Path to Sustainability:

ADAPTIVE DIGITAL POWER™

Helping enable…

Practical & Efficient NH3 Implementation

STURMAN INDUSTRIES

Sturman Capabilities

130+ PATENTS

40+ Years Experience

450 Acre Colorado Innovation Park Campus

"It is the most exciting engine technology in the world that I know of. It has revolutionary implications in many uses, not only vehicles."

Amory Lovins
Chief Scientist & Chairman
Rocky Mountain Institute

Redefining How Mechanical Things Work…..

"The most advanced R&D facility for controls research and development in the world."

-Rob Wilson-
Past Editor Diesel Progress Magazine

Proprietary

Mechanical SYSTEM Transformation

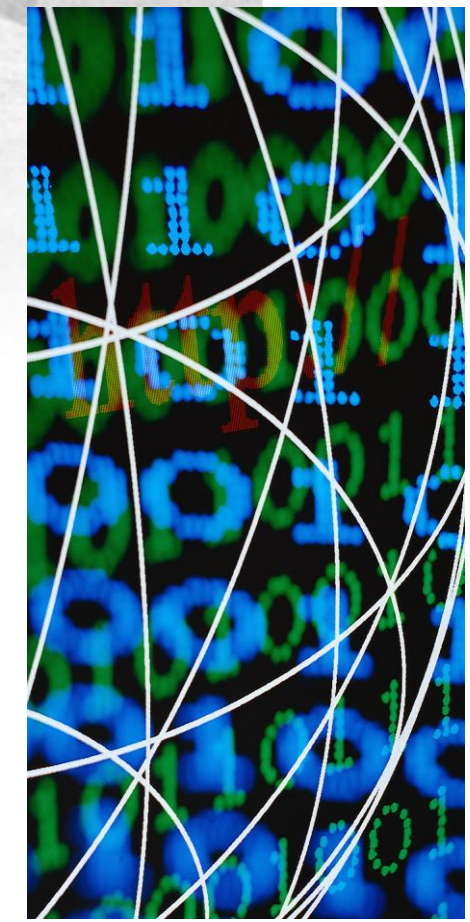
Via DIGITAL HYDRAULIC CONTROLS & OPTIMIZED SYSTEMS:

- ✓ Ultra precise,
- ✓ Intelligent
- ✓ Flexible
- ✓ Powerful
- ✓ Proven

STURMAN INDUSTRIES

Proprietary

Digital Systems ADVANTAGE



1. Stable States
2. Compact Integration
3. Ultra Flexible & Precise
4. Intelligent
5. Breakthrough efficiency
6. Economical
7. Superior Products

for
INDUSTRY LEADING
GROWTH & PROFIT

Some Collaborative Partners

INTERNATIONAL

GM

TENNECO

TACOM

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

ROCKY MOUNTAIN INSTITUTE

BORG WARNER

TARDEC

FEV

UNITED STATES AIR FORCE ACADEMY

The California ENERGY COMMISSION

Universal Instruments

OAK RIDGE NATIONAL LABORATORY
Managed by UT-Battelle for the Department of Energy

NACFE

CALSTART

Westport

CLEMSON UNIVERSITY

MICHIGAN

New A.C.E Institute CO., LTD

JARI 財団法人日本自動車研究所 Japan Automobile Research Institute

TERC Environmental Improvement Through Research

HARC

TECHNISCHE UNIVERSITÄT CAROLO-WILHELMINA ZU BRAUNSCHWEIG

VOLVO

Mack

PAST COLLABORATION &//OR CUSTOMERS

MIT Massachusetts Institute of Technology

DEPARTMENT OF ENERGY UNITED STATES OF AMERICA

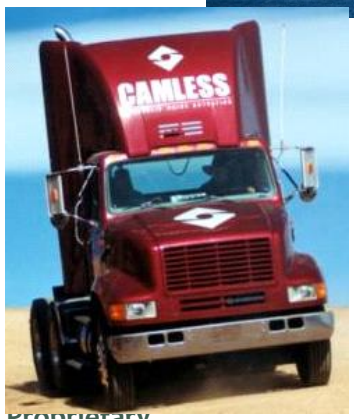
AVL

NREL

PROVEN PRODUCTION CORE TECHNOLOGY

- *LARGE SCALE PRODUCTION*
- *DIGITAL VALVE & INJECTORS*

2002 – 2011+



Truck

Marine, Locomotive, Automotive,

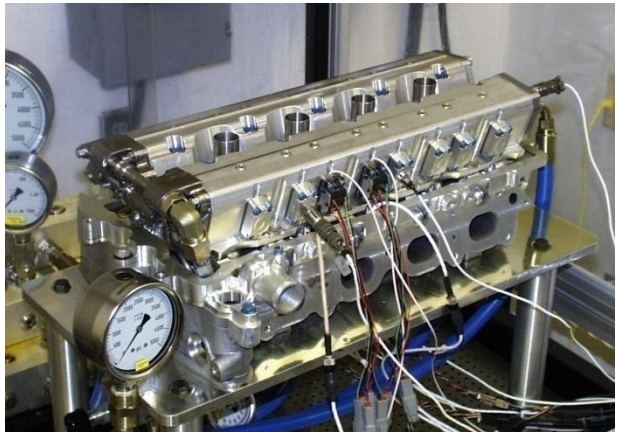
+ Power Generation

Application

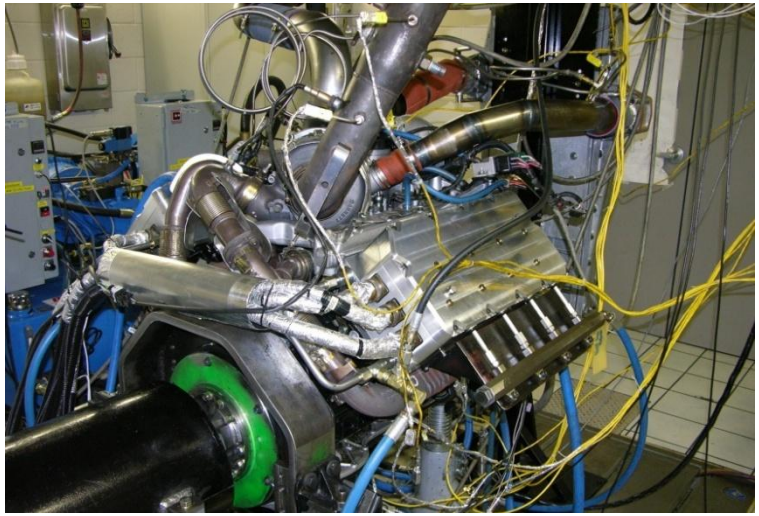
Proprietary

Digital Hydraulic Controls - Engine Development

- An intelligent combination of Digital Technology
- Incorporating digital **AIR** control
  - **Control** over air delivery and flow
  - **Enables** multiple fuels
  - High **efficiency** power
  - **Safe** engine braking



- Harnessing existing digital **FUEL** control
  - **Control** over fuel delivery
  - **Improved** fuel usage
  - **Multiple** fuel and **renewable** potential
  - **Existing** technology



2006 - 2011+

Proprietary

Diesel Combustion by means of Variable Valve Timing

* Hideaki Osada*1, Yuzo Aoyagi*1, Takuya Yamaguchi*1 and Masayuki Kobayashi*1
Eddie Sturman*2 and Eric Drummond*2
Akira Noda*3, Yuichi Goto*3 and Hisakazu Suzuki*3
*1New ACE Institute Co., Ltd.
2530 Karima, Tsukuba-shi, Ibaraki Pref. 305-0822, Japan
*2Sturman Industries
One Innovation Way, Woodland Park, CO 80863, U.S.A.

ABSTRACT

The Digital Hydraulic Variable Valve Actuation (DHVVA) - one of the enabling technologies for the reduction of exhaust emissions utilizing flexible valve lift and timing.

The timings of intake valve close (IVC) are significant to increase volumetric efficiency

VVA is one of the effective technologies for the next step of emissions reduction and fuel consumption improvement for diesel engines.

DHVA simplicity

Volvo - NREL - SWRI - Sturman Camless

JSAE 20077207
SAE 2007-01-1930

US 2010 Emissions Capable Camless Heavy-Duty On-Highway Natural Gas Engine

James P. Chiu
Southwest Research Institute
Joshua D. Taylor
National Renewable Energy Laboratory
Chun Tai
Todd Reppert
Volvo Powertrain North America
Lane Christensen
Sturman Industries, Inc.

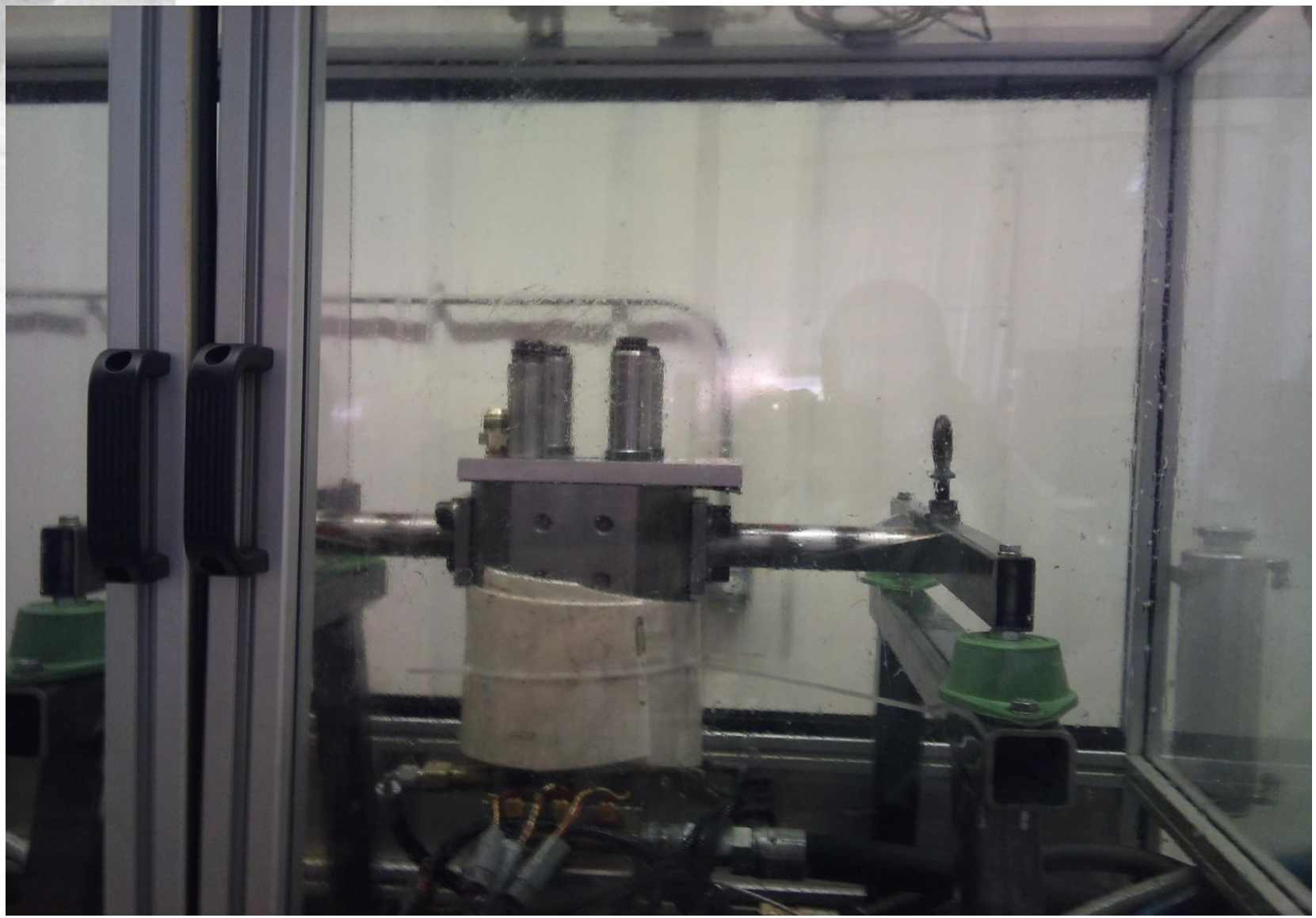
High conversion efficiencies are

possible through proper control of air-fuel ratio.

The HVA system
can also enable the use of high compression ratio pistons

The results show a weighted 13-mode NOx emission level of 0.005 g/kW-hr, which easily meets the NOx emissions target of 0.27 g/kW-hr (0.2 g/bhphr).

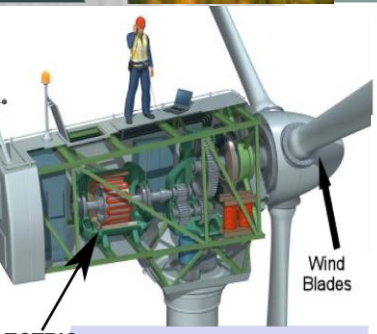
Adaptive Digital Power™



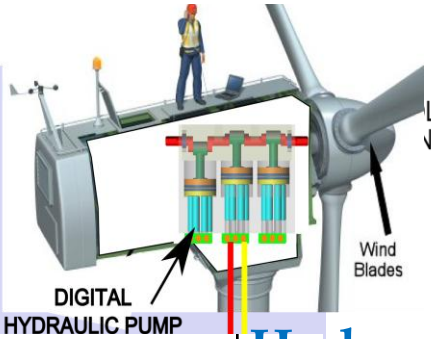
ADPt™ – Auto Ignition

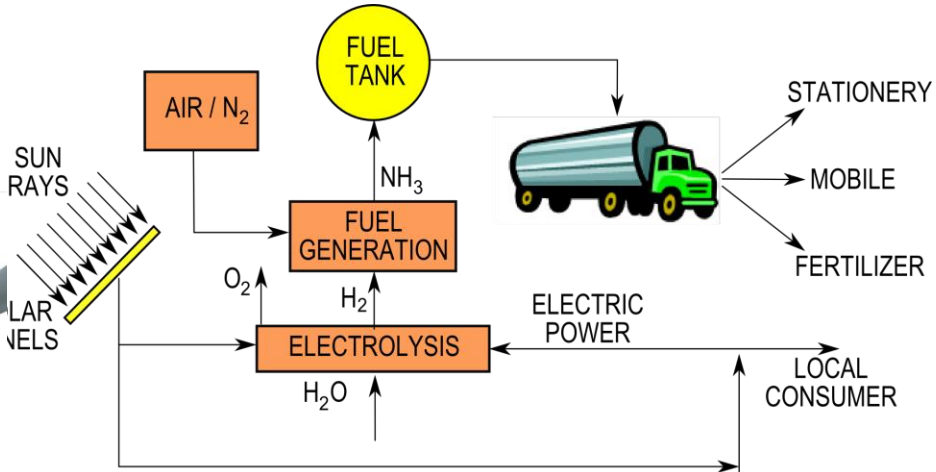
ADPt_033011 Bench 30 sec_revB_HD.wmv

Digital Hydraulic NH3 System Solution

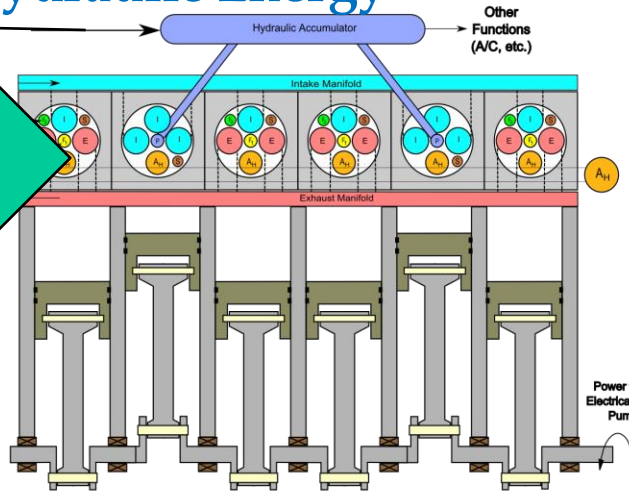


Conventional replaced with **ADAPt™**

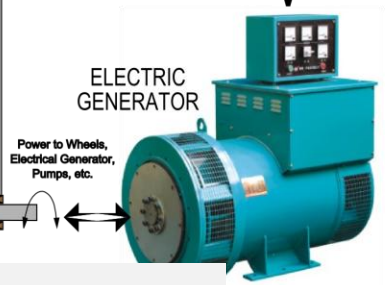




Hydraulic Energy



Stored Air



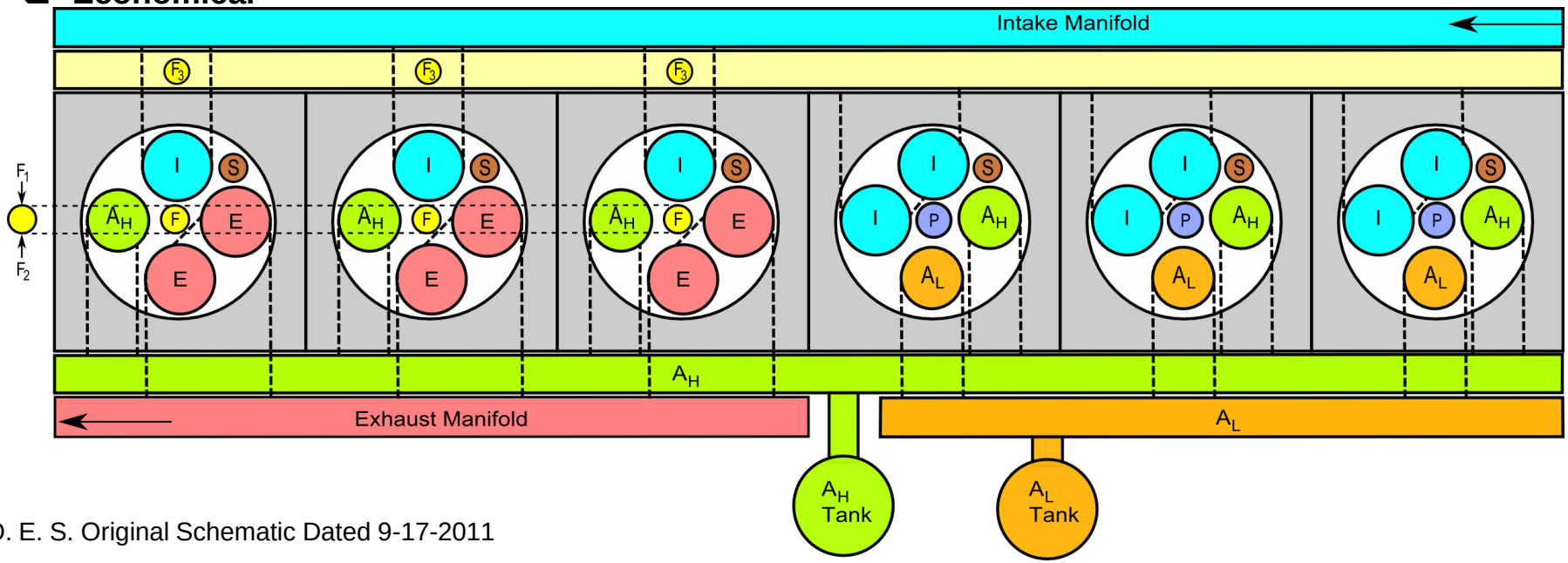
Sturman Adaptive Digital Engine™

Sturman Air Controlled Engine

Alternative Configuration for the "A.C.E."

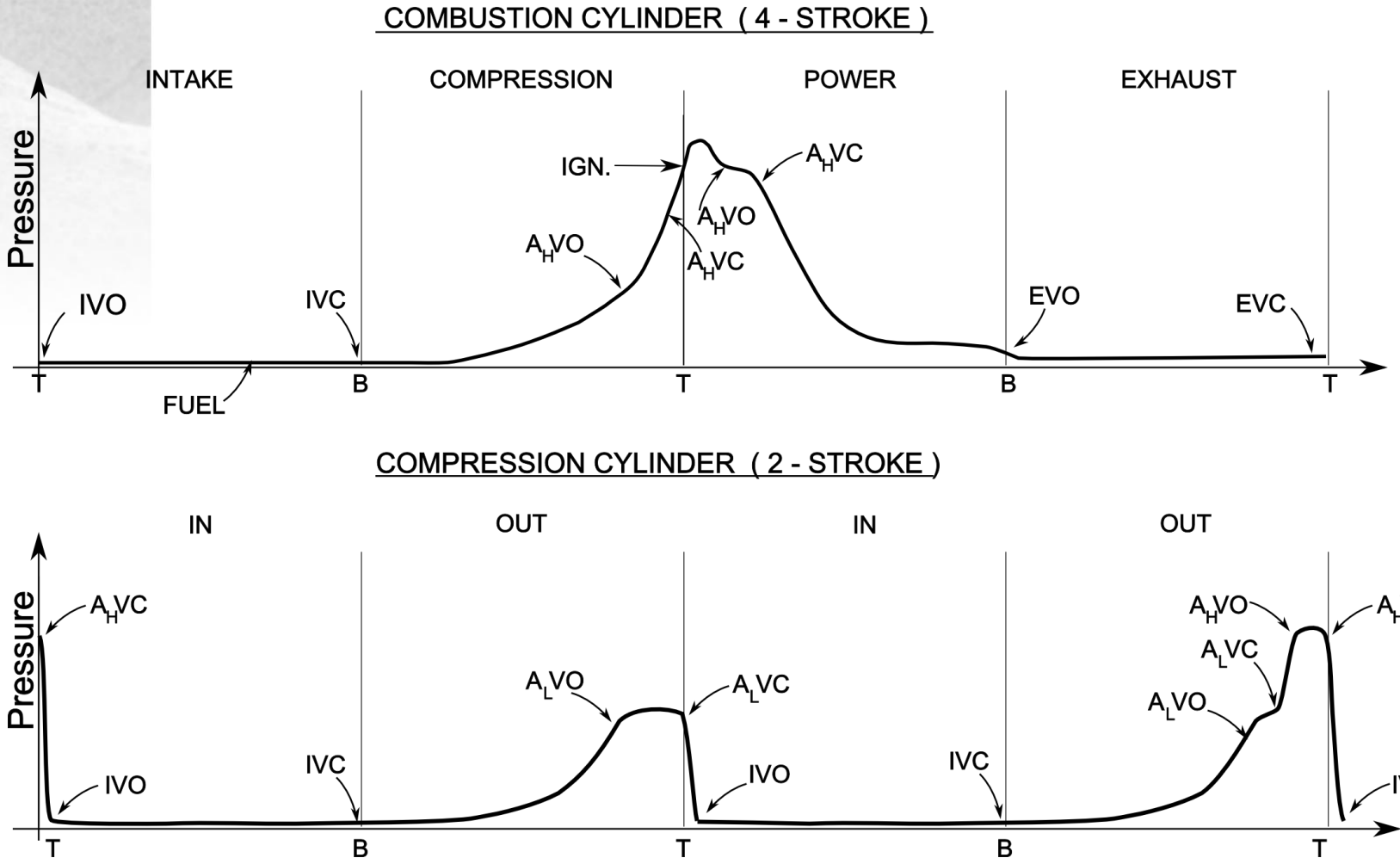
- Hydraulic Hybrid
- Air Hybrid
- Multi Fuels
- Integrated Hydraulic Pump
- Sturman Cycle
- Camless
- Digital Valves
- New or Retrofit
- Low Emissions
- High Efficiency
- Economical

- S = Pressure Sensor
- P = Hydraulic Pump
- I = Intake Valve
- F = Injector for Fuels 1 & 2
- F_1 = Fuel 1 Feed
- F_2 = Fuel 2 Feed
- F_3 = Injector for Fuel 3
- A_L = Air Low Pressure
- A_H = Air High Pressure
- E = Exhaust Valve



O. E. S. Original Schematic Dated 9-17-2011

Thermodynamic Cycle for Above Configuration of "A.C.E."



O. E. S. Original Schematic Dated 9-17-2011

Saving Their Future ….. Mike Bowman

Working Together for ECO-NOMIC SOLUTIONS

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Web site:
www.sturmanindustries.com