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Strength through Industry & Technology

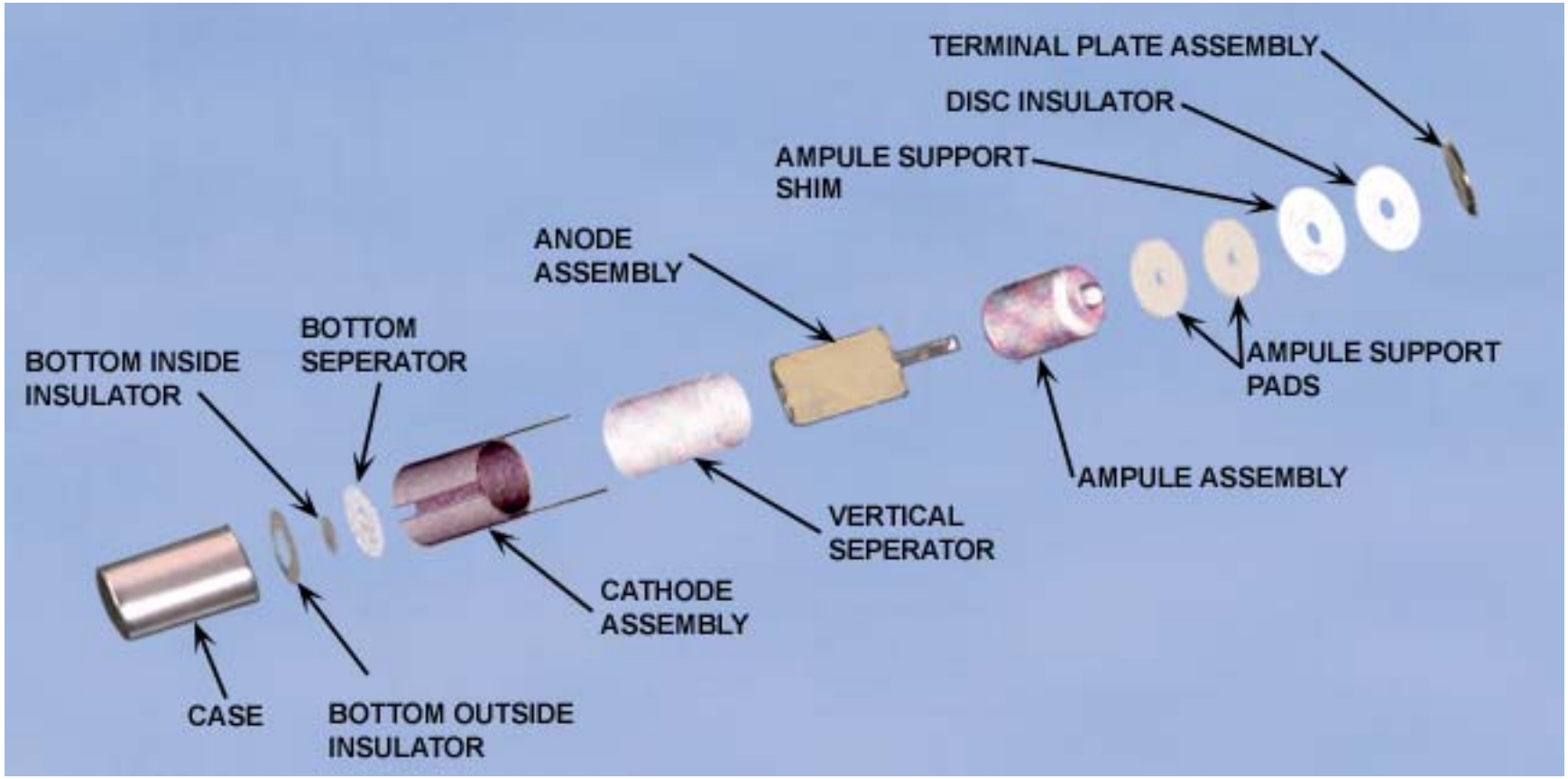
Safety and Reliability Through Technology

M762A1/M767A1 ET Artillery Fuze Single Cell Reserve Battery

AGENDA

- Battery Assembly
- Battery Description
- Program History
- Process Flow
- Equipment Description
- Process Control/Material Handling
- Summary

Battery Assembly



BATTERY DESCRIPTION

- The M762A1/M767A1 ET Artillery Fuze Single Cell Reserve Battery is a reserve lithium Thionyl Chloride Battery.
  - It's chemistry consists of lithium, composition cathode, and Thionyl Chloride.
  - It can be stored for twenty(20) years prior to being activated.
  - It is a pre-launch battery, which can be hand-activated and set, or inductively set.
  - It is used in the 105mm artillery and 155mm artillery, both howitzer munitions.
  - The battery is also used in the MK432 Fuze, which is a time fuze used for artillery cargo rounds on the 5 inch gun. The fuze is set by the gun inductively. The battery is activated when launched.

BATTERY DESCRIPTION

- The battery powers a timer, which is set by the soldier prior to launch, and the countdown is initiated by the launch and spin of the round.
- The M762A1 is used tactically in timer rounds, which are non-booster cargo rounds.
- The M767A1 is flown Point Denotation , which is a pre-dominantly HE round.
- Full voltage of the unit is 3.6 volts. Duration of the battery's life, once activated, is 15 days minimum, per specification, but testing has shown it can last up to 30 days.

PROGRAM HISTORY

- In 2002 L-3 KDI-PPI was selected as a second source supplier for the prime BT Fuze Products.
- Automated/ semi-automated equipment was necessary to produce the quantities required, in order to maintain repeatable/consistent assembly operations.
- Selection of the equipment supplier, RD Systems, was based on the following criteria:
  - Technical Expertise
  - Facilities/Personnel
  - Schedule
  - Financials
  - Intangibles

PROGRAM HISTORY (CON'T)

- September 2002 Completion of the Preliminary Design Review (PDR), which included reviewing and approving the initial concept for the machines at RD Systems.
- November 2002 the Integrated Product Team (L-3 KDI-PPI, RD Systems, BT Fuze Products, and ARDEC) Completed the Critical Design Review (CDR), and approval of the detailed drawings of the assembly equipment. This also included resolving all manufacturing risk points.

PROGRAM HISTORY (CON'T)

- December 2002 L-3 KDI-PPI/RD Systems began the fabrication of automated/semi- automated assembly equipment for producing the M762A1/M767A1 ET Fuze Single Cell Reserve Battery Assembly.
- December 2003 Completion of the final prove-out of the machines at RD Systems, which included the approval of the preliminary production review of each assembly machine, as well as approval of the Acceptance Test Plan (ATP). As part of the ATP all inspection stations were verified, capability studies were conducted, and through-put, first pass yield, and uptime were verified.

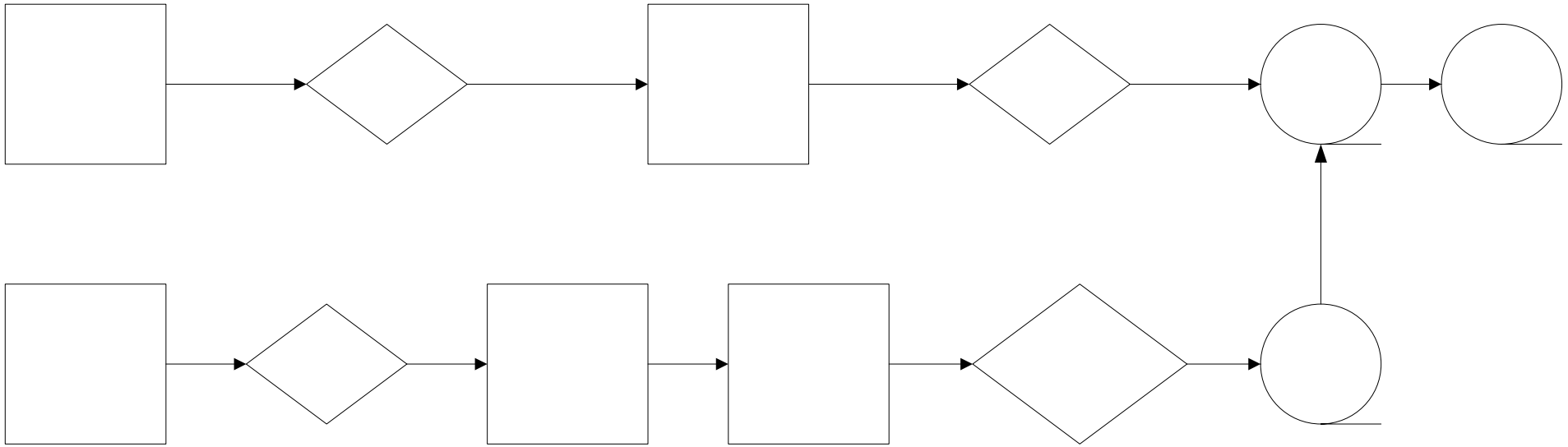
PROGRAM HISTORY (CON'T)

- January 2004 The assembly equipment was delivered and installed at L-3 KDI-PPI, Cincinnati, OH, and the previously-mentioned ATP was repeated at our facility.
- Current production rates are approximately 25,000 pieces per month, with over 100,000 batteries produced on the equipment.
- The M762A1/M767A1 ET Fuze Single Reserve Battery assembly equipment is stationed in a 2000 square foot dryroom with relative humidity maintained at < .2%.

M762 BATTERY PROCESS FLOW

- The five (5) semi-automated/automated assembly machines are as follows:
  - Case assembly (semi-auto) (Machine #100)
  - Anode/Cathode/Cell assembly (semi-auto) (Machine #200)
  - Ampule Fill and Seal (auto) (Machine #300)
  - Ampule to Case Assembly (semi-auto) (Machine #400)
  - Final Case Weld (semi-auto) (Machine #500)

M 762 BATTERY PROCESS FLOW



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M 762 BATTERY PROCESS FLOW (CON'T)

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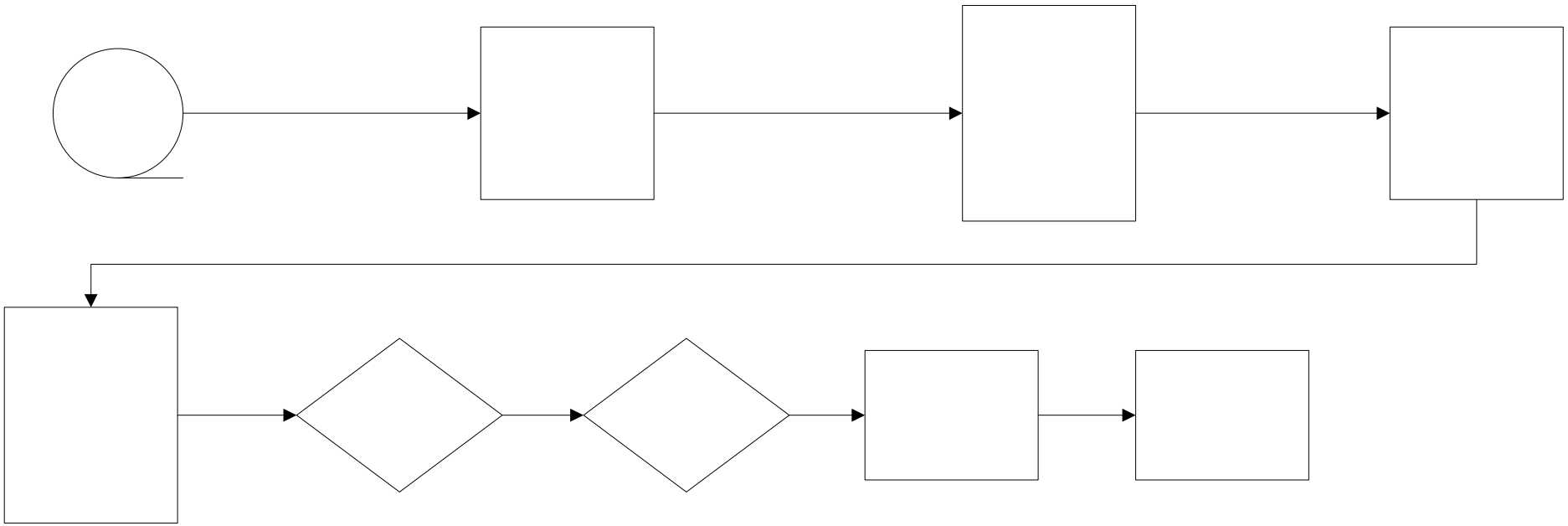
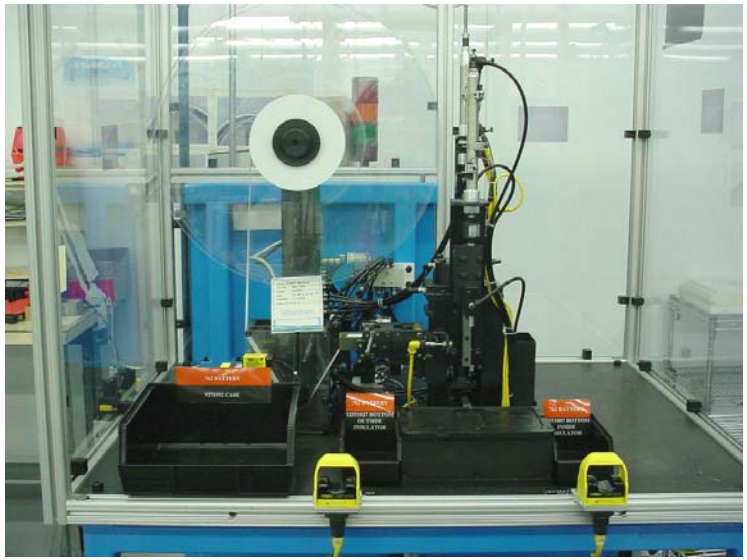


EQUIPMENT DESCRIPTION

- Case Assembly (semi-auto)
  (Machine #100)
  - The case is manually loaded into the equipment.
  - The bottom outside and inside insulators are manually assembled using equipment tooling, and are loaded, automatically by the machine.
  - The bottom separator is produced by a punch and die set and placed into the case on top of the two (2) insulators.



EQUIPMENT DESCRIPTION (CON'T)

- Tooling is specifically designed to assure proper assembly of all three (3) components. Improper assembly, i.e., too many components, missing components, mis-oriented, or improperly assembly components will be detected by machine sensors, and the machine will stop and identify the fault mode.
- Sample inspection, at initial start-up, on an hourly basis, and at the completion of the run, of both piece parts, and completed assemblies, verifies proper assembly of the case assembly.

ANODE/CATHODE/CELL ASSEMBLY (SEMI-AUTO) (Machine #200)

- The anode substrate is automatically loaded, folded, welded, and the anode pad, is cut to size and applied to the processed anode substrate, by the machine, completing the anode assembly.
- The cathode substrate is manually loaded onto the machine tooling and the composition cathode is cut to size and pressed onto the cathode substrate, by the machine, producing the cathode assembly.
- The vertical separator is automatically cut to size by the machine.
- The cathode assembly and vertical separator are manually wrapped around the anode assembly using machine tooling, which positions the pieces within print tolerances, and then manually inserted into the case assembly using machine tooling.

ANODE/CATHODE/CELL ASSEMBLY (SEMI-AUTO) (CON'T)

- The cathode leads are manually folded over the edges of the case wall and a 100% resistance check is completed on all final assemblies.
- Sample inspection, at initial start-up, on an hourly basis, and at the completion of the run, of both piece parts and completed assemblies, verifies proper assembly of the cell assembly.
- Tooling is specifically design to properly orient and position all piece parts, and components for proper assembly. Sensors are in place to identify missing components, which stop the machine and identify the fault mode.

AMPULE FILL AND SEAL (AUTO) (Machine #300)

- Glass ampule blanks are pre-dried at 210°F in a vacuum oven for 48 hours prior to being processed.
- The ampule blank is automatically loaded into the machine, filled with Thionyl Chloride to within its specified tolerance, and laser sealed to complete the ampule assembly.
- The over-all height of the ampule assembly is measured prior to discharge from the machine, and is dispositioned accordingly, i.e., acceptable or non-acceptable.
- The fill level of Thionyl Chloride in the ampule is monitored on an hourly basis using in-process statistical process control (SPC) to verify the accuracy of the fill pump.

AMPULE FILL AND SEAL (AUTO) (CON'T)

- The ampule assemblies are then ultrasonically washed and dried, and placed into ovens for a 24 hour heat-soak at 165°F.
- Sample inspections verify accurate processing of the ampule assembly.

AMPULE TO CASE ASSEMBLY (SEMI-AUTO) (Machine #400)

- The glass ampule assembly is manually loaded into the cell assembly. The cell assembly is manually loaded into the machine tooling, and two(2) ampule support pads, produced by a punch and die set are automatically placed into the assembly.
- The ampule support shim is manually assembled to the cell assembly.
- The disc insulator is manually assembled to the terminal plate assembly, and the anode lead is then welded to the center-pin of the terminal plate.

AMPULE TO CASE ASSEMBLY (SEMI-AUTO) (CON'T)

- Specialized tooling is used to form the anode lead. Then the terminal plate assembly is initially seated into the cell assembly.
- Perishable tooling is maintained on a predictive maintenance schedule
- Sample inspections verify accurate assembly of the cell.

FINAL CASE WELD (Machine #500)

- The cell assemblies are manually loaded into the machine and the following items are completed automatically: the terminal plate assembly is seated in its final position, the cathode leads are trimmed off of the assembly, the terminal plate is laser welded in place, and the completed cell is electrically tested. The cell is then manually removed from the machine.
- Sample inspections verify accurate assembly of the cell.
- 100% visual inspection of the weld integrity is completed before a final leak check of the cell assembly.

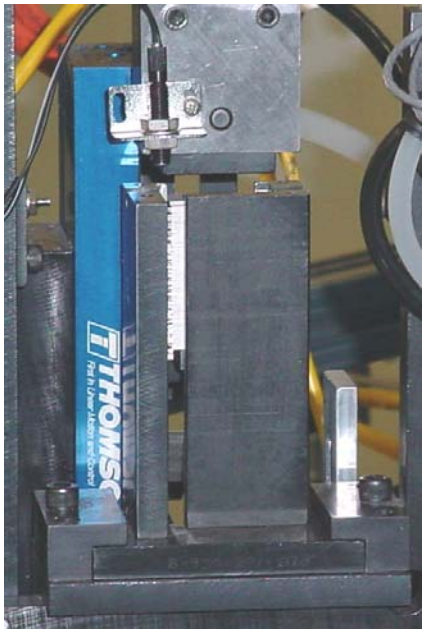
PROCESS CONTROL/MATERIAL HANDLING

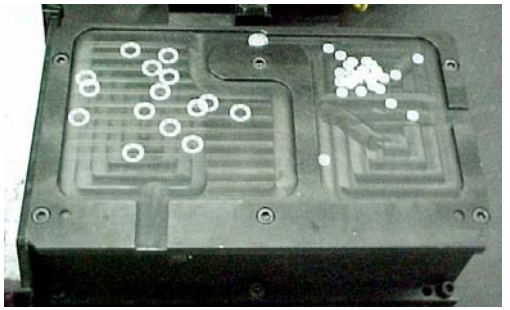
- Kanban system utilized on this product line to maintain a constant flow of piece parts into the production area on an as-needed basis.
- Small batch processing was incorporated to decrease WIP, and maintain a steady assembly flow.
- “Point Of Use Parts Storage” is utilized, so that all components for a particular assembly are within a close proximity, so that production downtime is minimized.

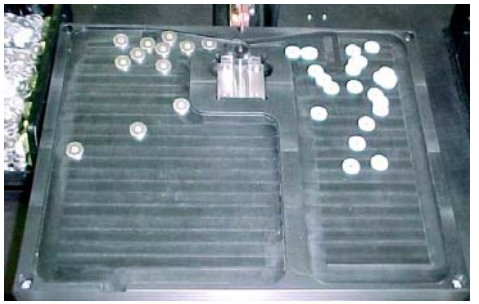
PROCESS CONTROL/MATERIAL HANDLING (CON'T)

- POKE YOKE tooling has been incorporated for assembly accuracy and simplification of operator training.

Examples of POKE YOKE Tooling







PROCESS CONTROL/MATERIAL HANDLING (CON'T)

- Lean Manufacturing concepts, such as Visual assembly instructions, Visual factory tools, and machine start-up/shutdown procedures are available on each assembly machine for operator training aides as well as quick reference.
- Operators wear moisture barrier protective equipment during the assembly and inspection processes to prevent moisture, contaminants, and/or oils to be transferred to the parts.

SUMMARY

- L-3 KDI-PPI has learned throughout the course of our initial battery contract that automated / semi-automated equipment maintains the repeatability and consistency needed to manufacture batteries in large quantities.
- Key points:
  - Cleanliness of incoming piece parts can have an effect on the assembly process.
  - Lean Tooling and fixturing shorten the learning curve in battery assembly while maintaining the quality of the product.

SUMMARY (CON'T)

- Small batch sizes allow for ease of tracking and reduction of WIP.
- Kanban system allows for piece parts to be available as needed.
- Visual aids in the form of instructions, start up/shut down procedures, and color codes maintain production stability.