1993 WINDSOR WORKSHOP ON ALTERNATIVE FUELS

DESIGN OPTIONS FOR HYBRID-ELECTRIC VEHICLES USING ULTRACAPACITORS

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Idaho
National
Engineering
Laboratory

DESIGN OPTIONS FOR HYBRID-ELECTRIC VEHICLES USING ULTRACAPACITORS

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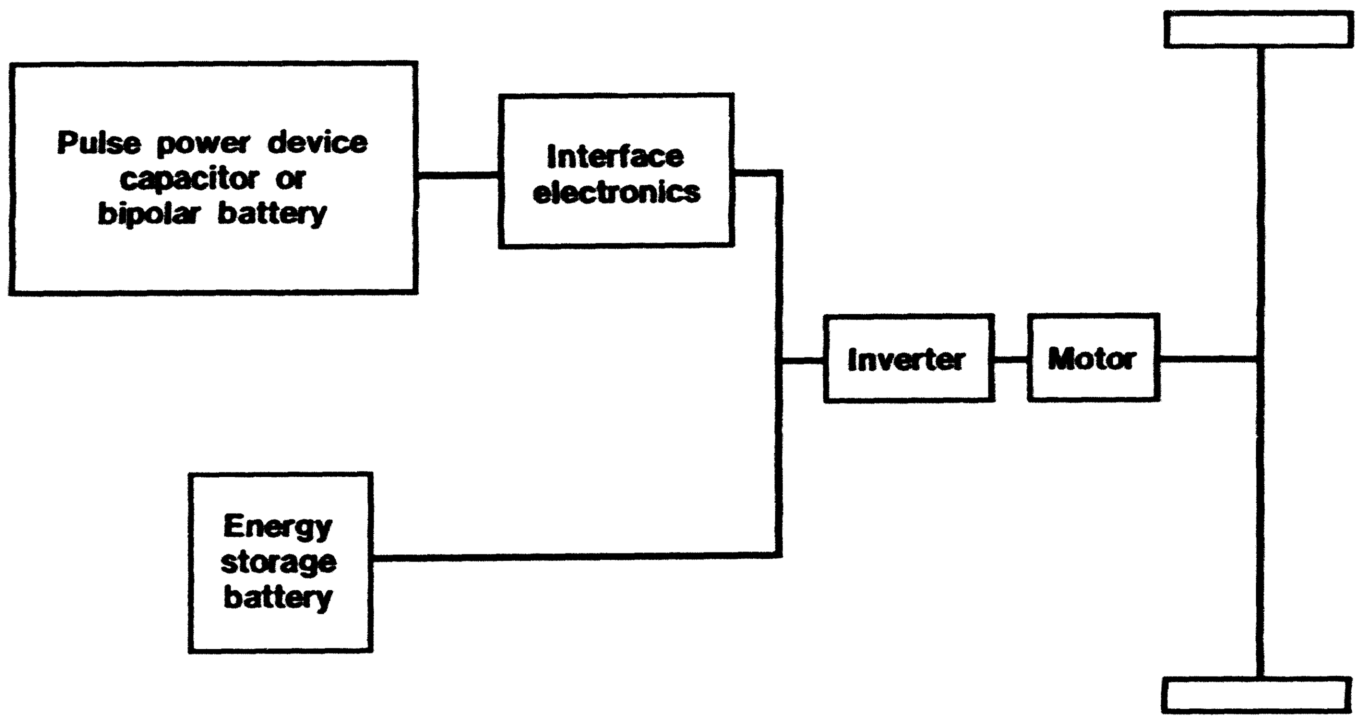
1993 Windsor Workshop on Alternative Fuels
Toronto, Canada
June 14-16, 1993

Work supported by the U.S. Department of Energy
Assistant Secretary for Energy Efficiency and Renewable Energy (CE)
Under DOE Idaho Operations Office Contract DE-AC07-76ID01570

Schematic of an Electric Vehicle Propulsion System, Including Battery Load Leveling



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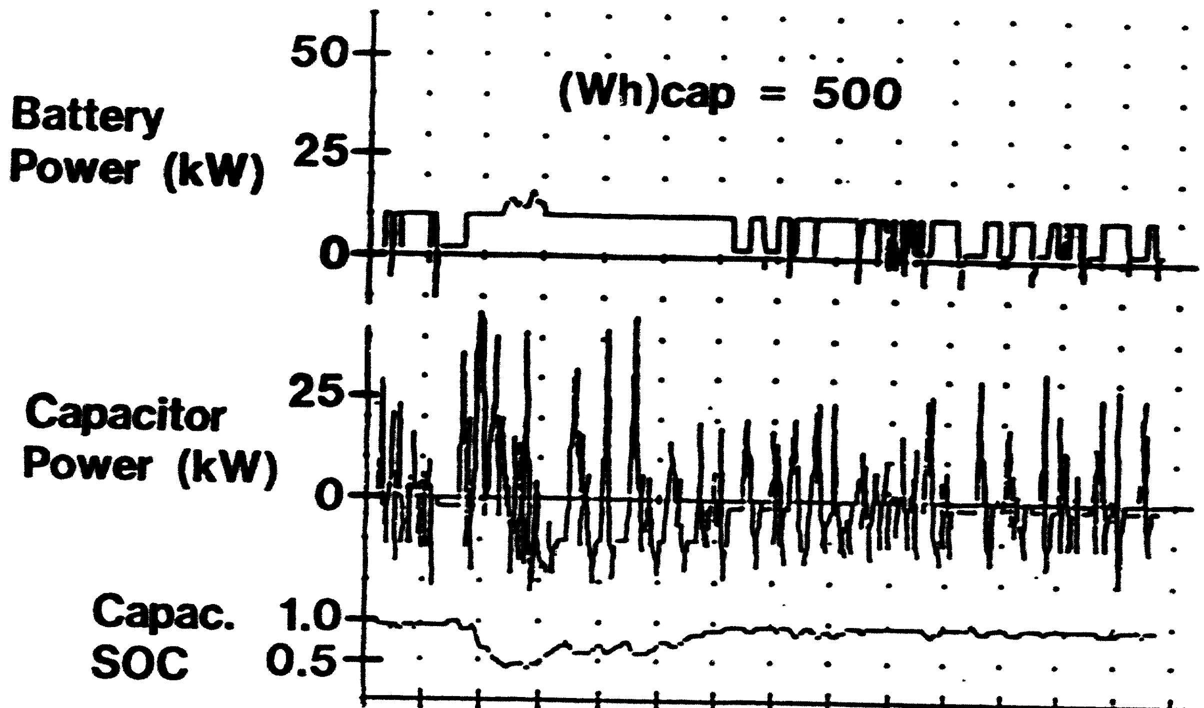
Load-Leveled Battery Discharge on the FUDS Cycle



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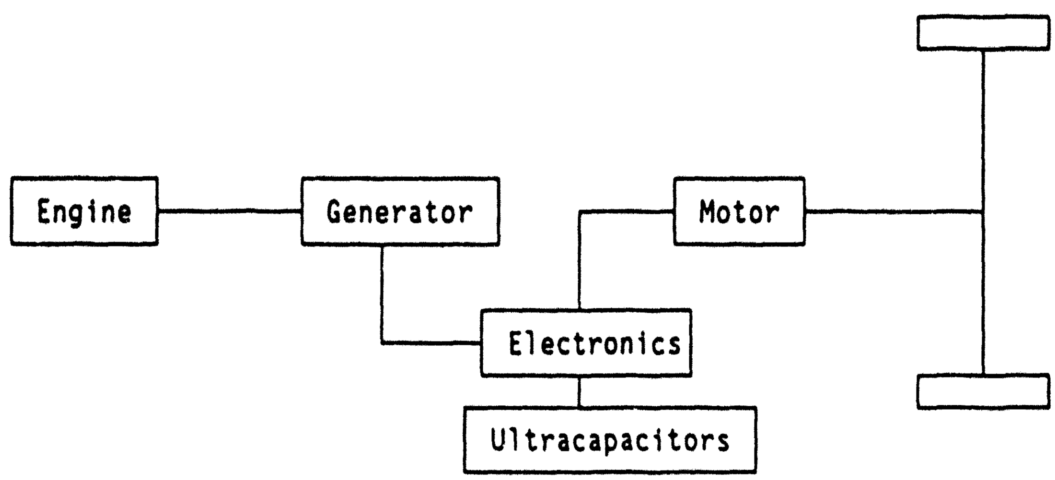

Figure 8. Engine-electric driveline schematic using ultracapacitors.

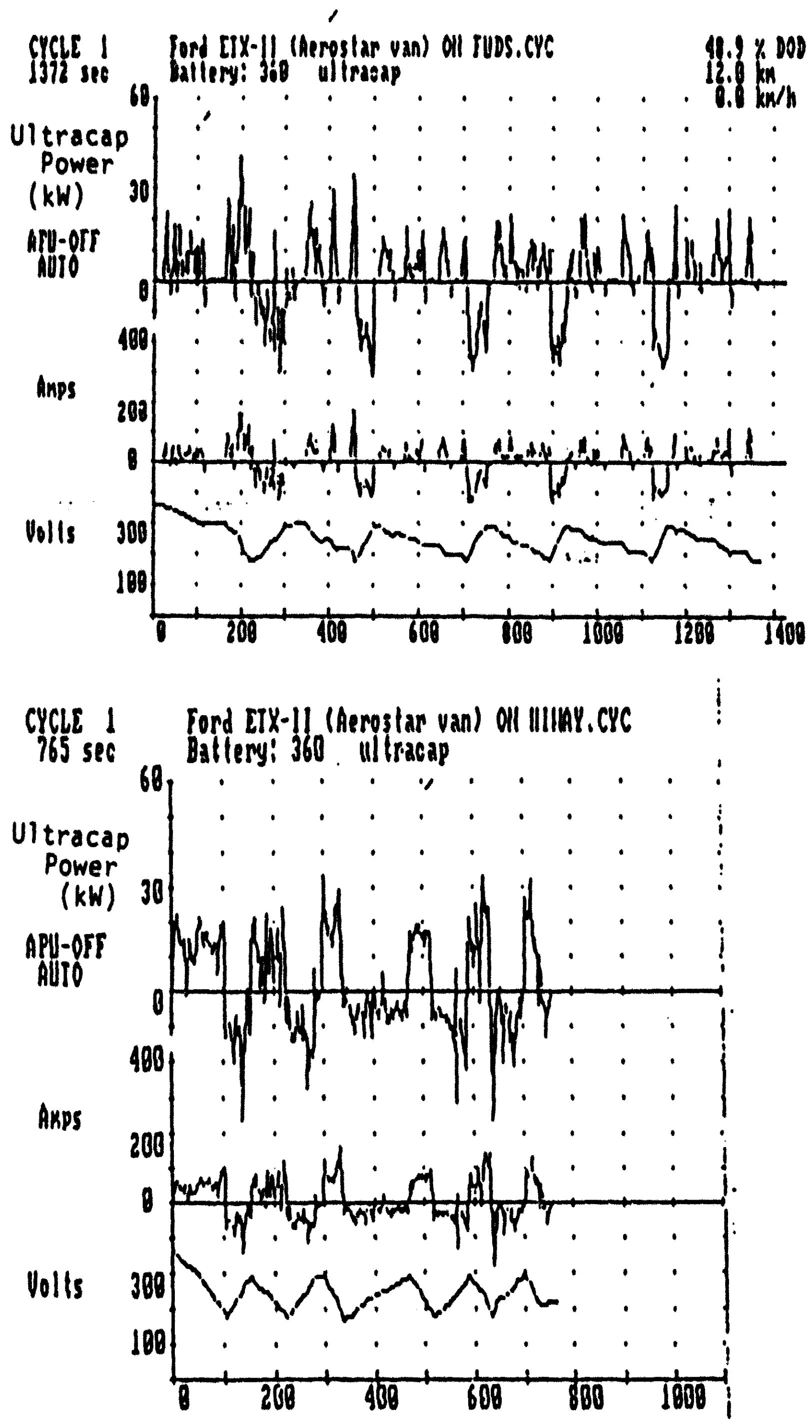

Figure 9. Ultracapacitor charge/discharge on the FUDS and FHWC cycles wth an APU.

Table 6. Series hybrid electric range, fuel economy, and acceleration characteristics.

Vehicle Type	Electric				Series Hybrid				Acceleration Times (sec)	
	FUDS		FHWC		FUDS		FHWC			
	Wh/km	Range[1] (km)	Wh/km	Range (km)	mpg[2]	Effic. (%)[3]	mpg	Effic. (%)	0-48 km/h	0-80 km/h
Minivan	185	93	188	86	26.1	0.85	26.4	0.88	4.7	12.1
Microvan	136	96	132	93	35.6	0.85	37.5	0.88	4.7	12.5
Compact Car	116	99	103	107	41.9	0.86	47.8	0.87	4.3	11.0

(1) Useable range to DOD = 80%

(2) Gasoline fuel and min bsfc = 300 gm/kWh

(3) Average efficiency from engine output to inverter input

Table 7. Engine-electric vehicle characteristics using ultracapacitors.

Vehicle				Motor/Generator			Ultracapacitors		
Type	Weight (kg)	C_DA (m^2)	fr (%)	Motor (kW)	Generator (kW)	Weight (kg)	Wh	(Wh/kg)	Max Power (kW)
Minivan	1501	1.16	0.85	56	25	85	500	5.9	60
Microvan	1200	0.759	0.85	37.5	20	68	400	5.9	46
Compact Car	1150	0.495	0.85	37.5	20	68	400	5.9	42

Table 8. Fuel economy of the engine-electric vehicles using ultracapacitors.

Vehicle Type	Fuel Economy (mpg)			
	FUDS		FHWC	
	Engine-Electric	Conventional ICE [1]	Engine-Electric	Conventional ICE
Minivan	33.1	18	30.5	22
Microvan	45.3	---	44.3	---
Compact Car	51.5	27	56.1	36

(1) 1992 EPA fuel economy rating for cars in this class

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930042

On-Off Engine Operation for Hybrid/Electric Vehicles

A. F. Burke
EG & G Idaho, Inc.

Reprinted from:
Electric and Hybrid Vehicle Advancements
(SP-969)

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Hybrid/Electric Vehicle Design Options and Evaluations

A.F. Burke
EG&G Idaho, Inc.

ABSTRACT

Various aspects of the design and evaluation of hybrid/electric vehicles are considered with emphasis on the consequences of utilizing advanced electric driveline components such as AC motors/electronics and ultracapacitors. Special attention is given to series hybrid drivelines, because they benefit much more directly than parallel hybrid drivelines from the recent large improvements in the specific weight and volume of electric drive motors/electronics. The results of the present study indicate that series hybrid vehicles with an electric range of 90-100 km and good acceleration performance (0-88 km/h acceleration times of less than 12 seconds) can be designed with a powertrain weight and volume comparable to that of a parallel hybrid of the same performance. The driveline efficiencies of the series and parallel designs for both city and highway driving differ by less than 15 percentage ponts. The control of the series hybrid driveline is expected to be significantly simpler than that of the parallel hybrid system and in addition, meeting the California ULEV emission standards should be less difficult for the series hybrid design, because the start of its engine can be delayed until the catalyst is warm without affecting vehicle driveability.

Simulation results for series hybrid vehicles on the FUDS and the Federal Highway cycles indicate that their fuel economy (miles per gallon) operating in the hybrid mode will be 25-50% greater than conventional ICE vehicles of comparable interior size. Hybrid/electric vehicles using ultracapacitors to load level the engine in the driveline showed even a greater potential improvement in fuel economy. Load leveled operation of the engine may make it less difficult to use high specific power engines, such as two-stroke and gas-turbine engines, in light duty vehicles having stringent emission control requirements.

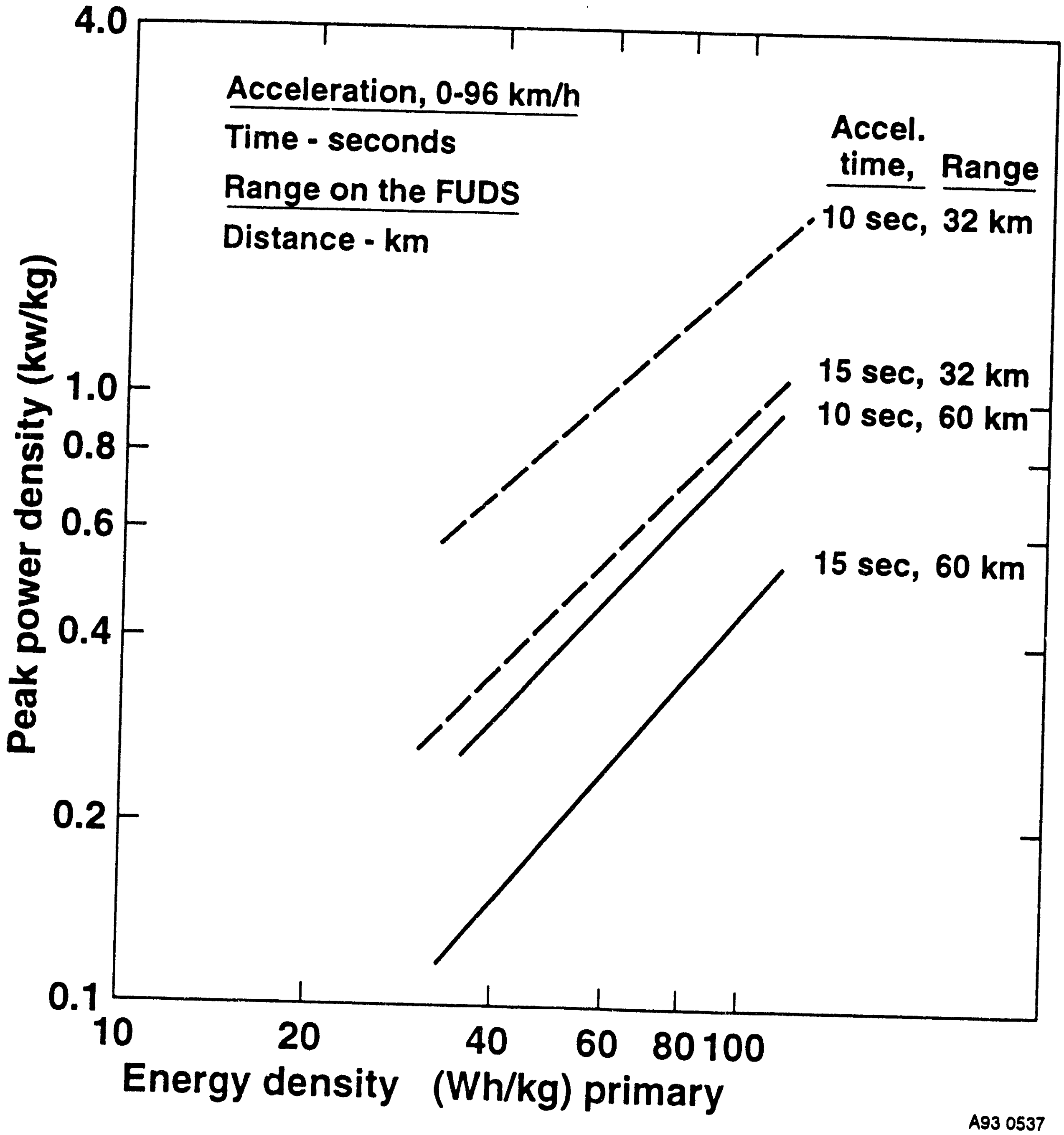
Work supported by the U.S. Department of Energy Assistant Secretary for Conservation and Renewable Energy (CE), under DOE Idaho Field Office, Contract DE-AC07-76ID01570.

INTRODUCTION

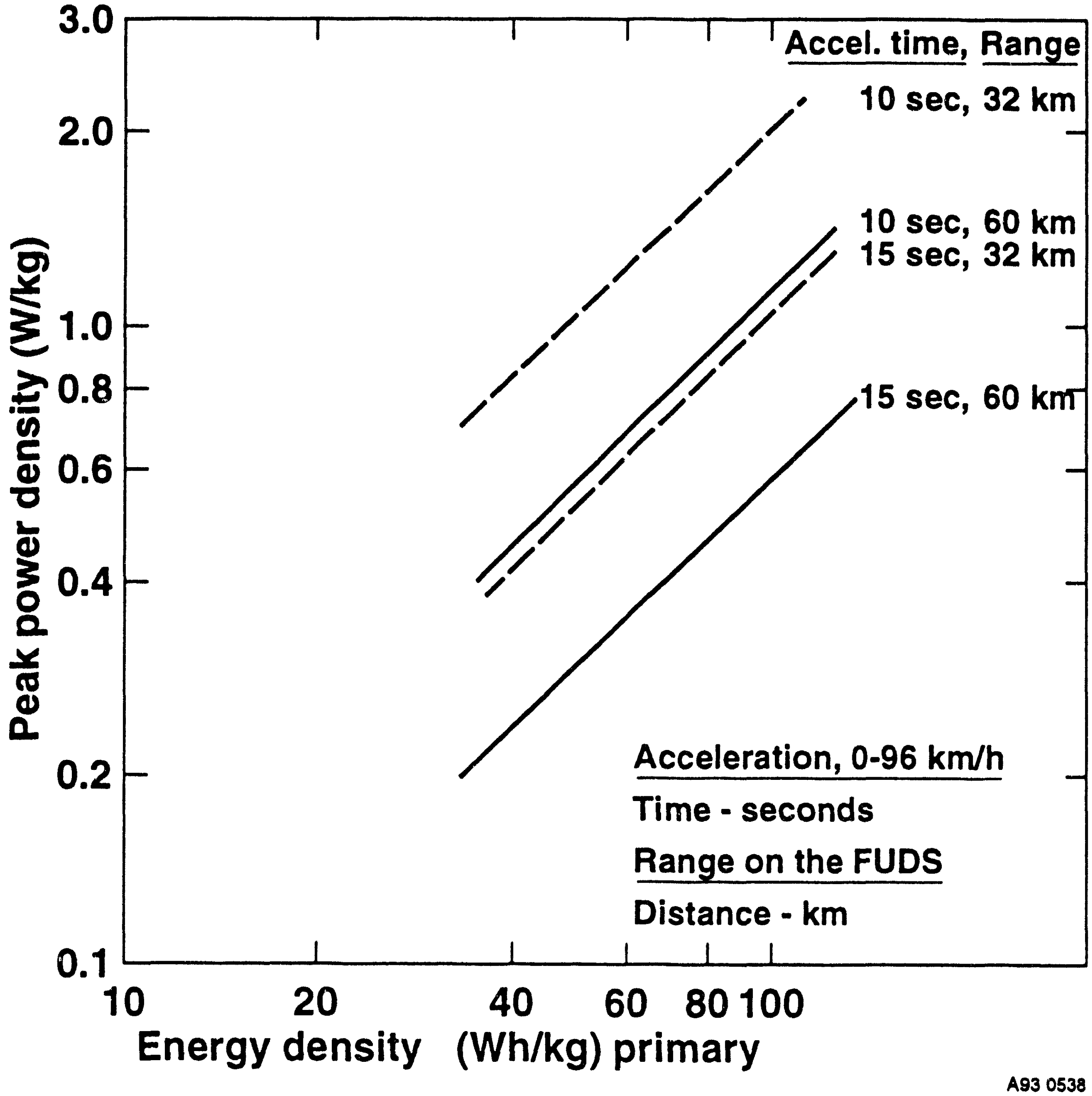
Hybrid/electric vehicles, which utilize both an electric driveline and an engine to provide the power and energy for propulsion, have been studied for the last 20 years. Hybrid propulsion systems are used primarily to overcome the range limitation of pure electric vehicles powered by batteries alone. A number of hybrid vehicles have been built and tested to demonstrate the viability of various hybrid powertrain approaches. Much of the engineering activity on hybrid vehicles occurred between 1978 and 1984 as part of the response of the United States to the oil crises of 1973 and 1979.

In recent years, interest in hybrid vehicles has been relatively low and most of the work on vehicles using electr

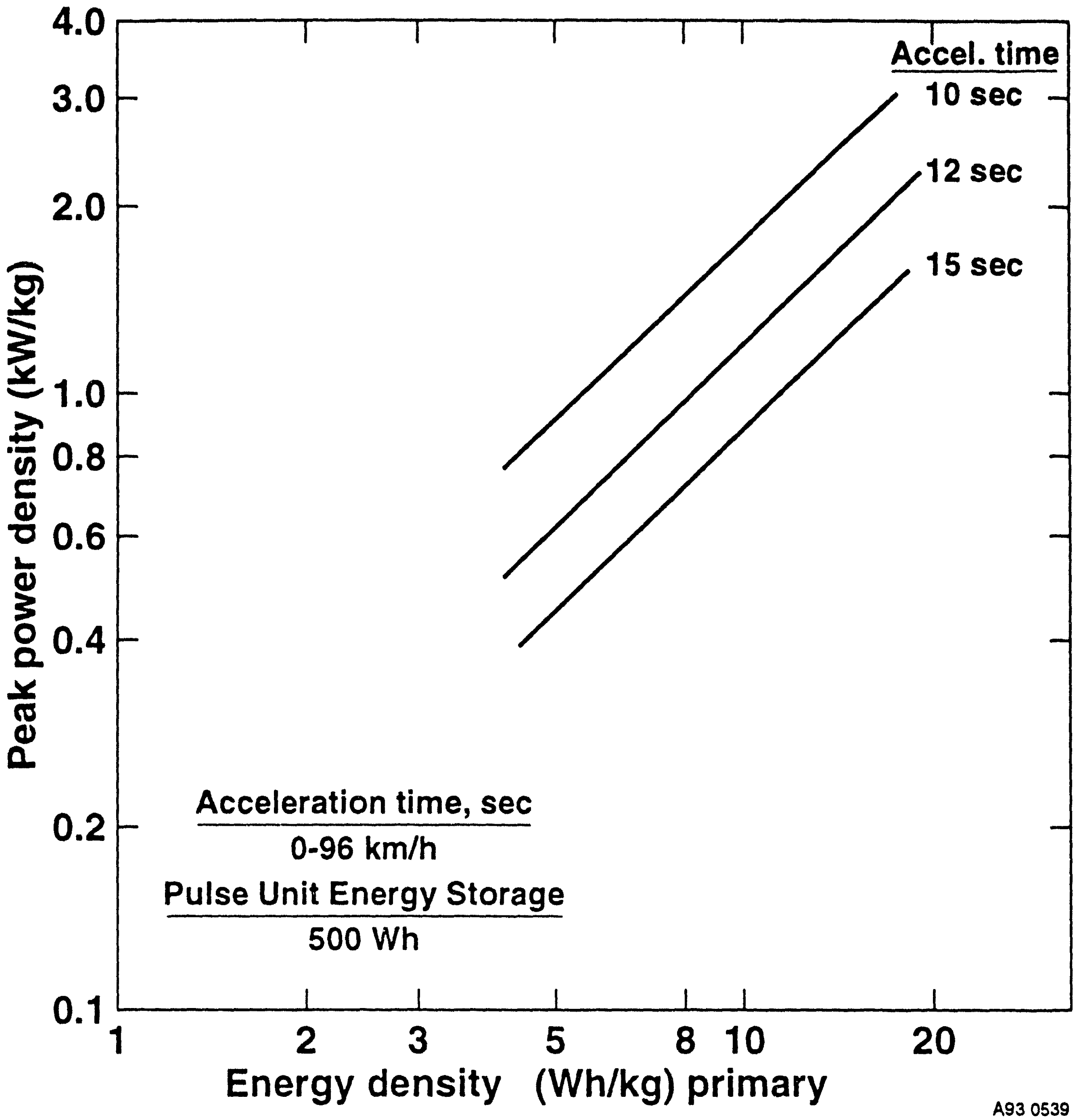
Peak Power Density Requirements for the Primary Energy Storage Unit in a Compact Car Without a Pulse Power Unit



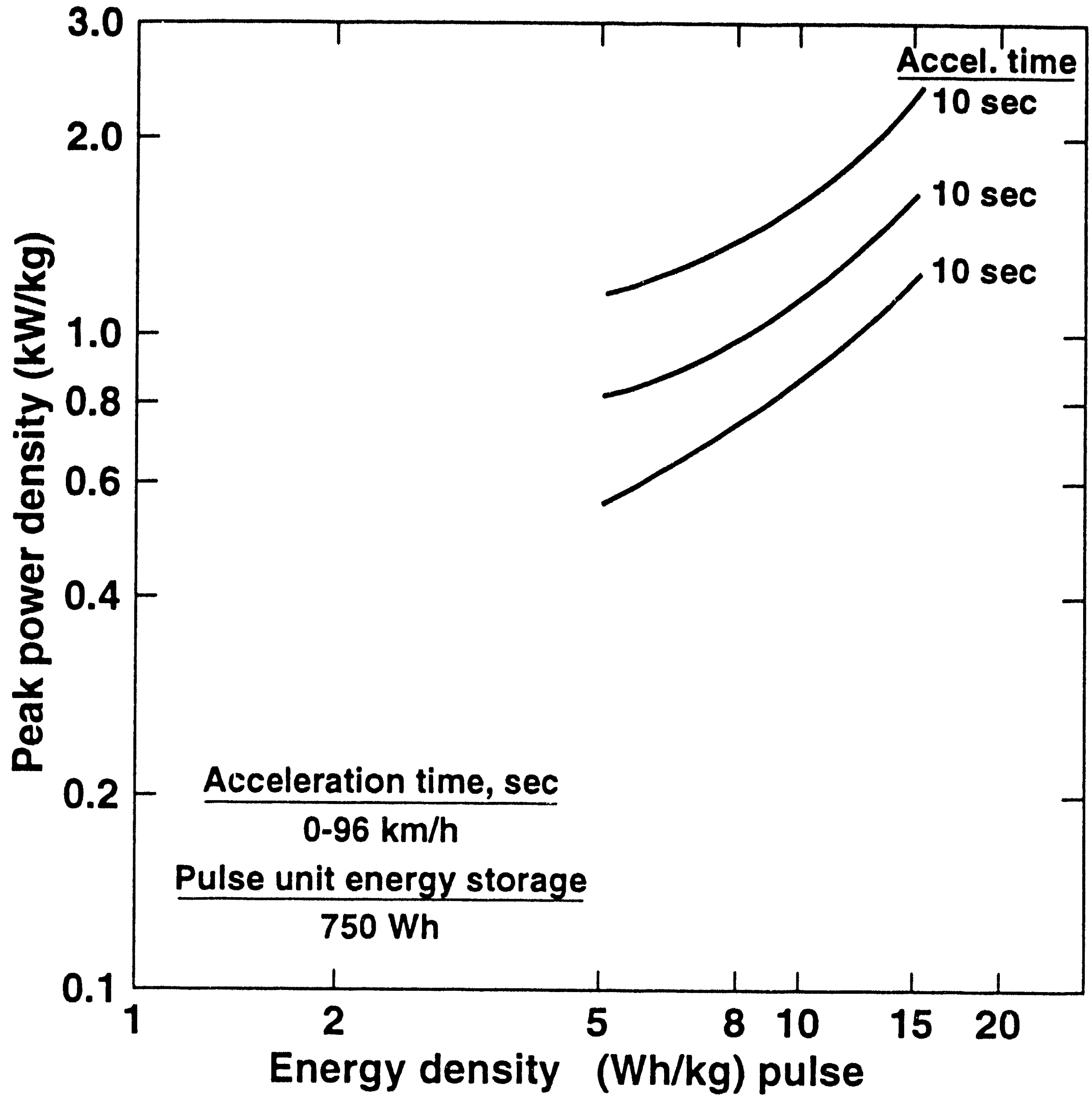
Peak Power Requirements for the Primary Energy Storage Unit on a Minivan Without a Pulse Power Unit



Peak Power Density Requirement for a Pulse Power Unit in a Compact Car



Peak Power Density Requirement for a Pulse Power Unit in a Minivan



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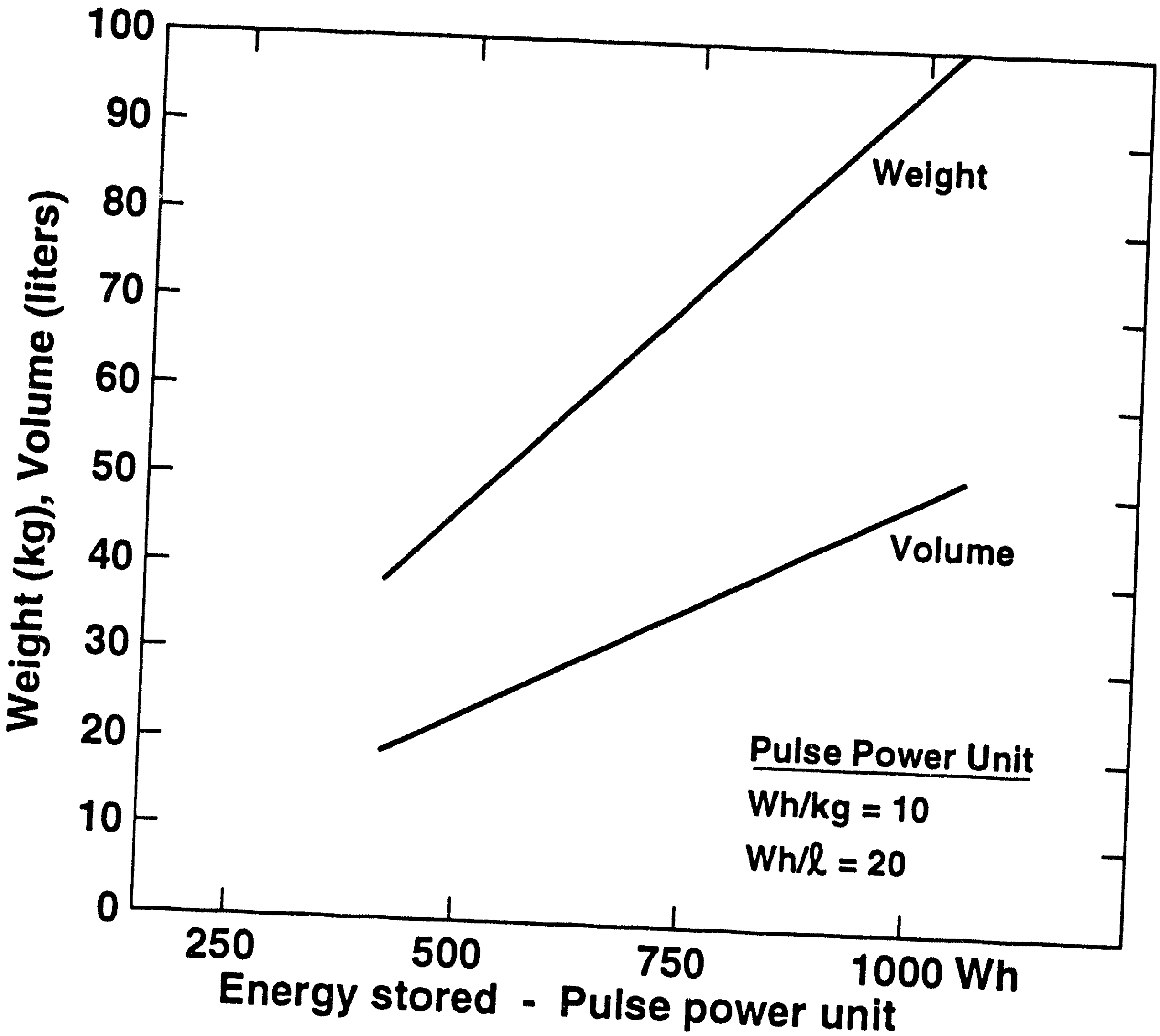
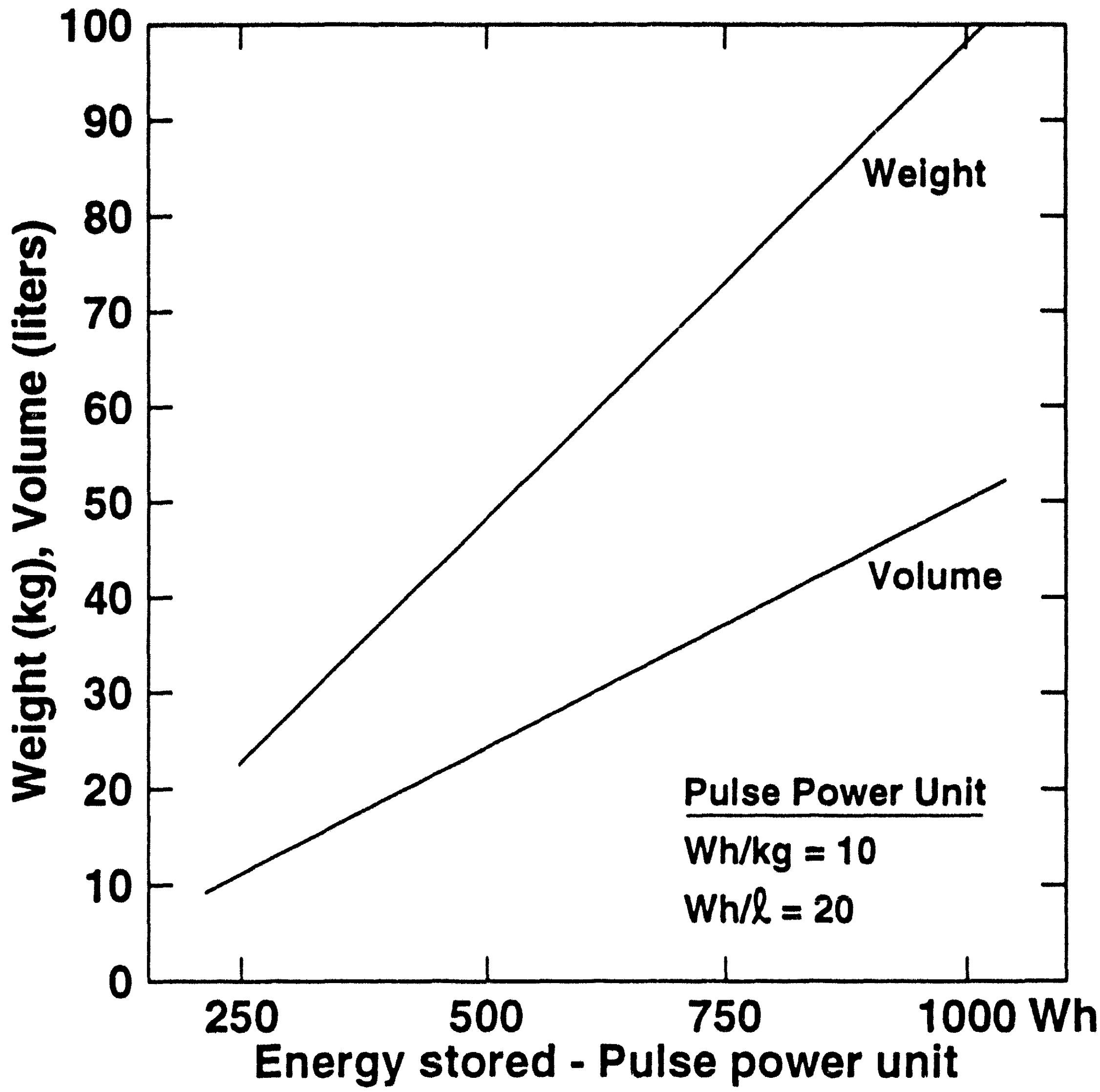
Weight and Volume of the Pulse Power Unit for Different Energy Storage Capacity (Wh) for a Minivan



A93 0543

Weight and Volume of the Pulse Power Unit for Different Energy Storage Capacity (Wh) for a Compact Car



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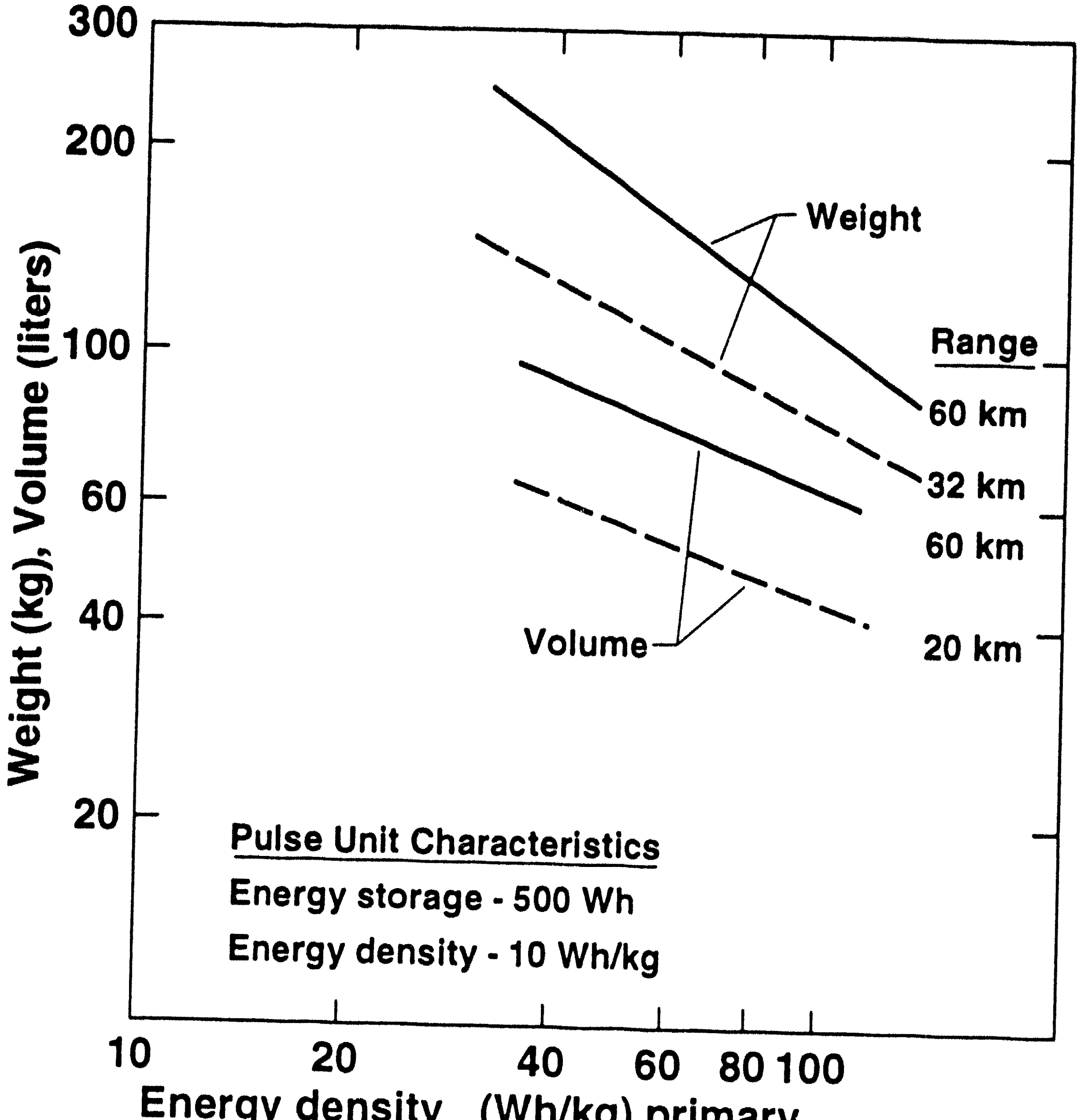
Energy Storage System Weight and Volume for a Compact Car



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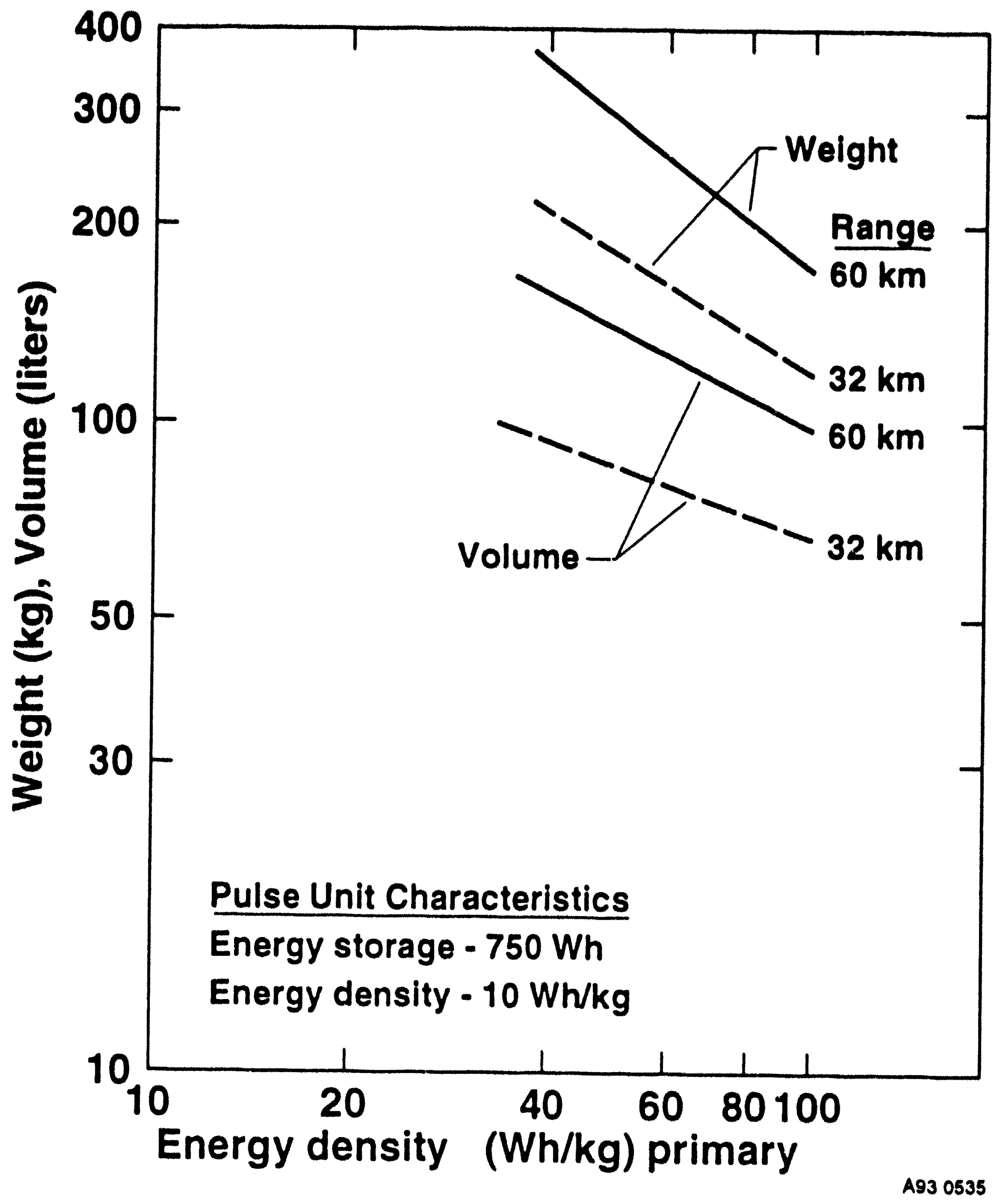
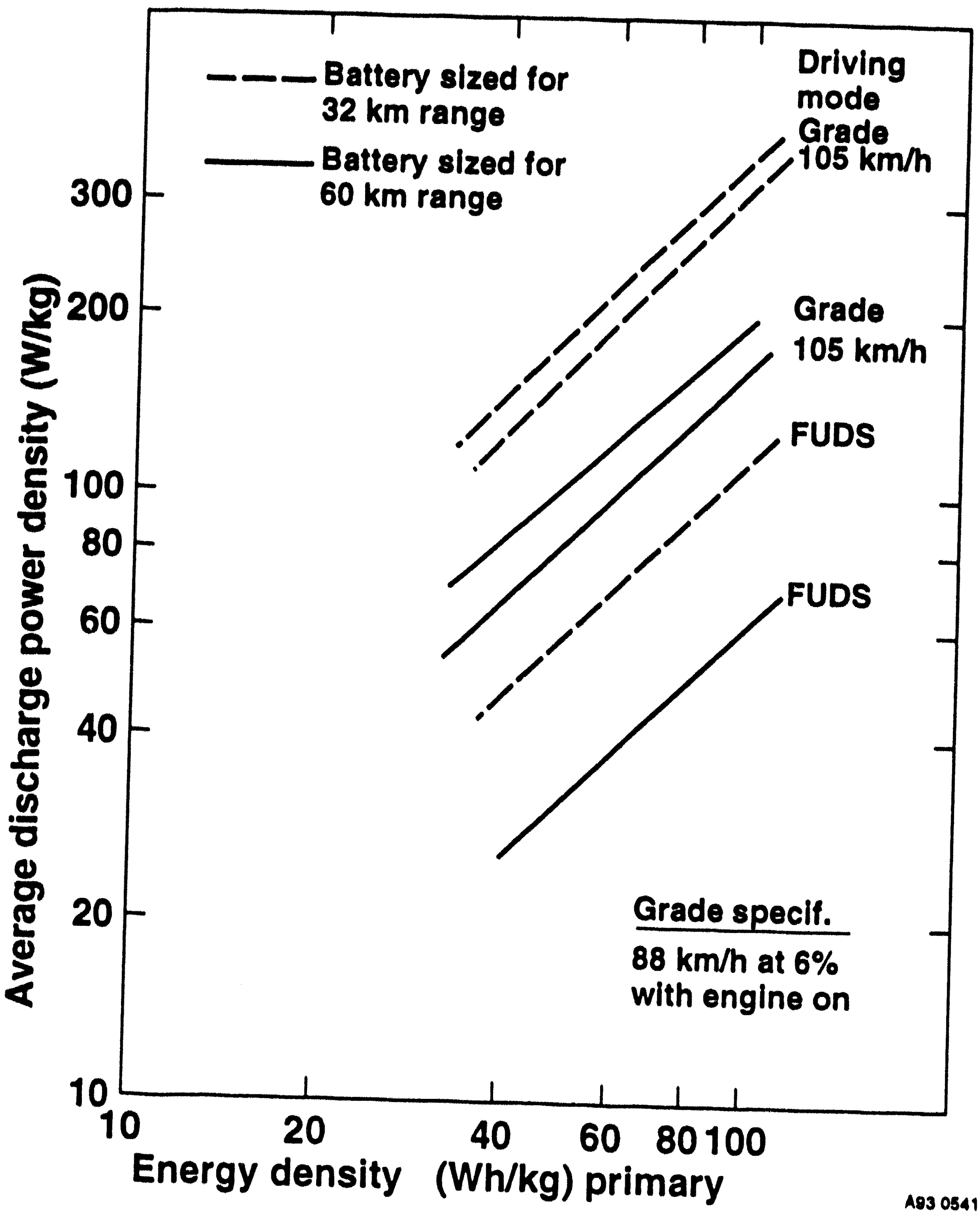
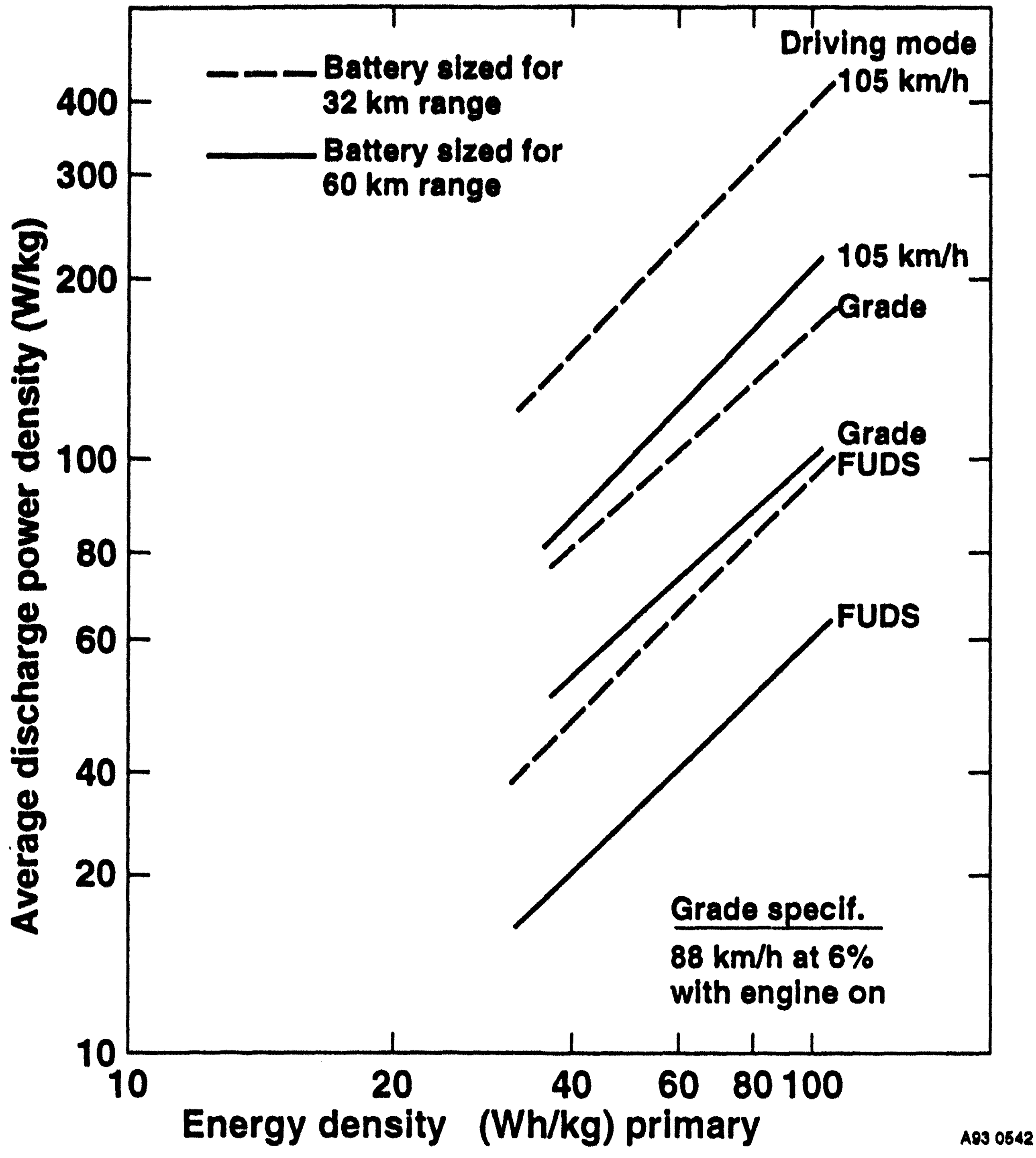
Energy Storage System Weight and Volume for a Minivan



Average Discharge Power Density for Different Driving Modes for a Compact Car



Average Discharge Power Density for Different Driving Modes for a Minivan



The U.S. Department of Energy (DOE) Ultracapacitor Program

Technologies

- Carbon/metal fiber composites - Maxwell/Auburn
- Monolith foamed carbon - Livermore National Laboratory
- Foamed carbon with a binder - Sandia National Laboratory
- Doped polymer layers on carbon paper - Los Alamos National Laboratory
- Mixed metal oxides (ceramic) on metal foil - Pinnacle Research Institute

The U.S. Department of Energy Ultracapacitor Program (cont'd)

Interface Electronics

- General Electric Corporate Research and Development

Interface Electronics

- Needed to:
  - Control power split between main battery and pulse power device
  - Match voltage between power sources as capacitor voltage varies between Vo, 1/2 Vo
  - Use at least 75% of energy stored in the capacitors
- As a function of:
  - State-of-charge of power sources
  - Average power demand of vehicle
- Pulse power device is recharged during periods of low vehicle power demand
- Energy storage in pulse power device is small compared to that of main battery (50 kWh battery, 500 Wh capacitor)

A91 2944

Applications

Near-Term
(Used With Near-Term Batteries)

- Initial thinking
  A. Load-level the battery on the FUDS
  B. Power share during vehicle acceleration (0-50 mph in 20 sec)
  C. Discharge battery at P_{AV}
  D. Capacity 300-500 Wh

- Battery requirements without the ultracapacitors

		W/kg	
Battery weight	Average	gradeability	Peak
500-600 kg	10	30-50	80

- Ultracapacitor unit
  500 Wh, 50 kW, 100 kg, 45 liter,
  5 Wh/kg, 11 Wh/ℓ, 500 W/kg
  >90% round trip charge/discharge efficiency

- Capacitor energy for vehicle acceleration
  20 sec, 280 Wh

A92 0203

Applications

Advanced

(Used With Advanced Batteries and High Performance EVs)

- Advanced thinking
  A. Load-leveling battery during FUDS
  B. Power share during vehicle acceleration (0-60 mph in 10 sec)
  C. Capacity 750 Wh

- Battery requirements without the ultracapacitors

Battery weight	Average	W/kg gradeability	Peak
200-300 kg	20	110-160	375-550

- Ultracapacitor unit
  750 Wh, 80 kW, 50 kg, 20 liter,
  15 Wh/kg, 40 Wh/ℓ, 1600 W/kg
  >90% round trip charge/discharge efficiency

- Capacitor energy for vehicle acceleration
  Acceleration: 10 sec, 230 Wh

A92 0204

Capacitor Specifications for Electric Vehicle Applications

Energy storage *(Wh, MJ)	500, 1.8
Power (kW)	50
Voltage (V)	200-300
Weight (kg)	< 100
Volume (ℓ)	< 45
Specific energy *(Wh/kg)	> 5
Vol. specific energy *(Wh/ℓ)	> 11
Capacitance (F/cm^2 1vcell)	> 1.5
Resistance (m-ohm cm^2/1vcell)	< 100
Discharge time (sec)	20-50
Charge time (sec)	60-120
Duty cycle	Continuous
Cycle life	> 100,000
Cost ($)	< 1,000

$$*1\ \frac{\text{Wh}}{\text{kg}} = 3.6\ \frac{\text{kJ}}{\text{kg}}$$

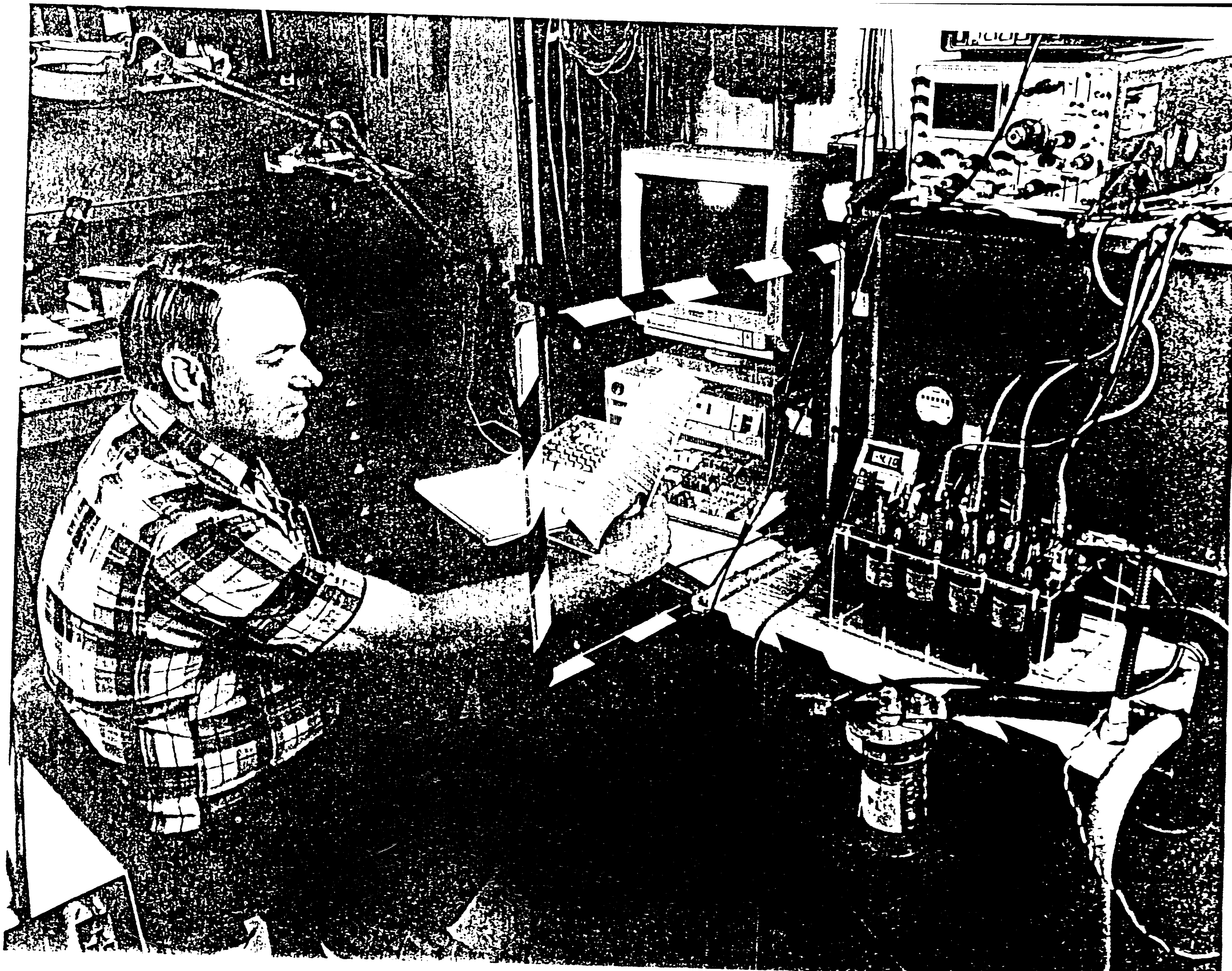
$$1\ \frac{\text{Wh}}{\ell} = 3.6\ \frac{\text{kJ}}{\ell}$$

A91 2945

Near-term and advanced goals for the DOE ultracapacitor development programs

Battery w/o Capacitor	Near-Term	Advanced
Weight (kg)	500-600	200-300
Power Density (W/kg) Average Gradeability Peak (accel)	 10 30-50 80	 20 110-160 375-550
Ultracapacitor Unit		
Energy stored (Wh)	500	750
Maximum Power (kW)	50	80
Weight (kg)	<100	<50
Volume (ℓ)	<40	<20
Energy density (Wh/kg)	>5	>15
Maximum useable power density (W/kg)	>500	>1600
Round trip efficiency (%)	>90	>90
Vehicle Acceleration		
0-88 km/h (sec)	<20	<8


SOLEQ P/N
470F 2.3V
70F



Panasonic 3 V, 1500 F Capacitors

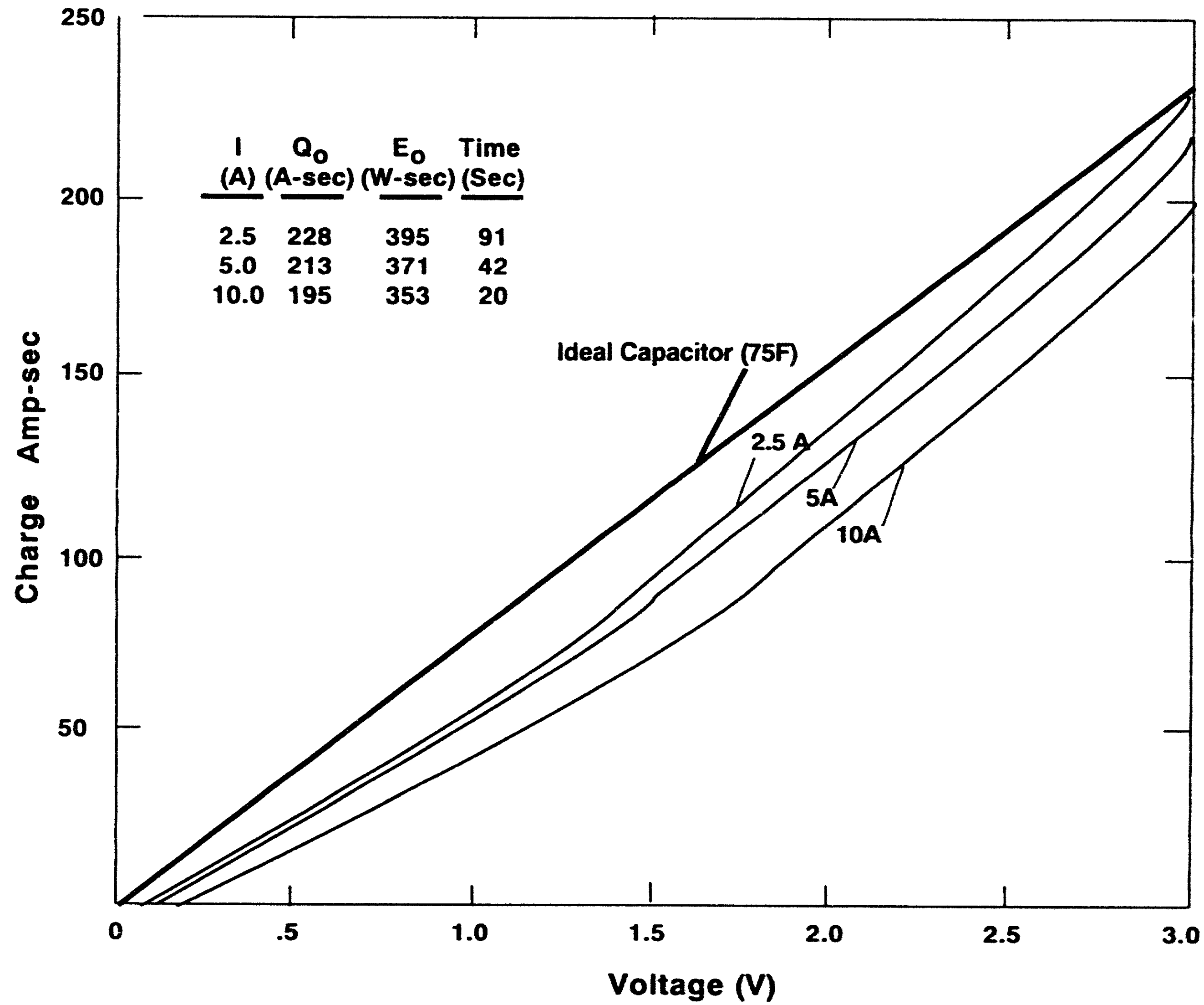
• Technology	Single cell, spiral wound, carbon-based, organic electrolyte
• Size	Diameter 7.7 cm Length 14.9 cm Volume 693 cm^3
• Weight	887 gm

Panasonic Capacitors (cont'd)

• Energy stored (charging 100 A, 0 to 3 V)	2.667 Wh (3.0 Wh/kg; 3.85 Wh/L)
• Energy Discharged (100 A, 3 V to 1 V)	1.89 Wh (2.13 Wh/kg; 2.73 Wh/L)
• Resistance	1.2 milliohms
• Maximum power* (3 V ---> 1.5 V)	2.1 kW/kg

* to a matched load

Charging Characteristic of the Japanese Capacitor at Several Charging Currents



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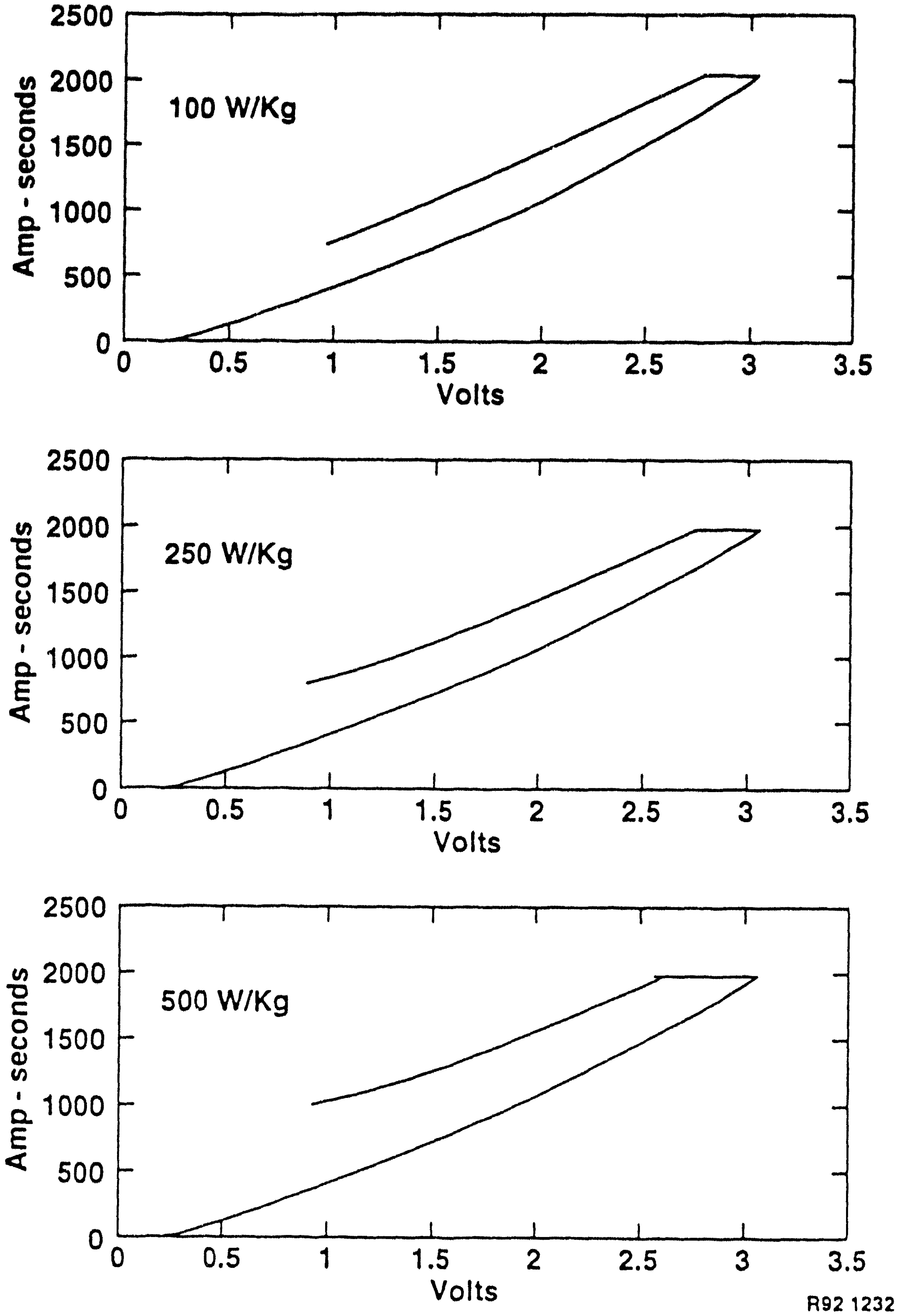
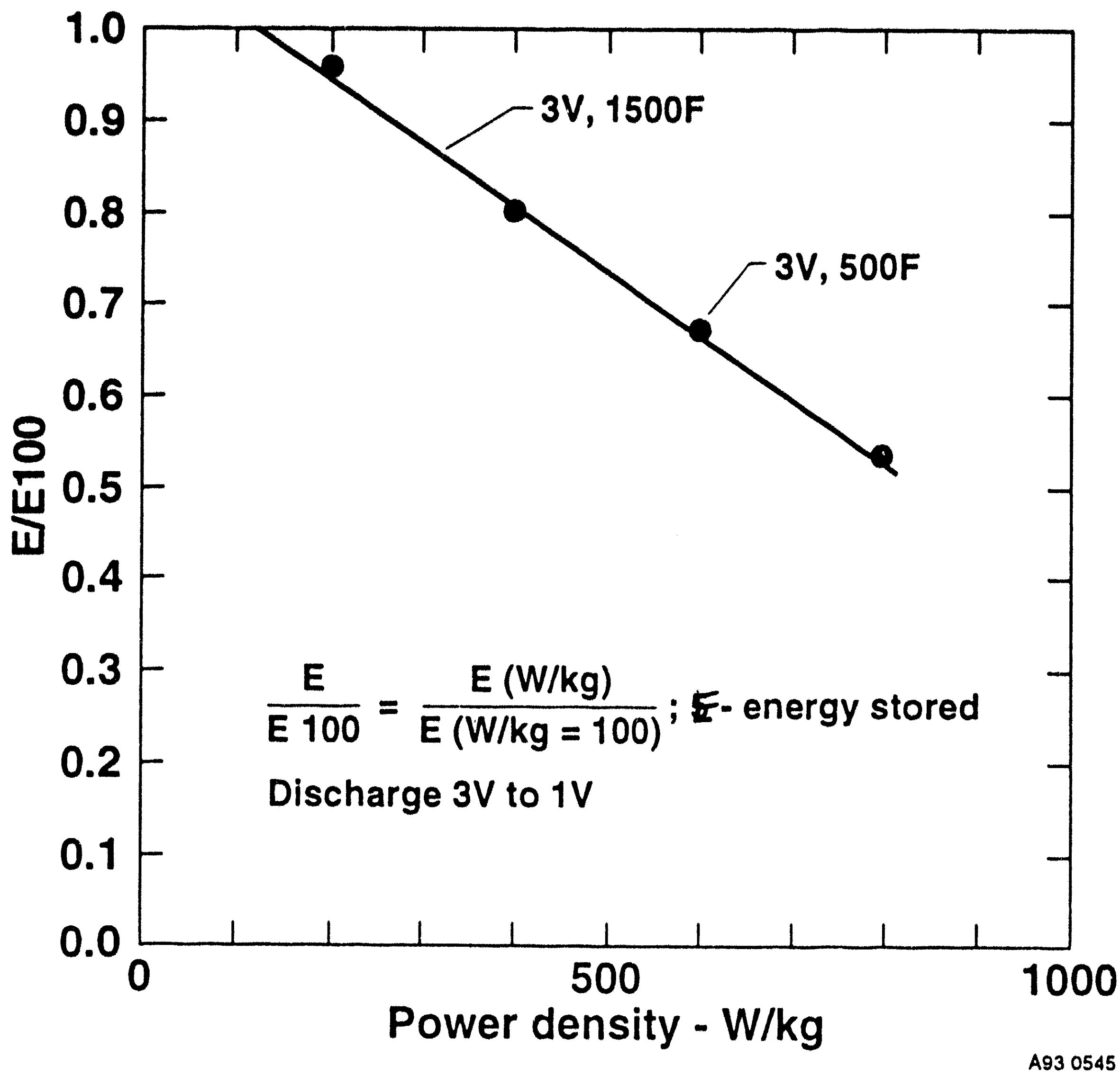
Discharge Characteristics of the 600 F Capacitors at Various Power Densities



Constant Power Discharge Characteristics of the Panasonic 3V, 500F and 1500F Capacitors



Life Cycle Test Results

Capacitor - 3 V, 600 F, Panasonic

- Cycle
  - 30 A charge in 15 sec (1.5-3 V)
  - 30 A discharge in 15 sec (3-1.5 V)
    Max power - 300 W/kg
    Average power - 225 W/kg
- Cycle life
  - 503,000 charge/discharge cycles
  - 7 months calendar time
  - 20% degradation in capacitance
  - V vs. time - Symmetric for all cycles

A92 2572

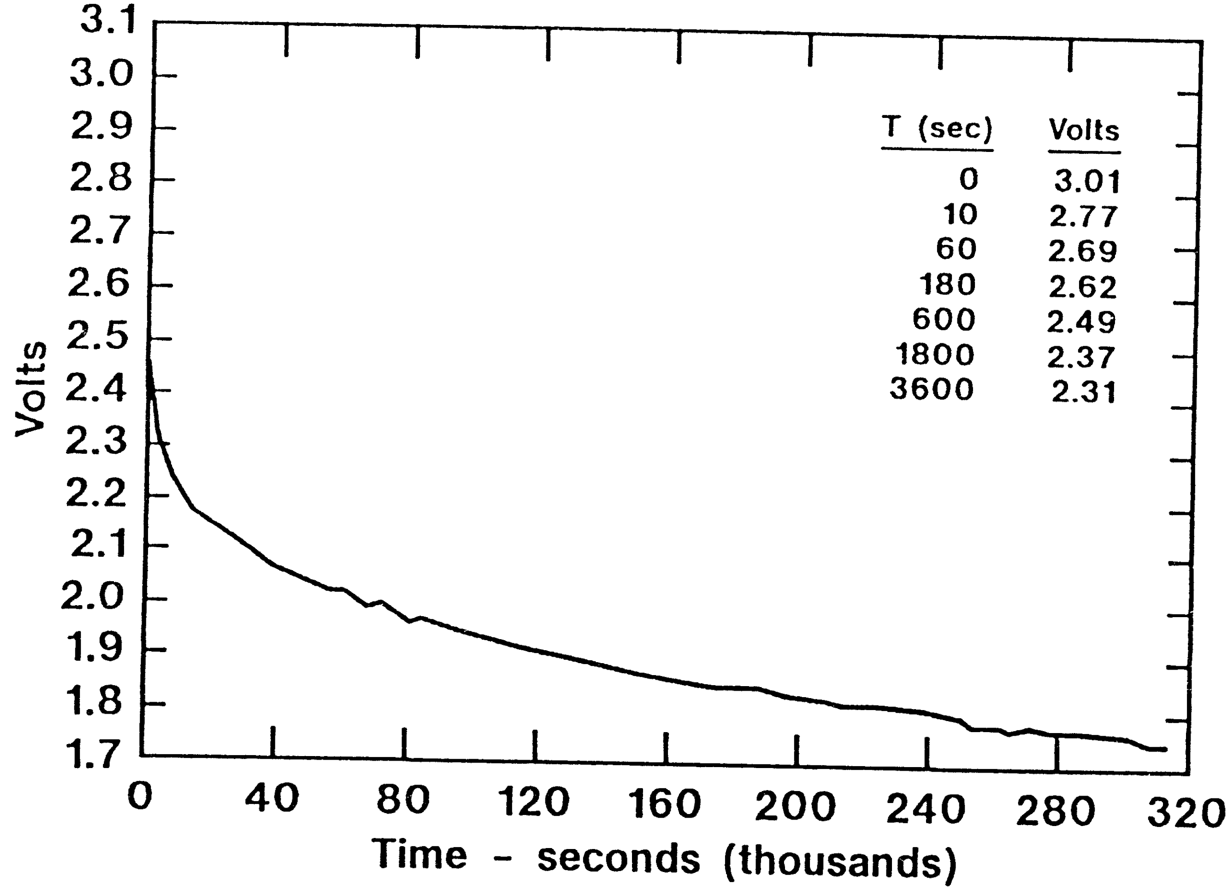
Summary of the 3V, 500 F Capacitor Life-cycle Test Data

DATE	CYCLES K	CHARGE/ DISCHARGE [1] CURRENT (A)	CHARGE TIME (SEC)	% CAPACITY	RESISTANCE [2] mOHM
01-16	10	20	29.1	100	6.25
02-11	48	20	28.5	98	6.25
02-28	71	20	28.35	97	6.7
04-01	124	20	27.1	93	6.7
04-01	124	30	15.6	93	6.7
04-17	165	30	15.4	92	6.7
04-22	180	30	15.2	91	6.7
04-30	200	30	14.8	88	6.7
05-18	256	30	14.5	86	6.7
05-26	280	30	14.4	85	6.7
06-08	320	30	14.2	84	6.7
06-15	341	30	14.0	83	6.7
06-29	384	30	13.9	83	6.7
07-06	405	30	13.9	83	6.7
07-13	424	30	13.8	82	6.7
07-27	468	30	13.7	81.7	6.7
08-07	503	30	13.5	80.5	6.7

(1) CHARGE/DISCHARGE BETWEEN 3.0V AND 1.5V

(2) BASED ON THE IR DROP AT BEGINNING OF CHARGE/DISCHARGE STEPS

Voltage Decay Characteristic of the Japanese Capacitor After Charging to 3V



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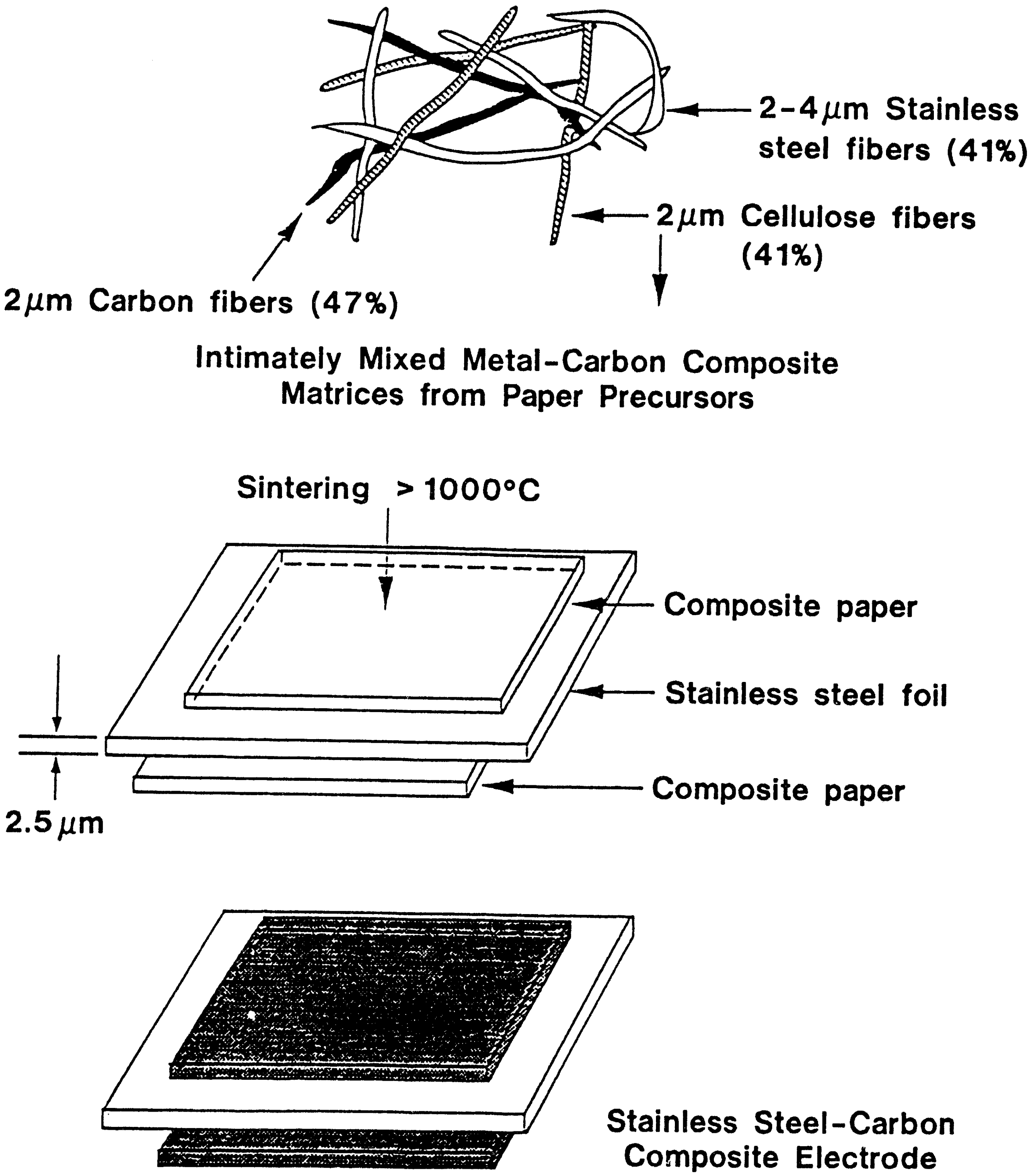
Carbon Metal Fiber Electrode Structure



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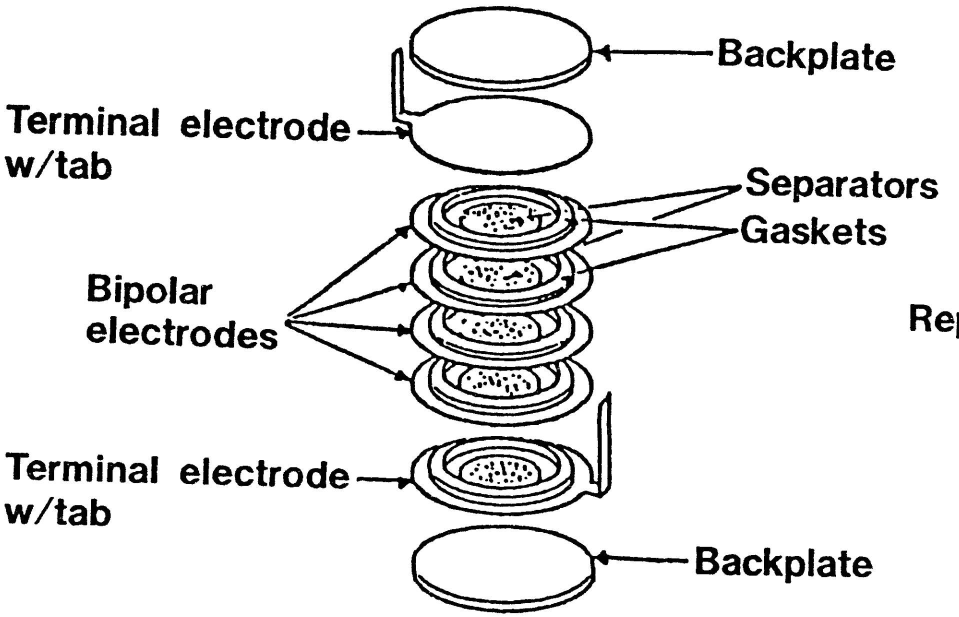
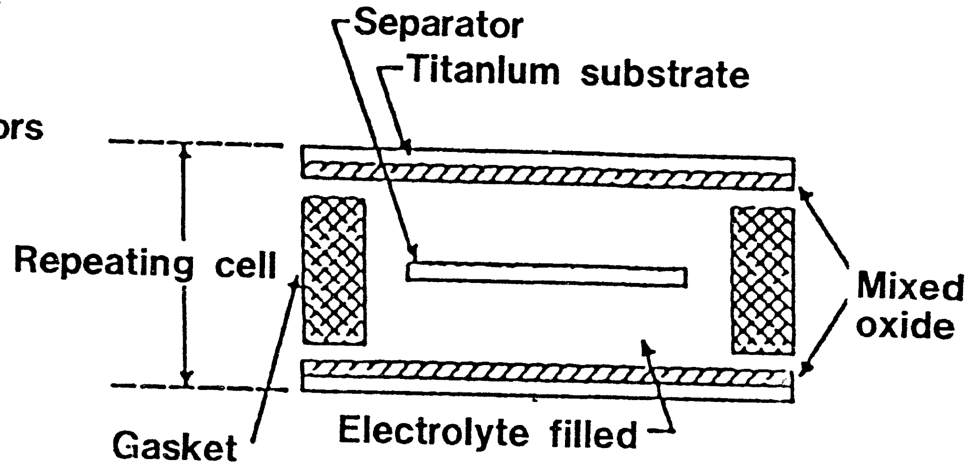
Schematic of Ultracapacitor Construction



Exploded View of a Small Ultracapacitor



Unit Cell Construction of Ultracapacitor

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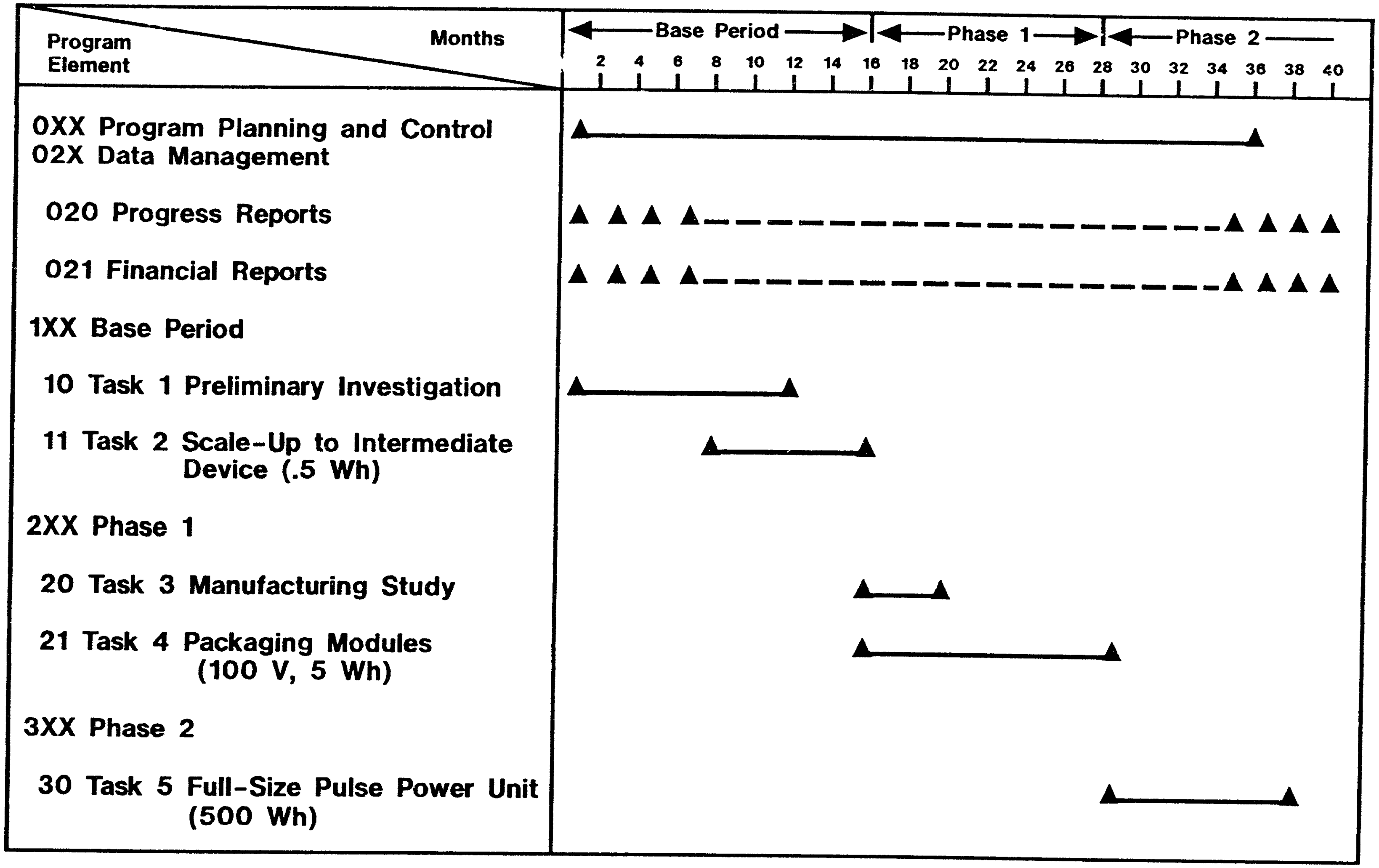
Milestone Chart for the Development of Ultracapacitor Technology Electric Vehicle Applications



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Maxwell/Auburn 1 V, 75 F Capacitor (as of April 1993)

• Technology	Single cell, 20 cm^2 disk, composite carbon-metal fibers, aqueous (KOH) electrolyte	
• Size	Diameter	5 cm
	Thickness	0.187 cm
	Volume	3.77 cm^3
• Weight	6 gm	

Maxwell/Auburn 1 V, 75 F Capacitors (cont'd)

Energy Stored/Discharged (1 A, 0 ---> 3 V)	39 W/sec (1.8 Wh/kg, 2.9 Wh/L)
Resistance	10 milliohmns
Maximum Power* (1 V to .5 V)	4.2 kW/kg

* to a matched load

Maxwell/Auburn 3 V, 27 F Capacitor (as of April 1993)

• Technology	Single cell, 20 cm^2 disk, composite carbon-metal fibers, organic electrolyte	
• Size	Diameter	5 cm
	Thickness	0.15 cm
	Volume	3 cm^3
• Weight	4.5 gm	

Maxwell/Auburn 3 V, 27 F Capacitors (cont'd)

Energy Stored/Discharged (1 A, 0 ---> 3 V)	121 W/sec (7.5 Wh/kg, 11.2 Wh/L)
Resistance	0.15 ohm
Maximum Power* (3 V to 1.5 V)	3.3 kW/kg

* to a matched load

Advantages of Ultracapacitors for Use in EV Drivelines

- Very high power — > 3 kW/kg
- Very high recharge rates — < 20 sec
- Long life — > 100,000 cycles
- High efficiency — > 95%
- Compatibility with electric drive system
  - Combine ultracapacitor unit with inverter electronics
  - Ease of microprocessor control

A92 0206

Conclusions

- Power capacitors are available commercially from Panasonic for laboratory tests.
- Good progress is being made in the U.S. DOE Program to develop capacitors with energy density of 5 to 10 Wh/kg.
- Ultracapacitors are likely to be key components in the drivelines of high performance hybrid-electric vehicles.

SUMMARY OF VERBAL COMMENTS OR QUESTIONS AND SPEAKER RESPONSES

DESIGN OPTIONS FOR HYBRID-ELECTRIC VEHICLES USING ULTRACAPACITORS
Andrew F. Burke, EG&G Idaho, Inc.

Q. Anonymous: Why is the ultracapacitor technology not used in Japan?

A. It is used in different applications. Isuzu uses it to extend life of batteries.

Q. Mehboob Sumar, ORTECH International: You mentioned an application with catalyst. How did this work?

A. We did an experiment with a 12-volt module to heat exhaust treatment catalyst to 700-800oC in 6-7 seconds. This use may be an ideal application for this type of device, where the capacitor could be charged off the vehicle battery. We will be studying costs for these devices over the next twelve months.

1993 WINDSOR WORKSHOP ON ALTERNATIVE FUELS

FLEET USERS' EXPERIENCE WITH ALTERNATIVE FUELED VEHICLES PANEL DISCUSSION

Panel Moderator: Mike Jackson

(Presentations made during this Panel Discussion were unavailable at time of printing)

SUMMARY OF VERBAL COMMENTS OR QUESTIONS AND SPEAKER RESPONSES

PANEL DISCUSSION: FLEET USER'S EXPERIENCE WITH ALTERNATIVE FUELED VEHICLES

Moderator: Mike Jackson, Acurex Environmental

Panel Members: (In order of presentations
David Ogilvie, National Association of Fleet Administrators
Michael Snodgrass, U.S. General Services Administration
Chris Burgeson, City of Glendale, California
Todd Krenelka, Batelle/Federal Express Fleet
Don Brunson, Xerox Corporation
Tom Finn, Avis Rent-A-Car

Each panel member made a short presentation. Then questions were directed at the panel. Some replies came from more than one panel member who are identified below by name.

Q. Matthew Bol, Sypher:Mueller International: Would you comment on resale value of the vehicles?

A. Tom Finn: Our contract required that the cars be returned to the vehicle manufacturer who then resold them in California. We have no information on dollar values.

A. Michael Snodgrass: We hope that there will be a market for alternative fuel vehicles in about three years. Also, that there will be fuel availability and other parts of the program in place to provide support to the vehicle owners.

Q. Norval Horner, Amoco Canada: The slides for Federal Express showed fuel economy data in gasoline equivalent. Was that volume equivalent or energy equivalent?

A. Todd Krenelka: It was energy equivalent based on lower heating value of the fuels compared with base gasoline from the Auto/Oil Industry Program.

SUMMARY OF VERBAL COMMENTS OR QUESTIONS
AND SPEAKER RESPONSES

PANEL DISCUSSION: FLEET USER'S EXPERIENCE WITH ALTERNATIVE FUELED VEHICLES

Q. Paul Wuebben, SCAQMD: Could you explain the permitting problems for M85 methanol storage?

A. Todd Krenelka: Federal Express policy is not to install underground tanks on their property. However, the City of Santa Ana ordinance required extra use permits for the aboveground tanks that were used.

Q. Paul Wuebben, SCAQMD: In the discussion of CNG refueling, a back-up fueling system was mentioned. What was the experience with that?

A. Todd Krenelka: We have not had a compressor failure yet and did not need to use the second system.

Comment: John Christie, General Motors; Resale value is an important issue. Our experience so far in turning over our own staff vehicles at dealer auctions is that they offer slightly less on flexible fuel vehicles than conventional vehicles. I think that is a temporary situation.

SESSION 3: OVERCOMING BARRIERS TO ALTERNATIVE FUELS COMMERCIALIZATION

Chair: Ron Neville, ORTECH

1993 WINDSOR WORKSHOP ON ALTERNATIVE FUELS

PROPANE MOTOR FUEL MARKETING - CHANGING THE PERCEPTION

S. Vedlitz
Conoco Inc.

Propane Motor Fuel Marketing

Changing the Perception

With this experience, clean air a primary social goal, and propanes advantages over other fuels, it is surprising that it's benefits are often overlooked and in the case of the OEMS all but forgotten.

Why is this?

Propane is primairly supported by private initiative falling short of the backing of other fuels -- this makes it difficult to promote propanes advantages and dispel the misconceptions that have become barriers to propanes acceptance.

Propane
A Viable Alternative Motor Fuel

- First Used in the 1920s
- 3.8 Million Vehicles Operating Worldwide
- 500,000 Vehicles Operating in U.S.
- 140,000 Vehicles Operating in Canada
- Annual Vehicle Growth 25,000 U.S.; 15-25,000 Canada
- Ranks Third in Motor Fuel Sales
- 10,000 Public Fueling Locations
- Highest Volumetric Efficiency After Gasoline

What are these misconceptions and what needs to be done?
One perception is that the use of propane as a motor fuel will result in engine power loss -- reduced performance capability.

Changing the Perception

- Performance Capability
- Safety Characteristics
- Fuel Cost & Supply
- Fueling Locations & Availability

The facts are:
Propane has 104 octane
excellent cold weather starting (vaporizes at temp. as low as -44F)
greatest range of any alternative fuel and
clean burning


WE'RE DOING OUR PART, THIS VEHICLE POWERED BY CLEAN-BURNING PROPANE MOTOR FUEL
CONOCO
PROPANE
CLEAN AIR MOTOR FUEL
CLEAN AIR MOTOR FUEL
CONOCO
PROPANE

398

The facts are:
as a result of modern conversion technology,
electronicly monitored, fuel injected engines
and the quality standardization of HD5 propane for motor fuel -
Performance is no longer an issue


FUEL FOR OUR FUTURE
conoco
400

Power loss is no longer a problem

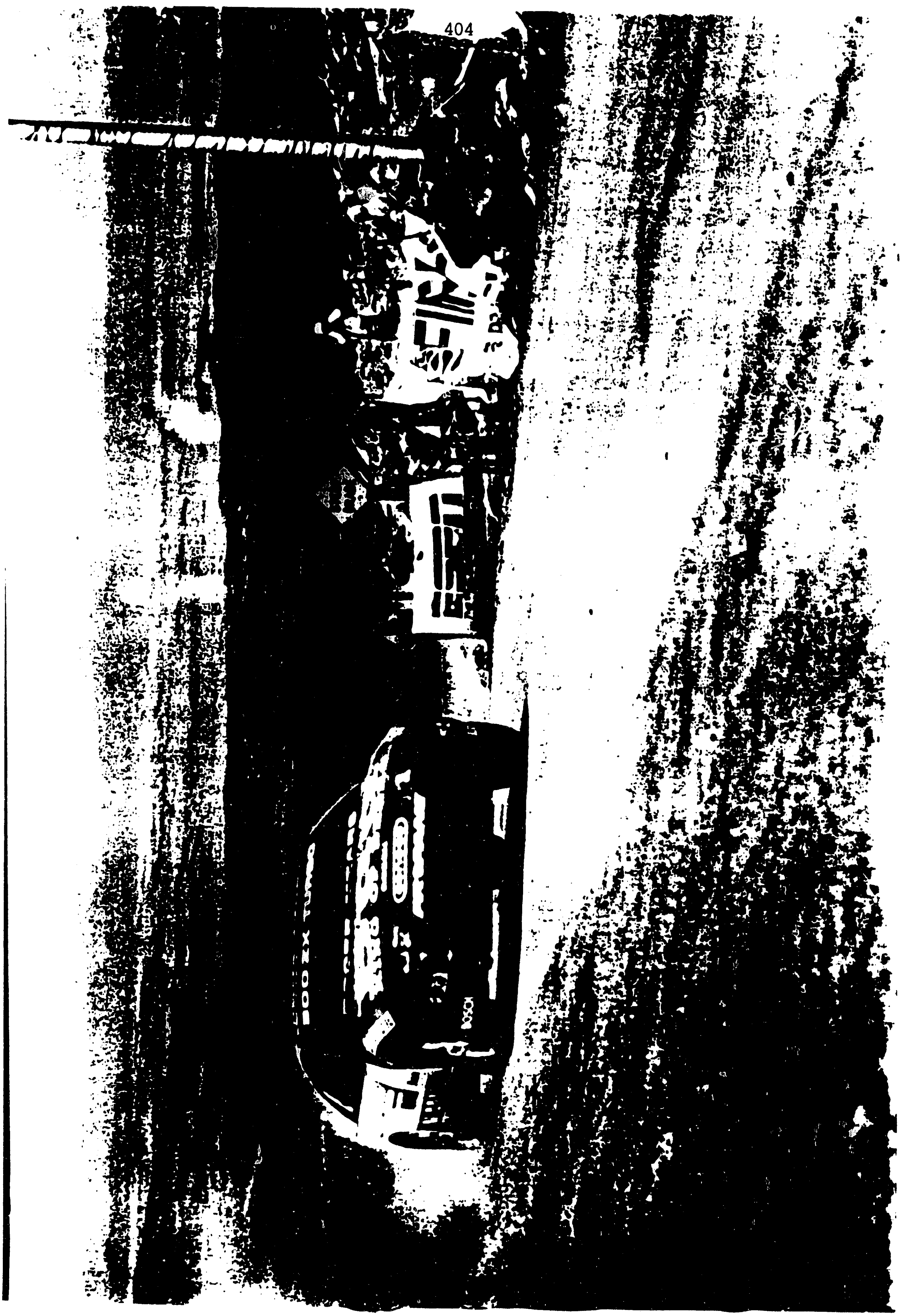
most vehicles experience less than a 4% power loss if that much

Propane has been tested under the most grueling conditions known in motor sports racing - Setting a world speed record for alternative fuels in 1991 at the Bonneville Salt Flats at 218.18MPH

and racing at Pipes Peak in 1991 and 1992. Coming in 2nd in 1992. Roger Mears, the driver, stated that he experienced no power loss at any point on the hill especially the upper third where other fuels always lose power. This year we will again be at Pipes Peak this time in a Dodge Dakota.

Performance is not the issue, education is

Establishing a network of certified conversion centers and promoting their existance is also the issue, not performance.



Safety is a concern with any fuel, but because propane is heavier than air it receives unwarranted notoriety

Changing the Perception

- Performance Capability
- Safety Characteristics
- Fuel Cost & Supply
- Fueling Locations & Availability

406

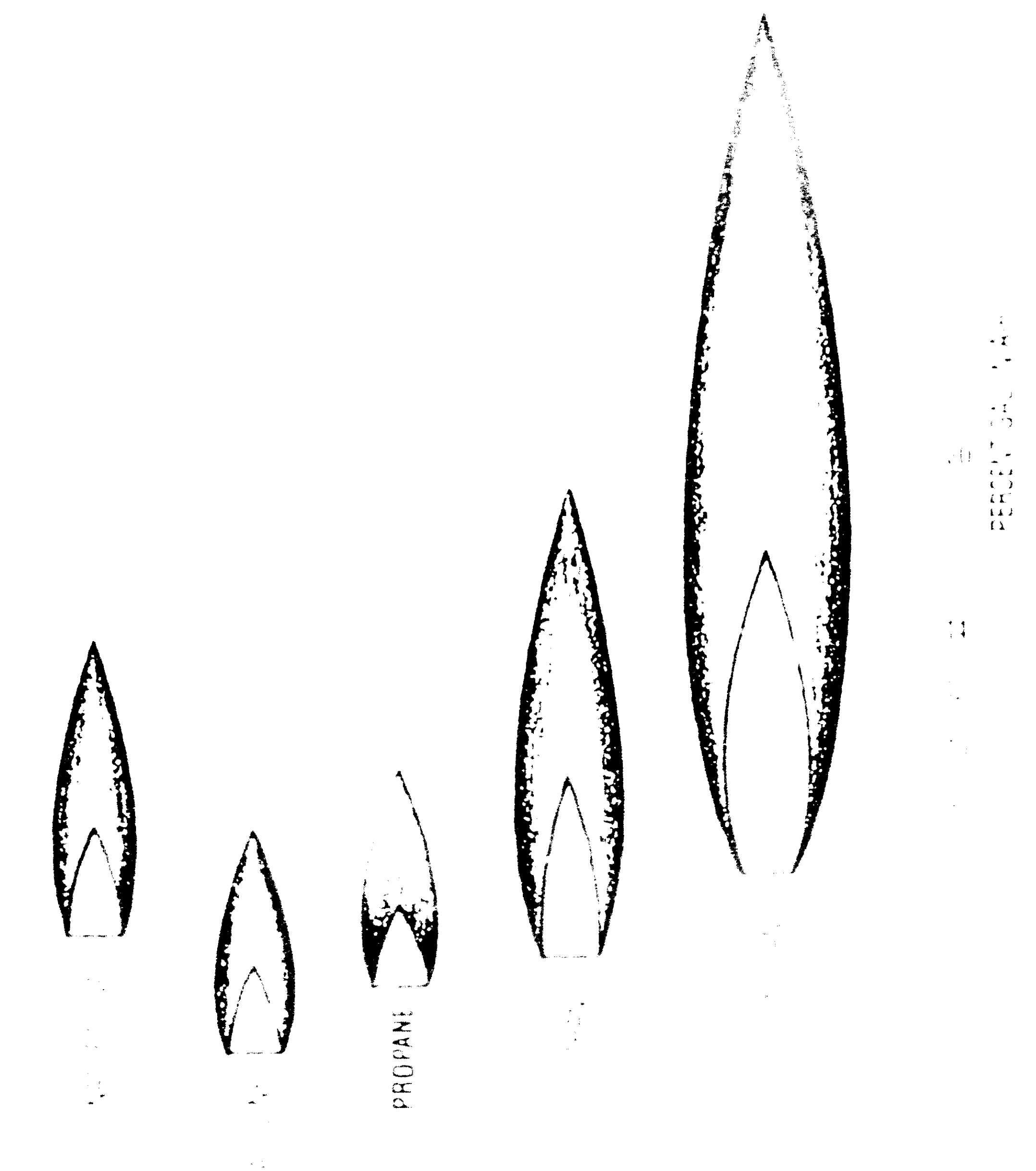
Propane has been in use as a motor fuel since the 1920's with an outstanding safety record

It is heavier than air, but it does not puddle and vaporizes quickly

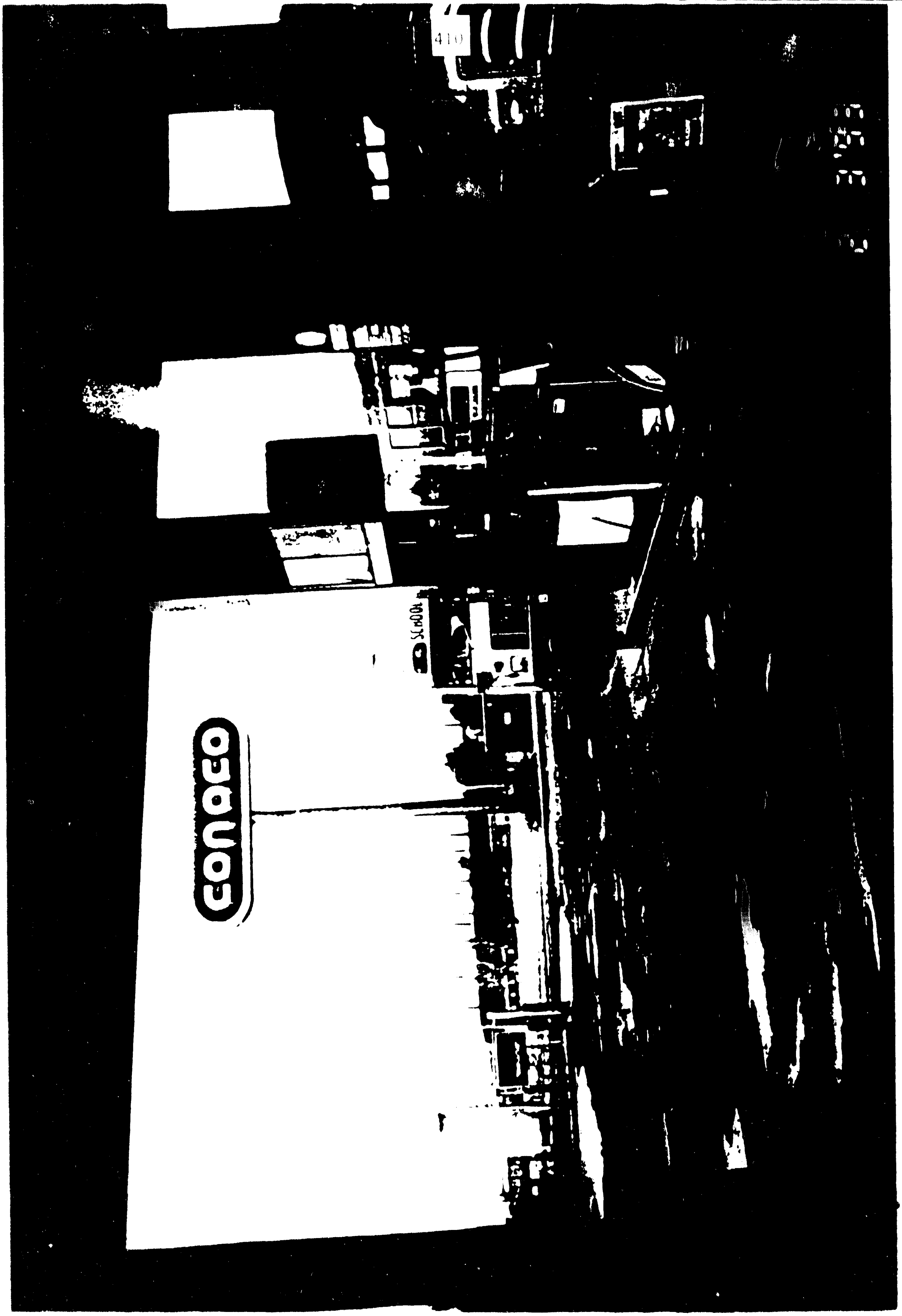
It has a norrow flammability range (2.15% - 9.6%) air/fuel mixture

It has high ignition temperature 920F - 1120F (gasoline 450 -900F)

FLAMMABILITY RANGE OF ALTERNATIVE FUELS



Considered safe by independent school districts throughout the country
Fuel tanks are 20 times more puncture resistent than gasoline tanks
With many safety features designed into the carburation system (like safety relief valves)


CONOCO

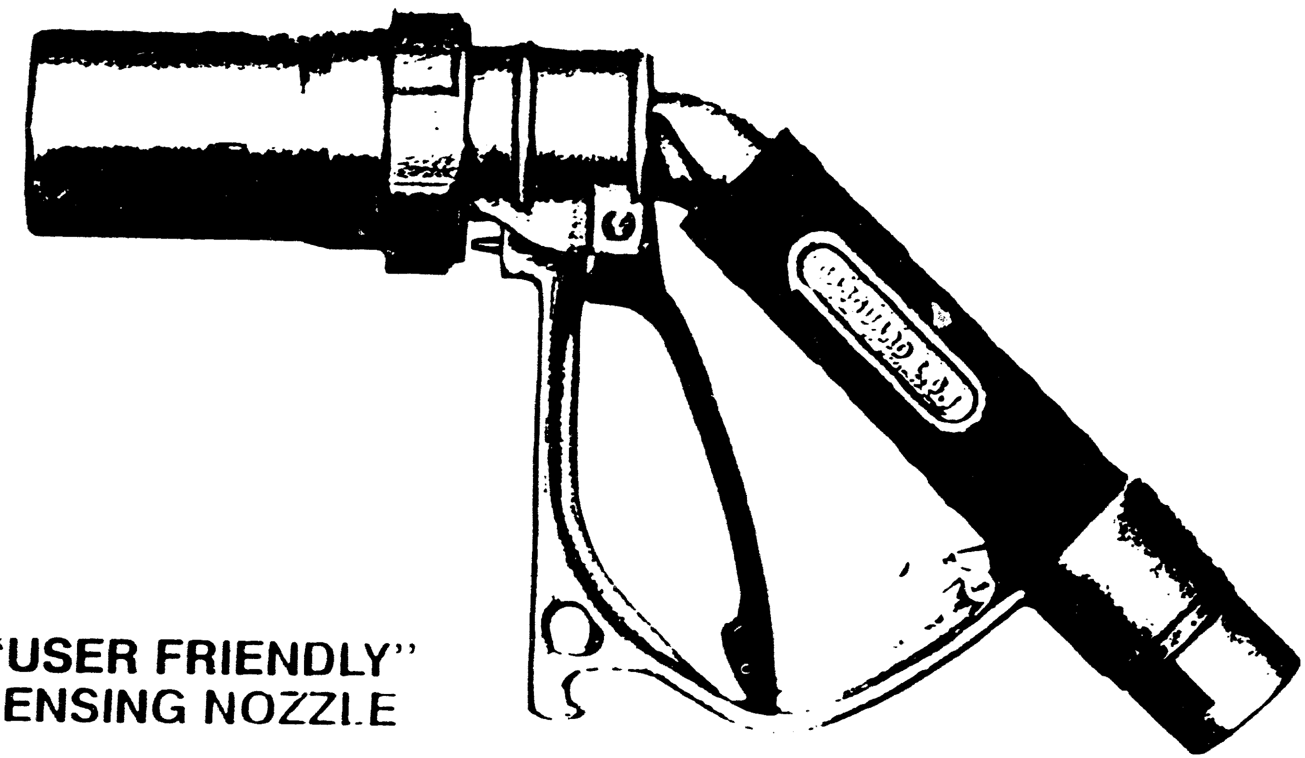
It is the current refueling procedure that reinforces the negative safety perception.

The spit valve needs to be eliminated (modern tanks have built in 80% fill levels)

and modern nozzles that eliminate the white fog and the need to wear gloves at the disconnect need to become common place.

THE "GASGUARD" L.G.1E LIQUEFIED PETROLEUM GAS (PROPANE) NOZZLE

[illegible]



THE "USER FRIENDLY" DISPENSING NOZZLE

Test after test and years of use have proven propane a safe motor fuel to handle and to use.

It is interesting to note that propane is pronounced unsafe by its critics, not by those who use the fuel on a daily bases.


conoco
SCHOOL BUS
414

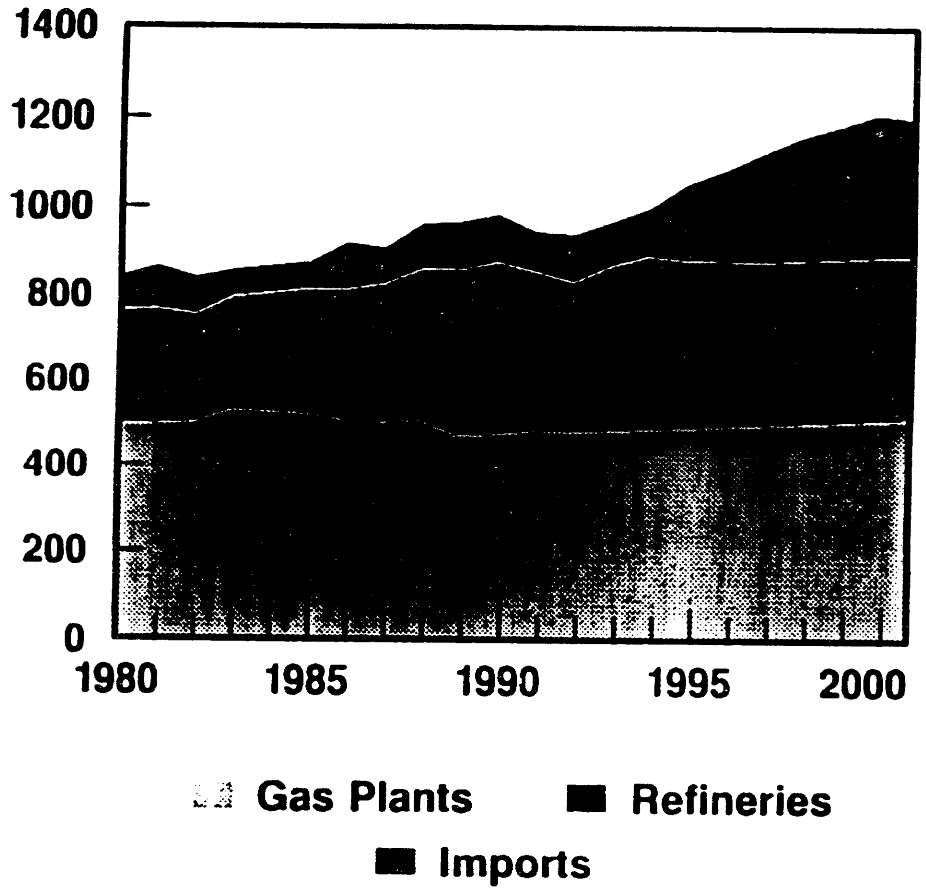
There have been stories and anti-propane publicity surrounding supply availability and unstable seasonal pricing, all designed to discredit propanes use and even its official consideration as an alternative motor fuel.

Changing the Perception

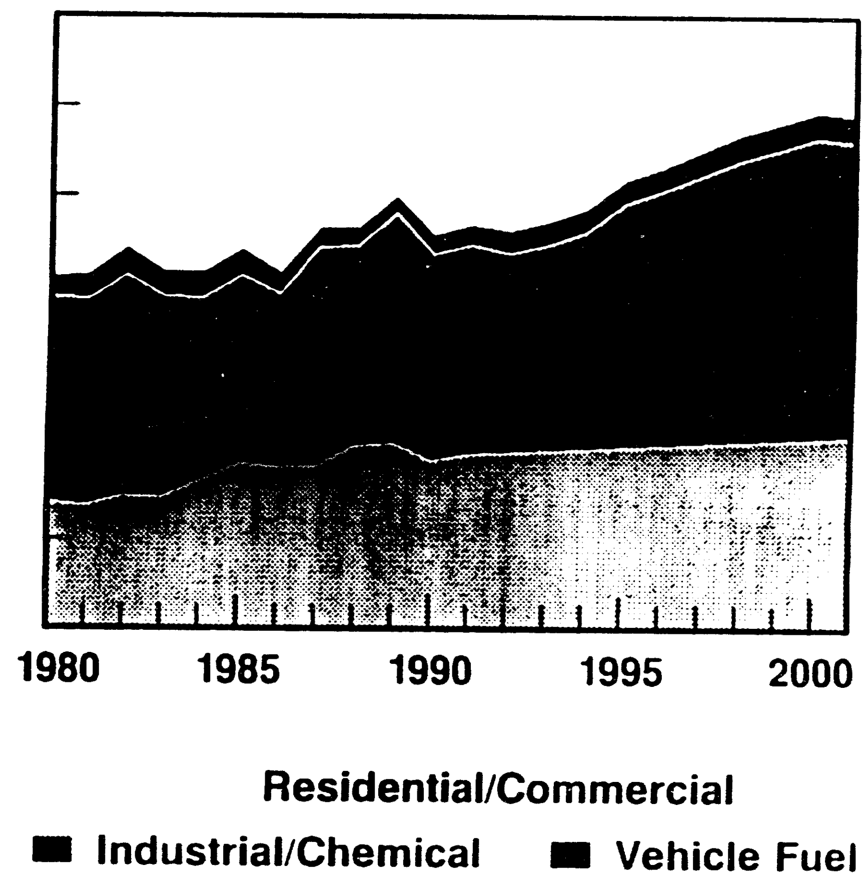
- Performance Capability
- Safety Characteristics
- Fuel Cost & Supply
- Fueling Locations & Availability

Recent supply analysis shows sufficient quantities of propane to extend its use as an alternative fuel - 6.5mm vehicles could be fueled with propane by the year 2004 without effecting domestic supply.
According to the recent Webb Study 17mm vehicles could be fueled by propane by the year 2010 with moderate capital investment.
There is also an adequate distribution system already in place which is under utilized today - it includes pipelines, storage & distribution terminals, railcars and tankers.

Propane Supply
Thousand Barrels Per Day



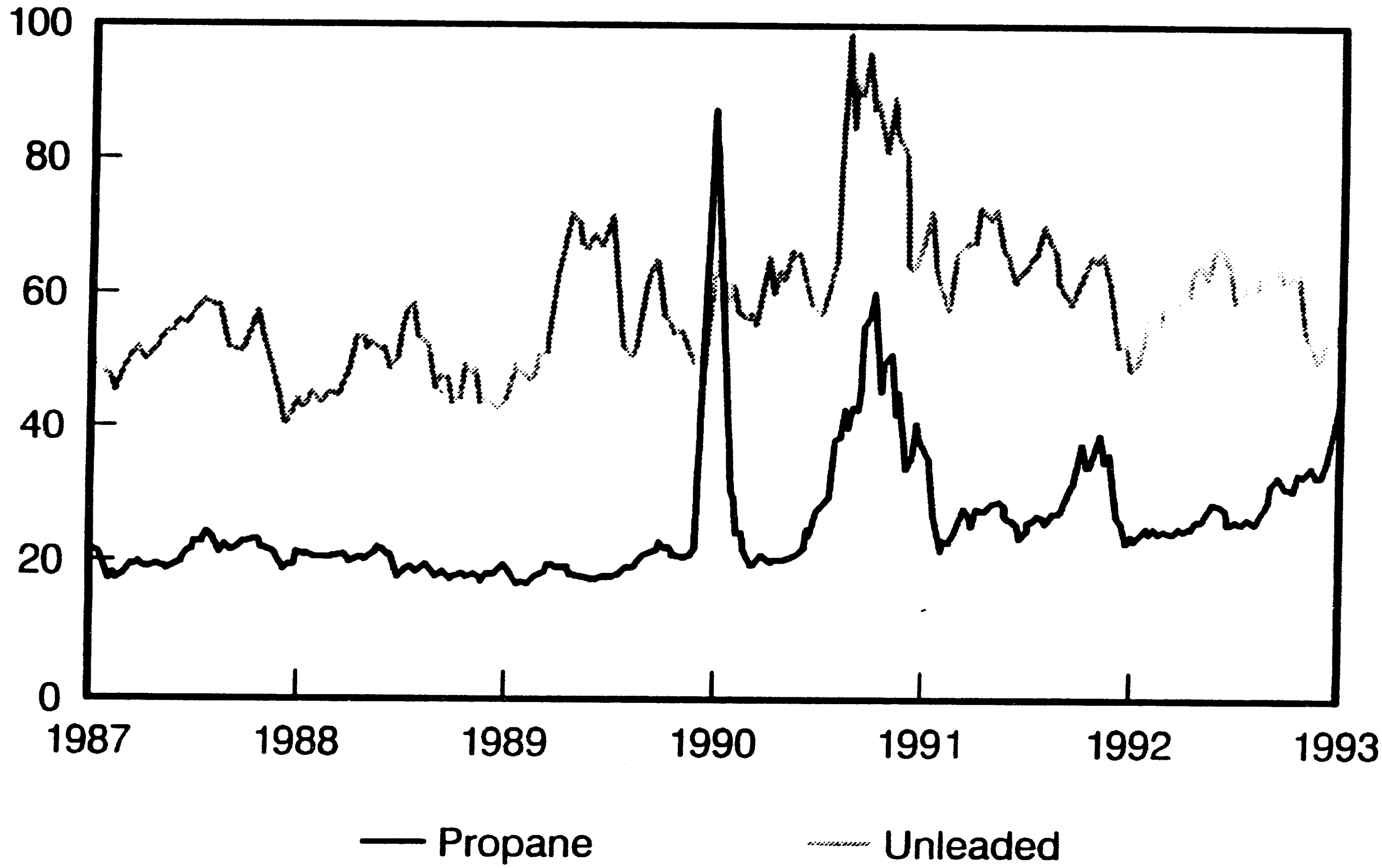
Propane Demand
Thousand Barrels Per Day



As for pricing instability and high winter prices, the perception is for the most part correct and the propane retailers need to change their pricing philosophy.

The wholesale price of propane only exceeded gasoline once in the past six (6) years - there is a sufficient delta between the two fuels to accomodate a pricing philosophy directly related to the retail price of gasoline.

Propane Vs. Gasoline Prices



Our pricing position is to price propane as a motor fuel below the retail price of gasoline, year round - we even post our price of propane at the street as we do gasoline for everyone to see.
Others need to and are following this example.


CONOCO
1.25^{9}
1.33^{9}
1.41^{9}
1.21^{9}
PROPANE
MOTOR
FUEL
.82^{9}
CONOCO

Last but not least - we have to upgrade our refueling facilities and thus improve the image of propane motor fuel marketing.

Changing the Perception

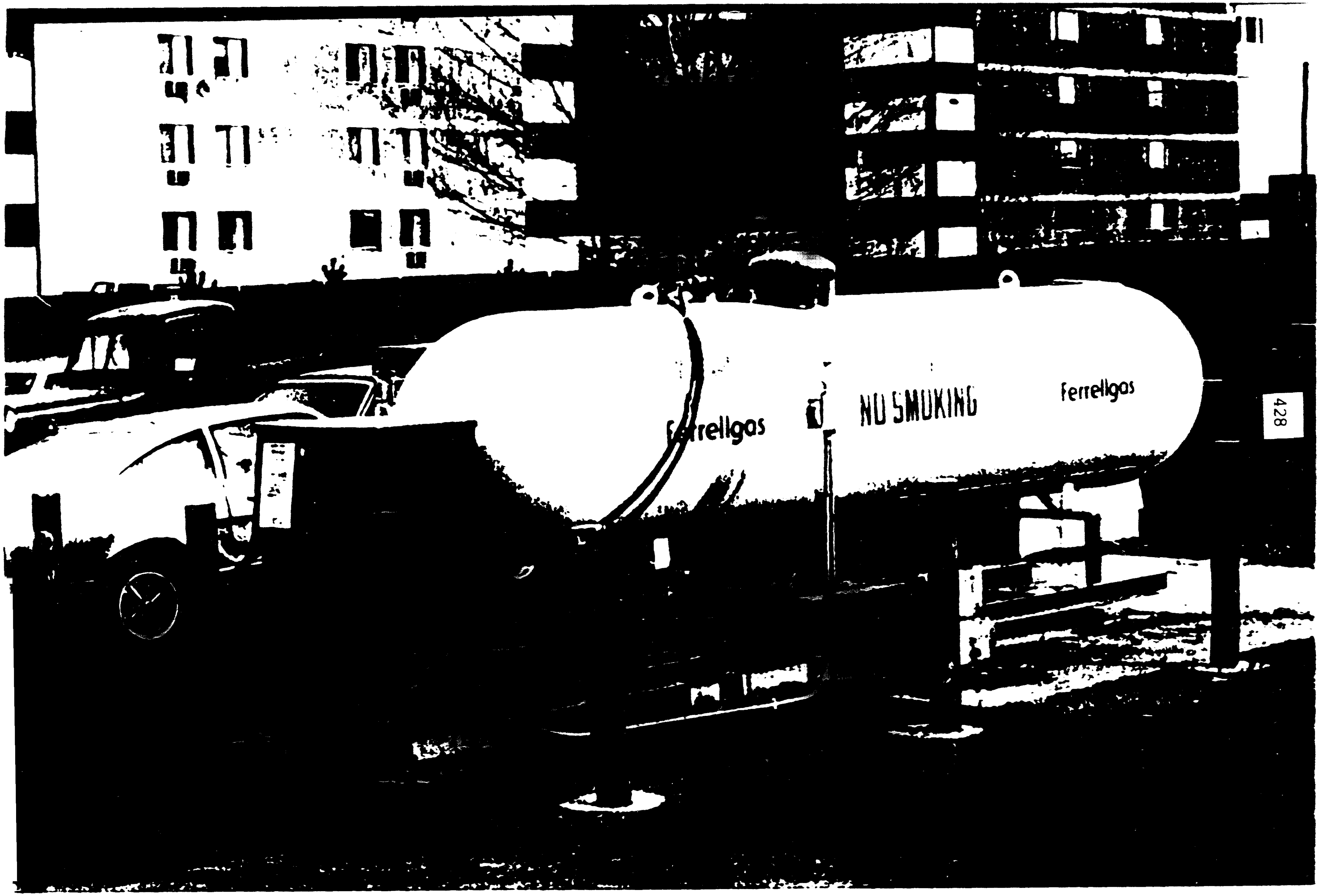
- Performance Capability
- Safety Characteristics
- Fuel Cost & Supply
- Fueling Locations & Availability

424

While there are 10,000 facilities open to the public, the overall image is poor. Set up for bottle fill or RV'S


PROPANE
426

Or in the back of some parking lot hard to find much less utilize.


Ferrellgas
NO SMOKING
Ferrellgas
428

We must upgrade these units, taking advantage of the thousands of fueling permits that have already been issued to dispense propane motor fuel. Securing a permit is a major hurdle for offering any alternative fuel to the motoring public. We also need to expand the current Alt. Fuel refueling directories to include most if not all of the 10,000 units open to the public. In other words take advantage of propanes built refueling infrastructure.

430

We must bring propane marketing to main street USA (like this s/s) as it has been done in Canada and other countries. We must look operate and be as accessible and convenient as gasoline is today.

431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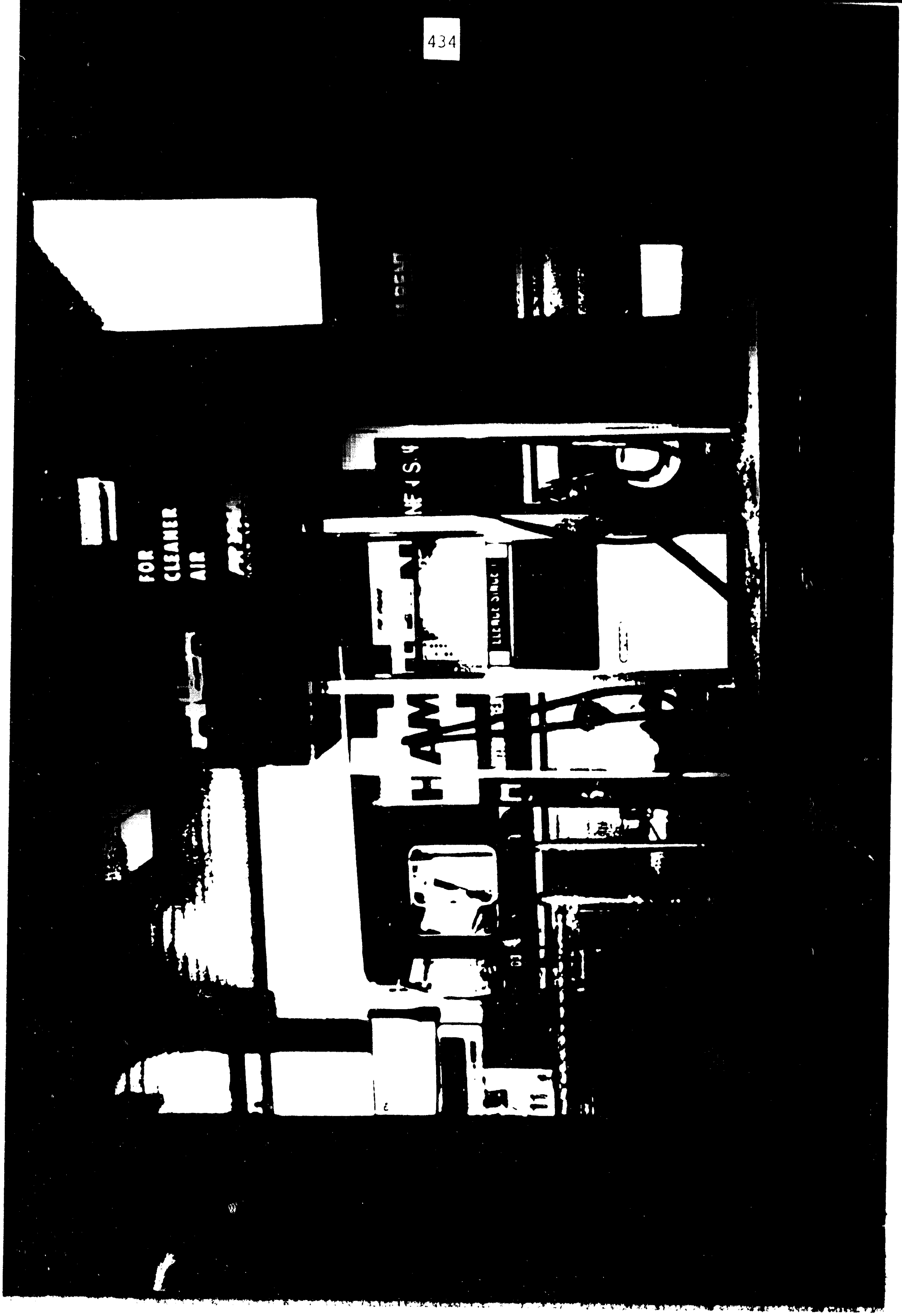
We must utilize modern, user friendly , self serve dispensing equipment - in other words, be inviting to the public like this unit in Denver, Co.


FOR
CLEANER
AIR

It is important for the industry
to work together
to work with government
to work with the OEMs
to educate and to create awareness
By working together, we can get more fleets to try propane, thus changing the perception of propane as a motor fuel - remember, those fleets that have tried propane as a motor fuel have a positive impression.

What's Needed

- OEM Support
- Fleet Demonstrations
- Education
- Advertising/Publicity

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Those fleets, like myself and many others believe propane deserves to be recognized as the viable clean-burning alternative motor fuel that it truely is.

Thank you

Propane Motor Fuel

A Viable Clean-Burning Alternative Motor Fuel

SUMMARY OF VERBAL COMMENTS OR QUESTIONS AND SPEAKER RESPONSES

PROPANE MOTOR FUEL MARKETING - CHANGING THE PERCEPTION
S. Vedlitz, Conoco Inc.

Q. Bernard James, Energy, Mines & Resources Canada: In the vehicle fuel tanks, will the stop-fill valve eliminate the need for the spit valve?

A. The stop-fill valve is required in all new tanks, so the spit valve is no longer needed. Its included because it is still required by regulations.

Q. Norman Brinkman, General Motors: What will happen with the price of propane relative to gasoline with an increase in demand for propane? Will it increase such as happened a few years ago with diesel fuel?

A. The same problem occurs with any alternative fuel today. We will have to change the pricing philosophy. Propane may reflect the gasoline fuel market in the future instead of being compared with heating oil or chemicals.

Q. Anonymous: Where does the excess propane go today?

A. It is used as a feedstock for ethylene or other chemicals. I would like to sell it as a preferred motor fuel.

Comment: Norval Horner, Amoco Canada: I agree. Ethylene can be made from ethane, butane, naphtha, or gas oil which would release a lot of propane for fuel at a modest price. A change of only a few cents per gallon would take propane out of the chemical market.

Q. Norval Horner, Amoco Canada: What is the price of M85 methanol?

A. Right now, M85 is about the same price as unleaded gasoline on a volumetric basis. That actually makes it about 50 percent more on an energy basis.

Q. Vinod Duggal, Cummins Engine Co.: Was your price chart comparison of propane and gasoline on a gallon basis or a BTU basis?

A. The chart was based on price per gallon in the sport market.

Q. How does the energy content of propane compare with gasoline?

A. Although the BTU content of propane is about 25 percent less, a propane-fueled vehicle will obtain about 15 percent less miles per gallon than gasoline.