U.S.Department
of Transportation

**Research and
Special Programs
Administration**

400 Seventh Street, S.W.
Washington, D.C. 20590

APR 17 1998

Mr. James A. Noone
G.H. Johnson & Associates, Inc.
1211 Connecticut Avenue, N.W., Suite 302
Washington, D.C. 20036-2603

Dear Mr. Noone:

This is in response to your letter of March 25, 1997, requesting clarification on the shipping requirements for batteries manufactured by your company under the provisions of the Hazardous Materials Regulations (HMR; 49 CFR Parts 171-180). Specifically, you ask if your batteries are subject to the HMR.

The information you provided demonstrates that your batteries are constructed in such a manner that the sulfuric acid electrolyte is completely sealed and cannot leak even if the battery is cracked open or punctured. In addition, the sulfuric acid electrolyte is absorbed in a fibrous glass separator. Thus, your batteries appear to meet the criteria for non-spillable batteries in § 173.159(d). When securely packaged and protected against short circuits, non-spillable batteries are not subject to the provisions of the Hazardous Materials Regulations.

In addition, under the International Civil Aviation Organization's (ICAO) Technical Instructions for the Safe Transport of Dangerous Goods by Air, special provision A67, a non-spillable battery is considered to be non-regulated if, at a temperature of 55°C, the electrolyte will not flow from a cracked or ruptured case.

I hope that this information is helpful. If you need further assistance, please contact us.

Sincerely,

Delmer F. Billings
Chief, Regulations Development
Office of Hazardous Materials Standards

G. H. Johnson & Associates, Inc.
Government and Military Marketing Representatives for:
OPTIMA BATTERIES
THE ULTIMATE POWER SOURCE
SPIRALCELL TECHNOLOGY

March 25, 1998

J. Suzanne Hedgepeth
Director
Office of Hazardous Materials
Exemptions and Approvals
Office of the Associate Administrator
For Hazardous Materials Safety
Research and Special Programs Administration
Department of Transportation
400 Seventh Street, SW
Washington, DC 20590

Re: Request for Determination

Dear Ms. Hedgepeth:

I am writing to seek an updated determination from the U.S. Department of Transportation ("DOT") that batteries manufactured by OPTIMA Batteries, Inc. ("Optima"), of Aurora, Colorado, are not subject to the Hazardous Materials Regulations and, therefore, can be shipped commercially by air and surface means without restriction.

Optima utilizes a spiral design for battery cells that was originally developed by The Gates Rubber Company ("Gates") of Denver, Colorado. The technology was invented by Gates in the 1970s, and commercial production began in 1987 under the Optima name. In 1990, Optima was incorporated as a division of Gates. In 1992, Optima was purchased from Gates by The Gylling Group of Scandinavia, the current parent company. This history of Optima is outlined in "The Optima Manual," Attachment A.

In 1981, in response to a request by Gates , the Research and Special Programs Administration ("RSPA") of DOT informed Gates that because of the sealed design of the batteries eventually to be sold under the Optima name, such batteries were not subject to the Hazardous Materials Regulations. See Attachment B, letter of February 18, 1981, from Joseph T. Horning, Chief, Regulations Development Branch, Office of Hazardous Materials Regulations, Materials Transportation Bureau, RSPA.

Colorado Office
270 Tahosa Road South, POB 457
Allenspark, CO 80510-0457
Tel: (303) 747-2065 Fax: (303) 747-2915
E-mail: ghjassoc@mci2000.com

Washington Office
1211 Connecticut Avenue, N.W., Suite 302
Washington, D.C. 20036-2603
Tel: (202) 466-7336 Fax: (202) 955-5879
E-mail: kn1211conn@aol.com

Optima would like to obtain a current determination by the appropriate DOT office that its battery is not subject to the Hazardous Materials Regulations and is authorized for shipping by commercial means. So that a proper evaluation may be done pursuant to this request, I am enclosing the following additional materials:

- One-page promotional sheet showing technical specifications (Attachment C)
- A current Material Safety Data Sheet (MSDS), most recently revised on December 5, 1997 (Attachment D)
- Letter of June 2, 1995, from the International Air Transport Association ("IATA") confirming that Optima batteries are not regulated by the IATA Dangerous Goods Regulations (Attachment E)

As explained in substantial detail in these attachments and in Attachment A, the Optima battery is completely sealed. In addition, the sulfuric acid electrolyte is absorbed in a fibrous glass separator material. Because of the design and construction, acid cannot leak even if the battery were to be punctured.

For your information, we have been in communication with the U.S. Postal Service ("USPS") in recent weeks with respect to a determination that the Optima battery can be shipped by the USPS as a non-hazardous product. We have been advised that USPS is in the process of revising its regulations to reflect such a determination. We will forward documentation reflecting this change as we receive it from USPS.

We would very much appreciate your expeditious consideration of this request. Please use the undersigned as the point of contact in the Washington Office of Johnson Associates/Optima: (202) 466-7330 (P); (202) 955-5879 (F). As indicated on this letterhead, the mailing address is: G.H. Johnson & Associates, Inc./OPTIMA Batteries, Washington Office, 1211 Connecticut Avenue, NW, Suite 302, Washington, DC 20036.

Please do not hesitate to contact me should you require additional technical or other information.

Sincerely,

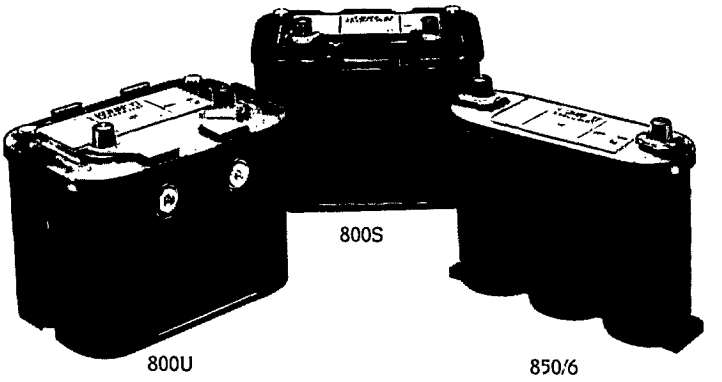
James A. Noone
Washington Representative

JAN:dkt

OPTIMA® BATTERIES

SPIRALCELL™ TECHNOLOGY

THE ULTIMATE STARTER



ONLY OPTIMA's SPIRALCELL TECHNOLOGY™ OFFERS ALL THESE BENEFITS:

OPTIMA is the most advanced engine-starting battery available. Our patented SPIRALCELL Technology provides many features and benefits not found in conventional automotive batteries:

FASTER, CRISPER STARTS.
The OPTIMA's SPIRALCELL Technology provides more power for faster, crisper starts. The 800U and 800S 12-volt models deliver 800 Cold Cranking Amps at 0°F.

LONGER BATTERY LIFE, GREATER SAVINGS.
In performance tests, the OPTIMA lasted three to five times longer than conventional, flat-plate batteries.

COMPLETELY SEALED.
Electrolyte in the OPTIMA is completely absorbed. It can't leak even if the battery is cracked open. This means the OPTIMA is safer for people, equipment, and the environment.

UNEQUALED VIBRATION RESISTANCE.
Vibration is a primary killer of conventional batteries. OPTIMA's tightly wound SPIRALCELL resists jarring and vibration, and eliminates plate shedding.

MORE POWER IN ANY CLIMATE.
Tests prove the OPTIMA performs better in extreme cold and hot temperatures than conventional lead-acid batteries of similar size.

ZERO MAINTENANCE / NO CORROSION
Thanks to recombinant technology, absorbed electrolyte, and sealed construction, the OPTIMA won't corrode battery terminals, cables, or the vehicle. And the OPTIMA never needs to have water added.

LONGER SHELF LIFE.
With its low rate of self discharge, the OPTIMA can go unused for up to a year without recharging. The OPTIMA is ideal for boats, farm equipment, collector cars, and other seasonal equipment.

FASTER RECHARGE.
Greater plate surface area and lower internal resistance allow the OPTIMA to be recharged in less time than conventional automotive batteries.

FAST ENERGY RESPONSE.
The OPTIMA's low internal resistance provides power faster when demanded by accessories such as stereos, winches, etc.

BETTER RECOVERY FROM DISCHARGE.
With 120 minutes of Reserve Capacity and a high-purity lead grid, the OPTIMA is less likely to be damaged by accidental deep discharge.

UNIVERSAL SIZE & FIT.
The OPTIMA fits a wide variety of cars, trucks, and other equipment. The OPTIMA can be mounted in any position -- even upside-down.

OUTSTANDING WARRANTY.
Because the OPTIMA is built for some of the roughest conditions, it's backed by one of the best automotive warranties. See an OPTIMA dealer for complete warranty details.

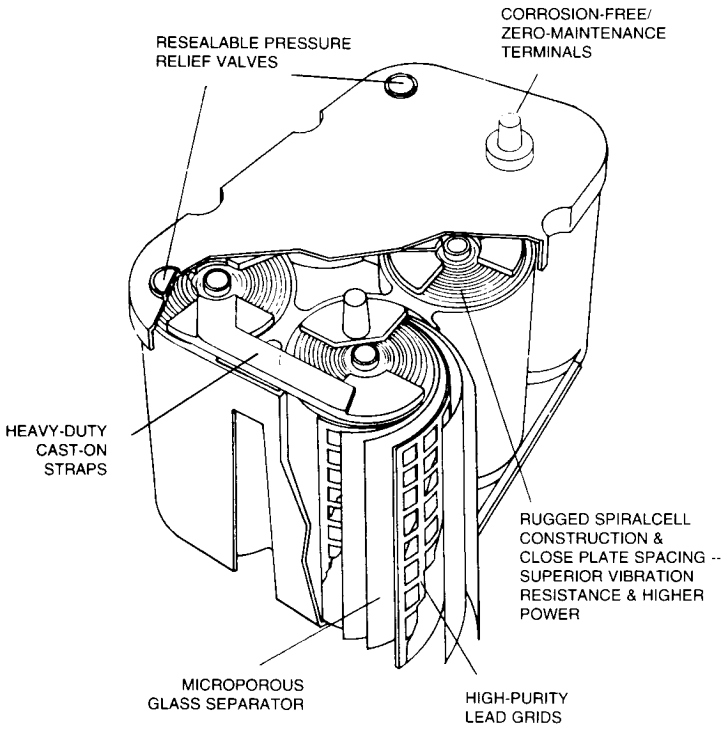
OPTIMA Batteries, Inc. / 17500 E. 22nd Avenue / Aurora, CO 80011 / Phone (303) 340-7440 / Fax (303) 340-7474
Gylling Group of Scandinavia -- Established 1912

PN 06-1001 3/96

OPTIMA® BATTERIES

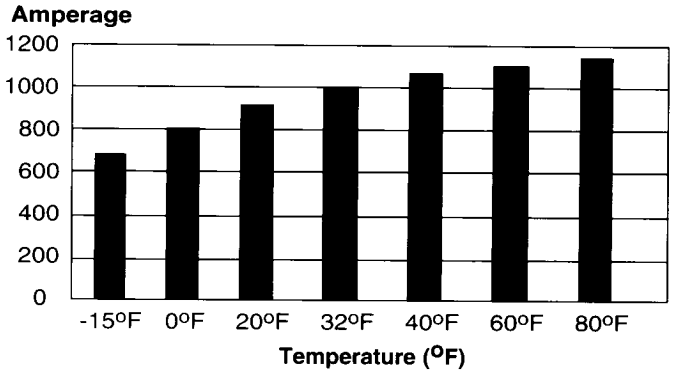
TECHNICAL INFORMATION

THE ULTIMATE STARTER



	800U	800S	850/6
PERFORMANCE			
Voltage	12	12	6
Cold Cranking Amps	800	800	850
Reserve Capacity	120 min.	120 min.	120 min.
Capacity (C/20 rate)	56 Amp Hours	56 Amp Hours	56 Amp Hours
DIMENSIONS			
Length	9 15/16"	9 15/16"	9 29/32"
Width	6 7/8"	6 3/4"	3 3/8"
Height	7 13/16"	7 13/16"	7 13/16"
Weight	39.5 lbs.	39.0 lbs.	20.0 lbs.
Type Post/Terminal	Dual SAE & GM	SAE Post	SAE Post
BCI Group	34	34	N/A

Cranking Amperes vs. Temperature



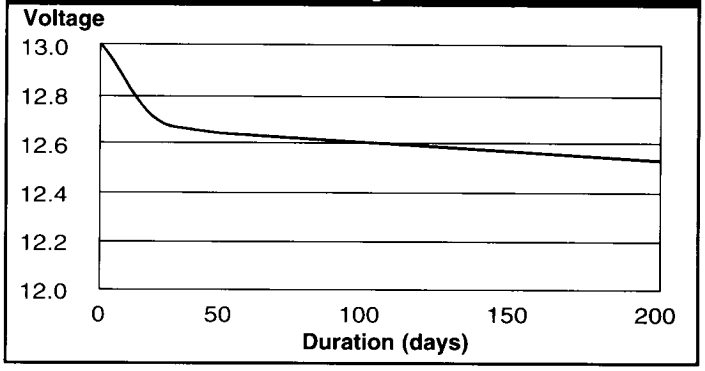
Charging Data

Vehicle Charge:		Voltage regulation - 13.8 to 14.4 Volts
Shop Charge	Normal Charging:	Voltage - 13.8 to 14.8 Volts Maximum Current - 10 Amps Maximum Time - 6-8 hours
	Float Applications:	Voltage - 13.2 to 13.8 Volts Maximum Current - 1 Amp Maximum Time - Indefinite (at lower charge voltages)
	Boost Recharge:	Voltage - 15.6 Volts (Regulated) Maximum Current - 60 Amps Maximum Time - 1 hour

NOTE: Charging systems should be voltage regulated.

Self Discharge

@ 74° Degrees F



Warranty Information

Consumer car/truck (72 month)	Two year replacement, remaining 48 months pro-rated
Commercial (36 month)	One year replacement, remaining 24 months pro-rated
Car stereo/racing (24 month)	One year replacement, remaining 12 months pro-rated
Abusive service	Determined on individual basis

YOUR DEALER / DISTRIBUTOR

OPTIMA Batteries, Inc. / 17500 E. 22nd Avenue / Aurora, CO 80011 / Fax (303) 340-7474 Phone (303) 340-7440

Gylling Group of Scandinavia -- Established 1912

OPTIMA BATTERIES®

THE ULTIMATE POWER SOURCE™

Material Safety Data Sheet

Number: OBI-0001 B
Issue Date: 02/20/90
Revision Date: 12/05/97

Section 1 - Material Identification

Product Name: Sealed Lead Acid Battery
Common Synonym: Automotive Battery
UN Number: UN2800 (See Section 16 for additional information)

Engine Starting Batteries

Battery Model No.	National Stock Number (NSN)
800U	6140-01-374-2243
800S	6140-01-378-8232
1000M	6140-01-441-4280
850/6	Not Available

Deep Cycle Batteries

Battery Model No.	National Stock Number (NSN)
D750U	6140-01-441-4272
D750S	Not Available
D900M	Not Available

Company Information
Optima Batteries, Incorporated
17500 E 22nd Avenue
Aurora, Colorado 80011
(303) 340-7400
Cage Code OUJ55

Emergency Phone Number
Chemtrec
United States: 800-424-9300
International: 703-527-3887
(collect)

The OPTIMA sealed lead acid battery is considered an article as defined by 29 CFR 1910.1200(c) OSHA Hazard Communication. The information on this sheet is supplied at the customer's request for information only.

Emergency Overview:

Exposure not expected for product under normal conditions of use. In its manufactured and supplied state, the product is considered non-hazardous. Keep away from flames during and immediately after charge. No significant health effects are associated with the product.

Section 2 - Composition (Hazardous Components

Material	% by weight or volume	CAS Number
Lead Compounds	63 - 81	7439-92-1
Sulfuric Acid Electrolyte	17 - 25	7664-93-9
Case Matl Polypropylene	2 - 6	9003-07-0
Separator/Paster Paper Fibrous Glass	1 - 4	65997-17-3

Section 3 - Hazards Rating

The Hazards rating for the Sealed Lead Acid Battery are:

Hazards Rating (HMIS System)	
Health	0
Flammability	0
Reactivity	0

Section 4 - Hazards Identification

Potential Health Effects

None expected for finished product under normal conditions of use.

Fire and Explosion

The sealed lead acid battery is not considered flammable, but it will burn if involved in a fire. Short circuit can also result in fire. Evacuate area. Self-contained breathing apparatus must be worn to prevent possible inhalation of acid mists, smoke and decomposition products in a fire. Remove all ignition sources. Cool battery(s) to prevent rupture.

Section 5 - First-Aid

Inhalation - Not expected for product under normal conditions of use. However, if acid vapor is released due to overcharging or abuse of the battery, remove exposed person to fresh air. If breathing is difficult, oxygen may be administered. If breathing has stopped, artificial respiration should be started immediately. Seek medical attention.

Eyes - Exposure not expected for product under normal conditions of use. However, if acid from broken battery case enters eyes, flush with water for at least 15 minutes. If irritation develops, seek prompt medical attention.

Skin - Exposure not expected for product under normal conditions of use. However, if acid contacts skin, flush with water and mild soap. If irritation develops, seek medical attention.

Ingestion - Not expected due to physical form of finished product. However, if any materials are ingested, seek prompt medical attention.

Section 6 - Fire-fighting Measures

Extinguishing media - Multipurpose dry chemical or multipurpose CO_2.

Fire fighting procedures - Evacuate area. Self-contained breathing apparatus must be worn to prevent possible inhalation of acid mists, smoke and decomposition products in a fire. Remove all ignition sources. Cool battery(s) to prevent rupture.

Unusual fire and explosion hazards - Hydrogen gas may be produced and may explode if ignited. Remove all ignition sources. Ventilate area.

Section 7 - Accidental Release Measures

Spill or leak cleanup procedures: Avoid contact with acid materials. Use soda ash, baking soda or lime to neutralize acid if released.

Waste disposal: Dispose of in accordance with all local, state, and federal regulations.

Section 8 - Handling and Storage

Handling - Do not carry battery by terminals. Do not drop battery, puncture or attempt to open battery case. Keep away from flames during and immediately after charge. Avoid prolonged overcharges in confined areas.

Storage - Store at ambient room temperature. Do not subject product to open flame or fire. Avoid conditions which could cause arcing between battery terminals.

Hygiene - Wash hands thoroughly before eating or smoking after handling batteries.

Section 9 - Exposure Control

Material	Exposure Limits
Lead compounds	0.05 mg/m3
Sulfuric Acid Electrolyte	1.00 mg/m3 OSHA

Section 10 -Personal Protection:

Eye: Not necessary under normal conditions of use for finished product.
Skin: Not necessary under normal conditions of use for finished product.
Respiratory: Not necessary under normal conditions of use for finished product.
Ventilation: Not necessary under normal conditions of use for finished product.
Work Practices: Not necessary under normal conditions of use for finished product.

Section 11 - Physical and Chemical Properties

Boiling Point:	N/A	Appearance/Odor:	N/A
Vapor Pressure:	N/A	Specific Gravity (H_2O=1):	N/A
Vapor Density (air=1)	N/A	Melting Point:	N/A
Solubility in water:	N/A	Evaporation Rate: (Butyl Acetate = 1)	N/A

Section 12 - Stability and Reactivity

Stability:	Stable
Conditions to avoid:	Avoid shorting, use only approved charging methods. Do not puncture battery case
Hazardous reactions:	N/A
Decomposition Products:	N/A
Hazardous Polymerization:	Will not occur

Section 13 - Toxicological Information

Threshold limit value: Not applicable for finished product.
Route of entry: Not applicable for finished product under normal conditions of use.
Signs of symptoms of acute exposure: None expected for finished product under normal conditions of use.
Chromic Exposure: None expected for finished product under normal conditions of use.
Medical Conditions aggravated by exposure: None expected for finished product under normal conditions of use.
Effects of overexposure, conditions to avoid: No exposure expected for finished product. However, do not puncture or open battery case. Acid electrolyte may be released. Use only standard charging methods. If overcharged, battery may release gases (Hydrogen and oxygen).
Carcinogen listing: NTS: no IARC: no OSHA regulated: NA for finished product under normal conditions of use.

Section 14 - Disposal Considerations

Send to a lead recycling facility which follows applicable Federal, State and Local regulations for routine disposition of spent or damaged batteries. The distributor / user is responsible to know that "spent" and/or "damaged" batteries (scrap batteries) are disposed of in an environmentally sound way in accordance with all applicable Federal, State, and Local Environmental Regulations. OPTIMA batteries are 100% recyclable by any licensed reclamation operation.

Section 15 - Regulatory Information

According to the OSHA Hazard Communication Standard, Sealed Lead Acid Battery in its manufactured and supplied state is considered non-hazardous.

Transportation:

Sealed Lead Acid Battery is not a DOT Hazardous Material.

Section 16 - Supplemental Information

Under the Dangerous Goods Regulations, 34th Edition, Effective 1 January 1993, produced by International Air Transport Association (IATA): OPTIMA batteries are classified as non-regulated by special provisions A-48 and A-67 for UN Number of UN2800: Batteries, wet, non-spillable, electric storage:

A-48: Packaging tests are not considered necessary.

A-67: Non-spillable batteries are considered to be non-dangerous if, at a temperature of 55°C (130°F), the electrolyte will not flow from a ruptured or cracked case and there is no free liquid to flow and if, when packaged for transport, the terminals are protected from short circuit.

The manufacturer of this finished article cannot foresee every possible use or misuse of the product. However, the following information is supplied:

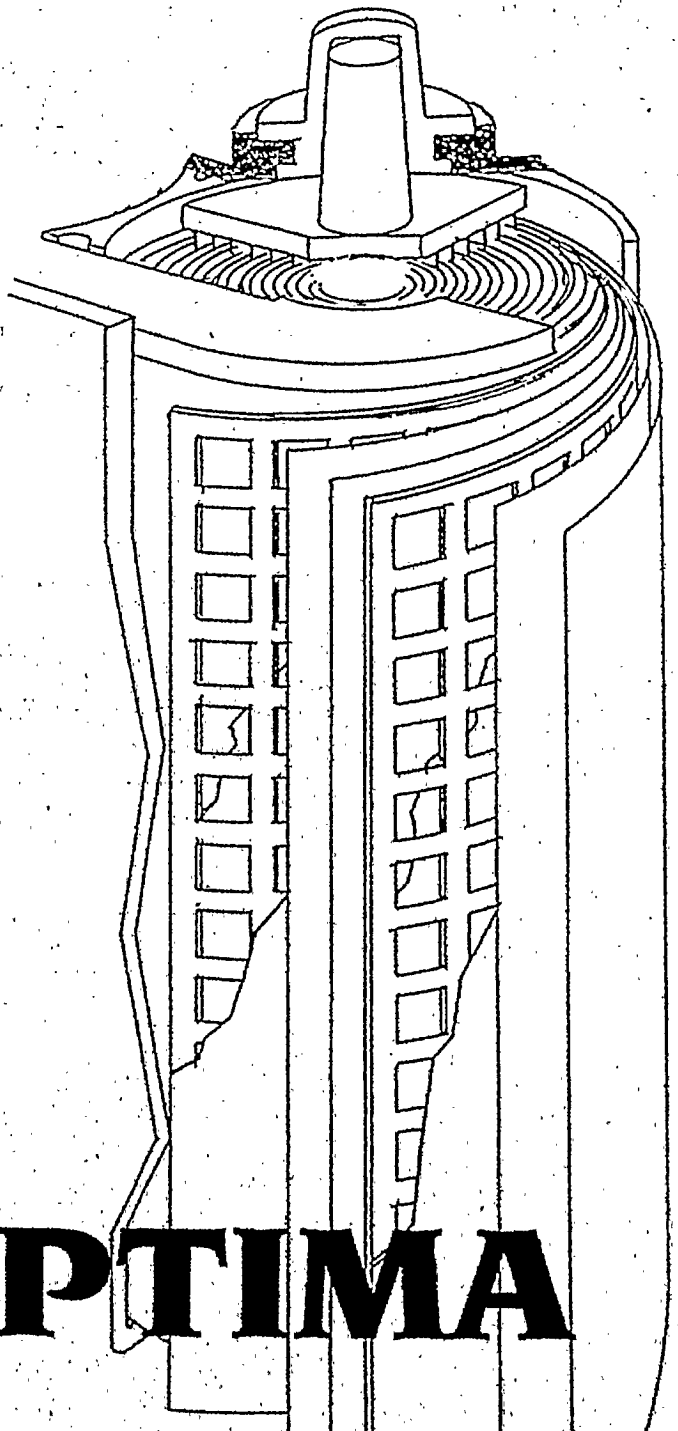
In its manufactured and supplied state, the product is considered non-hazardous. Excessive overcharging or abuse to the terminals can result in the release of gases (hydrogen and oxygen). As a general practice, batteries should not be used in enclosed, non-ventilated spaces. Avoid immersion in water as it may lead to hydrogen generation. If the battery is crushed in a collision or similar accident, the absorbent separator may be squeezed causing the release of a small amount of acid electrolyte. Neutralize the acid electrolyte with baking soda and flush with plenty of water.

Under the Code of Federal Regulations #49, October 1, 1994 Edition, OPTIMA batteries are classified as an exception from all other requirements or conditions as stated in the following areas: Batteries, wet, 173.159 (d)(3)(i) and (d)(3)(i)(i).

(d)(3)(i):	vibration test
(d)(3)(i)(i):	pressure differential test

These conditions have been tested and certified by the following: Energy Research Laboratory (ERL A/S), Batteritest Laboratory, Munkebjergvaenget 13, DK-5230, Odense M. Denmark. Information is on file at main company location.

The information and recommendations contained herein have been compiled from sources believed to be reliable and to represent current knowledge on the subject. No warranty, guarantee, or representation contained herein and OPTIMA Batteries, Inc., its subsidiaries or affiliates assume no responsibility in connection therewith, nor can it be assumed that all acceptable safety measures are contained herein, or that other or additional measures may not be required under particular or exceptional conditions or circumstances.



the

OPTIMA

MANUAL

the

OPTIMA MANUAL

OPTIMA® BATTERIES

THE ULTIMATE STARTER

TABLE OF CONTENTS

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1. INTRODUCTION

The **OPTIMA** battery represents a new standard for the automotive S.L.I (Starting, Lighting, Ignition) market. Its superior starting ability, high reserve capacity, long life, safety, and versatility make it outstanding for a wealth of uses. One customer recently praised it as "the most dependable, lowest maintenance battery on the market today."

What makes the **OPTIMA** unique? Its SPIRALCELL, sealed design provides more power for faster, crisper starts at any temperature. It outperforms flat plate batteries by three to one. The **OPTIMA** delivers an amazing 800 cold cranking amps for the 12 volt 800S and 800U models. Completely sealed, the **OPTIMA** is maintenance-free; it is much safer than conventional batteries since it cannot spill or leak. Its tightly-wound spiral elements resist jarring and vibration, making the **OPTIMA** an ideal choice for almost any application or equipment.

Introduced in 1984, the **OPTIMA** is the result of nearly 20 years of research and development. Originally developed by the Gates Rubber Company of Denver, Colorado, **OPTIMA** Batteries, Inc. is now owned by Gylling **OPTIMA** Batteries, A.B. of Stockholm, Sweden. All **OPTIMA** batteries are manufactured at the company's Colorado facility in Aurora. **OPTIMA** batteries are sold wholesale to distributors throughout the U.S. and abroad.

While originally designed for the automotive S.L.I market, **OPTIMA** batteries are finding acceptance in a wide range of applications including:

- Commercial fleets - passenger cars, light trucks, vans, utility vehicles
- Private automobiles, light trucks and vans
- Diesel-powered vehicles - light and medium sized trucks
- Agricultural, forestry and construction equipment - tractors, harvesters, dump trucks, water trucks, generators, fork lifts, skid loaders
- Marine starting applications - fishing boats, house boats, sail boats, ski boats
- Collector and specialty vehicles - antique cars, show cars, custom cars, street rods, lowriders
- Motor sports and racing cars
- Car audio systems
- Military Aerospace Ground Support Equipment (AGE), generators, and military vehicles

This manual is a complete reference source regarding the **OPTIMA**'s design, technical specifications, features, benefits, applications, warranty and more. Please contact us at 303-340-7440 (phone) or 303-340-7474 (fax) with any questions you many have about the **OPTIMA** battery.

2. THE OPTIMA MANUAL

This manual is your source for reference, background information, and tools to enhance your success in representing **OPTIMA** batteries.

REFERENCE:

Use this manual as a reference tool. You'll find the answers to most questions in "The **OPTIMA** Manual." We've included summaries of features, functions, and benefits; specifications; applications; basic battery technology; warranty procedures; a glossary; and more.

BACKGROUND INFORMATION:

Learn about the **OPTIMA** battery, its advantages, and how it compares to conventional battery technology. We start by explaining the new **OPTIMA** technology, describing why it is superior for so many applications. We've included a time line describing the battery's development. This manual also covers basic battery technology, terminology, and testing procedures.

TOOLS:

Understand the **OPTIMA** technology and how to apply it to applications. Testimonial letters that describe how the **OPTIMA** battery is saving customers time and money are available.

3. HISTORY OF THE OPTIMA BATTERY

1973

Gates Rubber Company, one of the world's largest producers of rubber products for the automotive industry, develops the initial battery technology incorporating a SPIRALCELL with recombinant technology. The company produces millions of battery cells for tools, appliances, and emergency lighting.

1983

Gates recognizes the need for an advanced automotive battery. The company begins research and development to further explore the battery technology.

1984

The S.L.I. (Starting, Lighting, Ignition) battery project team is established at Denver, Colorado.

1987

Limited S.L.I. production begins; the first automotive batteries go to market.

1990

Gates incorporates the division as **OPTIMA** Batteries, Inc.

Gylling Teledata A/S of Norway begins limited importation and distribution of **OPTIMA** batteries. Soon after, Gylling obtains distribution rights for all of Scandinavia.

1991

Gates divests itself of **OPTIMA** Batteries, Inc.

1992

The Gylling Group of Scandinavia purchases **OPTIMA** Batteries, Inc. from Gates.

1993

Public demand for the **OPTIMA** battery begins to rapidly increase.

1994

OPTIMA Batteries, Inc. breaks ground for a new, larger, modern manufacturing facility in Aurora, Colorado.

1995

OPTIMA Batteries Inc. moves into its new headquarters in Aurora, Colorado. Sub-contract with General Motors is signed to develop a monoblock battery for their hybrid vehicles.

1996

Full production begins at new facility and sales efforts expand throughout the North and South America as well as world-wide.

4. OPTIMA CONCEPT AND DESIGN

Several parameters were of critical importance during the design of the **OPTIMA** S.L.I. (Starting, Lighting, & Ignition) battery.

What requirements were crucial for the design of the OPTIMA battery?	
Capability (Performance)	✓ High power for quick, sure engine starts.
	✓ Ample electrical reserve capacity.
	✓ Safe to operate.
Construction	✓ Compact in size and weight compared to traditional S.L.I. batteries with similar output.
	✓ Compatible with most vehicles.
	✓ Operates in any position or orientation, even upside down.
	✓ No spillage even if the case is cracked.
	✓ Recyclable.
Maintenance	✓ Truly zero maintenance. ✓ Low self discharge rate for a long shelf life. ✓ Long operational life. ✓ Rapid charge (recharge) rate.
Resilience	✓ Dependable even in extreme hot and cold temperatures. ✓ Resistant to vibration, impact, and jarring.

The **OPTIMA** battery, with significantly fewer parts, appears to be simple in design when compared to traditional battery construction. Still, it is a very complicated battery to mass produce. Not only is the design unique, but most of the manufacturing equipment had to be specially designed and built to produce the **OPTIMA**.

5. SUMMARY OF FEATURES AND BENEFITS

- **SUPERIOR STARTING CAPACITY.**
  The **OPTIMA** delivers 800 Cold Cranking Amps (C.C.A.) for the 800S and 800U models and 850 C.C.A. for the 6 volt battery (CCA is measured @ 0°F or -18°C). The 1000M marine starting battery is rated at 1000 Cranking Amps (CA is measured @ 32°F or 0°C).

- **CANNOT CRACK DUE TO FREEZING.**
  OPTIMA's unique separator material allows for expansion in the event of freezing.

- **ZERO MAINTENANCE.**
  Completely sealed. There is no venting to corrode the terminals, connectors, battery tray, or surrounding equipment. Customers never need to add water.

- **EASY TO TRANSPORT.**
  Because the **OPTIMA** battery is considered non-hazardous/non-dangerous, it can be shipped by air.

- **FASTER RECHARGE.**
  Recharge in less time due to low internal resistance and tight plate spacing.

- **FITS MOST VEHICLES AND EQUIPMENT.**

- **HANDLES ABUSIVE TEMPERATURES.**
  Operates effectively in extreme hot or cold temperatures.

- **HIGH RESERVE CAPACITY.**
  OPTIMA has a reserve capacity of 120 minutes.

- **LONGER SHELF LIFE.**
  After one year it will start most engines. Total shelf life is 2 years or more.

- **MUCH SAFER.**
  Absorbed electrolyte, no free acid to spill or leak. The **OPTIMA** can be installed in any location and is less likely to explode.

- **OUTLASTS CONVENTIONAL BATTERIES.**
  The high purity lead grids minimize plate corrosion and plate deformation in the **OPTIMA**.

- **RESISTANT TO VIBRATION.**
  Tightly-wound SPIRALCELL™ resists jarring, vibration, and shedding of the active paste material.

- **VERSATILITY OF INSTALLATION.**
  OPTIMA can be installed in any orientation, even upside down.

6. UNDERSTANDING THE OPTIMA TECHNOLOGY,

To better understand the **OPTIMA** battery, let's compare it to the design and construction of a conventional battery.

Traditional batteries are constructed with about 120 different parts and have undergone little change in approximately 100 years.

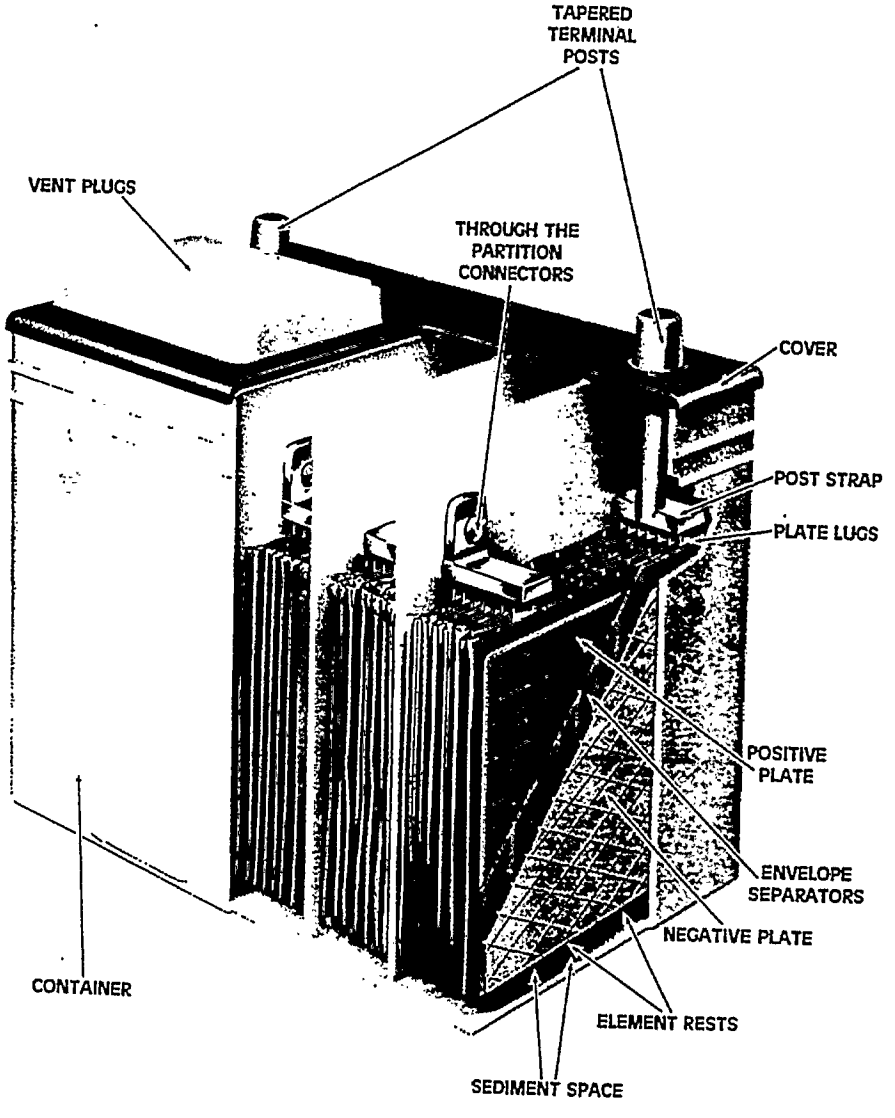

Figure 1

CONVENTIONAL FLAT PLATE BATTERY

The **OPTIMA** battery requires only 30 components; this means there is less opportunity for failure. In the **OPTIMA**, each cell has one long positive and one long negative plate (each of which are about four feet long). The positive and negative plates are separated by an absorbent glass material wound into a tight spiral configuration. The six cells are each compressed into individual cylinders within a strong, injection-molded case. The cells are electrically connected with thick cast lead intercell straps. The electrolyte is injected and totally absorbed within the separator material between the plates. This unique design greatly reduces the potential for mechanical failure.

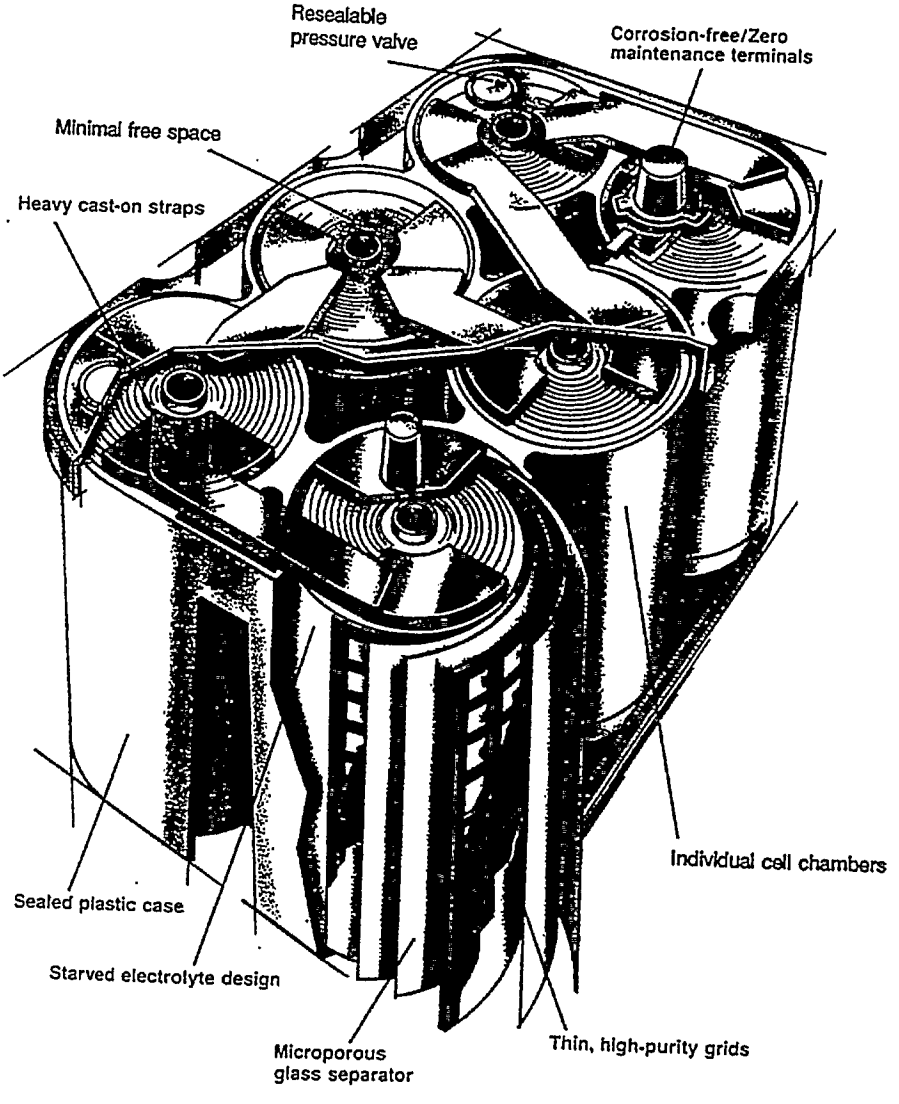

Figure 2

OPTIMA SPIRALCELL BATTERY DESIGN

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7. OPTIMA VERSUS CONVENTIONAL BATTERIES

PLATE / GRID CONSTRUCTION	
OPTIMA	**Conventional battery design**
High purity lead plates are used to make the grid for cells of the **OPTIMA** battery. Two long continuous bands of grid are wound into a tight spiral configuration then pressure inserted into individual cylinders within the case. This design provides the cell's mechanical strength, eliminating the need for alloys in the lead. Using unalloyed lead extends the life of the **OPTIMA** battery by reducing grid corrosion. The **OPTIMA** grid will resist corrosion and last longer in high temperature environments. While conventional batteries are adversely affected by heat, the effects of heat on a high purity lead **OPTIMA** battery are minimal. The use of high purity lead contributes to the low internal resistance. This low resistance allows the **OPTIMA** to deliver high amounts of power quickly to meet the demands of vehicle electrical systems and on-board electronic components. Another advantage of using the high purity lead is a low self-discharge rate. The alloys in conventional batteries accelerate the reaction between the active material and the grid, causing a loss of electrical charge. (See Figure 2)	In conventional batteries, each cell contains a series of short flat grids. Materials such as antimony and calcium are added to the grids to improve strength and stiffness needed for manufacturing. These alloys can increase plate corrosion, self discharge, internal resistance, and promote shedding of the active material (lead paste applied to grid). With age, the grids shed their active paste material. As a result, the battery loses capacity and power. This power loss becomes especially noticeable when engines are harder to start and in cold temperatures. Using alloys in the grid sacrifices performance for strength. For example, antimony improves castability and paste adherence but lowers electrical conductivity and increases the rate of self discharge and gassing. When a conventional battery is stored for long periods without recharging, the alloys in the grid corrode. This shortens the battery's life considerably. (See Figure 1)

CELL DESIGN	
OPTIMA	**Conventional battery design**
Individual cells of the **OPTIMA** contain only two plates, one positive and one negative. These thin high purity lead plates are wound into a tight spiral, and are separated by an absorbent glass material. The separator is very thin, allowing for closer plate spacing. The close proximity of the plates enhances the flow of current and lowers the internal resistance. The porous separator material retains the electrolyte like a sponge, preventing the active material on the plates from drying out. The tightly wound spiral allows the use of a very thin high purity lead grid. Using thinner plates allows more winds in the spiral. This increases the amount of surface area in the cell, thus boosting the amount of power generated from the battery. The plate surface area of an **OPTIMA** cell is much larger than that of a similar size conventional battery and utilizes almost the full height of the container. After the cell is wound, it is pressure-inserted into an individual cylinder chamber with a tight interference fit. This design increases the strength of the cell and prevents the active paste from falling off or shedding. The tightly wound cell resists vibration. There is no free space between the plates. This prevents movement of the plates which causes plate to plate shorting and shedding of the active material.	The cell of a conventional battery contains several plates connected together and suspended in a pool of electrolyte. Alloys are added to the lead grid to increase its strength and stiffness. Stiffness and strength are required for the plates to retain the active material during operation and to make the plates easier to work with during manufacturing. While the alloys add strength to the grid, they also contribute to corrosion, higher internal resistance and shedding of active grid material. Sufficient space between the plates in the cell is required for shedding of the active material to prevent electrical shorts. This material falls from the plates and accumulates at the bottom of the case. The extra space results in a larger battery with higher internal resistance and lower energy density (energy per pound) than the **OPTIMA**. The flat, suspended grids cannot retain the active lead material throughout the life of the battery. When a conventional battery is used in harsh conditions such as high temperatures or high vibration, shedding of the active material increases. This causes a loss in battery power and capacity which leads to battery failure. Typically, the battery fails due to loss of active material or plate to plate shorting.

ELECTROLYTE	
OPTIMA	**Conventional battery design**
The **OPTIMA** battery is an absorbed electrolyte, gas recombinant battery. All the electrolyte is absorbed (like a sponge) within the separator material between the plates in the SPIRALCELL. The electrolyte consumes approximately 95% of the voids in the separator material. The remaining 5% is left as open space for gas passages. During the charging procedure, oxygen from the positive plate combines with the hydrogen at the negative plate to form water which recombines with the electrolyte. Thus, the **OPTIMA** battery can be totally sealed. Since the electrolyte is contained within the separator, it cannot leak, even if the case is ruptured or broken. Since the electrolyte cannot escape via leakage, evaporation or venting, the plates will not dry out and cause loss of capacity. Because the **OPTIMA** never needs water and does not vent, it can be mounted anywhere in the vehicle. Good engineering practices dictate that any battery should not be installed in an air-tight space. Some ventilation is necessary in case the vehicle's charging system fails, causing an abusive overcharge. Overcharge could cause the **OPTIMA's** internal safety valves to release some of the pressure within the battery case. If this happens, some of the internal gases would escape. The sealed, no-venting design eliminates corrosion of battery cables, connectors, and vehicle components.	A conventional battery is a flooded system. Flooded means that there is excess electrolyte in the battery above the level of the plates. This excess electrolyte is required to prevent the plates from drying out, which causes sulfation of the active material. This leads to a failure of the sulfated part of the plate, which reduces the capacity of the battery. Gases in a conventional battery collect in the free space above the plates; which are then vented from the battery. When a battery is overcharged, gassing increases. The gases being vented (hydrogen and oxygen) are **very** combustible. If ignited, they could cause a **battery explosion** A portion of the vented gas corrodes the battery cables and connectors. This corrosion is often noticeable by the appearance of a white powder or blue/green fuzz on the terminals. The conventional battery case must contain vents for gases to escape. If the battery is tipped over or tilted, acid will leak from the vents. If the case is cracked or ruptured, the acid will spill. Loss of the acid will cause the conventional battery to fail. The escaped acid can also cause harm to people, equipment, and the environment.

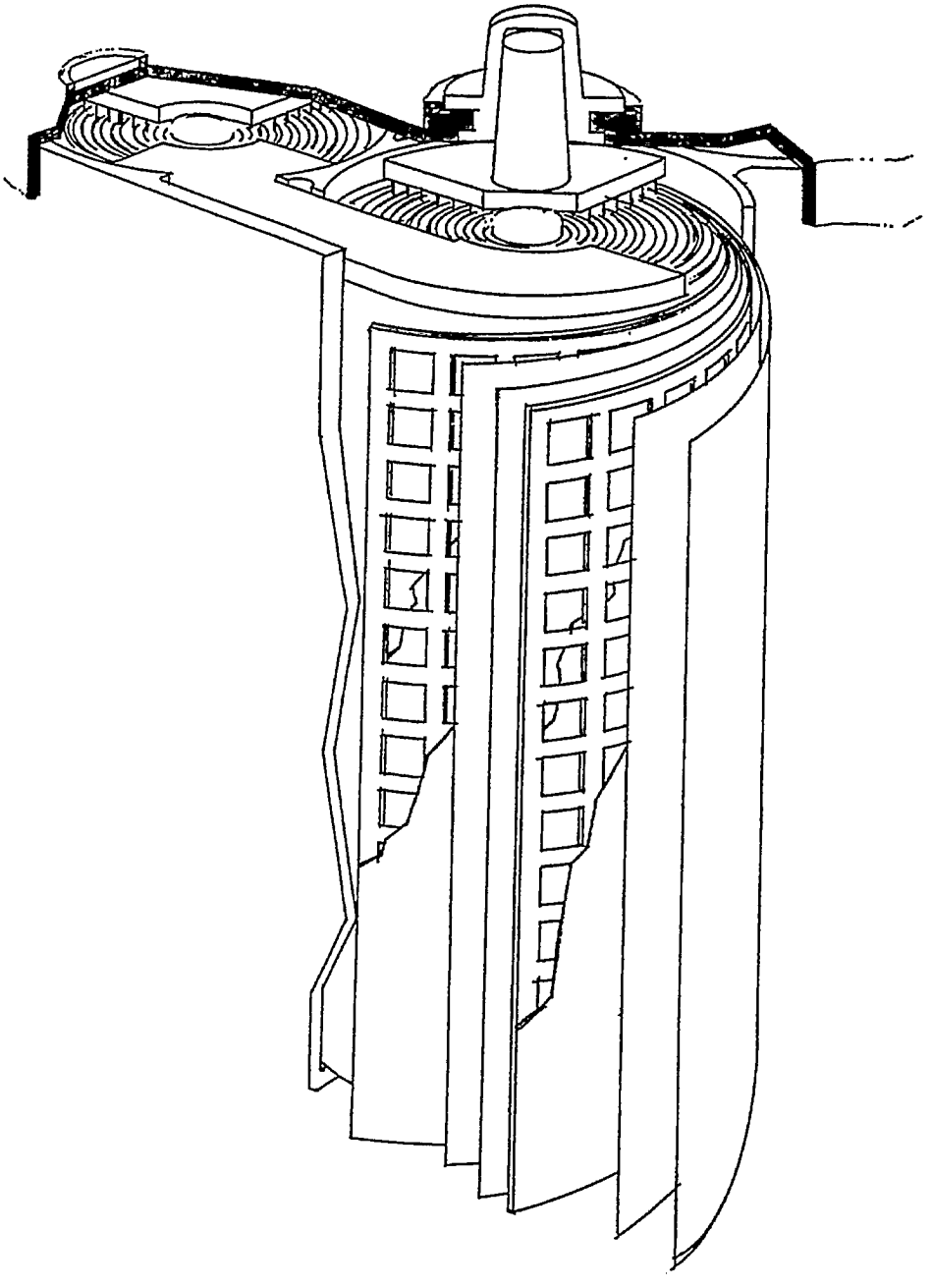

Figure 3

THE OPTIMA SPIRALCELL

8. THE OPTIMA: FEATURES, FUNCTIONS, AND BENEFITS

OPTIMA BATTERIES

FEATURE	FUNCTION	BENEFIT
SPIRAL CELL DESIGN	Greater plate surface area	✓ Increases starting power. ♦ 800 C.C.A. (cold cranking amps). ✓ Recharges more quickly.
	Stronger mechanical design	✓ Withstands vibration thereby increasing life. ♦ Eliminates shedding of active material. ♦ Reduces internal shorting.
	High purity lead grid	✓ Reduces corrosion for longer life. ✓ Lower self discharge. ✓ Lower internal resistance increases conductivity for more starting power and quicker recharging.
	Thinner plates / grid	✓ Higher C.C.A. means more starting power. ✓ Faster recharging.
	Closer, consistent plate spacing	✓ More effective chemical reaction increases starting power. ✓ Faster recharging.
	Reduced battery size	✓ Higher power-to-weight ratio ♦ Produces power equivalent to conventional batteries several times its size. ✓ Fits more vehicles.

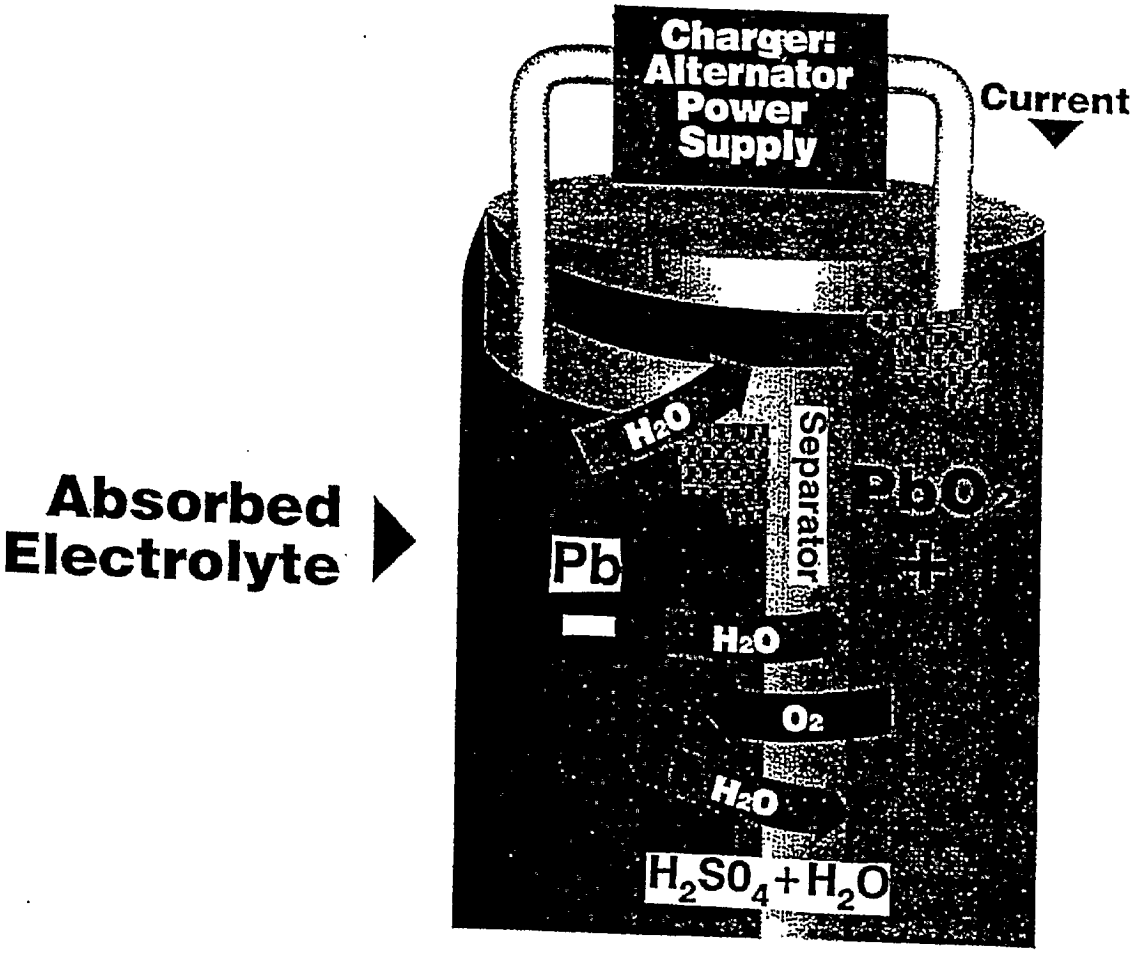

Figure 4

ABSORBED ELECTROLYTE

Figure 4 shows the absorbent separator material wound between the positive and negative plates of the **OPTIMA** SPIRALCELL.

OPTIMA BATTERIES

FEATURE	FUNCTION	BENEFIT
ABSORBED ELECTROLYTE	Precise quantity of electrolyte in each cell (computer controlled filling process)	✓ Fills approximately 95% of the voids in the separator material. 5% of the remaining voids are left for gas recombination, resulting in a totally sealed battery. ✓ Proper distribution of acid for efficient operation and longer life.
	Absorbent separator material	✓ Allows hydrogen and oxygen gases to recombine into water, making the battery completely maintenance free. ✓ Tightly wound separator material prevents internal shorting between the plates, eliminating a common cause of battery failure. ✓ Voids in the separator material provide expansion capacity in case the battery freezes. This helps to prevent the case from cracking. ✓ No spilling/leaking. Absorbent separator retains electrolyte even if case is ruptured. ✓ Allows use of taller plates to better utilize case height. This results in more plate surface areas and higher power.

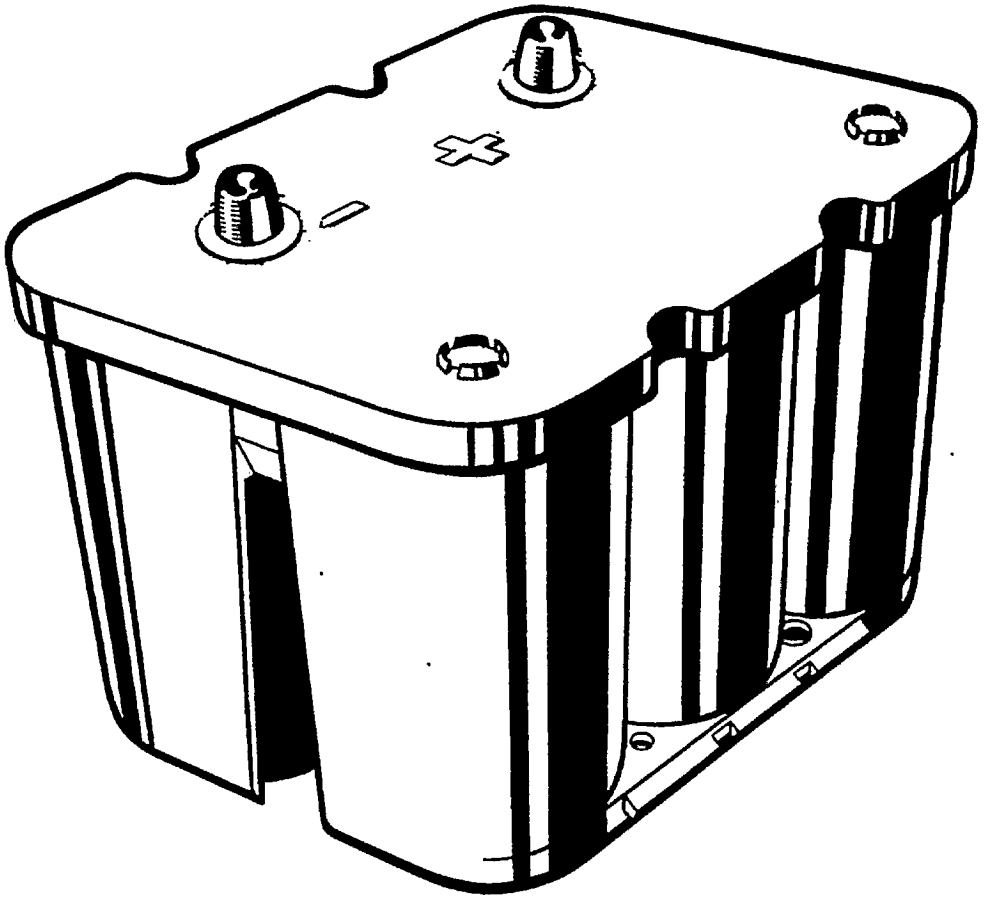

Figure 5

The completely sealed **OPTIMA** recombinant battery prevents electrolyte from escaping. It can be mounted in any orientation, even upside down.

OPTIMA BATTERIES

FEATURE	FUNCTION	BENEFIT
COMPLETELY SEALED	Totally contained system	✓ Allows battery to be mounted in any position, even upside down, for more flexible installation options. ✓ Safer for people, equipment and the environment. It will not leak even if the case is broken. ✓ Eliminates corrosion of battery terminals, cables and surrounding equipment . Completely eliminates battery maintenance. ✓ Sealed, contained system can be transported conveniently by air, U.P.S. or other methods as the **OPTIMA** is non-regulated. ✓ The **OPTIMA** requires no special storage and handling procedures.
	Recombinant technology	✓ Since the **OPTIMA** never needs water, it is completely maintenance free. ✓ Does not lose water which would cause cells to dry out, leading to failure.

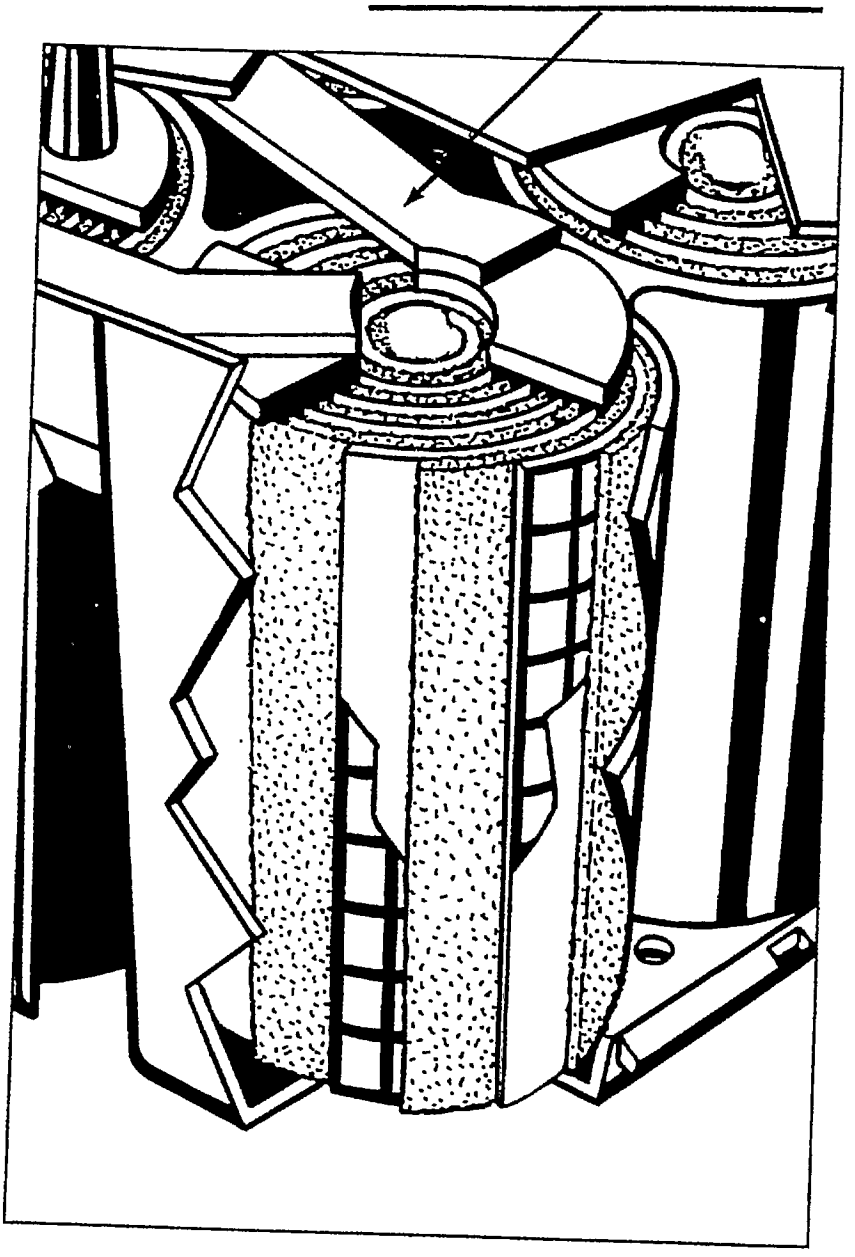

Figure 6

The **OPTIMA**'s thick cast on straps.

FEATURE	FUNCTION	BENEFIT
THICK CAST ON STRAPS	Stronger intercell connections	✓ Lower internal resistance. Delivers energy more efficiently, improving power for engine starting and accessories. ✓ No "through the partition" connections, another potential point of corrosion or failure from vibration. ✓ Larger connection area between cell and straps for more efficient current flow.

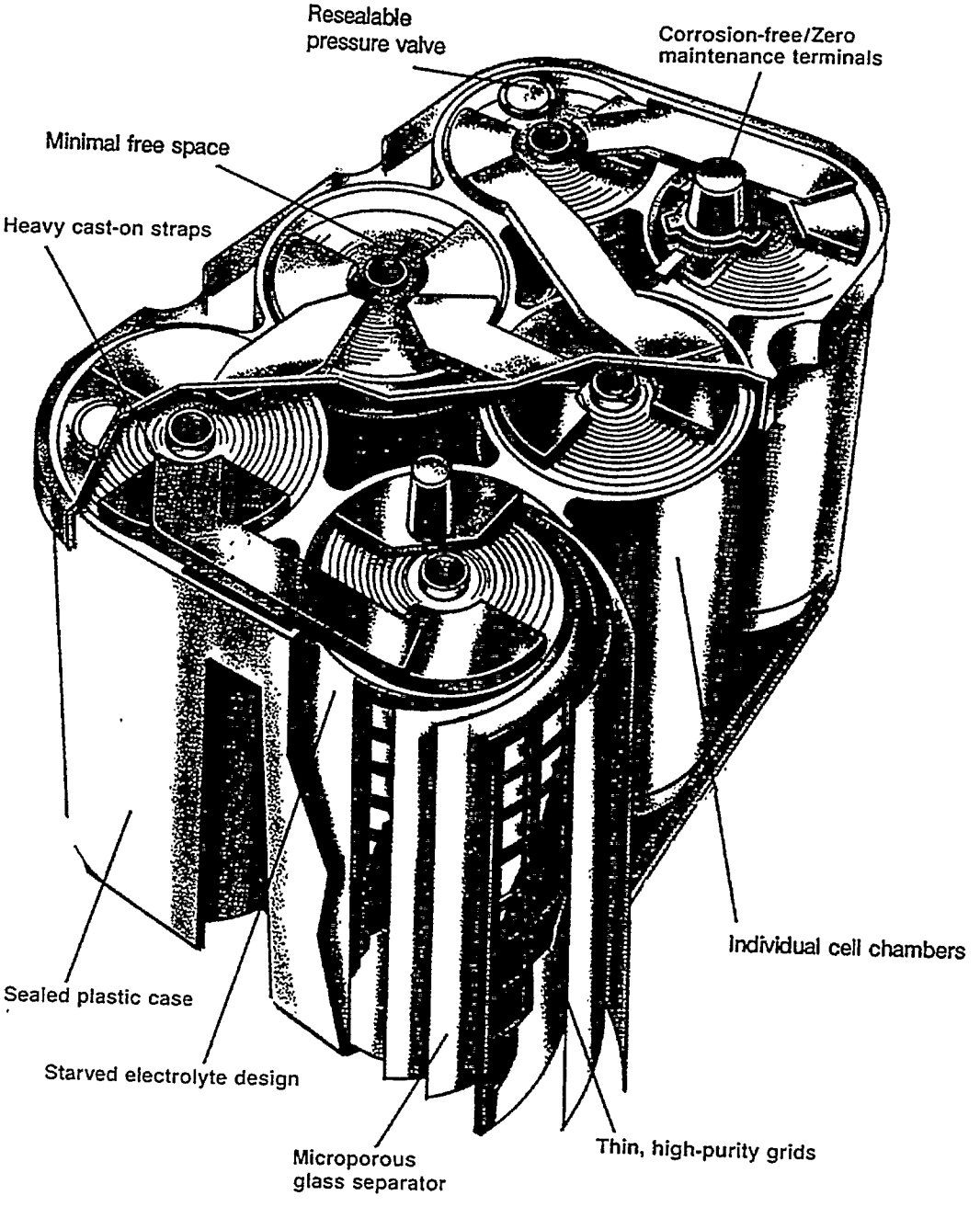

Figure 7

OPTIMA's unique case construction.

OPTIMA BATTERIES

FEATURE	FUNCTION	BENEFIT
UNIQUE CASE DESIGN	Minimal free space within the cells	✓ Minimal free space for gas build-up eliminates the chance of explosion. ✓ Efficient use of case volume for plate surface area.
	Individual cylinders	✓ The spiral cells in individual compartments are stronger, resisting wear and abuse. This eliminates shedding of active material and increases battery life. ✓ Greater outside surface area provides better dissipation of heat, increasing battery life.

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9. THE OPTIMA BATTERY: APPLICATIONS AND ADVANTAGES

The **OPTIMA** 12V group 34 and 6 volt batteries were designed as automotive S.L.I. batteries. Understanding the **OPTIMA** battery's strengths and limitations is important in order to properly determine the right application for each individual customer.

OPTIMA has an estimated life three to four times longer than that of conventional batteries but the actual life will vary depending on the application.

APPLICATION	VEHICLE TYPE	THE OPTIMA ADVANTAGE
Commercial fleets	Passenger cars, Light trucks, Vans, Utility vehicles (Vehicles 2 tons and less)	♦ In the S.A.E. (Society of Automotive Engineers) J240 life cycle tests, the **OPTIMA** battery outperformed average flat plate conventional batteries more than 3 to 1 (12,000 start cycles for the **OPTIMA** compared to 4,000 for the average conventional battery). This makes the **OPTIMA** ideal for commercial vehicles and fleets (taxis, ambulances, police cars, military, etc.). ♦ Numerous engine starts and punishing operating conditions result in more frequent replacement of conventional batteries. Although an **OPTIMA** costs more initially, it is the most economical battery based on actual cost of ownership. An **OPTIMA** has been known to continue to operate even after being shot. ♦ The **OPTIMA** will recharge more quickly from the heavy loads created by additional accessories such as sirens, communication radios, emergency lights, etc. ♦ The **OPTIMA** starts engines better in cold temperatures and has a longer life in hot climates. ♦ Because the **OPTIMA** does not leak or vent, it eliminates routine battery-related maintenance such as replacing and/or cleaning battery cables, connectors and trays. This adds cost savings. ♦ Since OPTIMA does not shed paste it doesn't lose power and capacity as it ages. In conventional batteries this puts more wear on alternators and starters. ♦ OPTIMA provides a consistent "flat" voltage to the starter when discharging, resulting in better starts and less wear.

APPLICATION	VEHICLE TYPE	THE OPTIMA ADVANTAGE
Private automobiles	Passenger cars, Light trucks, Vans	♦ **OPTIMA** lasts 3 to 4 times longer than a high quality conventional battery. ♦ The **OPTIMA** does not corrode and is completely maintenance free. A true "install it and forget it" battery. ♦ The **OPTIMA** is ideal for extreme climates. It provides quick, sure starts in very cold weather. Also important is **OPTIMA**'s long life in very hot climates.
Diesel engine vehicles (commercial and private)	Light trucks, Medium trucks, Passenger cars	♦ The **OPTIMA** has more starting power than any battery its size. Hard cranking diesel engines will start more readily, especially in cold weather climates. ♦ The **OPTIMA** does not corrode terminals and trays and is completely maintenance free. Note: Although one **OPTIMA** battery will usually start most large diesel engines, the correct number of **OPTIMA**s must be configured to match the starting system and electrical accessories such as winches, emergency lights, etc. Operating conditions, such as extremely cold weather, are also an important consideration.
Agricultural, forestry and construction equipment	Tractors, Harvesters, Dump trucks, Water trucks, Generators, Fork lifts (gas/diesel), Skid loaders, etc.	♦ The **OPTIMA** delivers enough starting power to crank rugged equipment, even in extremely hot and cold temperatures. ♦ In machinery that must perform over rough, uneven terrain, the **OPTIMA**'s resistance to vibration provides a longer lifetime. The SPIRALCELL prevents shedding of the active material and weakening of the plate structure. ♦ The leak-free design reduces corrosion and equipment maintenance. ♦ The **OPTIMA** can remain safely in machines left dormant from season to season. Due to the low rate of self discharge, operators of seasonal equipment find they can usually restart engines after many months of inactivity. ♦ Because of **OPTIMA**'s many features and benefits, the 850/6 (six volt) is widely accepted in the agriculture market. Its unique size and shape allow it be installed in a large variety of equipment. ♦ Reduces down time and service calls.

APPLICATION	VEHICLE TYPE	THE OPTIMA ADVANTAGE
Marine Craft	Ski boats, Fishing boats, House boats, Sail boats	♦ The **OPTIMA** is ideal for boats since their engines are often difficult to start. ♦ The **OPTIMA** recharges much faster than conventional batteries. ♦ The **OPTIMA**'s resistance to vibration eliminates plate shorts which can kill a battery in inconvenient places. ♦ The low rate of self-discharge is a plus because boats sit idle during the winter. The **OPTIMA** has the power to start a boat engine that has been sitting for an extended period. ♦ The **OPTIMA** can be mounted in a confined space in any position. Since it is completely maintenance free, there is no need for periodic access. (All batteries should have adequate ventilation.)
Collector and Specialty Vehicles	Antique cars, Show cars, Street rods, Custom cars, Lowriders	♦ These vehicles often sport expensive specialty equipment such as gold plated battery connectors and chrome plated installation hardware. Since the **OPTIMA** is completely sealed, it eliminates the corrosion damage associated with conventional batteries. ♦ The low self-discharge rate provides the starting power when vehicles have been garaged for months at a time. ♦ The **OPTIMA** delivers 800 C.C.A. and a high "flat" voltage to turn over large, high performance engines. ♦ Many specialty cars require that the battery, or multiple batteries, be installed on their sides or in out of the way places, such as the trunk. Since the **OPTIMA** is completely sealed, it can be installed anywhere, in any position. ♦ Best 6 volt available for antique cars, there is no need to do an 8 volt upgrade.

APPLICATION	VEHICLE TYPE	THE OPTIMA ADVANTAGE
Motor sports and racing	Racing cars, Off road trucks, Dune buggies	♦ The **OPTIMA** provides the cranking power for large, high compression engines. ♦ The **OPTIMA**'s resistance to vibration reduces battery failure. This is especially important for off-road vehicles that operate in isolated areas. ♦ The **OPTIMA** recharges quickly, a plus for vehicles with hard starting engines and accessories such as winches and fog lights. ♦ The low self discharge provides starting power for vehicles that are only used periodically. ♦ The **OPTIMA** will not explode or leak, even in a collision. This makes it safer for both the driver and the pit crew. ♦ SPIRALCELL design prevents "plate collapse" during rapid acceleration such as with drag racing.
Car audio systems	Cars and trucks with high power car audio systems	♦ The **OPTIMA**'s high C.C.A. (Cold Cranking Amps) and low internal resistance quickly delivers the power required by large amplifiers. This helps generate clearer bass and purer sound. ♦ Due to its sealed, leak-proof design, the **OPTIMA** can be installed in any location and in any position, even upside down. ♦ The **OPTIMA**'s corrosion-free, sealed container prevents costly damage to gold plated battery terminals and other specialty hardware. <u>Note:</u> We do not recommend the **OPTIMA** S.L.I. battery if the customer typically operates in a deep-cycle manner (long periods of stereo operation with the car engine off). However, most high end car stereo owners use their equipment only when the engine is running or they have an external power source.

APPLICATION	VEHICLE TYPE	THE OPTIMA ADVANTAGE
Military and Commercial Equipment	A.G.E (Aerospace Ground support Equipment), Electrical generators, General purpose cars and light trucks	♦ Thanks to its high cranking ability, the **OPTIMA** can power many types of special purpose equipment. Therefore, agencies can stock fewer varieties of batteries. ♦ The sealed, maintenance-free design makes the **OPTIMA** easier to transport and store. The International Air Transportation Association designates the **OPTIMA** as a <u>non-regulated</u> battery. This means agencies can use standard procedures for transporting and storing **OPTIMA** batteries. ♦ The **OPTIMA** outperforms conventional batteries in extremely hot and cold climates. ♦ The **OPTIMA**'s quick recharging capability is ideal for demanding applications such as emergency vehicles, tactical vehicles, ground support equipment, etc. ♦ A low self-discharge rate makes the **OPTIMA** ideal for powering generators that sit unused for long periods. ♦ The **OPTIMA**'s corrosion-free design reduces maintenance costs. It eliminates replacement or cleaning of battery terminals, cables, and battery trays. ♦ **OPTIMA**'s longer life reduces battery consumption. Therefore, fewer batteries need to be purchased and ultimately discarded or recycled. ♦ The **OPTIMA** has proven successful in the following military applications: → Aircraft Ground Support Equipment (AGE) → Command and Control Equipment → Communications vehicles → Generators and compressors → Tactical and Non-tactical Vehicles (pickup trucks, hummers, weapons carriers, passenger cars) In 1993 after competitive tests, the U.S. Air Force selected the **OPTIMA** as the battery of choice for aerospace ground support equipment!

OPTIMA Application Benefit Reference Sheet

★ = *Customer "hot buttons"* x = *Other features to discuss*

Application	Vehicle type	800 C.C.A.	Vibration resistance	Low internal resistance	120 minute reserve capacity	3 - 5 times longer life	Fast recharge	Corrosion & maintenance free	Safe, no spills or leaks.	Long shelf life	Page # for info.
Fleet vehicles	Trucks/ vans Less than 2 tons	★	x	x		★	x	★		x	25
	Sedans				x	★	x	★	x	x	25
Personal	Automobiles	x			x	★	x	x	x		26
	Pickup trucks and 4 X 4's	★	x		x	★	x	x	x		26
Forestry Mining Building Farming	Dump trucks	★	★			★		★	x	x	26
	Large hauling trucks	★	x			★	x	★	x	x	26
	Tractors	x	★			★	x	★	x	★	26
Boats and Marine	Motor boats	x	★		x	★	x	x	x	★	21
	Sail boats House boats	x			x	★	x	x	x	★	21
Custom and Specialty Cars	Antique cars Show Cars	x	x	x	x	★	x	x	x	★	27
	Street Rods, Custom Cars, Lowrider	★	★	x		x		★	x	x	27
Car audio	Large car stereo systems	x		★	x	x	x	★	x		28
Racing vehicles	Racing cars With regulated charging sys.	★	x	x		x	x	★	★	★	28
Off road & 4 X 4	Trucks, Jeeps, cars sport utility vehicles	x	★		x	★	x	x	x	x	28
Military	AGE Aerospace ground support equipment	★	x			★	x	★	x	★	29
	Trucks, vans & general purpose vehicles	x			x	★	x	★	x	x	29

10. INAPPROPRIATE USES OF OPTIMA S.L.I. BATTERIES

The OPTIMA S.L.I. battery is not recommended for the following applications:

CYCLE SERVICE APPLICATIONS (DEEP CYCLE)

OPTIMA S.L.I batteries are not suitable for electric power applications that must withstand repeated deep discharges such as in wheelchairs, golf carts or forklifts. (You must use OPTIMA's deep cycle battery for this type of application.) Cycle service (traction) batteries require thick plates because they must deliver lower amperage for a long period of time. S.L.I. batteries have thin plates that cover a greater surface area, making them able to deliver high amperage for short periods. For example:

S.L.I.

An S.L.I. battery must deliver 250 to 350 amps for a few seconds to start a vehicle. It is typically used to power vehicle accessories such as lights and windshield wipers for a few minutes while driving slowly or during short trips. This load is usually about 10 to 25 amperes. The average depth of discharge for an S.L.I. battery is approximately 2% to 3% of its capacity.

Deep cycle

In a deep cycle application such as a trolling motor, the battery may need to deliver 15 amps for a couple of hours. The average depth of discharge is typically 60% to 70% or more of the battery capacity.

When an S.L.I. battery is used in deep cycle applications, its life will be greatly reduced. Deep cycling an S.L.I. battery will hasten decomposition of the active material on its plates While the **OPTIMA** is not designed for these deep discharges, it will outperform conventional S.L.I. batteries under deep discharge conditions.

For RV applications, battery requirements depend on individual conditions. The **OPTIMA** S.L.I. performs well during moderate use requiring frequent, shallow discharges. This is sometimes referred to as "wet-camping"; an R.V. owner parks at a facility where the vehicle can be plugged into an electrical power source. Most of the accessories are then powered by the external source.

Applications requiring repeated deep discharges are best handled by batteries designed for this use, such as the OPTIMA Deep Cycle battery. Regardless of the application, the total capacity of the replacement battery(s) should meet or exceed the average load requirements.

11. QUALITY CONTROL IN ACTION - THE FINISHING LINE

OPTIMA Batteries, Inc. prides itself on the quality of its batteries. Every unit leaving the production facility has undergone many strenuous tests to ensure that it is the highest quality battery that can be produced.

Every battery manufactured at **OPTIMA** is subjected to a computer monitored, fully automated, five-stage quality test. This assures that our customers receive the highest quality, battery on the market. No other S.L.I. battery manufactured in the United States has such high quality standards.

As each battery moves through the line, it is tracked by a computerized bar code system that records and stores the date, lot number, work shift and battery number. This information is then combined with the test results as described below.

Any battery that fails to meet specifications in the following system is "kicked out" and sent to the Test Lab for analysis.

OPTIMA QUALITY TESTING PROCEDURES:

1. **O.C.V. (Open Current Voltage).** This test measures the existing voltage in the battery and detects those which do not receive a proper formation (formation is the initial charge applied to a battery during the manufacturing process).

2. **LOAD TEST.** A 1200-1400 ampere load test is applied to each battery to check strap (intercell connector) integrity. This detects weaknesses in the strap such as cracks, shorts and/or poor strap to cell bonding.

3. **VOLTAGE UNDER LOAD.** During the load test, the voltage is measured and recorded. Voltage analysis testing and statistical modeling has enabled **OPTIMA** to accurately predict battery life expectancy.

4. **INTERNAL RESISTANCE.** Low resistance translates to greater cranking power for engine starting and quicker charging. Resistance readings also detect various manufacturing defects.

5. **WEIGHT.** During the last stage, each battery is automatically weighed to verify the correct acid to lead relationship.

Quality control is evident throughout the entire **OPTIMA** manufacturing process. In addition to the five step quality process described above, every stage of production is monitored for quality of material and accuracy. Also, due to the sealed design of the **OPTIMA**, every battery made is checked for case integrity. After the top cover is sealed, each battery is pressurized with air and submerged in water. If the battery were to have any leaks they become immediately evident.

12. RATING OF S.L.I. BATTERIES

Reserve Capacity and **Cold Cranking Amps** are the industry standard measurements for S.L.I. batteries.

Reserve Capacity (R.C.) - Time in Minutes: This test measures, in minutes, how long a battery can maintain a minimum of 10.5 volts (at 80°F) while being discharged at 25 amps. The R.C. rating is especially important for emergency situations such as in the case of alternator failure.

Cold Cranking Amperes (C.C.A.) - Power: The primary function of an S.L.I. battery is to start the engine. Since starting is increasingly difficult as the temperature drops, the best measurement is the amount of power a battery can deliver in cold temperatures. This unit of measurement is called C.C.A. (Cold Cranking Amps).

C.C.A. is measured in accordance with the S.A.E. (Society of Automotive Engineers) standards. It measures how much current can be delivered for 30 seconds at 0°F (-18°C) while staying above 7.2 volts (1.2 volts per cell).

Cranking Amperes (C.A.): C.A., sometimes referred to as Marine Cranking Amps (MCA), measures how much current can be delivered for 30 seconds at 32°F (0°C) while staying above 7.2 volts.

Formerly, the measure of a battery's electrical storage was **Ampere-hour (amp-hr).** It was determined by multiplying the current in amps by the time of discharge. Example: A battery that delivers 5 amperes for 20 hours (5 amperes times 20 hours), has a 100 amp-hr capacity. The amp-hr rating has been replaced by C.C.A. and Reserve Capacity (R.C.).

The following table compares the **OPTIMA**'s Reserve Capacity and Cold Cranking Amperes to traditional B.C.I. (Battery Council International) Group 34 batteries. However, the unique characteristics of the **OPTIMA** allow it to be used in applications beyond those requiring a B.C.I. Group 34.

BATTERY TYPE	C.C.A. (Cold Cranking Amperes)	RESERVE CAPACITY
OPTIMA	800 C.C.A. (1000 MCA)	120 minutes
Standard Group 34 (from B.C.I. manual)	375 - 650 C.C.A.	100 - 110 minutes

OPTIMA versus the conventional Group 34 battery

13. BASIC BATTERY TECHNOLOGY AND TERMINOLOGY

On the surface, battery technology appears simple. However, the electrochemical reactions within a battery are quite complicated.

A. WHAT IS A BATTERY?

A battery is an energy storage device that converts chemical energy into electrical energy. The electrochemical reactions involve the transfer of electrons from one material to another through an external electrical circuit and the motion of ions in an internal medium (the electrolyte).

While the term "**battery**" is often used, the basic electrochemical unit is the "**cell.**" A battery contains one or more cells, connected in a series, parallel, or both, depending on the desired output voltage and/or capacity.

A cell consists of three major components:

- **Electrodes**: more commonly called plates. Each cell requires at least one positive and one negative electrode. Cells may contain multiple electrodes.
- **Electrolyte**: typically a liquid that provides the medium for the transfer of charge, as ions, between electrodes inside the cell.
- **Separator**: a divider between the positive and negative plates which allows the current to flow through it. The separator prevents the positive and negative plates from contacting each other and causing an electrical short. Separators are typically made of glass material, plastic, or a void (space between plates).

When the battery is discharged, the negative plate reacts, transferring electrons to the external circuit (head lights, starter motor, etc.). To complete the circuit, the positive plate reacts, accepting electrons from the external circuit. When the battery is being recharged, a similar process occurs in reverse order.

Gassing is the generation of hydrogen and oxygen from plates in a cell. This occurs during the battery's charging cycle. Gasses must be vented to relieve internal pressure and the lost water must be replaced regularly. If the gasses are not vented, they must be recombined as water inside the cell (as with sealed batteries such as the **OPTIMA**).

B. VARIOUS TYPES OF BATTERIES

Different materials can store energy and the names of batteries often identify their active materials such as Nickel-Cadmium, Nickel-Iron, and Lithium-Ion. Other batteries are named for the type of material found in the plates and the type of electrolyte system used; the most common is the lead-acid battery.

Batteries are classified in two ways. They are either rechargeable (also called secondary) which can be recharged repeatedly, or non-rechargeable (also called primary) which consist of single cells usually configured as flat buttons or cylinders for one time use.

Various types of electrolytes are used in batteries. The lead-acid based battery uses sulfuric acid electrolyte (H_2SO_4), while alkaline-based batteries, such as nickel-cadmium, use potassium hydroxide (KOH).

Most large lead-acid batteries are "flooded cell" batteries with large reservoirs of electrolyte covering the plates.

Some lead-acid batteries are named for their electrolyte systems such as "gel cells" and "absorbed electrolyte". Gel cells use electrolyte in a gel form instead of a free flowing liquid electrolyte. Absorbed electrolyte batteries (such as the **OPTIMA**) have the electrolyte retained by the absorbent separator material between the plates, preventing the electrolyte from flowing freely.

The trade-offs in performance, weight, volume, cycle life and cost dictate the need for many battery types. No one battery system can meet all the needs of all users.

Lead-acid Batteries

Lead-acid batteries were first manufactured in the mid 1800s when scientists found that lead immersed in a sulfuric acid solution produced an electric voltage and could be recharged. Lead-acid batteries are unique because they typically use inexpensive lead for both the negative and positive plates.

Despite extensive research into alternative technologies, lead-acid batteries are still the most prevalent today. Their popularity and widespread use are largely due to the following benefits:

- Wide temperature range for cycling and non-cycling operations
- Low cost materials
- Ready recycling of lead and other components
- Reliability
- Proven manufacturing process
- High power density

In a lead-acid battery, the active material reacts with the electrolyte to produce the chemical reaction that creates electrical energy. The active material in the positive plate is lead dioxide (PbO_2) and the negative is pure spongy lead (Pb). The electrolyte is sulfuric acid (H_2SO_4). When we talk about the active material in lead-acid batteries, we mean the lead dioxide and spongy lead.

Lead dioxide and spongy lead are made into paste and applied to lead grids. This grid is not active material but acts as the electrical conductor or path to cell terminals. In most designs, the grid provides mechanical strength to support the active material in the cell.

C. WHAT HAPPENS INSIDE A LEAD-ACID BATTERY?

In most cell designs, the plates are immersed in a free liquid acid. In sealed cells, the acid is absorbed completely in the plates and separator structure (absorbed acid technology) or converted to a gel by an additive (gel-cell technology).

All lead-acid batteries have the same general overall chemical reaction for charge and discharge.

$$PbO_2 + Pb + 2H_2SO_4 \underset{\leftarrow\ \leftarrow\ \leftarrow}{\overset{\rightarrow\ \rightarrow\ \rightarrow}{=}} 2PbSO_4 + 2H_2O$$

Discharge cycle

Charge cycle

On discharge, the lead dioxide (PbO_2) of the positive electrode and the spongy lead (Pb) of the negative electrode are both converted to lead sulfate ($PbSO_4$). On charge, the lead sulfate in the positive electrode is converted to lead dioxide (PbO_2), which then converts to oxygen on overcharge. The lead sulfate sponge lead in the negative electrode is converted to spongy lead, which then converts to hydrogen on overcharge. The electrolyte, sulfuric acid (H_2SO_4), is an active component in the reactions at both plates.

If a flooded type battery is overcharged, oxygen gas is generated at the positive electrode. Gas bubbles rise to the surface and escape from the cell. At the same time, hydrogen gas is generated at the negative electrode and also escapes from the cell. The overall result is water loss which must be replaced periodically.

In the **OPTIMA** battery, during charge, oxygen combines with the freshly formed lead at the negative electrode in the presence of H_2SO_4, to form lead sulfate and water. This oxygen recombination prevents hydrogen from forming at the negative electrode. **Therefore, there is no water loss during charging.**

Electrolyte:

The electrolyte in the lead-acid cell is a solution of sulfuric acid (H_2SO_4) and water. It plays an active role in the chemical reactions that convert energy within the cell. Changing the density (specific gravity) of the acid solution affects performance factors such as capacity, maintenance, and battery life. Table 1 (below) shows the relationship between acid specific gravity and battery capability.

Acid specific gravity	Battery capacity	Maintenance of battery	Battery life (longevity)
Higher	Increase	Increase	Decrease
Lower	Decrease	Decrease	Increase

Table 1
The effect of specific gravity on battery performance

A fully charged conventional battery at 80°F (26.7°C) has electrolyte with a specific gravity of 1.265.

Because the **OPTIMA** is completely sealed, it does not lose water during the charging cycle as does a conventional battery. Within the **OPTIMA,** a measured amount of electrolyte is absorbed in the separator material between the plates. It is the precise amount to generate chemical reactions that optimize battery capacity and life.

Plate Materials

In a conventional battery, the lead grid must be strengthened with alloys such as antimony or calcium.

While alloys add mechanical structure, they increase the rate of corrosion within a battery. More alloys are added to counteract this corrosion. This decreases the battery's performance. Antimony improves castability, mechanical properties, and paste adherence, but reduces the grid's electrical conductivity and increases self-discharge. Antimony can be completely eliminated from the battery by hardening the lead with a small amount of calcium.

Some non-antimony alloys are an improvement, offering a longer shelf life and good cold cranking characteristics. Still, while tin-calcium grids reduce the tendency of lead calcium positive plates to resist recharge when deeply discharged, they do not completely eliminate corrosion.

OPTIMA batteries use high purity lead for a long life, high cranking capability, low self discharge and maintenance free operation. The physical design of the plates and the SPIRALCELL configuration strengthen the **OPTIMA** without alloys.

D. TYPES OF LEAD-ACID BATTERIES

Lead-acid technology can be varied to meet different requirements. Batteries are classified according to their applications and their designs differ in three major ways: plate structure and design, composition of the active material, and the specific gravity of the electrolyte. Applications for lead-acid batteries fall into three broad categories:

- **Standby (Float) Service**
- **Cycle Service**
- **Starting/Lighting/Ignition (S.L.I.)**

♦ Standby (Float) Service

Standby battery systems provide an uninterrupted supply of power to an electrical load component. They discharge immediately when primary (AC) power is interrupted. The electrolyte and electrode grid material are designed for long term service life. Typical standby applications include emergency lighting and computer backup.

♦ Cycle Service

Batteries in cycle service are used as primary energy sources for applications such as:

- Backup power for devices in photovoltaic systems.
- Electric vehicles such as fork lifts and golf carts.
- Recreation vehicles.
- Trolling motors.
- Wheelchairs.

In each of these applications, the battery is the primary energy source. It must deliver sufficient power to the vehicle or device before requiring recharge. The number and depth of cycles limits the life of these batteries; hence, their life is expressed in cycles rather than years. These batteries are subject to a constant, relatively low rate of discharge over a long period. Cycle service batteries typically have very thick plates with heavy duty grids to provide as many cycles as possible.

♦ Starting/Lighting/Ignition (S.L.I.)

S.L.I. batteries are primarily used for starting internal combustion engines. Their duty cycle is characterized by a short discharge at a very high current, immediately followed by recharging. During a normal start, the battery loses very little capacity.

S.L.I. batteries also operate lights, radios, and other equipment for short periods without running the engine or when the engine is operating at low speeds (idling). S.L.I. batteries can keep the engine running for a short time if the alternator fails.

To start engines, the battery must produce high power for short durations. This capacity is designed into the S.L.I. battery via increased plate surface area and heavy-duty intercell connectors.

14. GENERAL CHARGING PROCEDURES

When a lead-acid battery is charged by connection to an external power source, the electrons flow in the opposite direction of that used in discharge. For this to happen, the outside power source must generate a higher voltage than the battery.

An example of recharging the battery with a vehicle alternator is shown graphically in Figure 8. In this example, the voltage limit is set at 14.4 volts and the alternator supplies 25 amps. The battery initially accepts the full 25 amps. Voltage increases proportionally to 13.9 volts as the battery becomes recharged. When the battery is fully charged, the current is reduced to less than one amp. The excess energy from the charge is converted into gas in ALL lead-acid batteries. In conventional flooded batteries, the gas escapes, allowing the battery to dry out. In a recombinant battery such as the **OPTIMA**, the gas recombines with the electrolyte to form water.

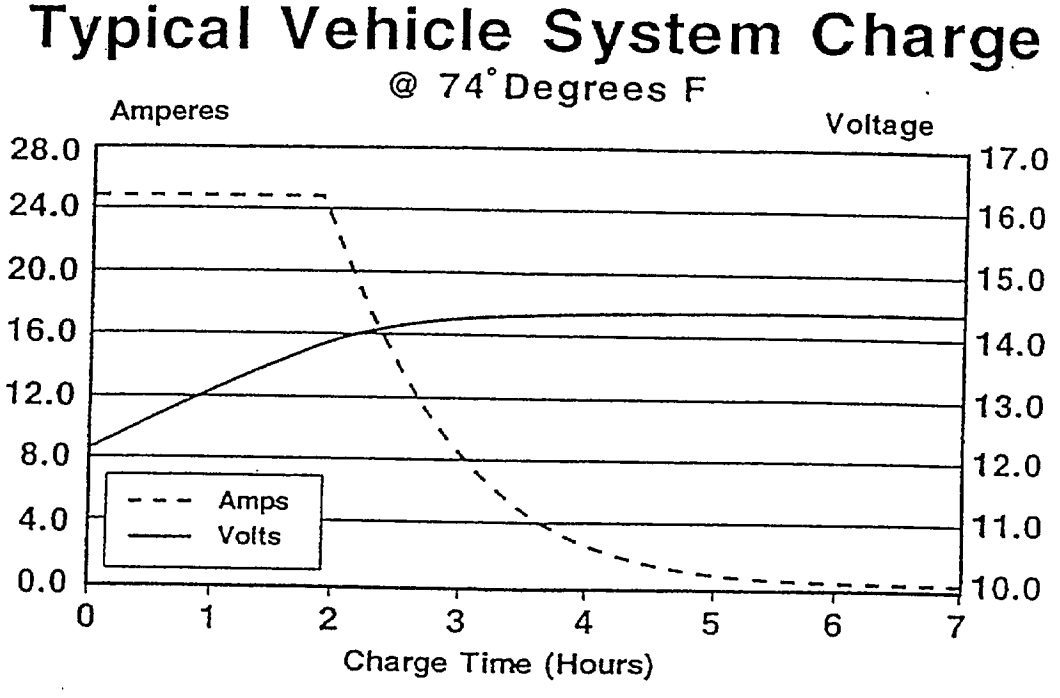

FIGURE 8

The charge curves in Figure 8 illustrate the relationship between voltage and current for the **OPTIMA** battery. In a properly functioning charging system, the battery will begin to limit charge current as it becomes fully charged. Voltage increases proportionally to the percent of the battery charge.

General guidelines for charging lead-acid batteries depend on the type of charging system being used.

A. Charging with a Vehicle Alternator: An S.L.I. battery is usually charged by the vehicle's alternator. An alternator setting of approximately 13.2 to 14.4 volts for automobiles in the United States will usually assure proper battery performance. Exceeding this voltage for long periods can overcharge the battery. When this happens the battery will gas excessively, lose electrolyte, and dry out the plates, deteriorating the active material and shortening life. Vehicles are generally equipped with voltage-regulated charging systems which allows the battery to reduce the amount of current it accepts as it becomes fully charged. Most vehicles also have temperature compensating regulators which automatically decrease the voltage setting as temperature increases. Thus, overcharging an S.L.I. battery in a vehicle with a properly working charging system is rare.

The way a vehicle is operated can also impact the effectiveness of the charging system. The following paragraphs describe typical charging conditions for passenger vehicles and commercial vehicles such as taxis.

Passenger Vehicles

High electrical power consumption and frequent short trips require a higher alternator voltage to recharge the battery more quickly. Long trips require a lower voltage. Owners generally use their cars for both long and short trips, requiring an alternator setting of about 14.4 volts.

Commercial Vehicles

Taxis and similar vehicles driven short distances are usually equipped with a high output alternator which produces a charging voltage between 14.4 and 14.8 volts. A higher output alternator is required to fully charge the battery during short trips.

B. Charging with an External Charger

Batteries used in non-automotive applications or a battery that has been inadvertently discharged and can no longer start the car must be recharged. A charger with voltage regulation is necessary to charge an **OPTIMA** battery. The regulated charging system will detect the degree of charge needed and adjust its charge rates accordingly (see Figure 8).

The **OPTIMA** battery can be charged with a bench charger. We suggest a voltage setting range of 13.8 to 14.8 volts and a suggested current output of 10 amperes. At 10 amps, a completely discharged battery will be fully recharged in 5.5 to 6 hours.

C. **Recommended charging limits for OPTIMA batteries:**

- Normal recharge: Voltage - 13.8 volts to 14.8 volts
  Maximum available current - 10 amps

- Float applications: Voltage - 13.2 volts to 13.8 volts
  Maximum available current - 1.0 amp
  Maximum recharge time - Indefinite at lower charge voltages.

  (The **OPTIMA** battery is not designed or recommended for float applications although many customers have successful used it for this purpose.)

- Boost recharge: Voltage - 15.6 volts maximum
  Maximum available current - 60 amps
  Maximum recharge time - 1 hour or when the battery starts to get hot.

D. Problems Caused by Incorrect Charging Procedures

Overcharging is a common problem caused by continuing to charge the battery after it has been fully charged. The following conditions will occur when a battery has been overcharged:

Oxy-hydrogen Gas: In a conventional battery, overcharging causes hydrogen and oxygen to build up and escape faster than normal. Since these gasses can form explosive oxygen and hydrogen, conventional batteries must always be charged in a well-ventilated area.

With proper charging recombination batteries are not as susceptible to loss of water. Their ability to recombine gases into water reduces gas build up. If overcharging occurs (usually from an unregulated charger or failed vehicle charging system), more gas may be generated than can be recombined. The pressure from this excess gas will eventually cause the safety valves to release, allowing gas to escape; the valves will then reseal. A hissing or whistling noise signals that pressure is being released. If this happens, immediately disconnect the battery from the charging system. If enough electrolyte is lost, battery performance will be reduced, similar to conventional S.L.I. batteries. Generally this happens to the **OPTIMA** battery only when it has been abusively overcharged. However, unlike conventional batteries, it is not possible to replace the water in the **OPTIMA** battery and the abusive overcharge can damage it permanently. Any battery that feels very warm or if the case is visibly damaged or distored should be removed from charging immediately.

When an **OPTIMA** battery overcharge is suspected, weigh the battery (see the warranty procedures, Appendix A).

Electrode Damage: When gassing occurs within a battery, water is evaporated from the electrolyte, reducing its volume and increasing its density (specific gravity). If enough water is lost, the active material on the plates is exposed to air. This will accelerate sulfation of the active material, leading to battery failure. Distilled water is usually added to a conventional battery to make up for loss during overcharge. The **OPTIMA** battery does not lose water unless it has been abusively overcharged.

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Appendix A GLOSSARY

- A -

Active material - Lead dioxide in the positive plates and metallic sponge lead in the negative plates which reacts with sulfuric acid during charging and discharging a lead-acid battery. $PbO_2 + Pb + 2H_2SO_4 = 2PbSO_4 + 2H_2O$

Ampere (amp) - The measure of electron flow or current through a circuit.

Ampere-hour - The measure of a battery's electrical storage capacity. It is obtained by multiplying the current in amperes by the discharge time in hours.

Antimony - A element alloyed with lead to achieve greater mechanical strength. Antimony improves cycle life but increases water consumption and corrosion.

- B -

B.C.I. - Battery Council International

Boost-charging - A short-duration charge applied to a battery that is nearly fully charged.

- C -

C.A. - Cranking Amps. Sometimes referred to as Marine Cranking Amps at 32°F. The discharge load in amperes that a new, fully charged battery at 32°F (0°C) can continuously deliver for 30 seconds while maintaining a terminal voltage equal to or higher than 1.2 volts per cell of a total of 7.2 volts (for a 12 volt battery).

Capacity - A fully charged battery's ability to deliver a specified quantity of electricity at a given rate over a definite period of time. A battery's capacity depends on many factors: the amount of active material on the grid, density of the active material, adhesion of active material to the grid, quantity of plates, the amount of surface area of the plates/grids, distance between the positive and negative plates, design of separators, specific gravity and quantity of available electrolyte, grid/plate purity, temperature, internal and external resistance.

C.C.A. - Cold Cranking Amps. Starting current available for 30 seconds at 0°F (-18°C) with a final voltage of at least 7.2 volts for a 12 volt battery.

Corrosion - The gradual oxidization of lead to lead oxide.

Current - The rate of electrical flow. Measured in amperes, it is comparable to the way a stream of water flows.

Cycle - The discharge and subsequent charge of a secondary cell that restores it to its original condition.

Cycle life - The number of cycles available from a secondary cell before it fails to meet specified performance criteria.

- D -

Deep cycle - Withdrawal of at least 80% of the rated capacity of the battery. (Also known as "deep discharge").

DIN - German standard. (Deutsche Industrienorm.)

Discharge - The conversion of a cell's chemical energy into electrical energy.

- E -

Electrode - The site, area or location where electrochemical processes take place. (Also called "plate".)

Electrolyte - The medium providing the ion (electron) transport mechanism between the positive and negative plates of a cell. (Sulfuric acid diluted with water in a lead-acid battery.)

Electron - A negatively-charged particle within an atom.

- F -

Flooded cell - A cell containing excess liquid electrolyte.

Formation - Electrochemical conversion of electrode materials to the active state.

- G -

Gassing - The evolution of gas from the plates in a cell. When it is charged, a battery generates hydrogen at the negative plate and oxygen at the positive plate. These gases result from the decomposition of water when a battery is charged at a higher rate than it can accept.

Gel cell - A cell in which the electrolyte has been immobilized by converting it into a gel-like mixture.

Grid - A framework for a plate or electrode which supports and/or retains the active materials and acts as a current transporter.

- I -

Internal resistance - The opposition or resistance to the flow of direct current within a cell. Its value may vary with the current, state-of-charge, battery age, and air temperature.

Ion - An electrically-charged atom or group of atoms that transports electricity through the electrolyte.

- L -

Lead sulfate - A lead salt formed by the action of sulfuric acid on lead oxide during paste mixing and formation. It is also formed electrochemically when a battery is discharged.

- M -

Maintenance-free - A term applied to batteries that never need maintenance.

- O -

OHM - A unit for measuring electrical resistance.

Over-charge - The forcing of current through a cell after all the active material has been converted to the charged state. In other words, continued charging after a battery has been totally charged.

Oxy-hydrogen gas - Oxy-hydrogen gas is a mixture of hydrogen and oxygen at a 1:2 ratio. Hydrogen and oxygen are formed by the negative and positive electrodes respectively.

- P -

Parallel connection - Two or more batteries connected together while the voltage remains the same. Batteries in parallel are connected by hooking like posts together, for example: positive to positive and negative to negative.

- R -

Rated Capacity - The number of ampere-hours a cell can deliver under specified conditions (rate of discharge, end voltage, temperature.)

Recombination - State where the gases formed within the battery cell recombine during normal operation to form water.

- S -

S.A.E. - Society of Automotive Engineers. American standard corresponding to the German DIN standard.

Safety valve - Re-closable valve activated if the gas pressure in the battery exceeds a safe level.

Self discharge - When a battery delivers current while in an open circuit (nothing connected). Typically caused by contaminants on the electrodes (plates) discharging the battery's active materials.

Series connection - A circuit in which the positive pole of one battery is connected to the negative pole of an adjacent battery to increase voltage while maintaining the same capacity.

Specific gravity - The density of a liquid compared with the density of water. The specific gravity of the electrolyte is the weight of the electrolyte compared to the weight of an equal volume of pure water.

Sulfation - The formation of lead sulfate on a plate whose physical properties make it extremely difficult, if not impossible, to reconvert it to active material.

- T -

Trickle charge - A continuous, low rate charge sufficient to compensate for self discharge loss.

- V -

Vent - A mechanism that allows gases to escape from a battery.

Volt - The measure of electrical potential.

CHEMICAL GLOSSARY

Pb	=	Lead	O_2	=	Oxygen
PbO_2	=	Lead Dioxide	H_2O	=	Water
H_2SO_4	=	Sulfuric Acid	(-)	=	Electrons
H_2	=	Hydrogen	$PbSO_4$	=	Lead Sulfate
Pb-Ca	=	Lead-calcium	Pb-Sb	=	Lead-Antimony

OPTIMA®
BATTERIES

THE ULTIMATE STARTER

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