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KDI Precision Products, Inc.

KDI Precision Products, Inc.
3975 McMann Road
Cincinnati, Ohio 45245-2395

Development of Battery Automation Equipment

Lithium Reserve Battery for the
M234/235 Self-Destruct Fuze

Alex Hughes

Director of Manufacturing Services

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Development of Battery Automation Equipment

Program History

- ***Phase I***
 - Initial Concept of the Process
 - Selection of Qualified Vendors
- ***Phase II***
 - Conducted Risk Review of the Piece Parts and the Equipment
 - Conducted Preliminary Design Review of the Equipment
 - Conducted Critical Design Review of the Equipment
- ***Phase III***
 - Final Proveout of the Machines
- ***Current Status***



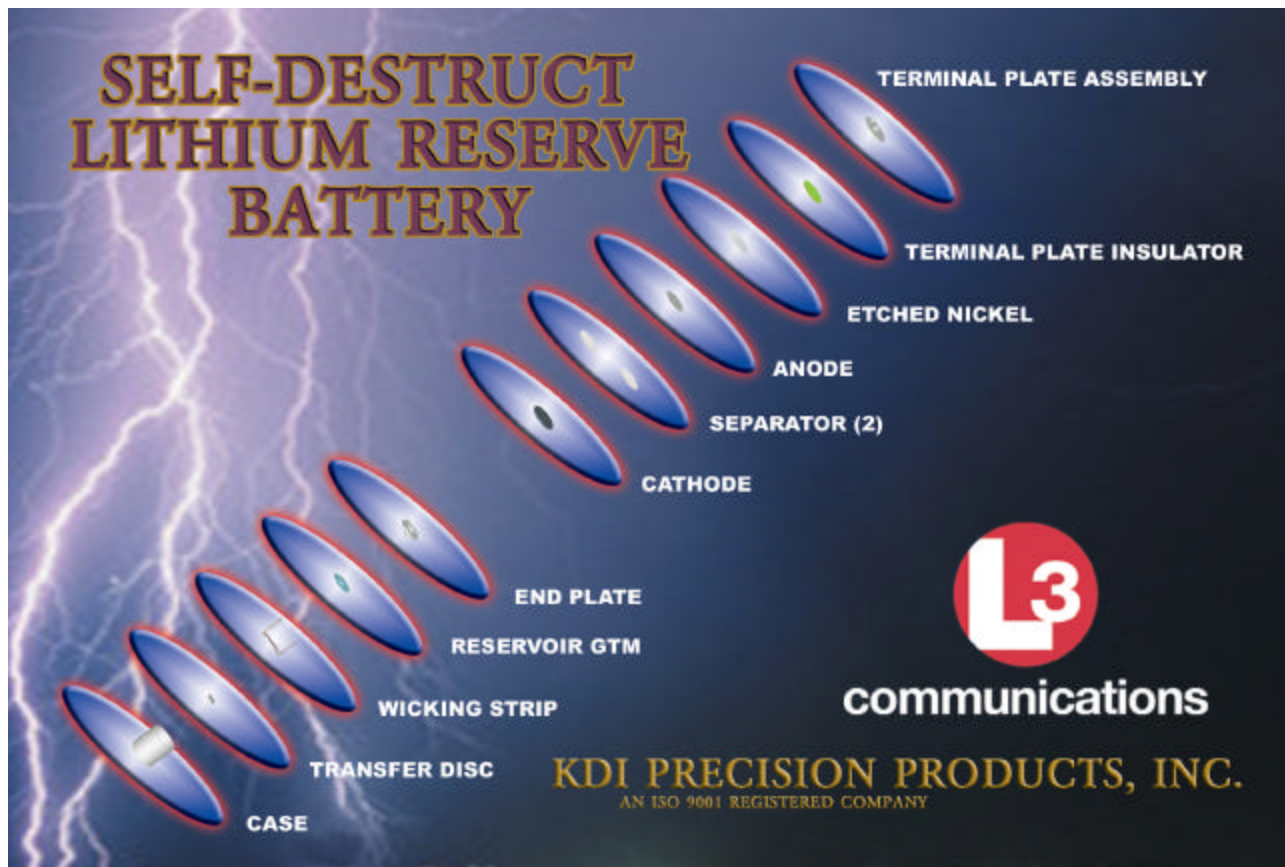
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Development of Battery Automation Equipment



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Program History

- The Automated Battery Line is part of a complete fuze assembly line contracted under the High Rate Equipment (HRE) contract, capable of delivering 190,000 fuzes/month on 1-8-5 shift basis.
- In 2000 an IPT Team was formed between KDI, ARDEC, and ARL to review the process and design requirements for the Self-Destruct Lithium Reserve Battery.



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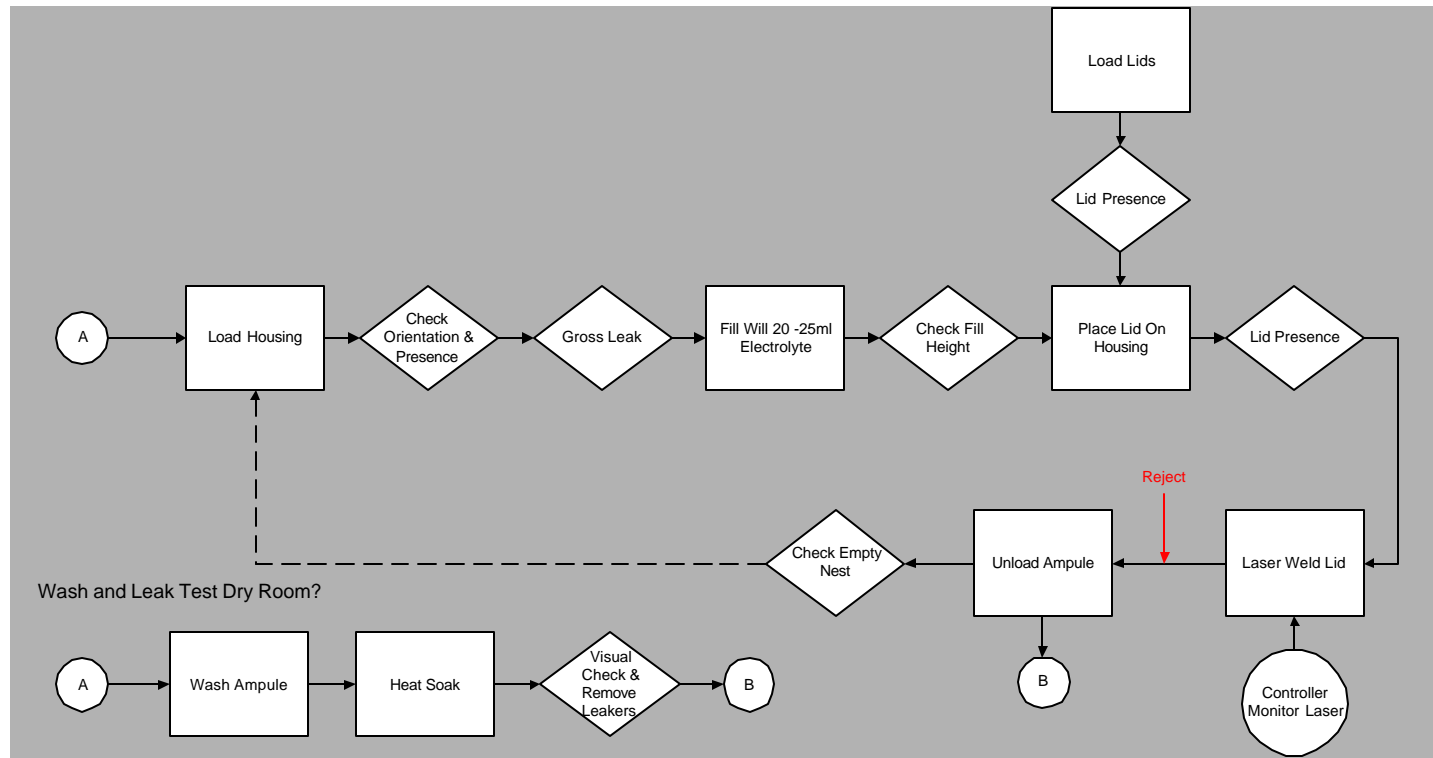
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Development of Battery Automation Equipment

Phase I

- **Initial Concept of the Machines**
 - Developed a Process Flow of the Assembly Equipment with Specific Quality Checks (SOW)



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Development of Battery Automation Equipment

Phase I

- **Selection of Qualified Vendors**
 - **Vendor Selection Rating Matrix**
 - Technical
 - Facilities/Personnel
 - Schedule
 - Financials
 - Intangibles
 - **Four Companies were reviewed**
- **RD Systems was the IPT's Final Selection**



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Phase II

- **Conduct Risk Review of Piece Parts and Equipment**
 - **Risk Assessment Metrics**
 - Probability of Occurrence
 - Severity of Impact
 - Risk Leveling of Scoring Matrix
 - **Management Board Approval**



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Risk Assessment Metrics

▪ **Probability of Occurrence**

✓ **High** (a 70% or Greater Chance That This Risk Will Occur)

✓ **Medium** (a 30-69% Chance That This Risk Will Occur)

✓ **Low** (a 10-29% Chance That This Risk Will Occur)

✓ **Very Low** (a Less Than 10% Chance That This Risk Will Occur)



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Risk Assessment Metrics

- Severity of Impact

	RISK TYPES		SEVERITY OF IMPACT
COST	SCHEDULE	PERFORMANCE	
Increase of \$500K or greater	Increase of 6 Months or greater	Customer-critical requirement will not be achieved; all margin has been exceeded	High (Critical): Will likely cause program failure and/or would not be able to meet primary requirements
Increase of at least \$200K but less than \$500K	Increase of at least 3 Months but less than 6 Months	Decrease in customer-critical performance eliminates all margin	Medium (Serious): Will cause major deviation from program plan and harm credibility with customer
Increase of at least \$20K but less than \$200K	Increase of at least 1 Months but less than 3	Customer-critical requirement will be achieved but all margin has been eliminated	Low: Will cause moderate deviation from program plan, but all key program requirements will be met
Increase of less than \$20K	Increase of less than 1 Months	Customer requirements will be met with adequate margins	Very Low: Will cause only a small deviation from plan and all requirements will be met.



Risk Assessment Metrics

- Risk Level of Scoring Matrix

S E V E R I T Y O F I M P A C T	High (4)	Medium (5)*	Medium (6)*	High (7)*	High (8)*
	Medium (3)	Low (4)*	Medium (5)*	Medium (6)*	High (7)*
	Low (2)	Low (3)*	Low (4)*	Medium (5)*	Medium (6)*
	Very Low (1)	Very Low (2)*	Low (3)*	Low (4)*	Medium (5)*
		Very Low (1)	Low (2)	Medium(3)	High(4)
		PROBABILITY OF OCCURRENCE			



Risk Assessment Metrics

- Risk Level of Scoring Matrix

S E V E R I T Y O F I M P A C T	High (4)	11		8	8
	Medium (3)	5	11		2
	Low (2)	1	8	11	
	Very Low (1)	15	5	5	11
		Very Low (1)	Low (2)	Medium(3)	High(4)
		PROBABILITY	OF	OCCURRENCE	



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- **Manufacturing Risk: (H8)**
 - Wicking of Electrolyte/Salt Build Up on Needle
 - Low / Over Fill of Ampule
 - Tight Tolerance (Needle to Hole)
 - Meeting rate / cycle time of Fill and Seal
 - Corrosion of Fill and Seal Equipment
 - Proper placement of Ball onto the Cover
 - Breaking of Ampule glass during the Ball press Operation
 - Obtain proper seal after the Ball is pressed into Cover
- **Manufacturing Risk: (H7)**
 - Cleaning and Etching of Terminal Pin
 - Lithium Punch Tool Build Up



Development of Battery Automation Equipment

- **Manufacturing Risk: (M5)**
 - Perpendicularity of Terminal Pin
 - Terminal Pin Tinning coverage (RD Prototyped a Process Developed by Ardec)
 - Solderability of Terminal Pins
 - Time between cleaning & tinning
 - Maintain Case flatness
 - Control the Welding Burrs on Case
 - Proper seating of Terminal Plate
 - Improper Terminal Plate Weld
 - Electrical Failure not detected
 - Gross Battery Leak not detected
 - Fine Battery Leak not detected



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- **Manufacturing Risk: Wicking of Electrolyte/Salt Build Up**
- **Manufacturing Operation: Electrolyte Fill**
- **Probability of Occurrence: High (Inherent properties of electrolyte to wick)**
- **Severity of Impact:**
 - ✓ **Cost: High** (may have to go to hand line \$20-\$60/battery)
 - ✓ **Schedule: High** (2 years to get new battery line)
 - ✓ **Performance: Medium** (heat soak/inspection will pick up low/over fills but chance of latent defect getting through)
- **Risk Level: High (8)**
- **Risk Manager: Alex Hughes / Ben Lagasca**
- **SAVIT Producibility Study (parts completed - testing in progress)**
 - ✓ **No hole cover & projection weld**
 - ✓ **No hole slip fit cover & laser weld**



Development of Battery Automation Equipment

- **KDI Fill & Seal Investigation (Data Gathering)**
 - ✓ Use of Inert Atmosphere
 - ✓ Pull vacuum then fill
 - ✓ Effects on electrolyte temperature
 - ✓ Needle size/material effects
 - ✓ Pump size/stroke/speed/suck back features
 - ✓ Fill with cover and no cover
 - ✓ Pelletize salt then fill
- **RD Systems Fill & Seal Prototype (Chill electrolyte/parts, Fill open reservoir then laser weld cover)**
- **HIBAR Fill & Seal Prototype (Pull vacuum, Fill through hole, Inert gas purge, press ball)**
- **MANTECH Fill & Seal prototype (process yet to be defined)**



Development of Battery Automation Equipment

- **Utilize phased approach to build/design equipment**
 - ✓ Build prototype and down select prior to final design of battery equipment
- **Utilize Thales expertise/support**
 - ✓ Hand build batteries - data gathering
 - ✓ Support production facility setup
 - ✓ Provide technical expertise
- **Revised Probability of Occurrence: Low (several approaches but nothing proven yet)**
- **Revised Severity of Impact:**
 - ✓ **Cost: Medium**
 - ✓ **Schedule: Medium**
 - ✓ **Performance: Low**



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- **Fill and Seal Results**
 - **Reduced Salting to a Manageable Level**
 - **Fill Volume (20-28 micro liters)***

✓ Stdev	0.70
✓ Average	23.33
✓ Max	25.73
✓ Min	21.36
✓ + 3 Sig	25.45
✓ -3 Sig	21.21

* Samples taken over a 4 hour run



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Phase II

- Lithium Laminate Assembly
 - Cutting the Lithium and Adhering the Lithium to the Nickel to Form the Anode



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Phase II

- Conducted Preliminary Design Review (PDR)
 - Reviewed the Initial Concept of the Machines at RD Systems

- Conducted Critical Design Review (CDR)
 - Reviewed the Detailed Drawings of the Assembly Equipment
 - Reviewed Exit Criteria for IPT's Technical Approval
 - All the Manufacturing Risk Points were resolved



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Phase III

- **Final Proveout of the Machines**
 - **Preliminary Production Review of Individual Machines**
 - **IPT Concurrence of Acceptance Test Plan (ATP)**
 - **Verify all Inspection Stations**
 - **Capability Studies of Each machine**
 - **Verify Throughput, First Pass Yield, and Uptime**
 - **Proveout of Assembly Line**
 - **Initial Proveout will be conducted at RD Systems**
 - **Final Proveout will be conducted at KDI**



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- **Current Status**
- **KDI's SD Fuze High Rate Equipment Complete**
- **Battery Automation Equipment**
 - **Phase I & II Complete**
 - **Phase III**
 - **PDR's & CDR's Complete**
 - **Began Proveout of individual work cells** 2/18/03
 - **Proveout RD Systems** June 03
 - **Proveout KDI** July 03
 - **First Article Battery Testing** September 03
 - **First Article Fuze Testing** November 03



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