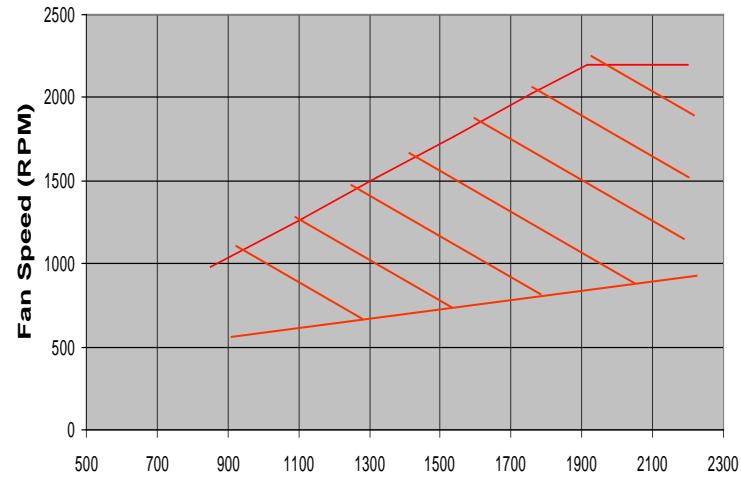


2X Fan Speed Requires 8X Hydraulic Power

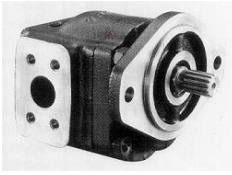
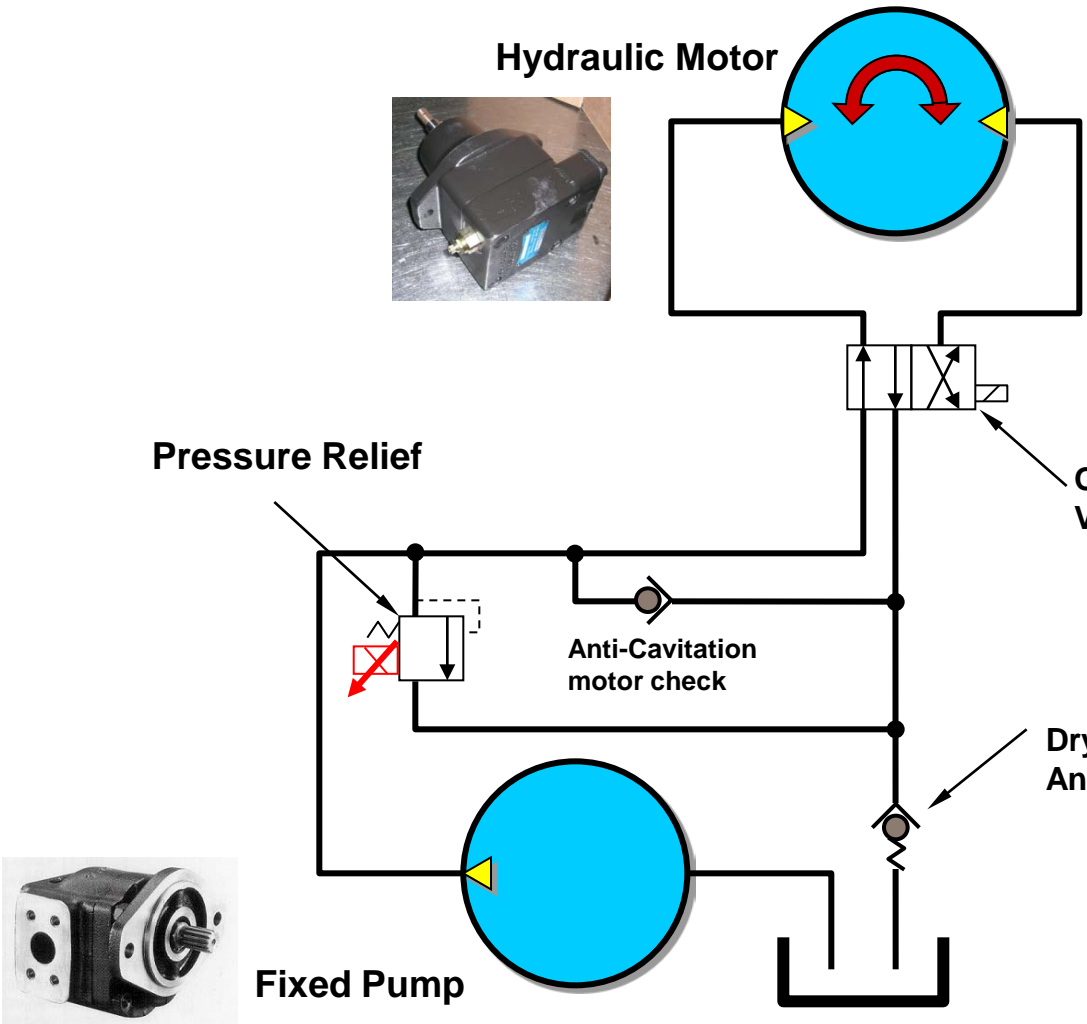
# Fan Drive:

## 'Bleed-Off' Variable Fan Speed

Engine Speed vs Fan Speed



Engine Speed (RPM)  
**Fan Speed now variable,  
 (Proportional Relief Command)**



# Gear Solutions: Fan Pumps & Motors

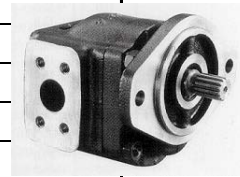
		CAST IRON				ALUMINUM				
		PGP/M 300		PGP/M 600		PGP/M 500				
Displ	0							503		
	10	315						505	S 511	
	20		330		610					
	30				620					
	40				S					
	50									
	60									
	70									
	80									
	90									
	100									
	110									
	120									
	130									
	140									
	150									

  Mature Product  
  Core Fan Drive Product

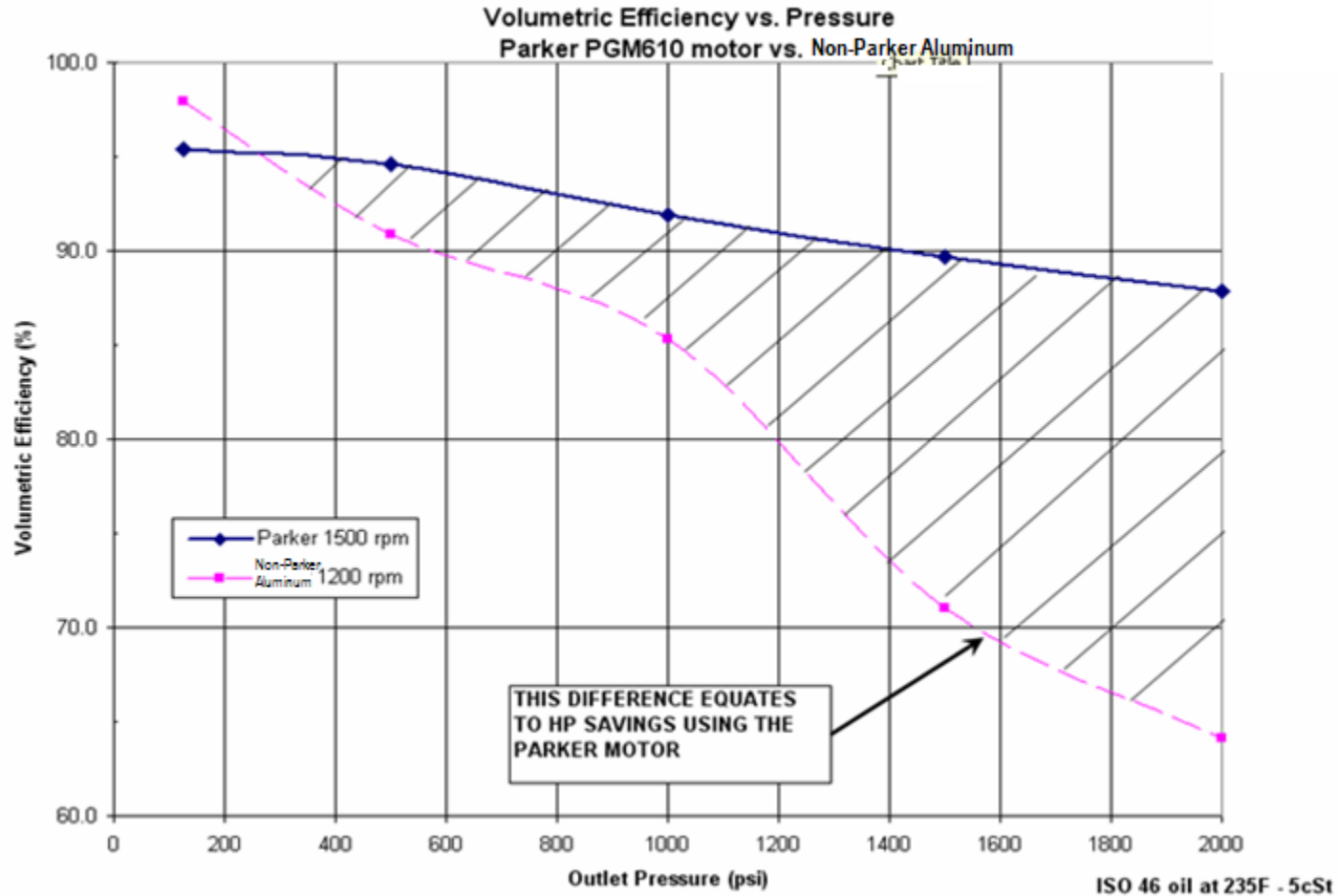
**S** Spilt Gear Available

Up to 4000 psi  
(270 Bar)

Up to 4000 psi  
(270 Bar)

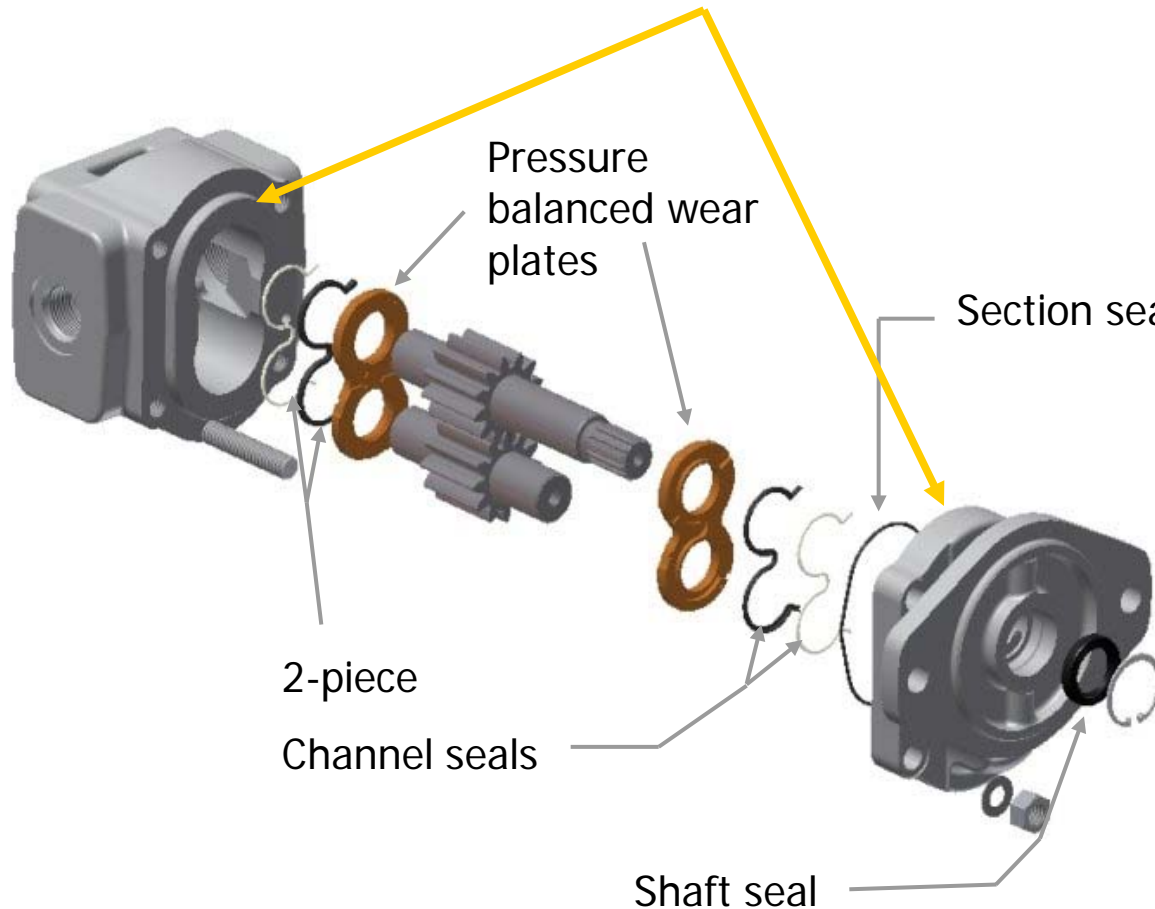


# Cast Iron Preferred for Fan Drives: Aluminum vs Parker 600 Iron Series Efficiency



# 600 Series Pump & Motor

## Patented 2 Piece Interlocking Body



### Stiffer Assembly

- Higher Pressures
- Higher Volumetric & Efficiency

### Compact Size

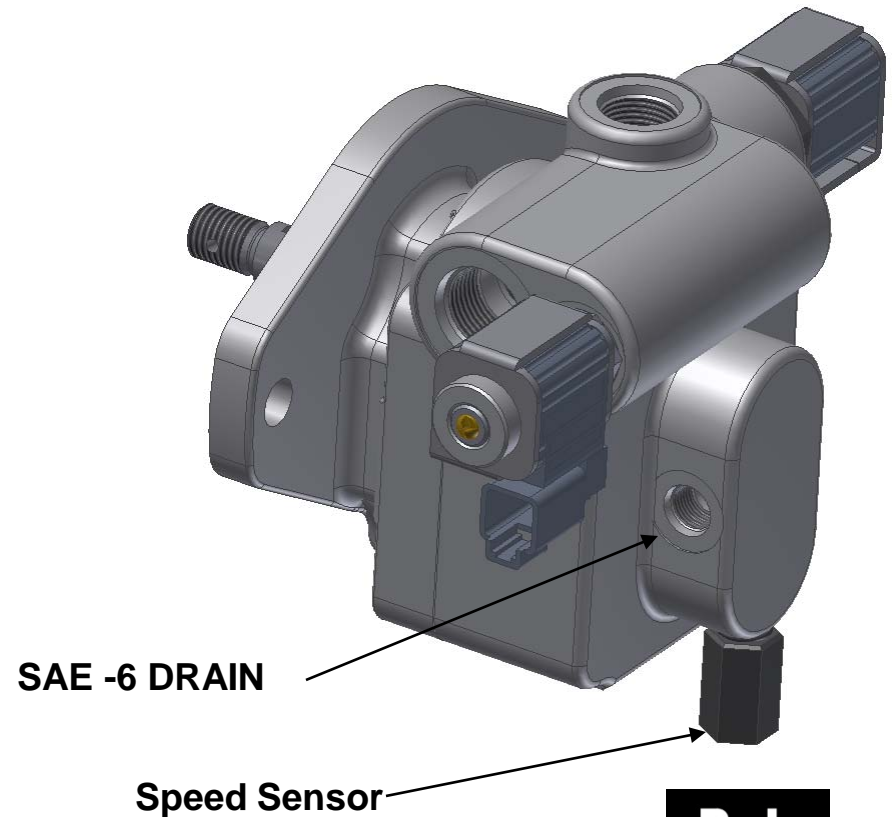
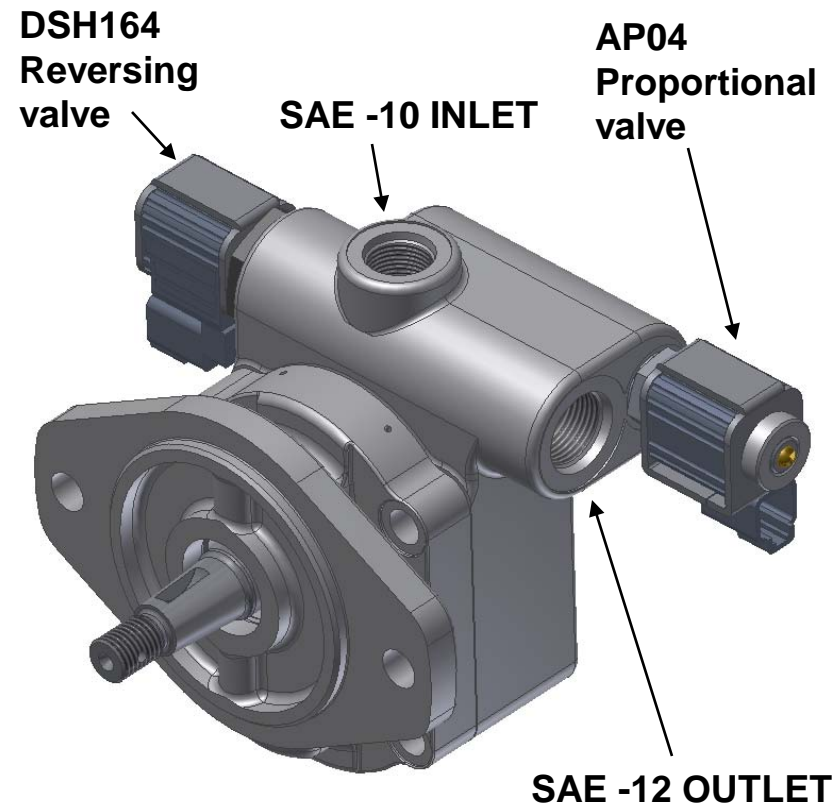
- Lower Weight
- Easier Installation

### Thermally Stable

Proven at Extreme Temps

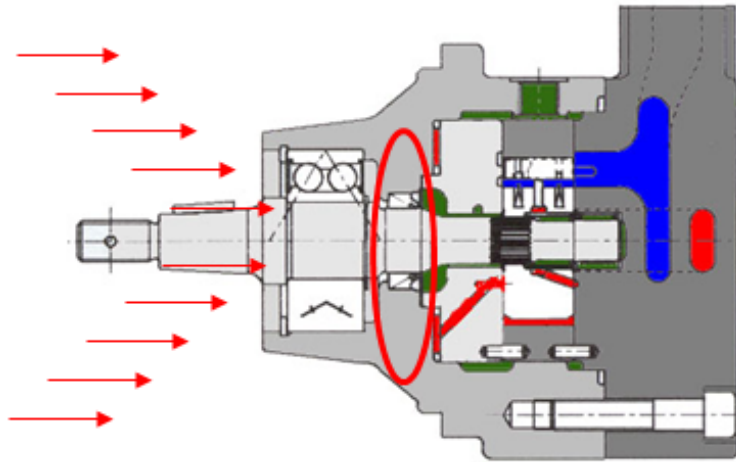
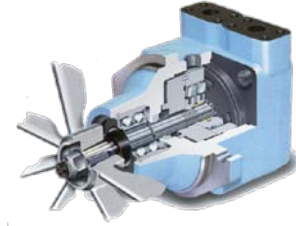
# New Integrated PGM620 Fan Motor

- Purpose build integrated design for lower cost and smaller package



# Vane Motor Solutions

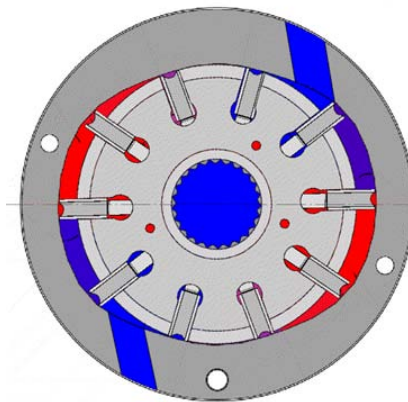
## “Designed For ” Fan Drives



- Unique protected shaft seal, barrier to blown in debris
- Heavy duty, long life bearings to support fan loads
- Very low noise



- Excellent mechanical efficiency from hydrostatically balanced rotor
- Double lip vanes resist contamination and maintain efficiency vs pressure and time



*Hydrostatically balanced rotor*



*Double lip vanes*

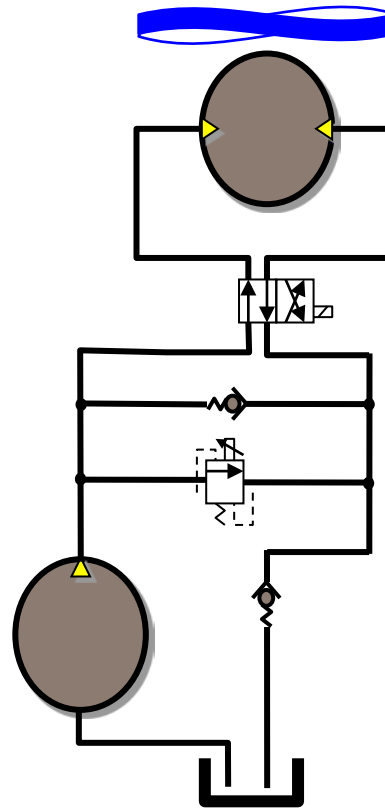




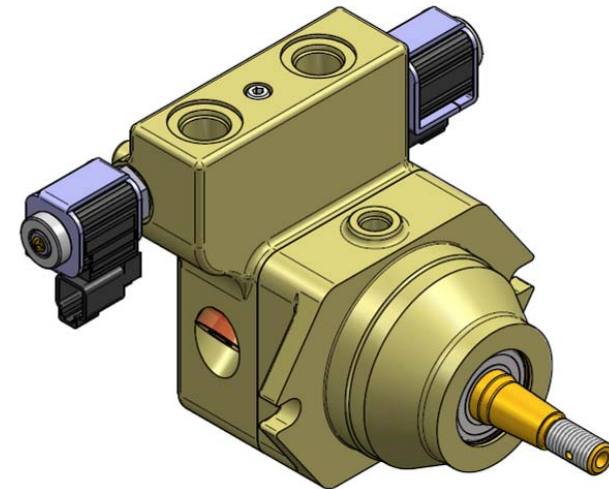
# M5 A, B and ASF All-In-One Integrated Fan Motor

- Proportional Relief
- Reversing Valve
- Anti Cavitation Check
- Anti-Drain Valve
- Speed Sensor

...Or various combinations



M5B



M5ASF

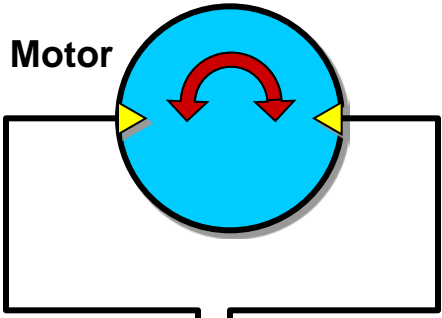


# Fan Drive:

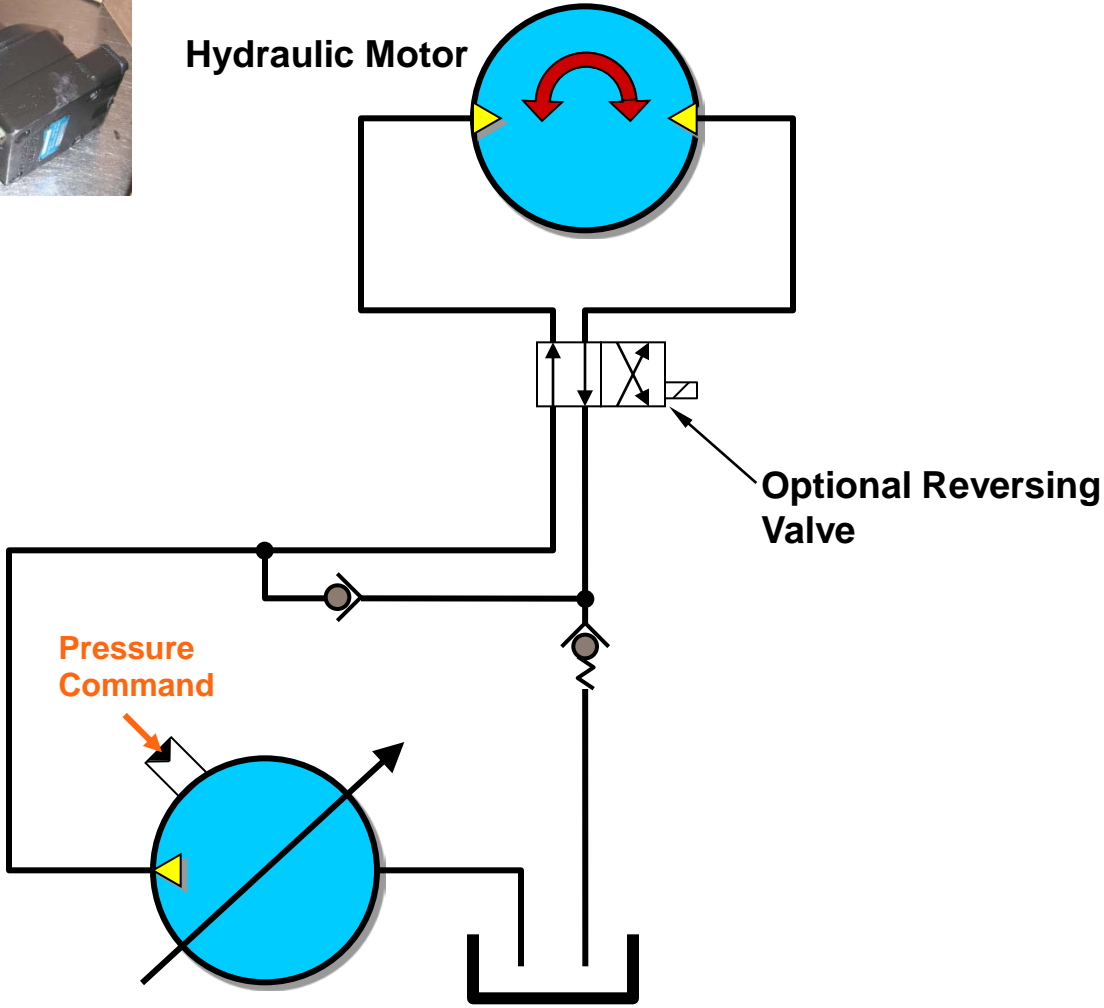
## Variable Piston Pump, Integral Proportional Pressure Control



Hydraulic Motor



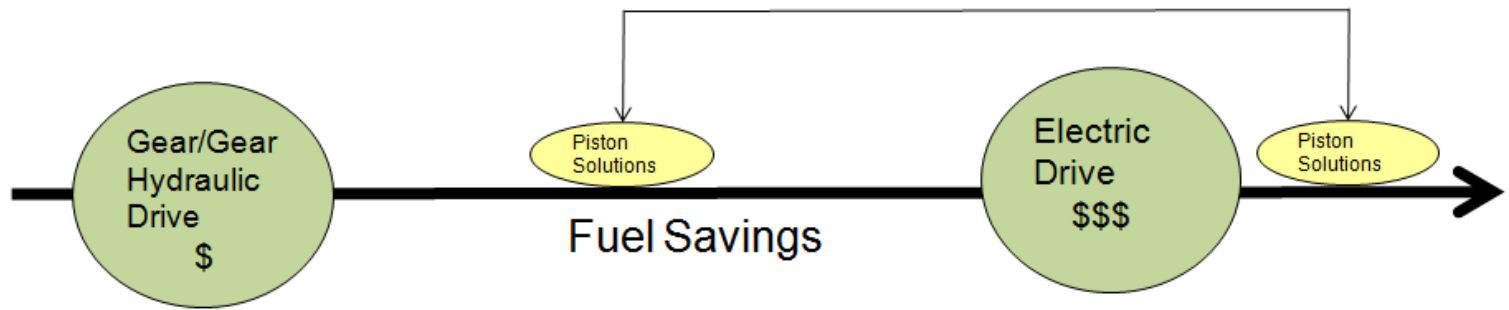
P1 Proportional Pressure Control



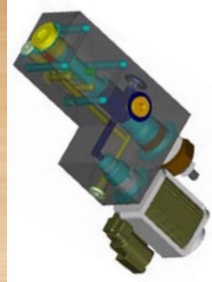
# Piston Pump Solutions

Bus Market:

- OEMs drove Gear/Gear solutions
- Transit Authorities demanded electric solutions



P1 Pump  
Proportional Pressure Control



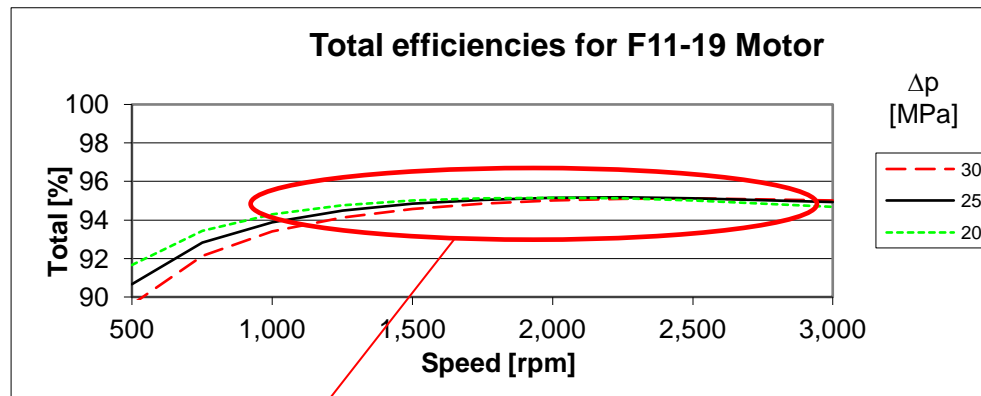
P1 Pump  
Electronic Displacement Control



# Bent Axis Pumps & Motors



- Unbeatable Power Density & Efficiency
- High Fan Speed – High air flow from small fans
- Speed sensor port for closed loop control
- Heavy duty bearings - direct fan mounting, axial & radial loads
- Wide Temperature Range (-40°C to +115°C)



**95% Total efficiency**  
**(volumetric + mechanical over wide range)**



# Parker Coolers



- Rugged Bar and Plate Coolers
- Combi Coolers
- Radiator, CAC, Oil
- Global: NA, Europe, China



# Full Cooling System Design Support



Olaer European version 4.01

Start **Cooler selection** Capacity calculation Dimensions Language

**Cooler type**

LAC, A.C. motor

LDC, D.C. motor

LHC, hydraulic motor

LOC, cooling system

LHC 044-1500 rpm

Subject to technical alterations.

Selected

**new**

**OLAER**

Copyright© 1988-2011 Olaer AB

**Type of oil**

ISO VG 46

**Oil flow**

120 l/min

**Max. oil temperature**

80 °C

**Air temperature**

40 °C

**Heat dissipation**

45.0 kW

**Altitude**

0.0 m

**Calculated data**

Inlet oil temperature: 76 °C

Outlet oil temperature: 64 °C

Outlet air temperature: 51 °C

Spec. heat dissipation: 1.25 kW/°C

Oil pressure drop: 0.47 bar

Air flow: 3.10 m³/s

Fan power required: 2.0 kW

LpA, 1 m: 86 dB(A)

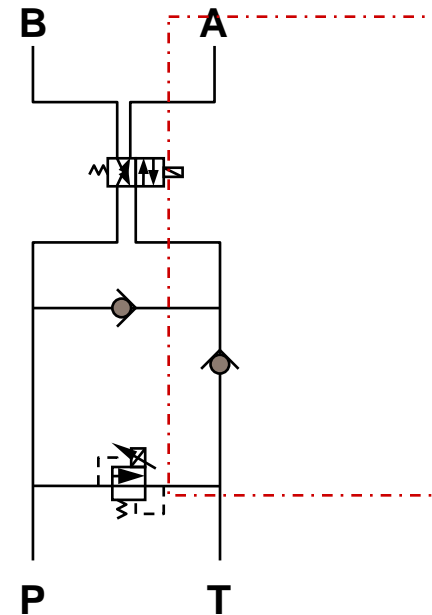
Cooler type	Spec. heat dissipation	Inlet oil temperature	LpA, 1 m	Oil pressure drop
LHC 044-1500 rpm	1.25 kW/°C	76 °C	86 dB(A)	0.47 bar
LHC 044-1000 rpm	0.98 kW/°C	86 °C	77 dB(A)	0.42 bar
LHC 056-750 rpm	1.08 kW/°C	82 °C	74 dB(A)	0.47 bar
LHC 058-750 rpm	1.30 kW/°C	75 °C	75 dB(A)	0.26 bar





# HCS/HCSE Manifolds

- **Multiple Fan Drive Circuits:**
  - **Stand Alone Fan Control**
  - **Or combine with Steering, Braking, etc**
- **Extensive Fan Drive Experience**
- **Wide Product Range**



# Fan Drive Reservoir & Integrated Filter



Bulletin 2300-455-1

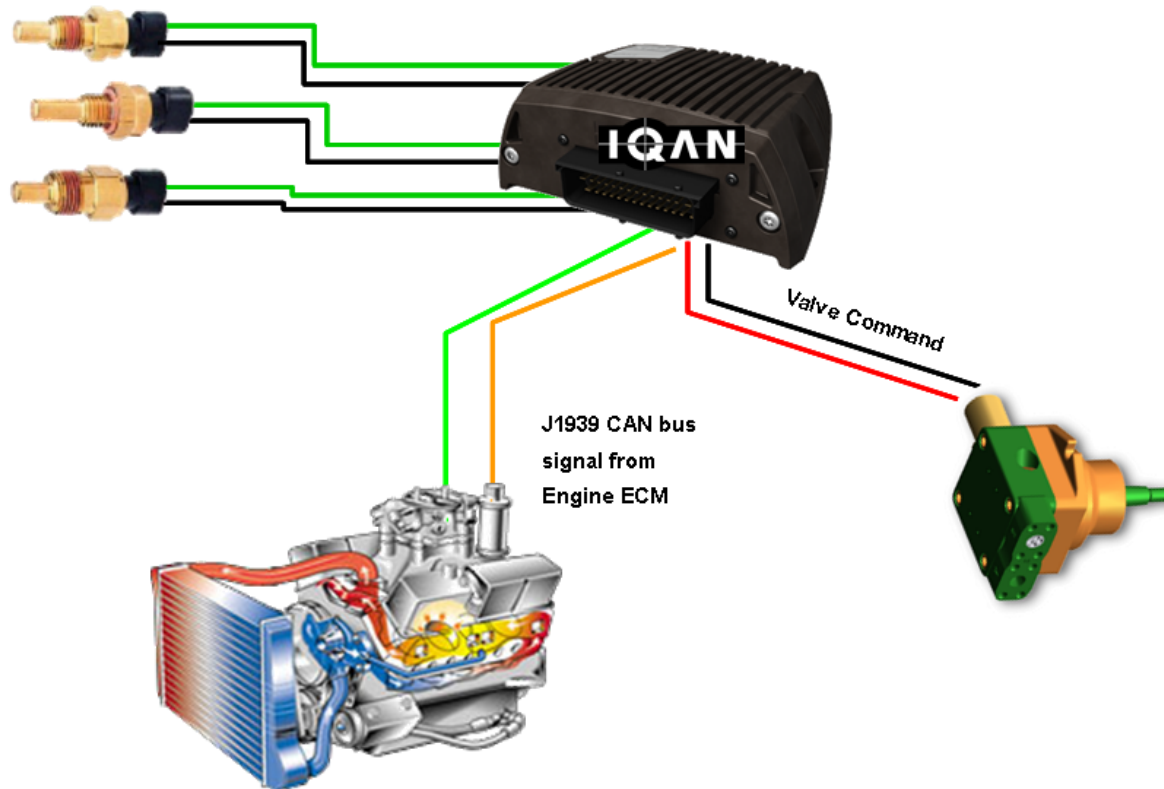
- Rugged cylindrical cold rolled steel
  - Rugged & Space efficient
- Aftermarket protected filter (patented element)
- Integral breather keeps dirt out
- Microglass media for cleaner fluid and extended service life
- Visual level and filter site gages
- Easy top service element replacement
- Multiple port options for power steering & case drain



# Fan Drive and System Controllers

- Parker Interfaces with Engine Controller
- Vehicle Controller Management

2 Wire Temp Sensor(s).



Stand Alone Fan  
Drive Controller



PFDC Series



# Pump & Motor Combinations

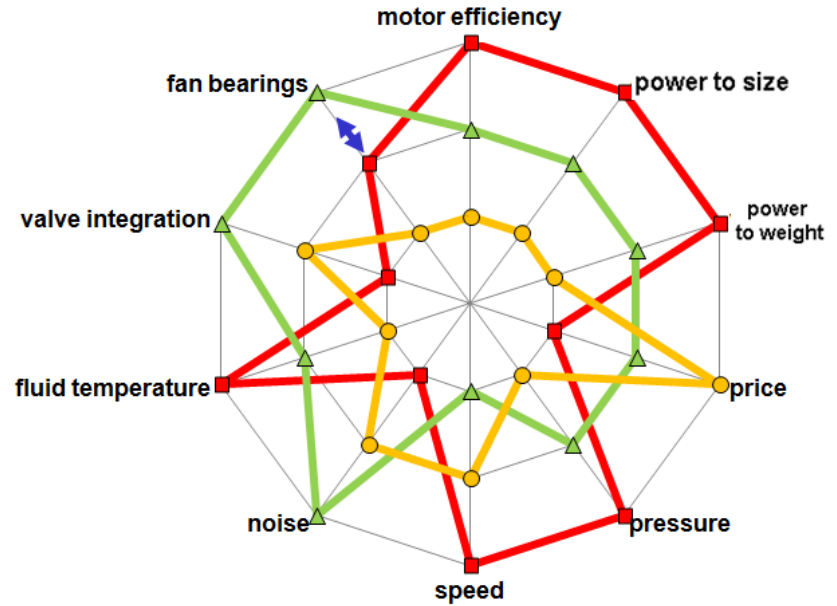
optimize performance and value

	Pump	Motor
Higher Performance ↑	Piston	Piston
	Vane	Vane
	Gear	Gear

Blue arrows indicate compatibility between Pump and Motor types in each row.



# Fan Motor Comparison



# Electric Fan Drive Solutions

# GMS - EM Fan Drive System Development

## Needs:

- Fuel Savings
- Reduced Fire Hazard
- Reduced Noise
- Green initiative



## Solution

- Parker Electric Fan Drive System
- Low voltage system for Transit Authorities, Bus Refurbishers / Repower facilities

## Lead Sales Contact

Patrick Berkner Global Mobile Systems

### Success Factors

- Able to be a full solution provider.
- System solution from ECD's MC2 controller, to Parker's low voltage inverters and motors

### Customer Value

- Improved fuel economy
- Reduction in parasitic losses
- Reduction in noise
- Reduction in fire hazards

Featured Products:

AUG motors and controllers

Market:

Bus & Coach, Construction

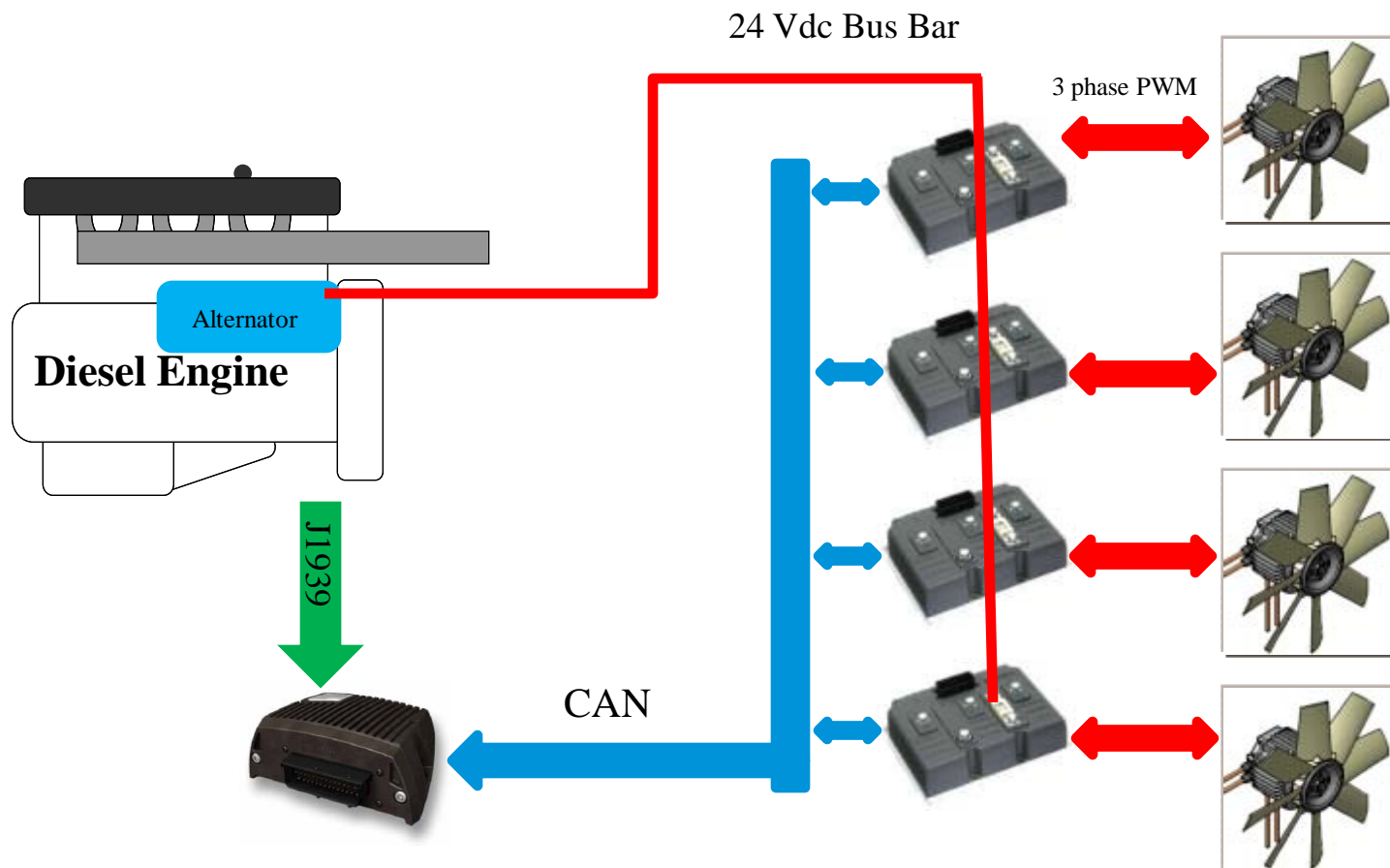
Distributor:

Direct



# GMS - EM Fan Drive System Development

## Block Diagram

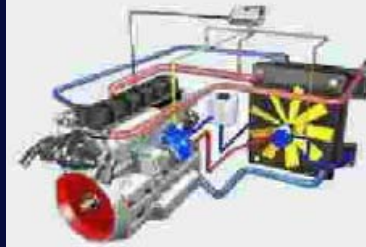


# GMS - EM Fan Drive System Development

## This Fan System is still in Development

- Target customer is the Transit Authority, bus refurbisher, repower facility
  - NOT OEM's
  - TA's look for Fuel savings, reduction in maintenance, etc.
- Now with Parker Olaer as a solution, Parker can be able to provide a full solution
- Olaer oil coolers
  - In the short term – they can supply oil coolers to the truck markets.
    - Can be used for smaller radiators for hybrid trucks, smaller vehicles.
- If you believe you have a potential opportunity, talk to Pat Berkner to discuss.

# Sizing & Specification



Fan Motor Input Information		
Fan Motor RPM	Input Torque (nm)	Required Fan Motor Power (kw)
500	10.4	0.5
1000	41.4	4.3
1500	93.3	14.6
1700	119.8	21.3
1700	119.8	21.3

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# Questions To Ask...

## Pump and Motor Sizing Questions:

- Maximum fan speed needed?
- Lowest pump rpm need to achieve the maximum fan speed?
- Rated power of the fan at its rated speed?
- Maximum power or torque available to drive the pump?
- Minimum and maximum engine speed?
- Maximum allowable or desired hydraulic pressure?

## Other Clarifying Questions:

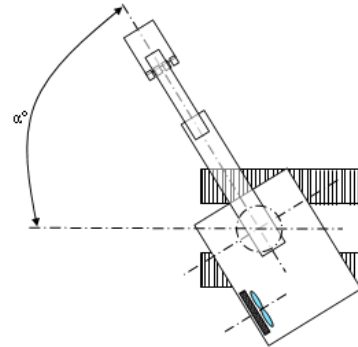
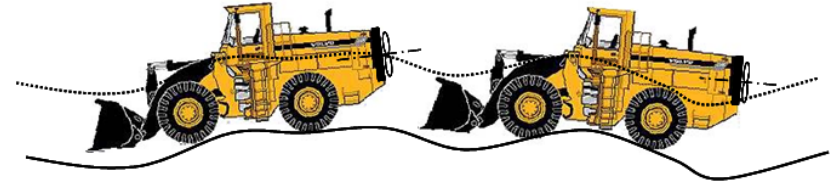
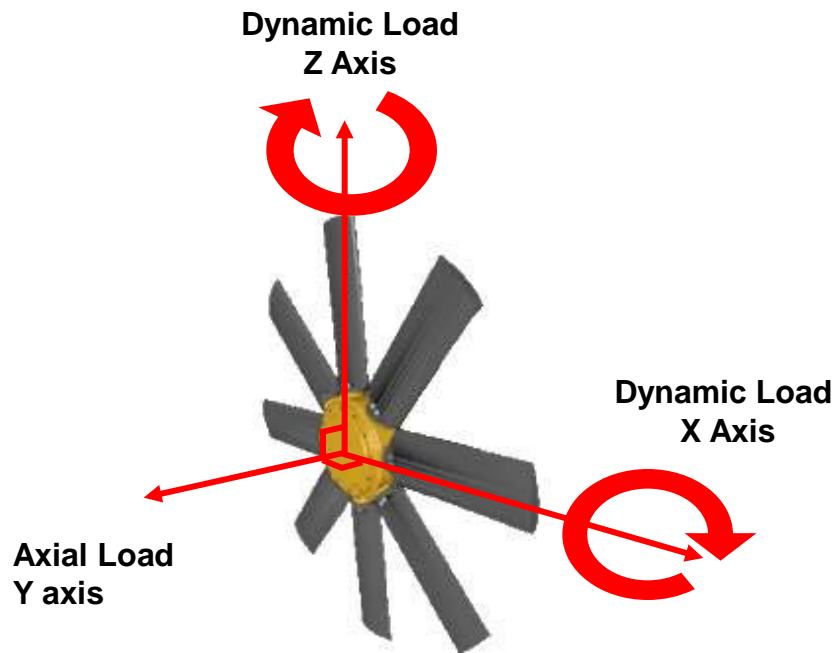
- Thrust, axial and dynamic loads on the fan motor?
- What features are needed {reversing, speed control, etc}?
- Duty cycle of the fan?
- Mounting, shaft and porting on the pump and motor?
- Space restrictions?



# Additional Factors:

To Accurately Calculate the Fan / Hydraulic Performance it is very important to:-

1. Account for Pump & Motor Efficiencies over the speed and temperature range.
2. Consider total hydraulic losses (hoses, valves...).
3. Address Dynamic Forces on the motor:



# Sizing Programs Available

**HydraCalc Plus**  
Print to File Information

**Parker** **DENISON Hydraulics**

Basic System Calculations

Fixed Pump-Fixed Motor

Fan Performance

Power	28.6	hp
Speed	1700	rpm

Max System Parameters

Fan Speed	1700	rpm
Max Eng. Speed	2180	rpm
Eng. Speed Where Max Fan Speed is Reqd.	2100	rpm
Pump : Eng. Drive Ratio	1.16	:1
Operating Pressure	3263	psi

Units

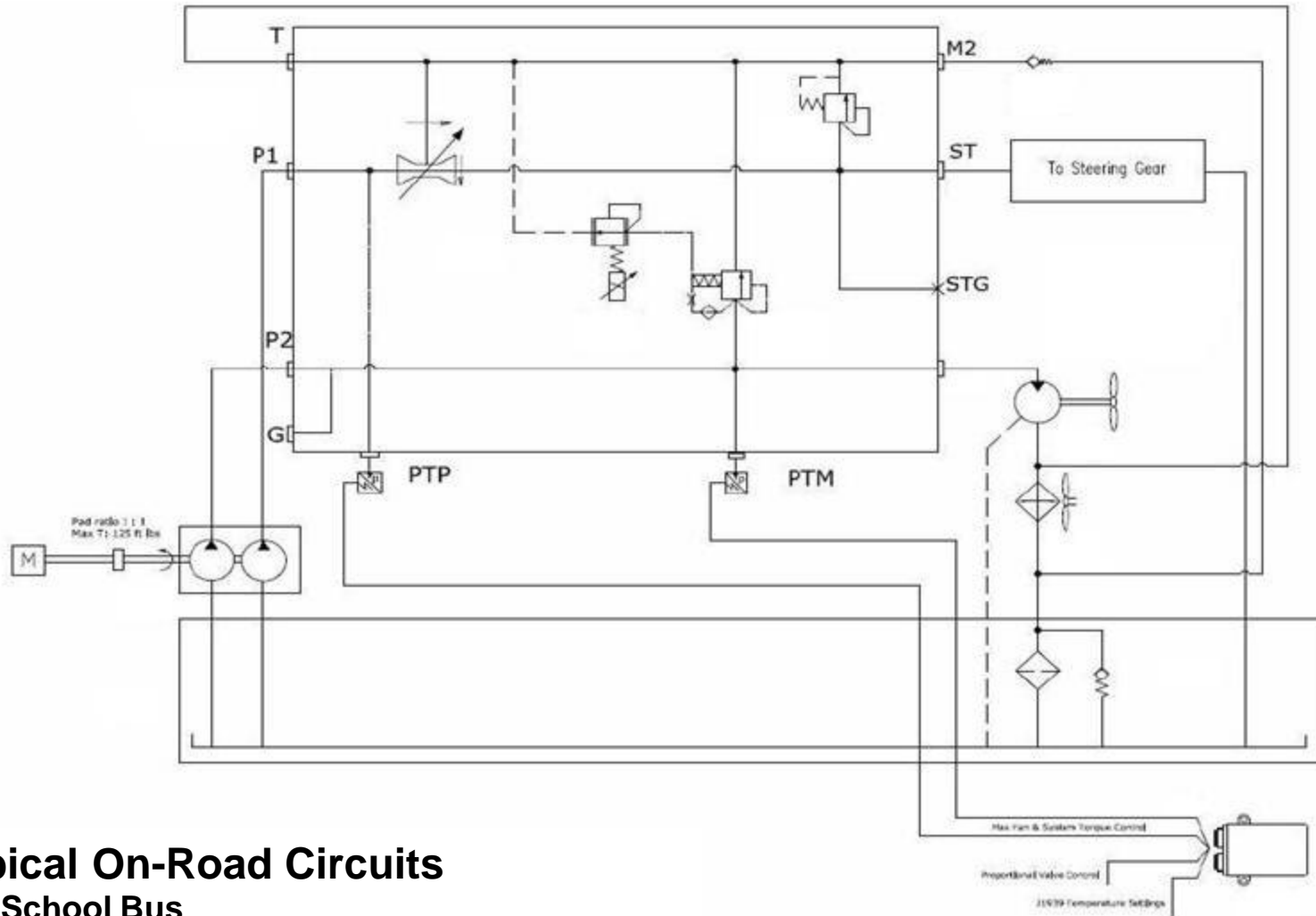
English  
 Metric

Output

Approx. Pump Disp.	1.83	cipr
Approx. Motor Disp.	2.22	cipr
Fan Power	28.6	hp
Fan Torque	1060	in-lb
Flow Reqd. from Pump	17.75	gpm
Approx. Eng. Power at Full Fan, Full Eng. Speed	41.4	hp

Calculate Performance with Known Components

# Typical Bus Circuit: Single Fan, Torque Limiting Option, Excess Flow To Tank



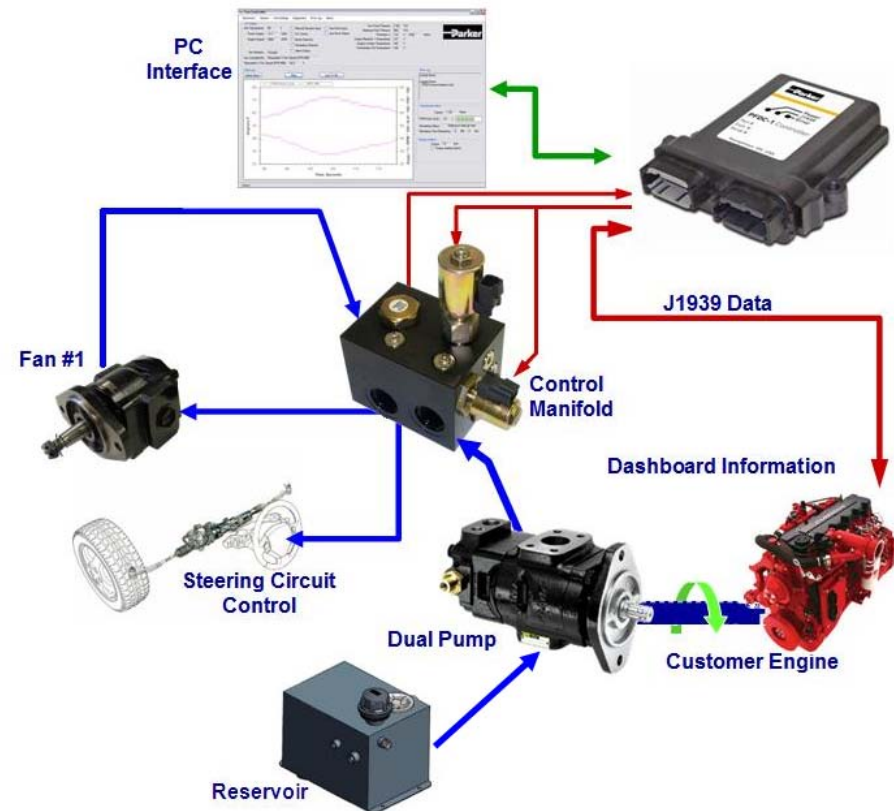
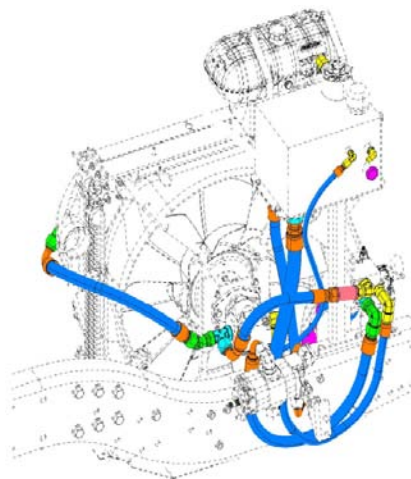
## Typical On-Road Circuits

- School Bus
- Transit Authority
- Airport Shuttle Bus

# Total System Solution – Bus OEM



- Parker Fan Drive System for all Tier III rear engine applications
  - Total System Performance was driving factor
  - Customer impressed with GPD & FCG service levels for prototypes and rapid system development



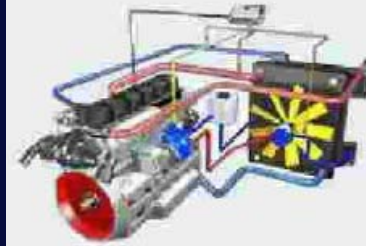
# Keys to the Win

- Focused Team (TBB unfamiliar with hydraulics)
  - 600 Performance
  - System Approach
  - Won with **Performance**, Maintained with **Support**
- 

## Lessons Learned

- High Temps: Controller, Pump/Motor
- System Cleanliness
- Validate to Entire Cooling Duty Cycle
- Bus Market: No BS, Field Support

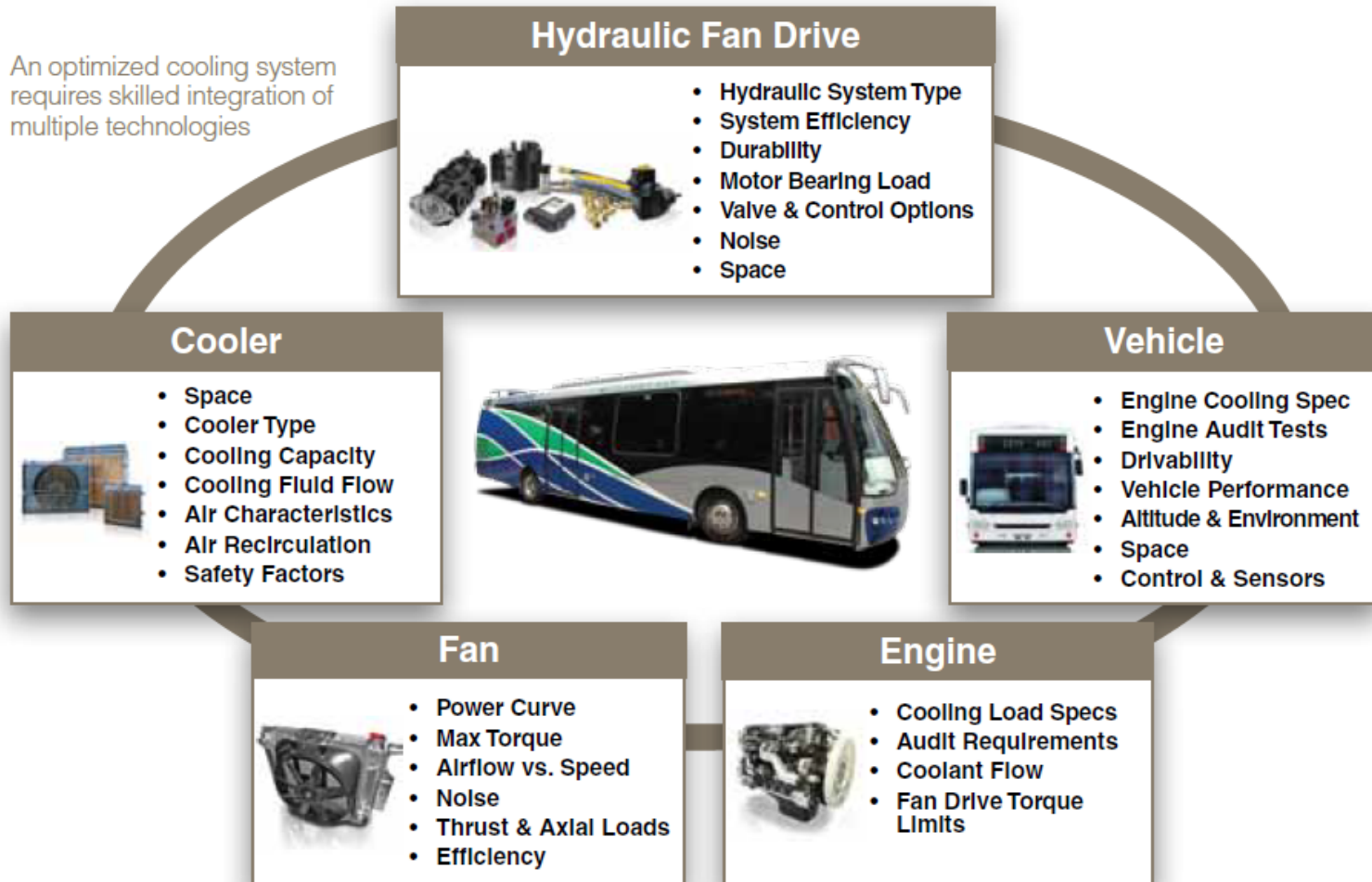
# Sales Strategy & Support



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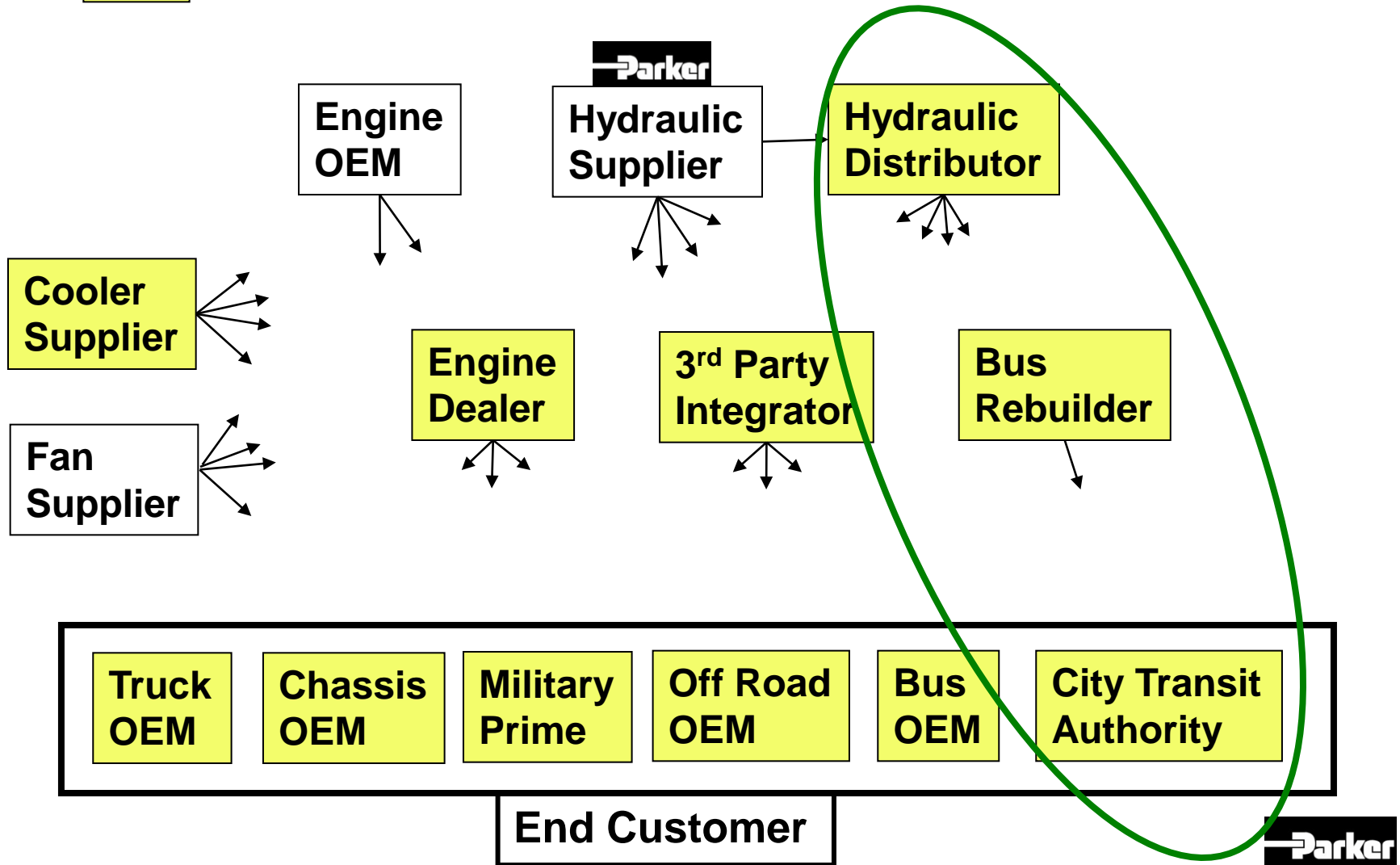
# Cooling System Integration is very Complex:

An optimized cooling system requires skilled integration of multiple technologies



# System Integration & Supply

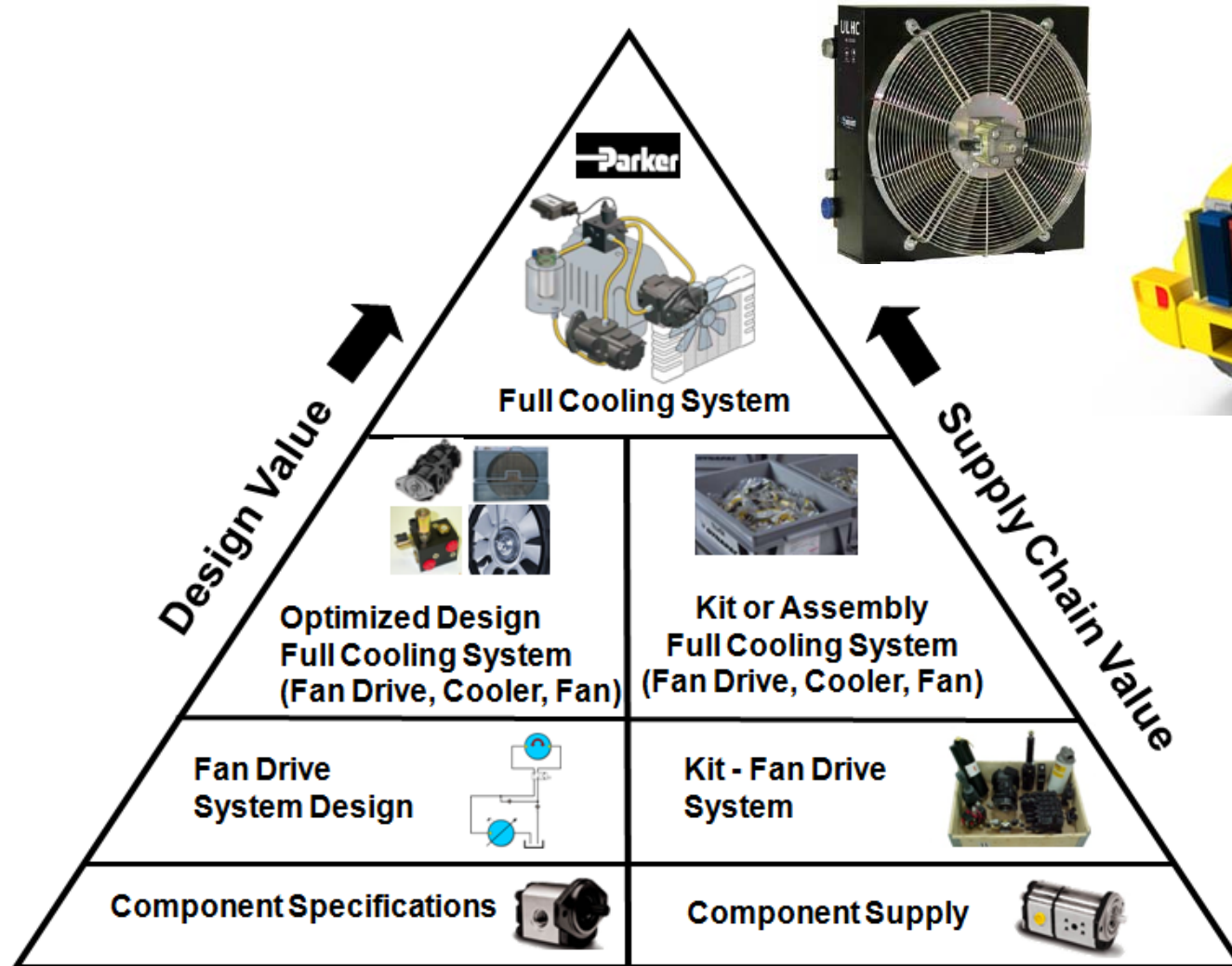
 = FD System Integrator     = Value & Supply





# Parker Capability

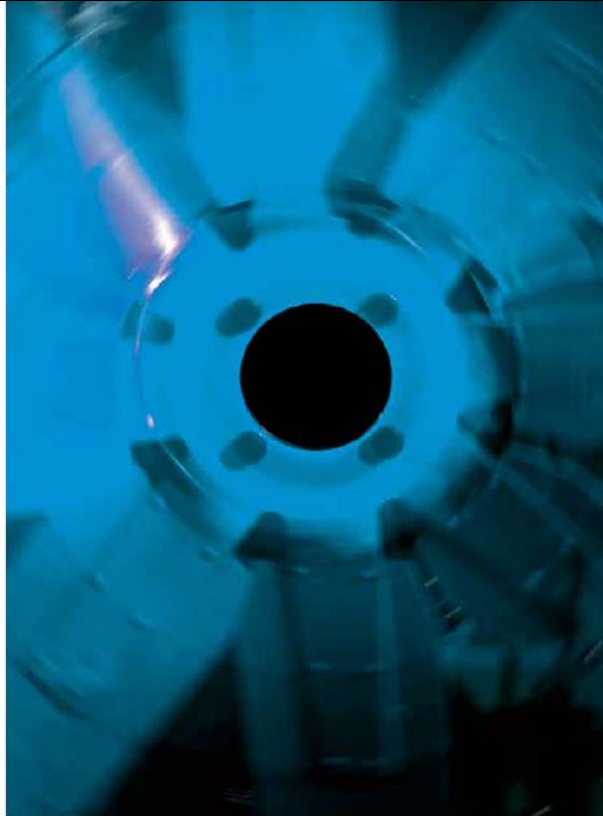
## Full Cooling System Integration



# Solutions Guide for the Bus Market:



- aerospace
- climate control
- electromechanical
- filtration
- fluid & gas handling
- hydraulics
- pneumatics
- process control
- sealing & shielding



## Hydraulic Fan Drive Solutions For the Bus Market



ENGINEERING YOUR SUCCESS.



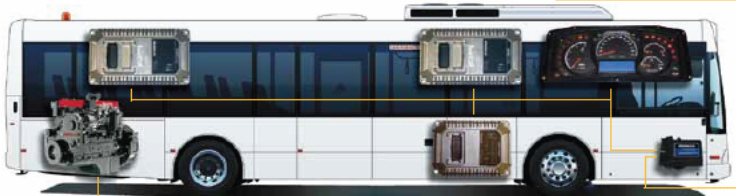
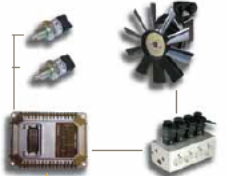
### Electronic Controllers - Fan Drive & Full System

With overall vehicle electronic control systems becoming more common in the bus market, the ability to integrate the fan drive control logic into the rest of the vehicle control system is important. Parker Hannifin offers a wide variety of CAN bus

based control platforms that can be integrated with the fan drive hydraulics. Integrating the fan drive into the overall vehicle control system can reduce the installation time and cost, reduce diagnostic time and increase fan drive efficiency by allowing all

the vehicle functions that could affect fan drive performance to be monitored. Integrating the fan drive into the vehicle control system still allows for full fan drive functionality, including:

- SAE J1939 CAN and analog inputs for fan speed control
- Fan reversing with ramps
- Automated and manual fan reversing
- Multiple fan locations with independent control
- Improved fault detection and diagnostics
- Software configuration of parameters



Full Bus System Controllers - Multiplexing Modules

