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Selecting and Specifying Lithium Batteries for Advanced Fuzing Systems

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Agenda

- General Selection Criteria
 - Specifying Requirements
 - Environmental Considerations
- Electrochemistry
 - Suitability
 - Power Versus Energy
- Battery Configurations
 - Configurations
 - Benefits & Limitations
- Common Battery Types
 - Thermal Batteries
 - Ambient Temperature Batteries
 - Secondary/Rechargeable Batteries
- Summary

General Selection Criteria

- Specifying Requirements
 - Voltage
 - Current
 - Activation Time
 - Operational Life
 - Capacity
 - Temperature Range
 - Size
 - Weight
 - Polarity



F-15 drops JDAM-equipped bombs in Afghanistan.

(U.S. Air Force photo by Staff Sgt. Michael B. Keller)



LiSi/FeS₂ Thermal Battery
(Device No. G3190B2)

General Selection Criteria

- Environmental Considerations
 - Launch Acceleration
 - Shock
 - Vibration
 - Spin
 - Temperature Range

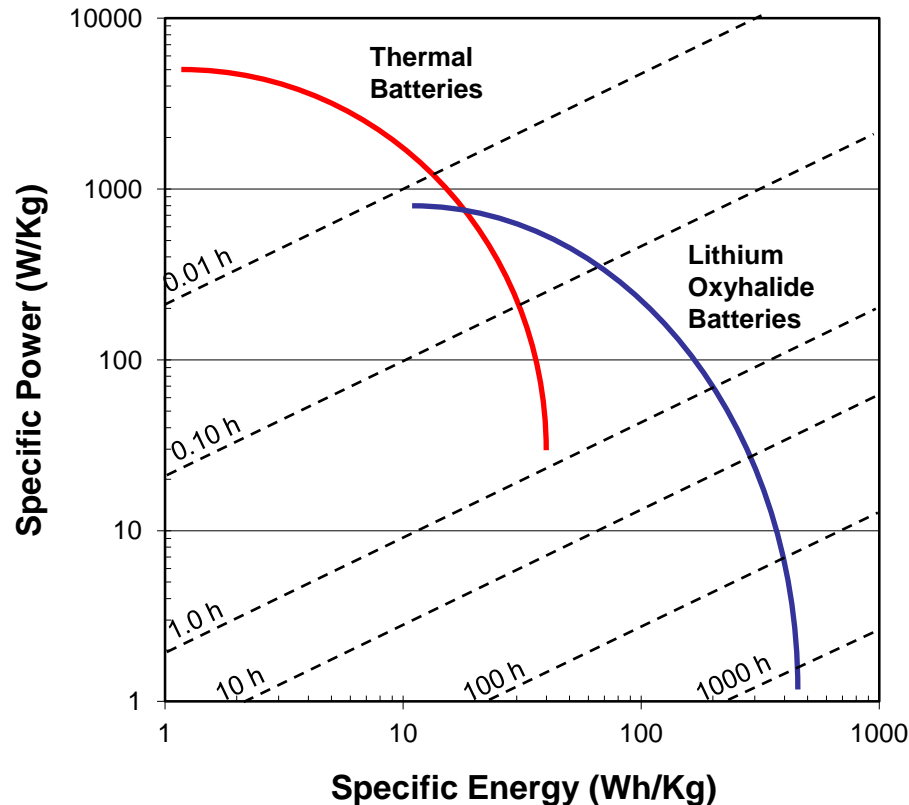


LiSi/FeS₂ Thermal Battery
(Device No. G3200A1)



*Artillery Fuzing
155 mm Projectile*

Electrochemistry



- **Certain battery systems are ideally suited to military applications.**
 - **Cold Operating Temp.**
 - **Long Shelf Life.**
- **Lithium Oxyhalide Batteries are best suited to applications that require extended life.**
 - **Lithium/Thionyl Chloride**
 - **Lithium/Sulfuryl Chloride**
 - **Lithium/Sulfur Dioxide**
- **Thermal Batteries are best suited to applications that require high power.**
 - **Lithium Silicon/Iron Disulfide**
 - **Lithium Silicon/Cobalt Disulfide**

Ragone Plot Comparing Thermal Batteries to Lithium Oxyhalide Batteries.

(Approximate data - plot for illustration purposes only)

Battery Configurations

Active Primary

- Ready for discharge

Reserve Primary

- Can be activated on demand or by the conditions of deployment using one or more of the following methods:

| Activation Method | Initiated By |
|-------------------|--------------------------------------|
| Electric primer | Electrical pulse |
| Percussion primer | Firing pin or lanyard |
| Stab initiated | Squib or thumb screw |
| G-activation | Launch acceleration or target impact |

- Batteries can be activated within milliseconds to seconds.

Secondary

- Rechargeable batteries with, and without, Battery Management Systems (BMS)

Benefits & Limitations

| Battery Type | Pros | Cons |
|--|--|--|
| Active Primary Lithium | <ul style="list-style-type: none"> • Immediate power & energy. • Operating temp. range. | <ul style="list-style-type: none"> • Environmental robustness. • Limited shelf life. |
| Reserve Primary Thermal Batteries Liquid Reserve | <ul style="list-style-type: none"> • 20 year shelf life. • Operating temp. range. • Environmental robustness. | <ul style="list-style-type: none"> • Activation rise time. (ms to sec rise times) |
| Secondary Lithium Ion | <ul style="list-style-type: none"> • Immediate power & energy. • High cycle life. | <ul style="list-style-type: none"> • Environmental robustness. • Operating temp. range. • Limited shelf life. |

Preferred technologies for Advanced Fuzing & Weapon Systems

Common Battery Types



AC130 Spectre - 105 mm Projectile

- Thermal Batteries
- Ambient Temperature Batteries
- Secondary/Rechargeable Batteries



LiSi/FeS₂ Thermal Battery
(Device No. G3208A1)

Thermal Batteries

LiSi/FeS₂

LiSi/CoS₂

Lithium Thermal Batteries

- Self-contained, hermetic, electrochemical power sources.
- Capable of being stored in excess of 20 years.
- Achieve dormancy by utilizing electrolytes which require elevated temperature to become ionically conductive.
- Provide high current density for high power applications.
- Highly reliable.



*Guided
Mortar*

**Key Design
Drivers – Mortar
Applications**



LiSi/FeS₂ Thermal Battery
(Device No. G3202A1)

Performance

Voltage (V): 11 to 24
Power (W): 11
Rated Capacity (mAh): 41
Activation Time (ms): < 500

Initiation Approach: Electric Igniter

Active Life (s): > 65.5
Operating Temp. Range (°F): -25° to +145°
Storage Temp. Range (°F): -50° to +160°

Physical Characteristics

Chemistry: LiSi/FeS₂
Size: 1.000" Dia. by 1.436" Length
Weight (g): 50

Environmental

**MIL-STD-331 Environments
MIL-STD-810 Environments**

The G3202A1 Lithium Silicon/Iron Disulfide Thermal Battery is designed to meet the extreme temperature and performance requirements of mortar applications.



*High-speed
Anti-Radiation
Missile
(HARM)*



LiSi/FeS₂ FTS Thermal Battery
(Device No. G3206A1)

**Key Design
Drivers – FTS
Applications**

Performance

- Voltage (V): 24 to 35
- Rated Capacity (mAh): 730
- Activation Time (ms): < 1000
- Initiation Approach: Electric Igniter
- Operating Temp. Range (°F): -58° to +178°
- Storage Temp. Range (°F): -65° to +221°

Physical Characteristics

- Chemistry: LiSi/FeS₂
- Size: 3.00" Dia. by 3.50" Length
- Weight (lbs): 3 Max
- 11 Pin Terminal Plate

3 Redundant Voltage Connections
Robust Bracket Design

Environmental

MIL-STD-331 Environments
NAVSEA 9310 Lithium Battery Safety
RCC319-10 Battery Requirements

The G3206A1 LiSi/FeS₂ Thermal Battery provides an active life greater than 35 minutes across the full temperature range (-58°F to +178°F).

Ambient Temperature Batteries

Li/SO₂

Li/SOCl₂

Li/SO₂Cl₂

Active Primary Batteries

- Self-contained, hermetic, electrochemical power sources.
- Capable of being stored in excess of 5 years.
- Highly reliable.
- Minimal thermal management issues.
- Provide high energy density for extended mission times.
- Cost effective in high volume production.

Ambient Temperature Batteries



Reserve Primary Batteries

- Self-contained, hermetic, electrochemical power sources.
- Capable of being stored in excess of 20 years.
- Achieve dormancy by physically separating the active components, i.e., the lithium foil anode and the electrolyte (catholyte).
- Provide high energy density for extended mission times.
- Highly reliable.
- Minimal thermal management issues.
- Cost effective in production.



G3168B1 Cell
Φ.220 x .215



G3201A1 Cell
Φ.275 x .325



G3198B1 Cell
Φ.319 x .359



G3165D1 Cell
Φ.350 x .435



G3207A1 Cell
Φ.450 x .395"



G2666B1
Φ.510 x .840



G3147A1 Cell
Φ.500 x .840

EnerSys offers a wide range of state-of-the-art Reserve Lithium/Oxyhalide Cells for medium and large caliber projectile fuzing.



*M767 Artillery Fuze,
155 mm & 105 mm
Projectiles*

**Key Design
Drivers – Fuzing
Applications**



**Artillery Fuze Battery
(Device No. G3147A1)**

Performance

Voltage (V): 2.5 to 3.6

Current (mA): 0.5

Rated Capacity (mAh): 280

Activation Time (s): < 800

Initiation Approach: Stab Initiation

Operating Temp. Range (F): -25° to +160°

Storage Temp. Range (F): -60° to +160°

Physical Characteristics

Chemistry: Li/SOCl₂

Size: 0.50" Diameter by 0.84" Length

Weight (g): 6.2

Environmental

MIL-STD-331 Environments

Acceleration (G): 30,000 max.

Spin (RPM): 30,000 max.

The G3147A1 Li/SOCl₂ Artillery Fuze Cell offers high energy in a robust design capable of withstanding the extreme conditions of ballistic launch.



*Extended Range
Guided Munition
(ERGM)
5" Projectile*

**Key Design
Drivers – Projectile
Applications**



**Data Hold Battery
(Device No. G3177A1)**

Performance

Voltage (V): 5.0 to 7.5

Current (mA): 36

Rated Capacity (mAh): 350

Activation Time (s): 2.0

Initiation Approach: Dual Electric Primers

Operating Temp. Range (F): -45° to +110°

Storage Temp. Range (F): -65° to +150°

Physical Characteristics

Chemistry: Li/SOCl₂

Size: 1.516" Width by 2.40" Length

Weight (g): 80

Environmental

MIL-STD-331 Environments

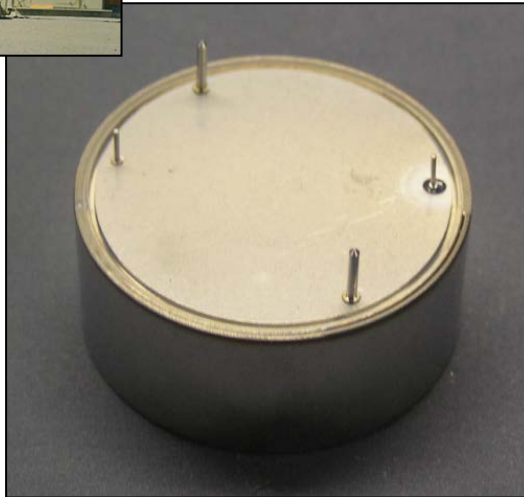
Acceleration (G): 12,600 max.

The G3177A1 Li/SOCl₂ Data Hold Battery utilizes a 2S2P configuration to support essential data hold functions in guided projectiles.



*Multi-Option Fuze
for Artillery (MOFA)
155 mm & 105 mm
Projectiles*

**Key Design
Drivers – Artillery
Applications**



**Artillery Fuze Battery
(Device No. G3158B3)**

Performance

Voltage (V): 5.6 to 12.0

Current (mA): 350

Rated Capacity (mAh): 35

Activation Time (s): ≤ 100

Initiation Approach: **Setback Initiation**

Operating Temp. Range (F): -45° to +145°

Storage Temp. Range (F): -60° to +160°

Physical Characteristics

Chemistry: Li/SOCl₂

Size: 1.50" Diameter by 0.67" Length

Weight (g): 71

Environmental

MIL-STD-331 Environments

Acceleration (G): 30,000 max.

Spin (RPM): 30,000 max.

The G3158B3 Li/SOCl₂ Artillery Fuze Battery can sit in the dormant state for in excess of 20 years and then be activated by the conditions of ballistic launch.

Secondary (Rechargeable) Batteries

- Lithium Ion & Lithium Ion Polymer Batteries
 - Robust battery designs for demanding environments.
 - High open circuit voltage.
 - No memory effect.
 - Low self-discharge.





*Joint Air-to-Surface
Standoff Missile
(JASSM)
Cruise Missile*

**Key Design
Drivers – FTS
Applications –
Li Ion**



**Li-Ion FTS Battery
(Device No. G3203B1)**

Performance

Voltage (V): 24 to 33.6
Current (A): 5 Discharge
1.0 Charge

Rated Capacity (Ah): 2.8 at 77^oF (25 ^oC)

Internal Heater: Yes

Operating Temp. Range (F):
Charge: 32^o to +113^o
Discharge: -4^o to +160^o

Storage Temp. Range (F): <95^o

Physical Characteristics

Chemistry: Li-Ion
Size: 6.26" x 3.56" x 1.34"
Weight (lb.): 2.05

Environmental

**RCC319-10 FTS Battery Requirements
NAVSEA 9310 Lithium Battery Safety**

*The G3203B1 Flight Termination Systems (FTS) Battery uses an
8S1P configuration of standard lithium-ion 18650 cells*



*Multiple-band
Avionics Radio
Suite (MARS)*

**Key Design
Drivers –
Communications
Applications**



Li-Ion Communications Battery

*The Communications Battery uses an 3S1P configuration
of standard lithium-ion 18650 cells*

Performance

Voltage (V): 6.0 to 10.8
Current (A): 0.03 Discharge
0.66 Charge

Rated Capacity (Ah): 1.3 C/5 at 77°F (25°C)
Operating Temp. Range (F):
-40° to 160°

Storage Temp. Range (F):
-40° to 160°

Physical Characteristics

Chemistry: Li-Ion

Size: 2.80" x 2.20" x 0.76"
Weight (oz.): 4.5 Nom.

Environmental

Altitude: 55,000 ft.

Summary

- Several battery types/configurations are typically used in advanced fuzing and weapon systems.
- Applications engineers can help in determining:
 - Requirements to specify
 - Suitability of the various battery chemistries for a particular application.

*EnerSys provides high energy density “**lithium/oxyhalide batteries**” and high power density “**thermal batteries**” as well as secondary “**lithium ion batteries**”.*

Thank you for your attention!