



STURMAN

**Hydraulic Valve
Actuation
“HVA”**

Presented to
CARB

April 20th 2004





Overview

- **STATE OF DEVELOPMENT**
 - Sturman HVA Technology
 - HVA History
- **COMMERCIALIZATION**
 - OEM Demonstration Programs
 - Production Target

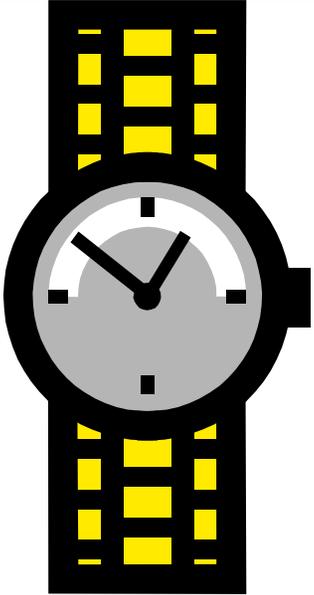


Sturman Industries Technology History





Technical Philosophy



**“Bringing the
Mechanical World into
the Digital Age.”**

Simple
Efficient
Needed
Safe
Economical



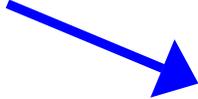


Sturman History

1965 – NASA Apollo program



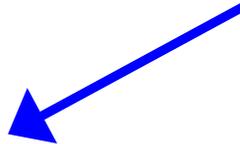
Eddie Sturman
**Latching Valve
Technology**



1989 – Sturman Industries, Inc.



Founded



April 10, 20

Space Foundation Hall of Fame

Digital Valve technology

“Products From Space Benefiting Planet Earth”



Facilities

This may be....
**“the most advanced R&D
facility for engine controls
research and development
in the world.”**

**-Rob Wilson- Editor
Diesel Progress Magazine**





MECHANICAL SYSTEMS
COMBINING BENEFITS
OF
DIGITAL & HYDRAULIC CONTROLS

- ✓ *Reduced Size*
- ✓ *Reduced Weight*
- ✓ *Energy Efficiency*
- ✓ *High Speed Response*
- ✓ *Precise Intelligent Control*
- ✓ *Economical*



- ✓ *SAFE & ECONOMICAL*

- ✓ *PROVEN AVAILABLE TECHNOLOGY*

- ✓ *MEET EMISSIONS STANDARDS*

- ✓ *MAINTAIN HIGH PERFORMANCE*

- ✓ *REDUCE AFTERTREATMENT*

- ✓ *CO₂ BALANCE*

- ✓ *REDUCE FOSSIL FUEL RELIANCE*



Technical Philosophy

Internal Combustion Engine With Complete Combustion Control

Reduce emissions

Logistically and economically feasible

Reduce need for after-treatment

Environmental conscious



Renewable fuels



Fuel Injector Production

- **PRODUCTION March 2002**
 - 6.0L V8- International Medium-Duty Trucks
- **PRODUCTION Nov 2002**
 - 6.0L V8- Ford F-250 E-250 (& Bigger)
- **CURRENT PRODUCTION VOLUME = 14,000/day**



E-Series

F-250

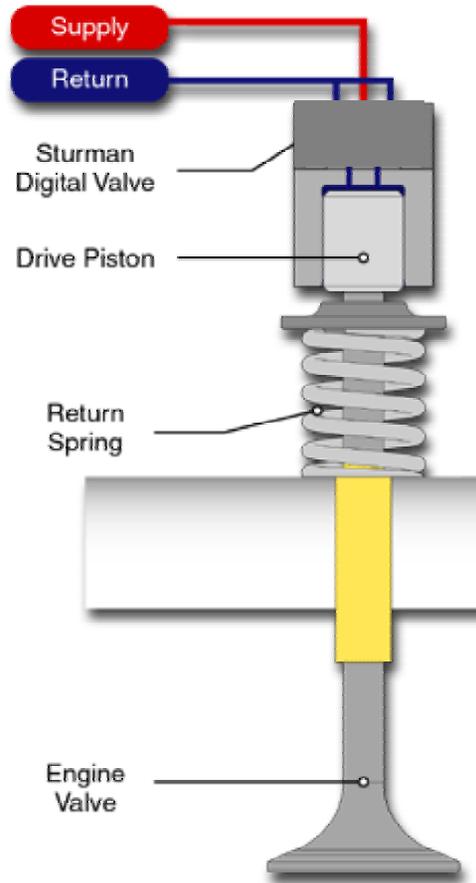
F-350





STURMAN

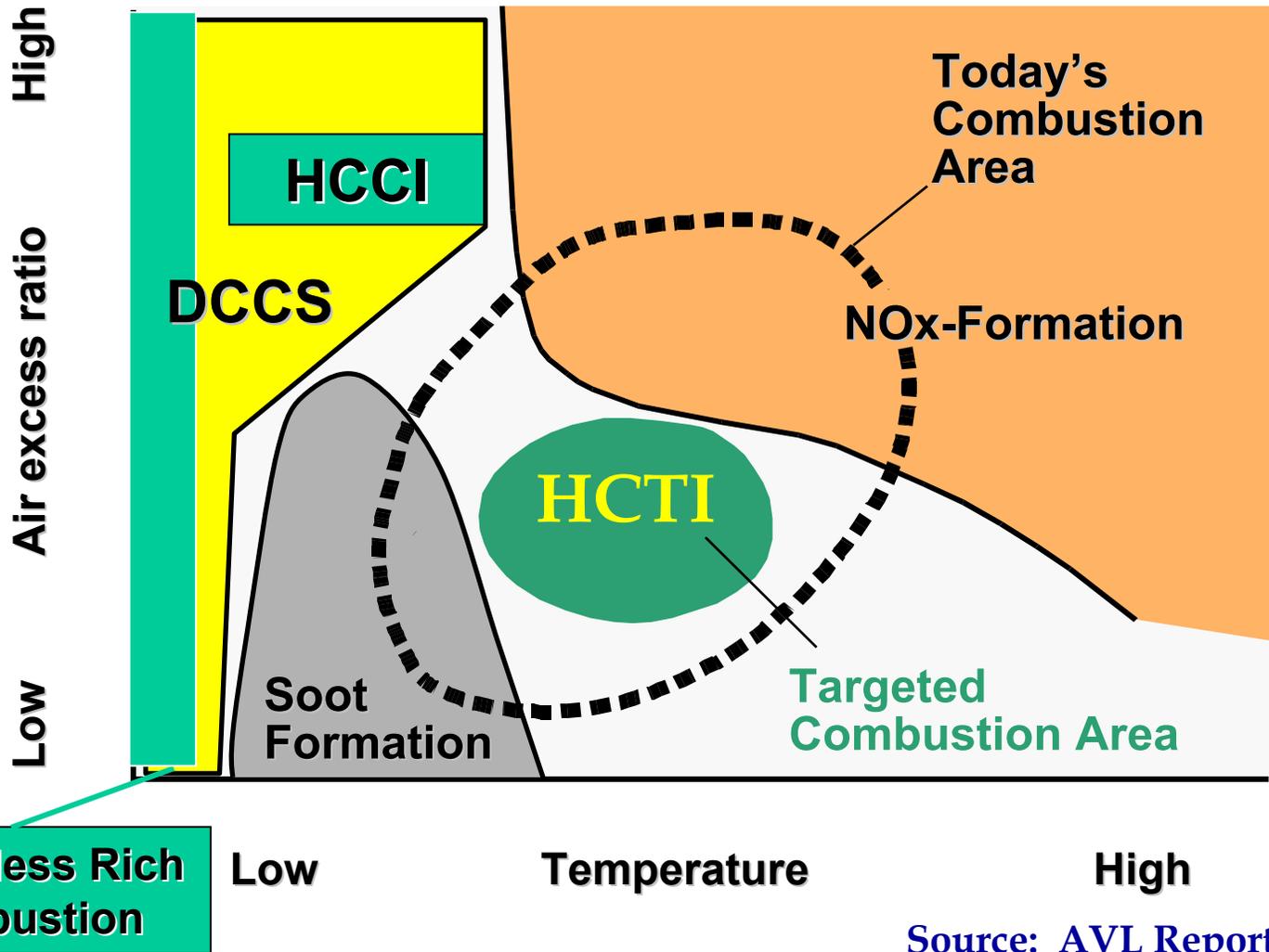
Hydraulic Valve Actuation



DHOS™ Technology



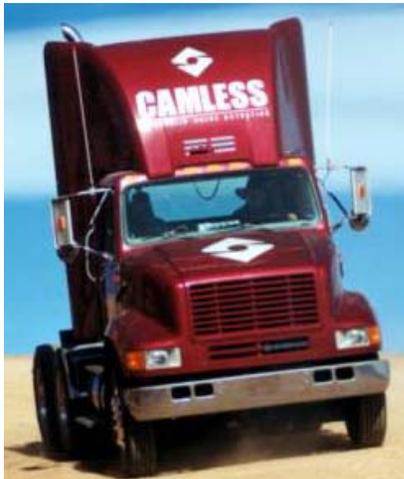
Controlling Combustion





HVA Vehicles

Proven technology exists today!



First Vehicle 1999



10,000 Mile trip to receive
Popular Science
2000 Technology Award



Passenger Car 2003



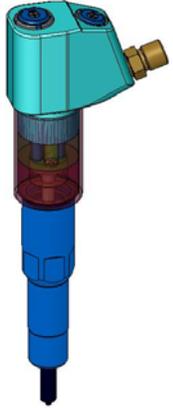
Sturman Industries Technology





Sturman Technology Triangle

Fuel Control



Air Control



Clean Air

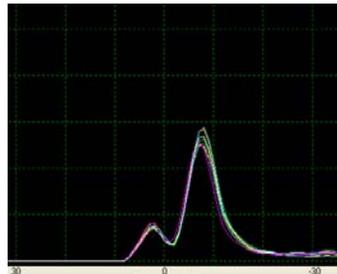
Improved Performance



Reduced Fuel Consumption



Flexible Combustion Control





Hydraulic Valve Actuation

Technology Status





HVA History

- **8 Years of experience in HVA**
- **World-Wide customers**
- **Test systems delivered to customers**
- **Multiple engines running**
- **Multiple vehicles in operation**



The technology is catching on....

The **flexible injector and valve actuation technology** is being tested by manufacturers around the world.

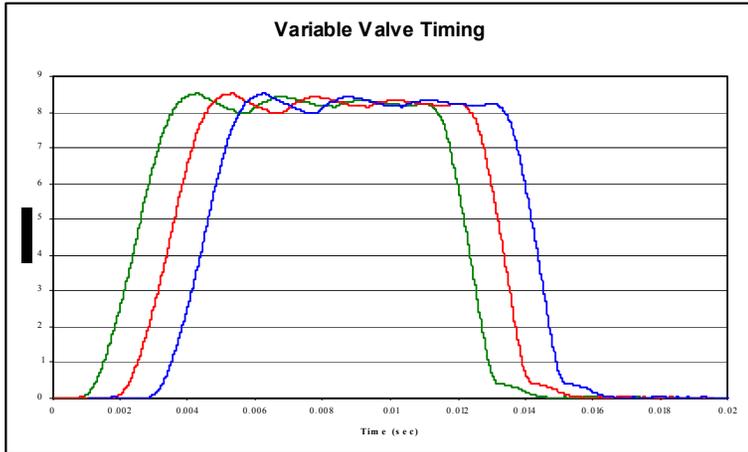


Japan, Europe, and the United States

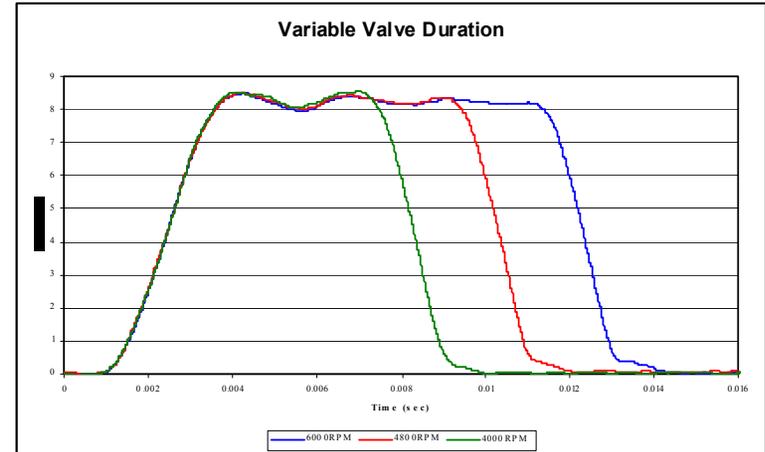


HVA-4A DATA

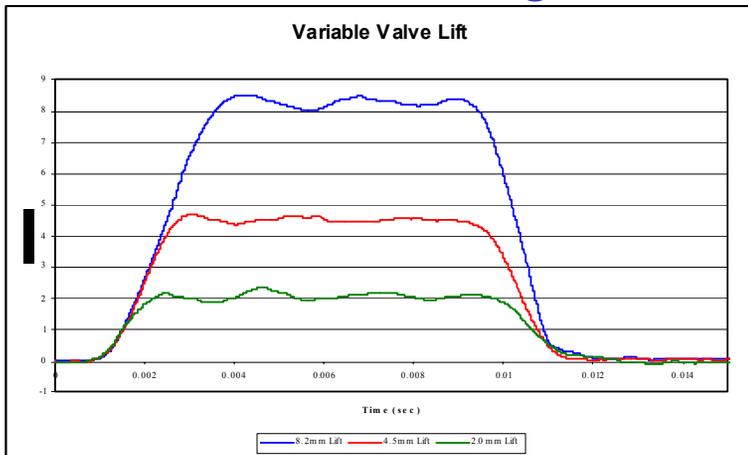
Performance Features



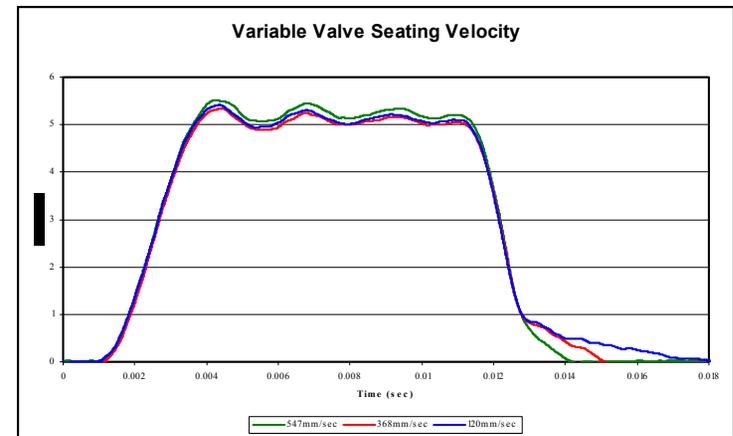
Variable Timing



Variable Duration



Variable Lift

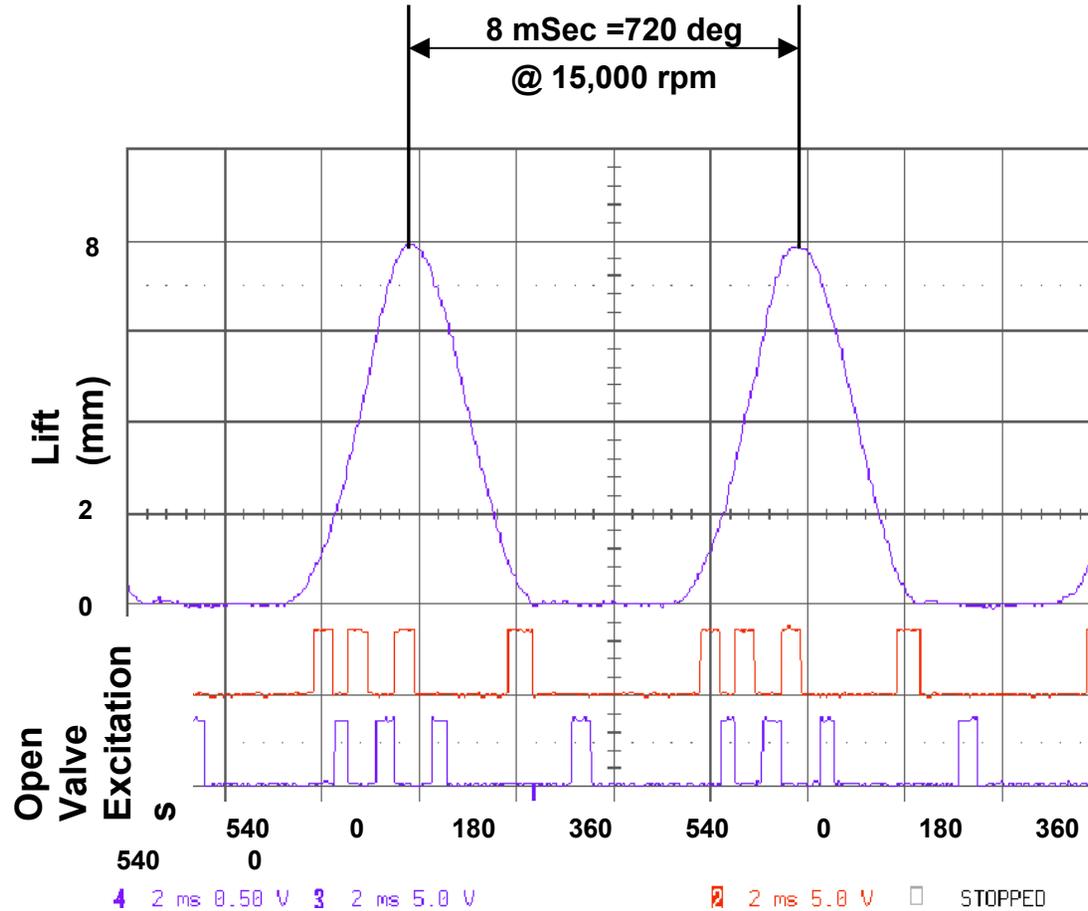


Variable Seating



HVA-4A DATA

High Speed Operation



Time (2 mSec/div = 180 deg/div)



HVA-4A Video

For copy of MPEG file demonstrating flexibility of HVA-4A system, please contact Dave Burt at Sturman Industries:

dburt@sturmanindustries.com

719-686-6165



HVA-4D Video

For copy of MPEG file demonstrating stability of HVA-4D system, please contact Dave Burt at Sturman Industries:

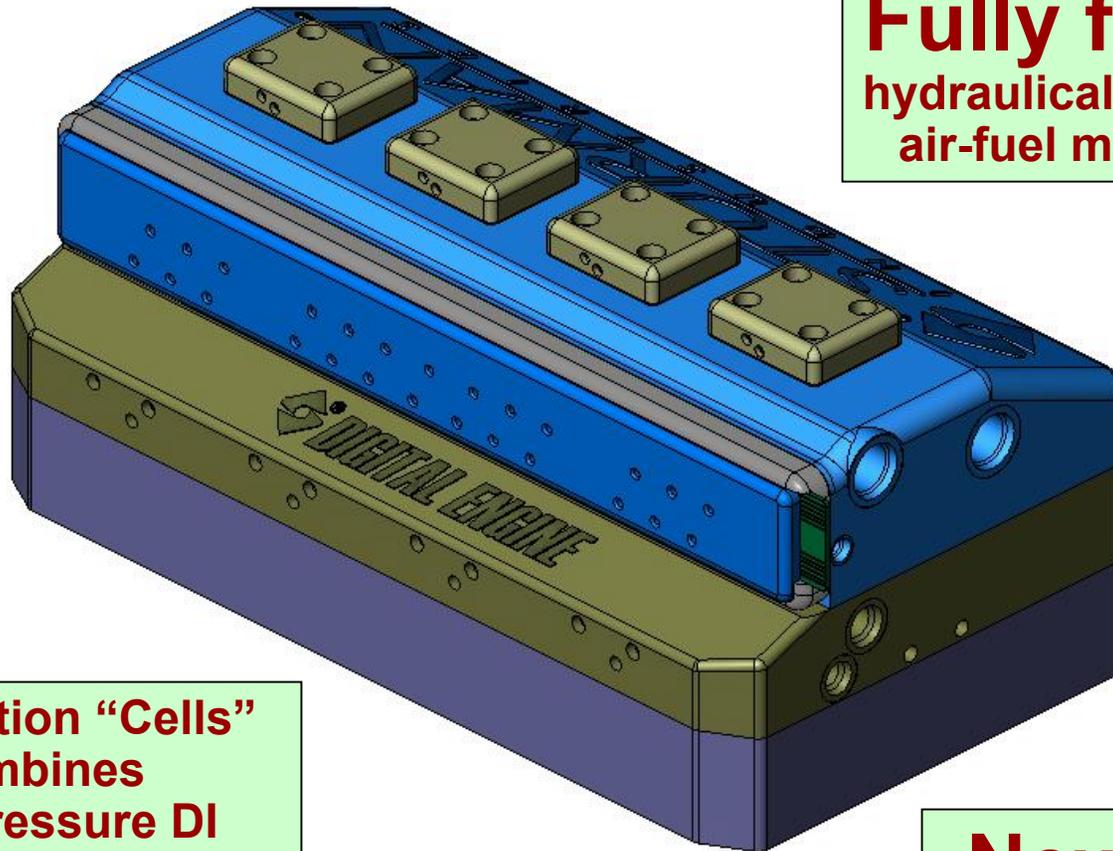
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- **DHOS proven technology**
- **HVA benefits demonstrated**
- **Production target = 2009**

Long Term Vision - Sturman Digital Engine

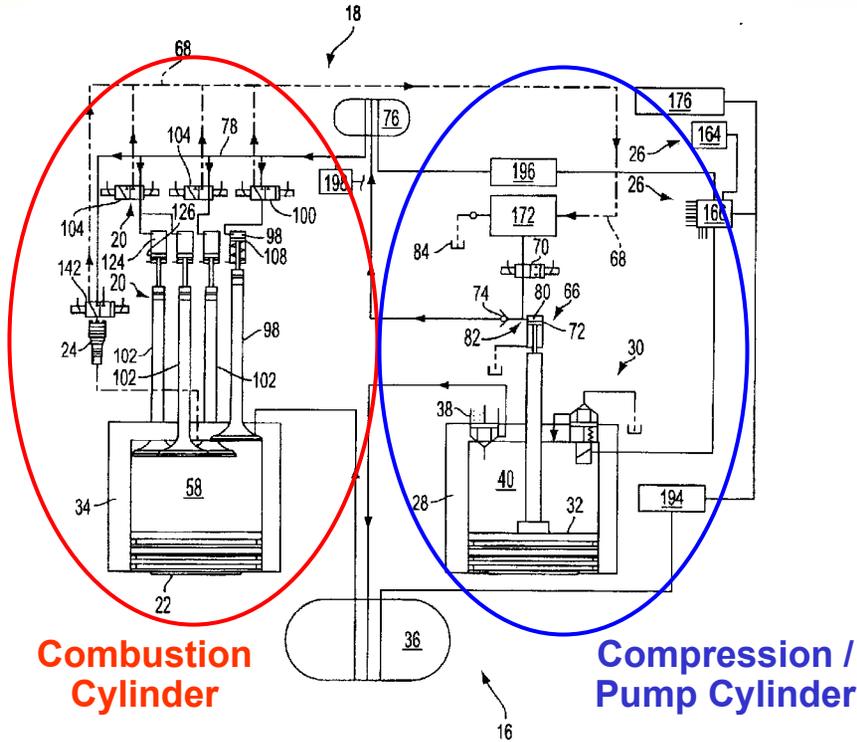


**Fully flexible,
hydraulically-controlled
air-fuel management**

**Combustion "Cells"
Combines
high pressure DI
gasoline injection &
HVA-4D technology**

**New or
Retro-fit**

Long Term Vision - Sturman Hybrid Engine



**Combustion
Cylinder**

**Compression /
Pump Cylinder**

FIG. 6

2-Cylinder Module Schematic

Efficient, Clean & Economical

**Head, consisting of
(3) 2-cylinder
modules**

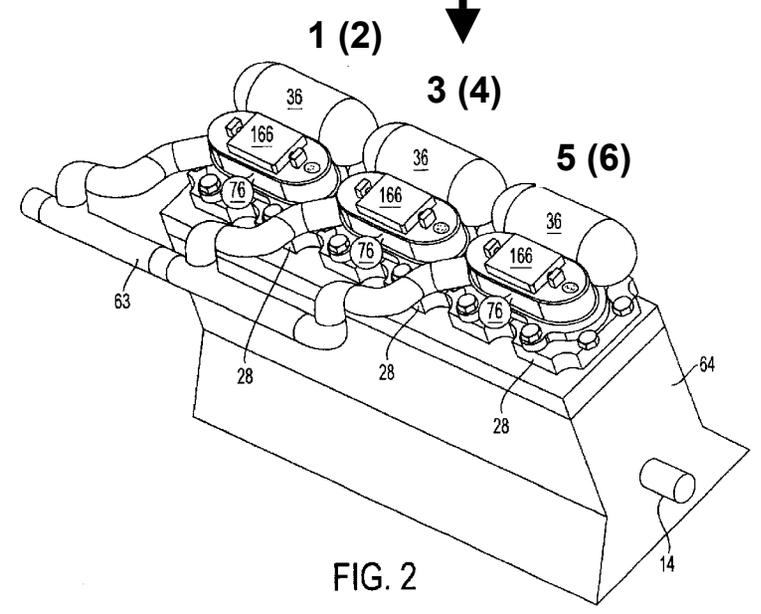


FIG. 2

**Patented
ENVIRONMENTAL
HYBRID ENGINE**



DATA

Gasoline HVA Benefits

Source:

2002 GLOBAL POWERTRAIN CONGRESS PAPERS
ADVANCED ENGINE DESIGN & PERFORMANCE

Sturman Industries / AVL Powertrain

*“Development of a Fully Flexible
Hydraulic Valve Actuation Engine”*



- **“Fuel consumption – 16-21% benefit”**
- **HVA offers:**
 - “The most flexibility-
- lift, duration & phasing”**
 - “Promise the largest gains-
-engine efficiency, emissions,
and performance.”**



RESULT

INTERNAL COMBUSTION ENGINE WITH HVA = LESS CO₂

For copy of AVL / Sturman paper contact:

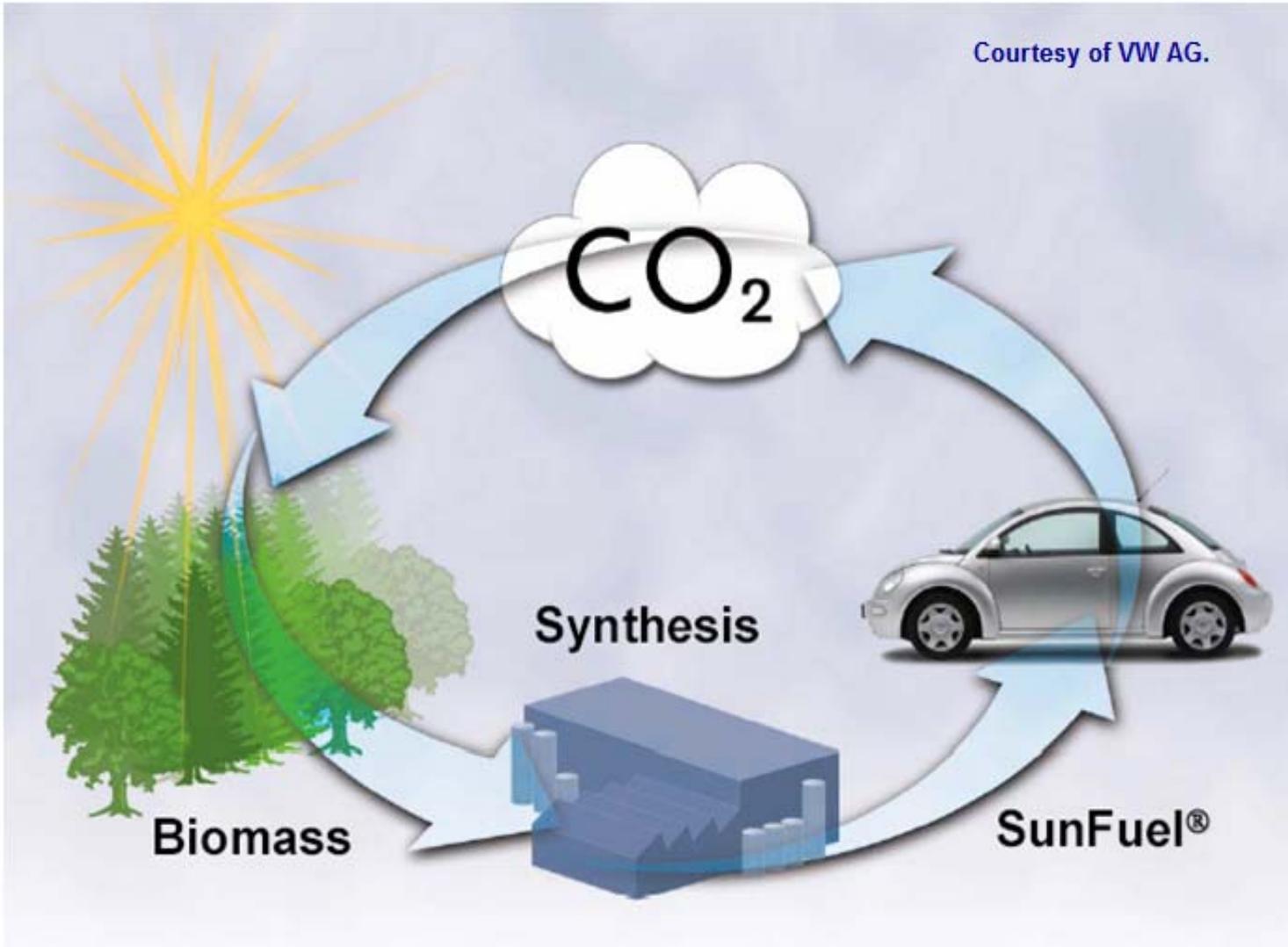
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719-686-6000



CO₂ Loop

+ With Sun Fuels





International Combustion and Fuels Meeting

Washington D.C.

March 17, 2004

Presentations of research and conclusion by the following companies
focused on practical combustion and fuels solutions

- AVL
- Daimler Chrysler
- VW
- Sasol Chevron
- Choren
- ANGTL
- NREL
- DOE

Organized by
Sturman Industries

Copies of presentations available by contacting Jacek Popiel:
jpopiel@sturmanindustries.com