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DESIGN AND PROVE-OUT OF A MATERIAL TRACKING SYSTEM WITH A PAD PRINTER AND LASER ETCHER SYSTEM

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14. ABSTRACT

A Material Tracking System and Bar-coding System was procured and installed at Kansas Army Ammunition Plant (KSAAP) as part of the Flexible Load, Assembly, and Pack (LAP) facility contract. The material tracking system uses a software program called Inventory Management, Process and Control Tracking System (IMPACTS) to provide paperless control of material on a production line. The bar-coding system consists of pad printers that apply 'blocks' of paint on the projectiles for the serial numbers and barcodes. The pad printers also apply warning labels and explosive marking to the projectiles. The bar-coding equipment is used in conjunction with a laser etcher that etches serial numbers and barcodes onto the projectiles and then scans them into the system using the IMPACTS software. The purpose of designing and implementing this system was to establish a tracking system for flexible LAP facilities within the United States industrial base.

This report discusses the tracking and bar-coding system, testing of the integrated systems, and the final prove-out, which were successfully completed on the 60-mm mortar line at KSAAP.

15. SUBJECT TERMS

Material tracking   Inventory management, process and control tracking system (IMPACTS)
Bar-coding   Traceability

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CONTENTS

FIGURES

FIGURES
(continued)

OVERVIEW

In April 2004, Day and Zimmerman, Inc. (DZI) was awarded a contract to design and implement a Flexible Load, Assemble, and Pack (LAP) Facility for smart munitions at Kansas Army Ammunition Plant (KSAAP). The effort was divided into two phases. Phase I was scoped to design a flexible LAP facility in order to address LAP needs for manufacturing high technology munitions (smart munitions) using press loading, cast cure, and melt-pour capabilities in low production quantities. The phase I design effort consisted of incorporating the most state-of-the-art technology available in production environments in order to process new insensitive munitions (IM) formulations. The design was completed in July 2006 and it included designs for process equipment, control systems, support equipment, process and instrumentation diagrams, process flow diagrams, preliminary operating conditions, utility requirements, and systems and control requirements. As part of the final delivery of phase I, DZI Kansas designed and demonstrated a material tracking system. Initially, the scope of work (SOW) for phase II was scoped for the implementation of the phase I design at KSAAP. However, due to the 2005 BRAC law the SOW for phase II was revised and divided into two parts. Part 1 called for the investigation of new explosive, detonator, and melt pour technologies and for the evaluation of equipment at KSAAP. Part 2 called for the procurement, installation, and prove-out of the material tracking system that was designed in phase I. The tracking system was to be installed on a production line at KSAAP.

The goal of the material traceability effort was to provide 'paperless' control by designing semi-generic material traceability software architecture that would be used for material tracking on explosive LAP lines. As part of the material tracking system effort, DZI personnel developed the Inventory Management, Process, and Control Tracking System (IMPACTS) software to be used with the tracking system. It allows a facility to define the following parameters in a production environment for tracking purposes: tracking locations (areas, bays); ammunition types; details (raw material, lot numbers, process parameters, recipes, inspections, and x-ray data); and users (supervisor, user, and administration) in different areas with different access levels. These variables are defined and then automatically set up in the various production locations throughout the LAP line. The IMPACTS software that was designed to be used for the material tracking system called for the use of a bar-coding system. The bar-coding system that was developed consisted of two pad printers that were purchased from Printex USA in Poway, California and one laser etcher that was purchased from Control Micro Systems in Winter Park, Florida. This system was necessary to help with the tracking of rejected and accepted projectiles and to help with quality control of the production process.

The material tracking, pad printer, and laser etcher equipment was installed and demonstrated on the 60-mm mortar production line at KSAAP on 3 September 2008 by DZI Kansas personnel. A mock production run was done with 60-mm production line workers in order to demonstrate the actual use of the system and to ensure a successful prove-out. This report will give details on the demonstrations and final prove-out of the entire material tracking system that was performed by DZI personnel. It discusses the tracking ability of the system from raw materials to pack-out, the different testing that was performed on the system, and the benefits of using this system.

The U.S. Army Armament Research, Development and Engineering Center (ARDEC), Picatinny Arsenal, New Jersey engineers worked in conjunction with DZI personnel during the design, procurement, installation, and demonstration of the material tracking system, with the intention of transferring the system to other Army Ammunition Plants (AAPs).

DISCUSSION

The material tracking system was designed to be as simple or intricate as desired by a production facility. The user requirements define the level of detail needed throughout the process. The administrator can designate rejection points, inspection points, and items to track; i.e., raw materials, shells, subcomponents, visual inspection data, and x-ray data. The tracking system also gives a production facility the capability to track manpower, machine downtime, and the time of a projectile in each operation (fig. A-7, app A). It will log accepted and rejected material and projectiles and send signals or alerts to technicians or supervisors.

Phase I

DZI personnel hosted a prototype demonstration of the material tracking design at KSAAP on 19 July 2007. The demonstration of the design consisted of a mock production line set up in a conference room at DZI Kansas. It was successful and required only minor debugging for the IMPACTS software. After the successful demonstration of the system, DZI personnel submitted a report that included the software, white pages, databases, and user manuals. The report was submitted to ARDEC personnel for review. ARDEC personnel tested the software to ensure that the system could be installed and setup at other production facilities.

To ensure that the system was transferrable, the IMPACTS software was installed successfully on a PC with SQL server at ARDEC by Information Technology (IT) personnel. Different projects, process parameters, parts, tracking options, and quality control information were inputted into the program for melt-pour, cast cure, and pressing operations. The type of explosive, materials, units of measure for the processes, parts, and descriptions of each process were also input during the setup of the system. After completing the setup of IMPACTS, it was determined that actual production environment testing would give a more definitive conclusion as to the effectiveness of the tracking system.

Phase II

The contract for the procurement, purchase, installation, and successful demonstration of the tracking system was signed and approved on 6 November 2007. The contract was modified to include the installation and demonstration of the material tracking system on a production line at KSAAP. The contract also included integrating bar-coding equipment with the material tracking system. The bar-code system allows the user to generate barcodes and serial numbers for the projectiles to be tracked throughout the production process. The bar-coding system is comprised of pad printers and a laser etcher that were designed to be compatible with 60- to 120-mm mortar bodies. This system included fixtures for the 60-mm mortars, but different tooling fixtures can be used to make the pad printer compatible with 81- and 120-mm projectiles. The change-out of the tooling can be done with minimal effort.

The material tracking and bar-coding systems were procured and installed at KSAAP by DZI personnel. The system was designed to track material during production on a flexible LAP line. As a result, the IMPACTS was created. IMPACTS is a robust system that was designed to fill a need for inventory and product tracking and control within the munitions industry in any production environment (app A). The design is flexible to cover all phases of munitions productions. The program allows control throughout the entire production process, gathers information for improved statistical analysis, and product monitoring. To help to control the production process, the material tracking system incorporates a bar-coding system. The bar-coding system consists of pad printers and a laser etcher (app B, figs. B-1 and B-2). It allows the user to apply bar-codes and markings on the munitions in order for it to be scanned into the IMPACTS database. DZI completed the installation of these two systems August 2008. On 3 September 2008, DZI performed a mock production run for final prove-out of the systems on a production line at KSAAP.

DZI Kansas personnel integrated the IMPACTS software and pad printer/laser etcher equipment on their 60-mm mortar production line. Material tracking, bar-coding equipment (laser etcher, pad printers, scanners, PCs, and control panels), and software were installed and tested on the 60-mm mortar line (staging, pre-conditioning, loading, conditioning, x-ray, and storage) before the final demonstration (app C). DZI personnel performed the final demonstration using three loading carts, each loaded with 64 60-mm mortars. At the first station of this process, the projectiles were hand loaded onto the pad printer. The pad printer applied the warning label (white paint) and then rotated 180 deg for the yellow 'block' of paint to be applied (fig. 1).

Figure 1
60-mm mortar with a 'block' of paint for future barcode placement

The location of the yellow 'block' is where the barcode is applied to the projectile (app B, figs. B-3 and B-4). The template for the labels is created on special plates that are provided by the pad printer manufacturer. The process of loading the projectile, applying the paint, and unloading the projectile on the pad printer takes approximately 10 sec.

The most critical part of this process is the mixing of the paint. The paint must be hand mixed following a specific process, mixing in volumetric ratios. The paint for the pad printer should be mixed at 70°F. Fluctuations in ambient temperatures will affect the mixing process. Projectiles that were cooled at temperatures at an approximate 70°F temperature needed 10 min to completely dry. However, if the temperature is warmer than 70°F, then the paint on the projectile dries quicker. The warning labels on the projectiles dried immediately, but the yellow 'block' of paint needed 10 min to dry. Each cup of paint will label approximately 1000 60-mm mortar projectiles before needing to be refilled. The clean up at this operation takes 20 min and it takes 30 sec to refill the paint cups. After the warning label and 'block' of paint were applied to the projectiles, they were sent to the laser etcher for the barcode and serial number markings.

At the laser etching station, the projectiles had barcodes (ID's) and serial numbers laser etched onto them (app B, fig. B-5). The projectiles were placed on a rotating circular table that is separated in half by a retractable separation wall. The projectiles were loaded on one side of the wall and laser etched on the other. The wall retracted and the table was rotated 180 deg. Once on the opposite side of the wall, the projectiles were laser etched. The laser etcher initially scans the projectile for a barcode to ensure that the projectile has not already gone through the process; if a barcode is already on the projectile then it is returned without any further processing. If no barcode is found, the laser etcher applies a barcode that the software pulls from a barcode database and then scans the completed barcode into the system as inventory (fig. 2).

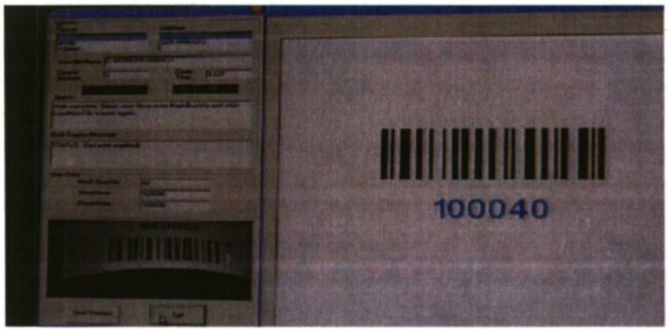


Figure 2
Serial number of a projectile scanned into the system and checked
(The next sequential number will be scanned next in the system.)

Once the barcode is read, the projectile body is returned back to production on the rotating table. After the shells were laser etched they were then placed into loading carts. This process requires approximately 10 sec. Each 60-mm mortar and cart was scanned and the information was automatically uploaded into the material tracking system (fig. 3). Although DZI personnel performed the demonstration by scanning the items after they were laser etched, the system allows for the projectiles to be scanned in conjunction with the pad printing and laser etching process.

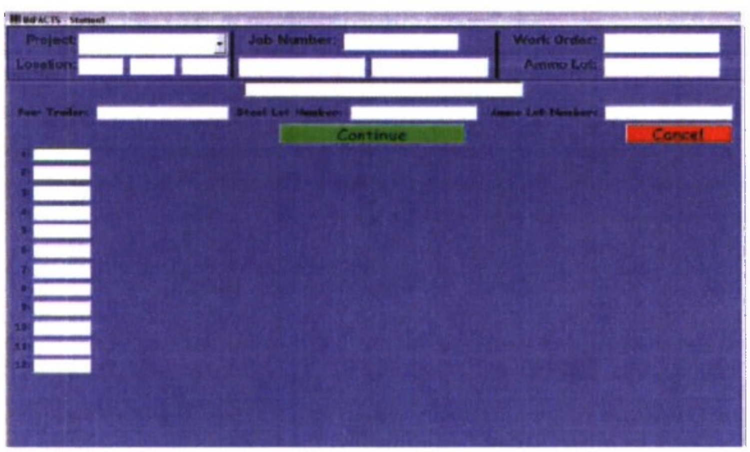


Figure 3
Traveler sheet that is completed when the projectiles are scanned into the system
(This traveler sheet is printed out and follows the projectiles throughout the production process.)

The system is designed to prevent a projectile and cart from being scanned twice by showing an error message and not allowing the process to continue until the mistake has been cleared (fig. A-9, app A). This ensures that the correct number of rounds is accounted for throughout the production process and in the tracking system. A traveler sheet was automatically provided for each cart that detailed the ID of each projectile in the cart, lot number, and project number [60-mm mortar production (fig. 4)].

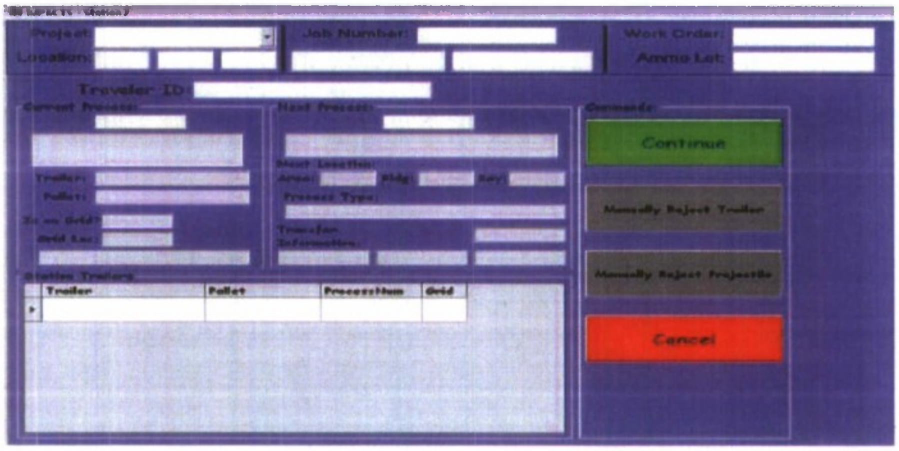


Figure 4
Screen that is available in the system for tracking once work has begun

This traveler sheet stayed with its specified cart throughout the entire production process and is scanned as each cart arrived in a new area of the LAP process. When the carts arrive in a new area of the process, they are scanned and the information is uploaded to the data acquisition system. The information that is included on the traveler sheets can be setup to provide any information required for a production environment.

During production of the 60-mm mortar, all projectiles have to go through a preconditioning process. After the information for the carts and projectiles were uploaded into the system, the carts were sent to preconditioning where they were scanned and the user's needs (i.e., number of projectiles, temperature, and time for preconditioning) were input into the system. During preconditioning, the projectiles and funnels were heated to a specified temperature. After preconditioning, the carts were sent to the loading station where the traveler sheets were scanned after the pour. At this station the variables can be manually input into the database such as pour time and pour temperature. Comments can also be added. After the projectiles are loaded, they are sent to the cooling process.

At the conditioning station the traveler sheet was scanned and the operator was prompted to indicate the location on the cooling grid where the loading cart would be placed. This step helps to increase the accountability during this critical stage in the LAP process, for melt-pour projectiles. This allows the operator to log where all projectiles are at all times. It also helps to ensure that the projectiles stay in the conditioning process for the required amount of time. The system is designed to designate time and temperature requirements for conditioning to be built into the process. For the demonstration, the carts were only scanned entering the conditioning process, however the system can be setup so that the carts are scanned entering and exiting this process. Each cart that is scanned at conditioning logs the time in, time out, lot number, and date. Once the travelers are scanned into the conditioning station the cart cannot be released until the cooling time/cycle is completed. If the cart was taken out of the cool down process early, then when it is scanned at the next step in the process the software would notify the supervisor that the cart should not be at that step. The operator has the option to either reject the cart or a single projectile.

The tracking system lets the operator know if and why a projectile was rejected at this station. If a projectile is rejected within the system and then found to be acceptable the projectiles cannot be re-evaluated and reclassified as acceptable unless a supervisor logs into the system and performs the action. If a mortar body was rejected at one point in the process and then removed from the loading cart, an alert will continue to pop up on the software screen every time its associated loading cart traveler sheet is scanned (fig. 5); this ensures redundancy to capture all rejects (this type of redundancy is optional for the user).

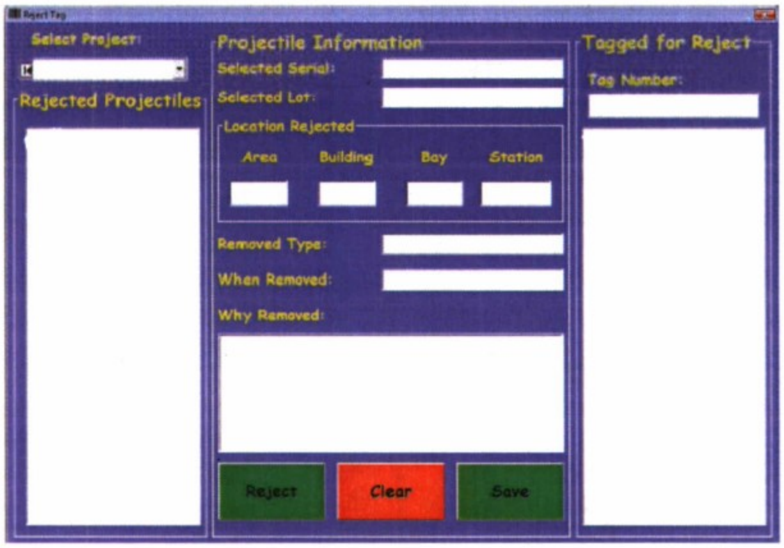


Figure 5
Information sheet for rejected projectiles that can be retrieved from the material tracking system

After the conditioning process was complete the projectiles were sent to facing and then to x-ray. At x- ray, the travelers were scanned and labels that contained serial numbers were printed for projectiles in a cart that were acceptable prior to this step. The labels were applied to the hard copy of each projectile for identification in the future and then the x-rays were read and either accepted or rejected. For this step in the process, the reject codes, parameters, and severity are established during the setup of the system and can be pulled from a drop down box during x-ray inspection (fig. 6), if needed (figs. A-15 to A-19, app A)).

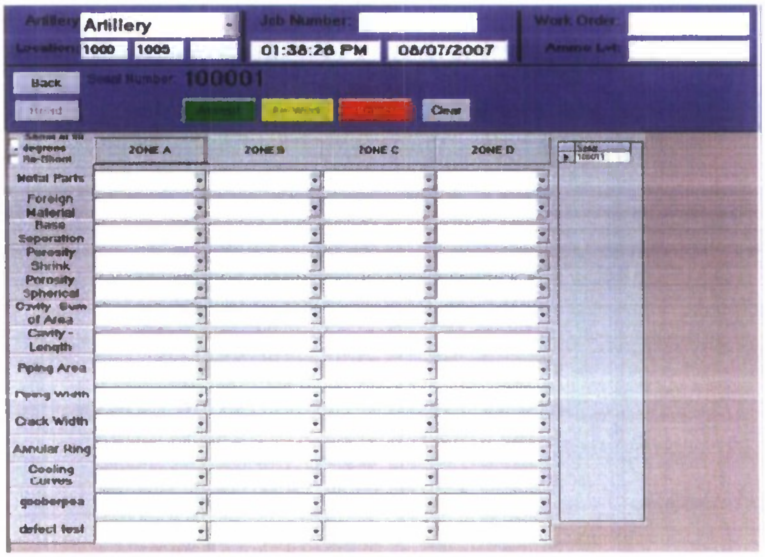


Figure 6
The projectile x-ray tracking sheet that shows the different testing performed during x-ray

The system includes x-ray monitoring and historical tracking capability so that each projectile will have its own x-ray history and inspection record. Each record will have a read only history so that defects and rework cannot be lost or removed from the system. In order to retrieve historical x-ray records, serial numbers are placed on the hard copy x-ray during radiographic inspection. The data associated with each production process is electronically stored for future retrieval. The material tracking system can be linked to a storage database so that historical data and reports can be pulled on an as needed and/or regular (daily, weekly, or monthly) basis.

During the demonstration, the projectiles that were accepted and rejected during x-ray were identified and separated during the inspection part of the process. DZI performed a mock transfer and receipt of projectiles from an igloo to show how the tracking system shows all projectiles or carts that are in storage. After the carts were received from the mock storage/holding area, they were sent to the second pad printer where the lot numbers and explosive markings were stamped on the projectiles (app B, fig. B-6). The second pad printer has a two head capability, but not a rotational capability. After the final markings were applied on the projectiles, they were sent to the pack-out line.

At the pack-out stage of the process the tail fins were attached and the serial number of each projectile was scanned into the system (fig. 7). At this point, the system will again catch a reject if it was not identified and pulled out in an earlier step. From this point forward in the process, the projectiles were tracked individually rather than by carts.

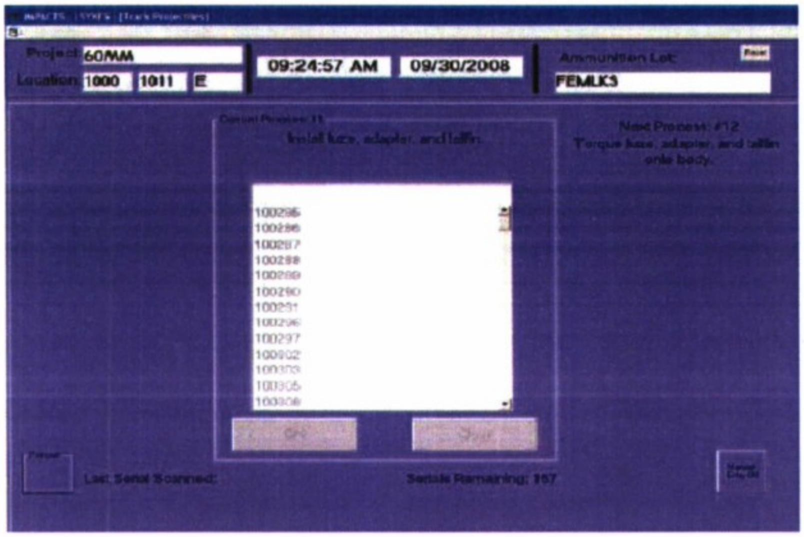


Figure 7
Tracking sheet for assembly

The projectiles were sent to the torque stations where the user has the capability of inputting the torque values (fig. 8) and the system will pass or fail a projectile based on these values.

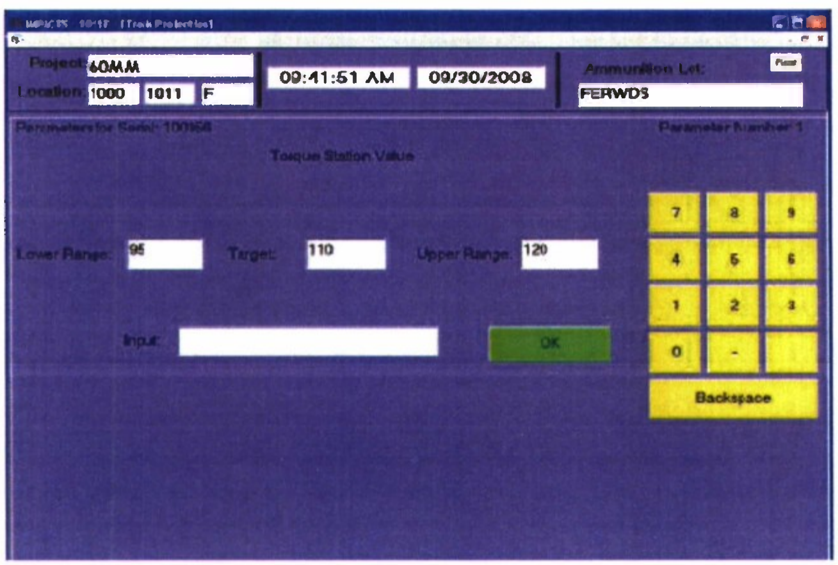


Figure 8
Tracking sheet for the torque station that shows the torque values

The projectiles were then sent to the gauge station where a pass or fail was also given. The next step that the projectiles went to was to the propellant charge process. After the charges were attached to the projectiles, the final assembly was scanned (fig. 9) and inserted into a tube. A new barcode sticker was printed that matched the body loaded assembly (BLA) and was affixed to the tube. The tube was then placed into a can where a new barcode was printed and placed onto a can.

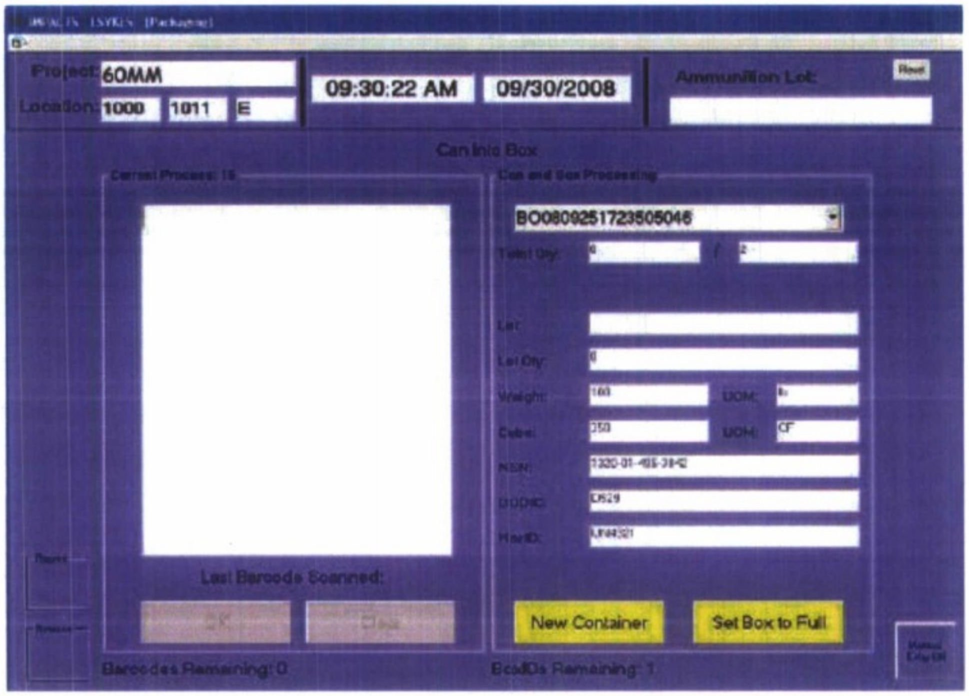


Figure 9
Tracking sheet for pack-out

During the prove-out, there were projectiles that were rejected throughout the process. This was done to illustrate how the rejected projectiles are tracked in IMPACTS (app D, figs. D-1). The tracking system is setup so that rejected projectiles can be removed at different points in production. Each time that a cart is scanned that contains a rejected projectile the user will be prompted to check the cart for rejected projectiles. A nonconforming report that shows the projectiles that were rejected and the reasons for the rejections can be pulled from the tracking system (app D, fig. D-2). All of the information that was collected from the beginning to the end of the 60-mm mortar production process was stored into to a historical database. This information is stored so that it can be retrieved if the history of a projectile or production lot needs to be identified (app D, figs. D-3). The IMPACTS software does not designate the amount of time that the database stores production information. The user of the system has the ability to determine how long the information is stored.

Additional Testing

Due to the addition of the bar-coding system, DZI personnel also performed salt fog testing on the laser etched projectiles. The salt fog testing requirement was to ensure that no damage was done to the undercoating of the shell during laser etching. During the initial testing of the pad printers and laser etching equipment, DZI personnel performed testing to ensure that the laser etcher did not damage the undercoating of the projectile. The testing that was done was in accordance with ASTM B117 specification (app E). During the initial testing, it was found that some oxidation did occur on the projectile (app B, figs. B-7 and B-8). DZI personnel performed additional testing on the projectiles in order to determine the problem. It was found that the oxidation varied at the different laser etcher power levels. DZI personnel performed testing with different laser etcher power levels for both the serial number and the barcode. It was found that a laser power of 27% for the barcode and 28% for the serial number provided the best visual results without showing signs of oxidation (app B, figs. B-9 and B-10).

BENEFITS

IMPACTS was designed so that it can be transferred to any production facility (app F). It is a flexible tracking system that can be used with melt-pour, cast cure, and pressing operations and requires minimal instructions once it has been set up. This system provides scalability over a wide range of production scenarios and was designed to be useable for all phases of munitions production.

IMPACTS does not replace any program that is already in place on production lines; therefore, no break in production is necessary to install this system. IMPACTS also provides tighter inventory and process controls that result in a product with higher quality, more consistency, and more reliability for the end user. By using the tracking system, rejects are able to be identified early within the process. This ability will help to lower the amount of rejects unnecessarily going through every step of the process, reducing the costs of production. With the presence of the storage database, IMPACTS allows for a quicker evaluation of the production process, which can lead to efficient modifications to the production process with less downtime.

IMPACTS has a storage system that provides the ability to retrieve historical data on production processes and allows for the identification of production patterns and the comparative analysis of individual products.

CONCLUSIONS

The final demonstration of this system was a complete success. No bugs or errors were found during the trial run and all of the production steps were performed by actual operators that work on the production line. The system is 100% government-owned and has been tested, proven, and is ready to be used in any production environment.

The material tracking system and software can be made as specific/generic, manual/automatic, and flexible as the user desires. The system is limited to actual user inputs, and real time data cannot be automatically uploaded. The parameters for the loading processes are input into the system before the production process begins. Once the production process begins, new information cannot be input by the user. However, the time stamped process parameters from process controls can be cross-referenced with the material tracking system. The information that is gathered can be further used to optimize process flow and identify bottlenecks as well as track all material and perform root cause analysis. In addition, reports of any kind can be created to summarize daily, monthly, and yearly production runs.

Based on the cost of this contract and an estimate by the U.S. Army Armament Research, Development and Engineering personnel, it is estimated that $1,173,690 will be needed to add this system to a production line. This estimate includes labor, materials, and contractor support.

PATH FORWARD/FOLLOW UP

Based on the successful demonstration and completion of the material tracking system with bar-coding equipment, this material tracking design is being included with facility designs as a result of the 2005 BRAC law and the subsequent facility upgrades. The material tracking system is currently being incorporated into the BRAC design for mortar production at Milan Army Ammunition Plant (AAP). Milan AAP will receive the government-owned material tracking software and equipment that was purchased as part of the Kansas AAP modernization effort.

In addition, the Explosive Pilot Processes Branch of the Energetics, Warheads, and Manufacturing Technology Directorate at the U.S. Army Armament Research, Development and Engineering Center, Picatinny Arsenal, New Jersey will propose a manufacturing technology program (ManTech) to various Program Managers. The scope of this effort will be to incorporate the material tracking system into the production facilities for medium and large caliber projectiles and related LAP functions within the United States Industrial Base. The goal of this effort will be to track and control all materials from the steel production of the projectile cases to the final LAP and storage of fully loaded projectiles by integrating each facility's current production line with a uniform tracking system.

This effort will require the buy-in of various production facilities and program management offices of the U.S. Army and will be a multi-year, multi-million dollar effort.

APPENDIX A
SETUP SCREENS FOR MATERIAL TRACKING SYSTEM

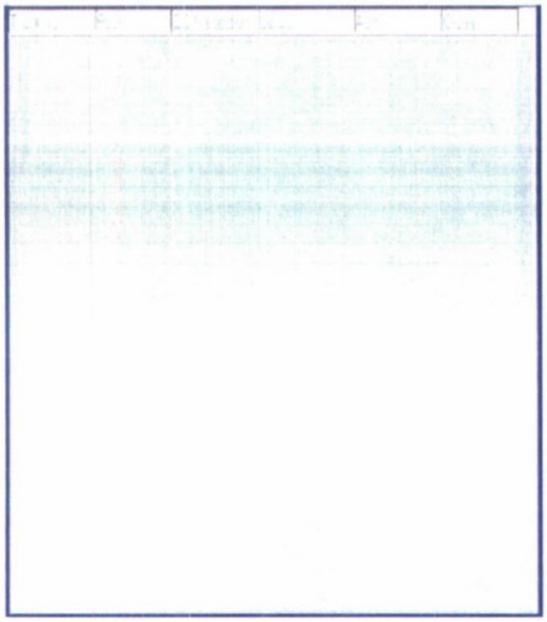


Figure A-1
Overall system screen

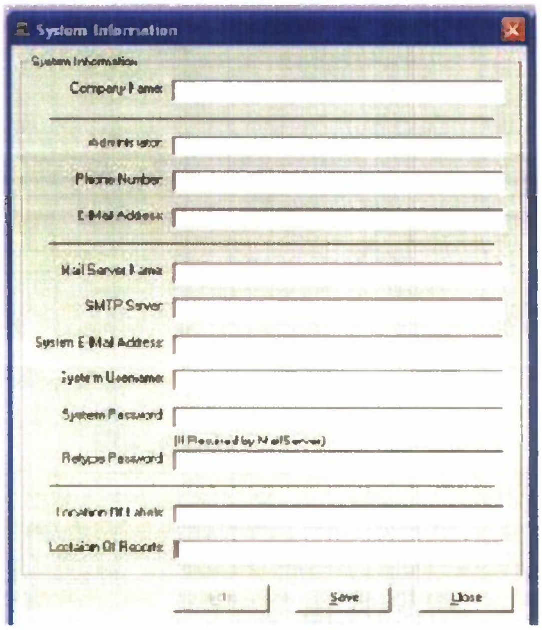


Figure A-2
System information box

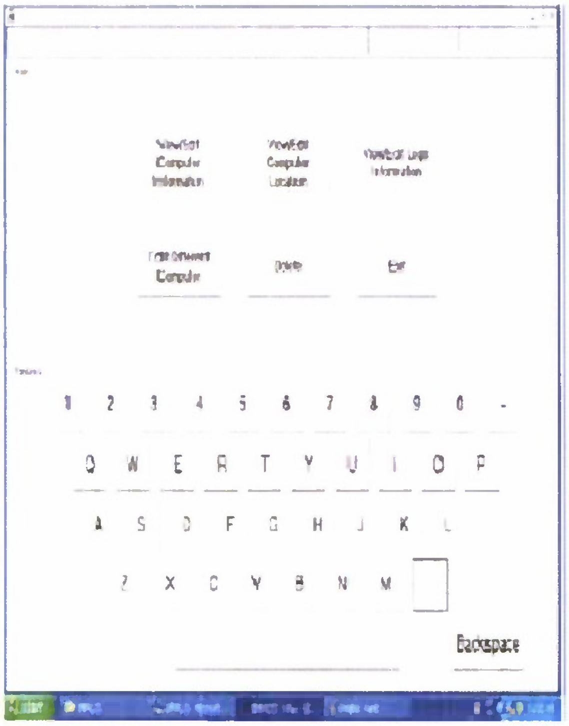


Figure A-3
Station setup screen

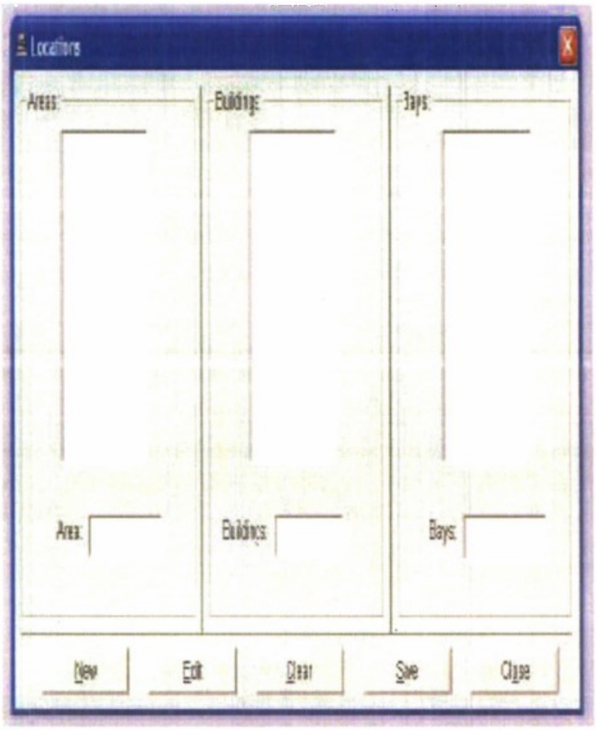


Figure A-4
Location screen

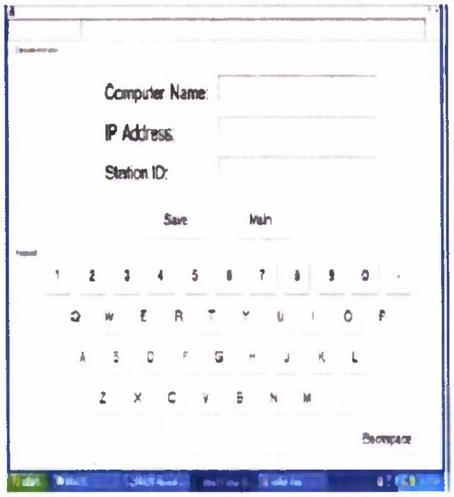


Figure A-5
Computer location

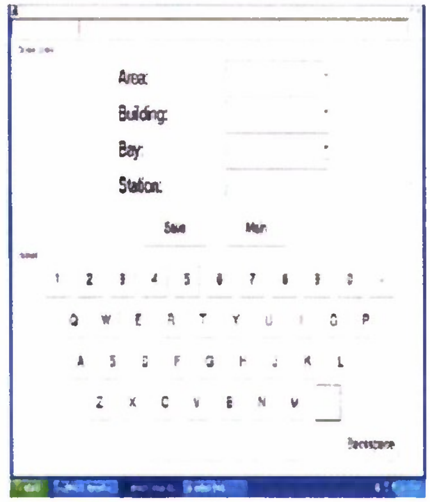


Figure A-6
Final setup screen

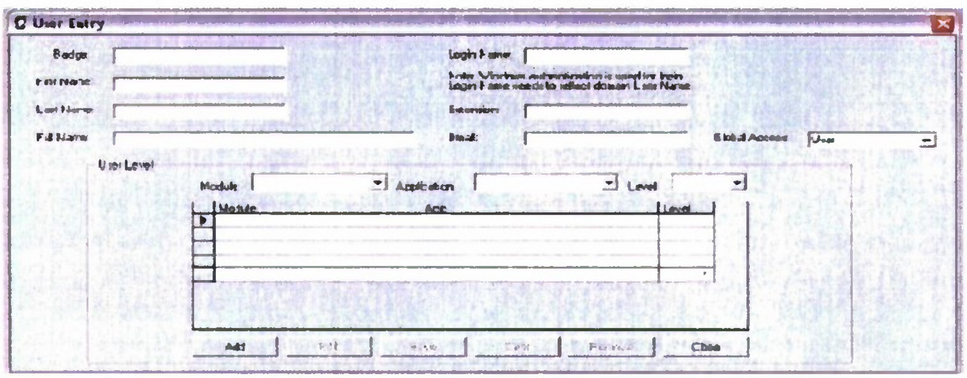


Figure A-7
User entry screen

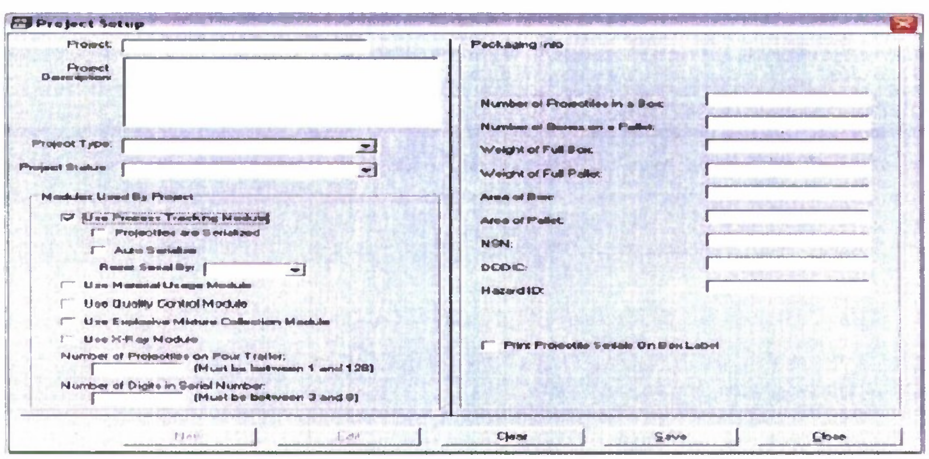


Figure A-8
Project set-up screen

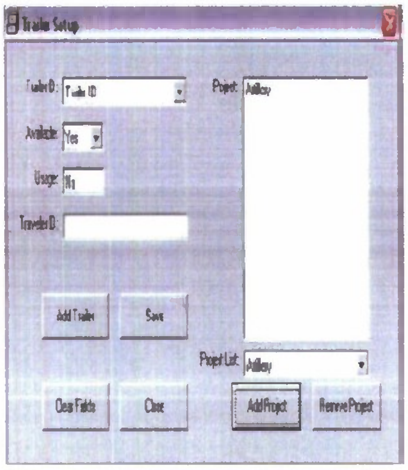


Figure A-9
Trailer identification

Figure A-10
Quality sign in form

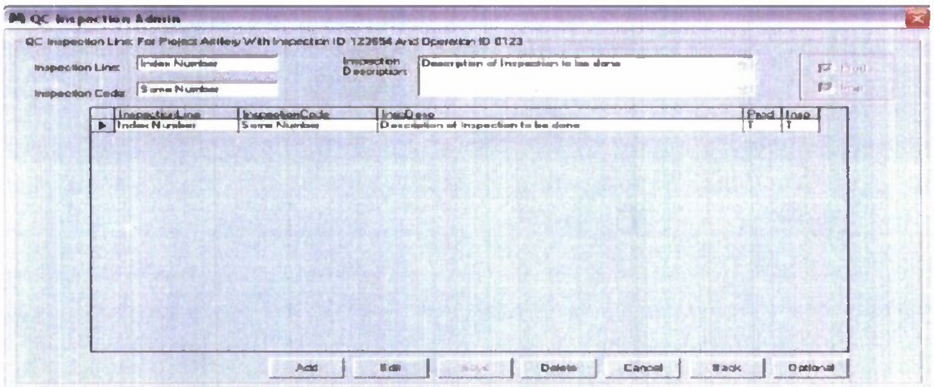


Figure A-11
Quality inspection set-up screen

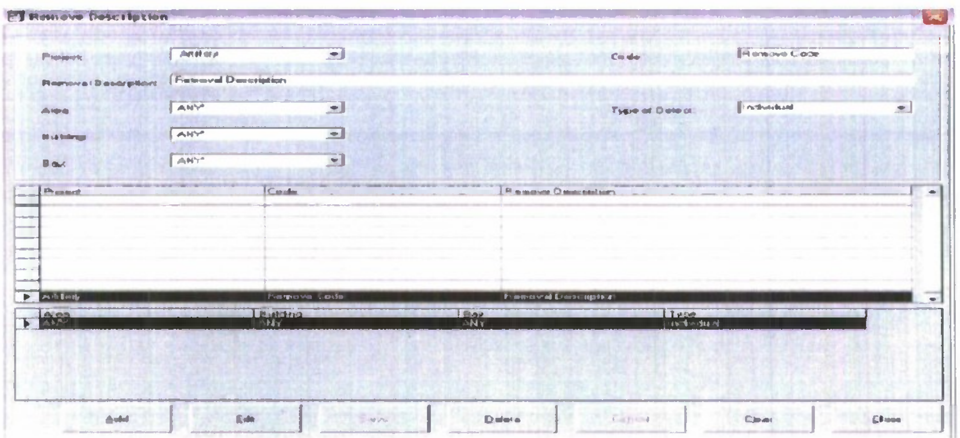


Figure A-12
Removal descriptions inputs and codes

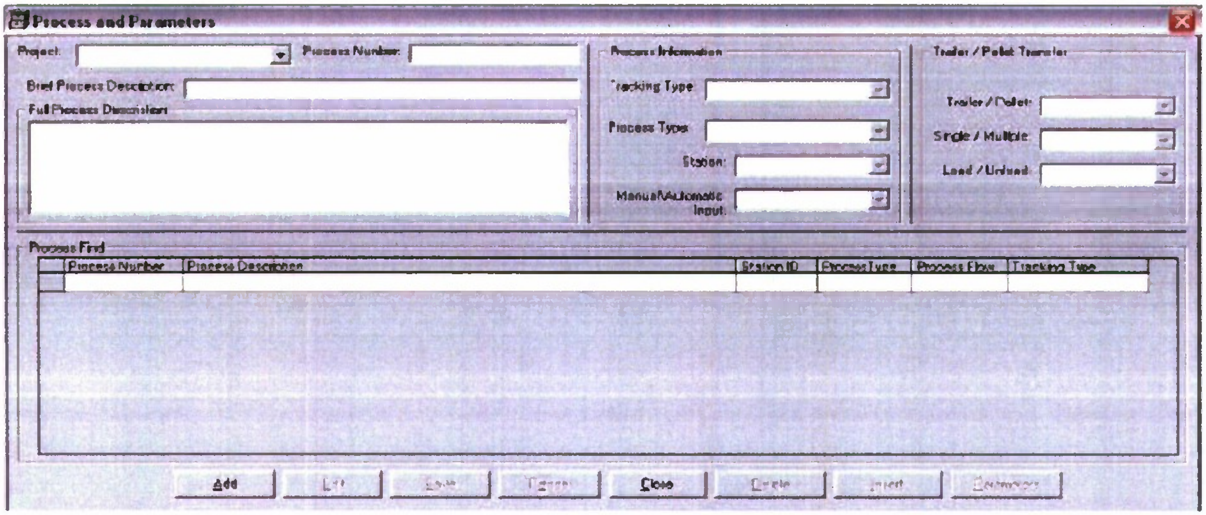


Figure A-13
Process Sequence Screen

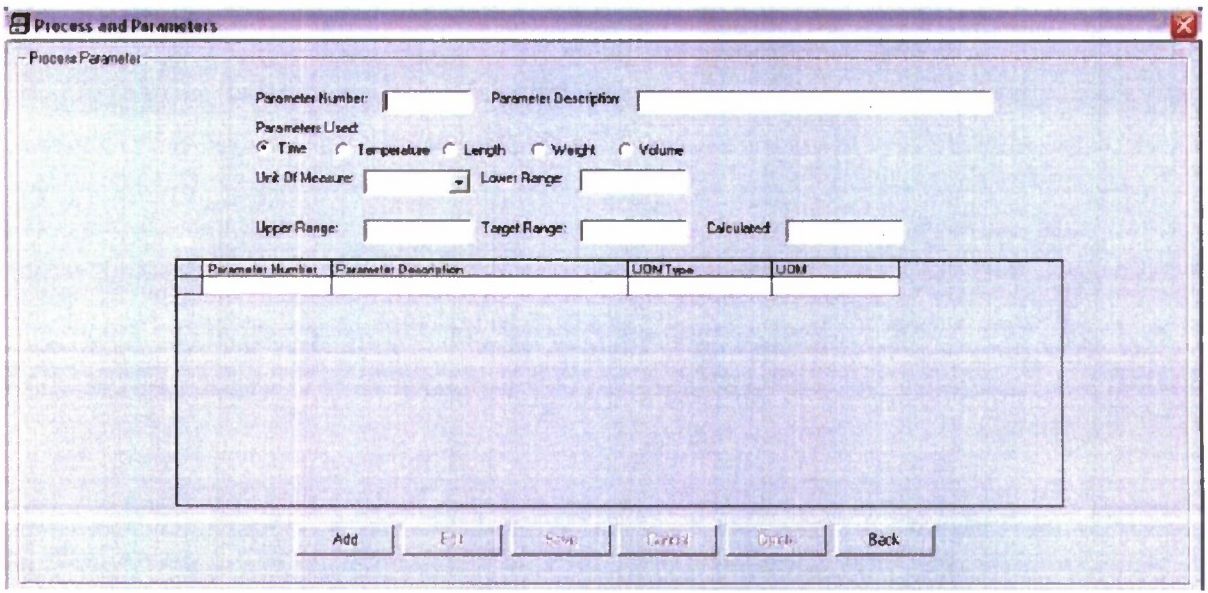


Figure A-14
Process Parameter Input Screen

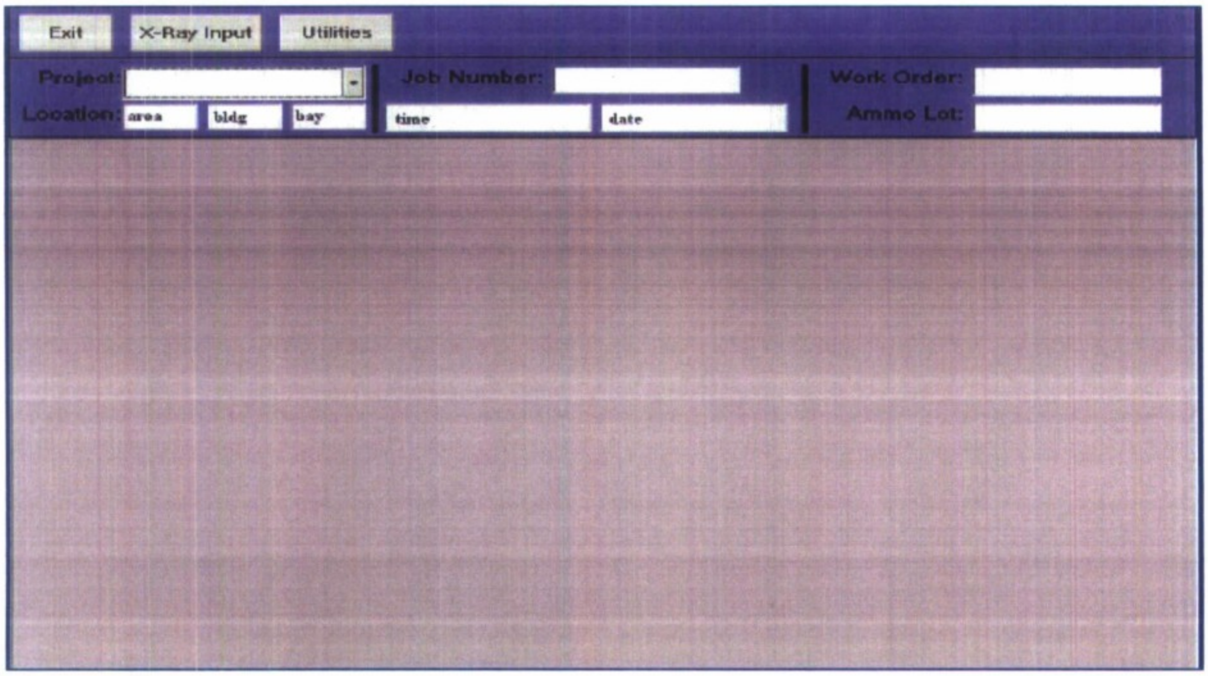


Figure A-15
X-ray utility and tracking screen

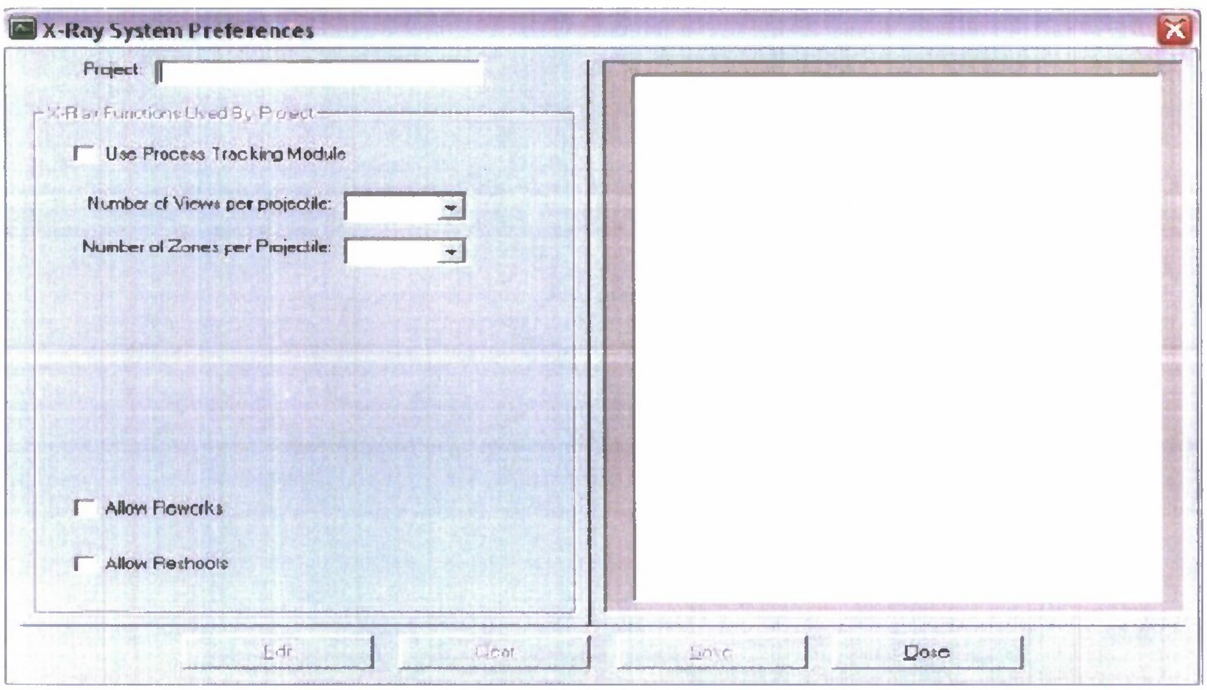


Figure A-16
X-ray system preference screen

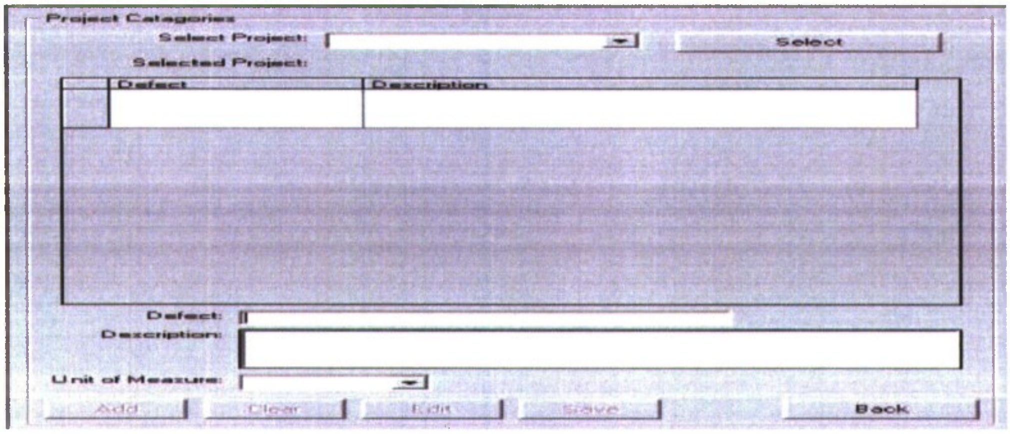


Figure A-17
X-ray defects configuration screen

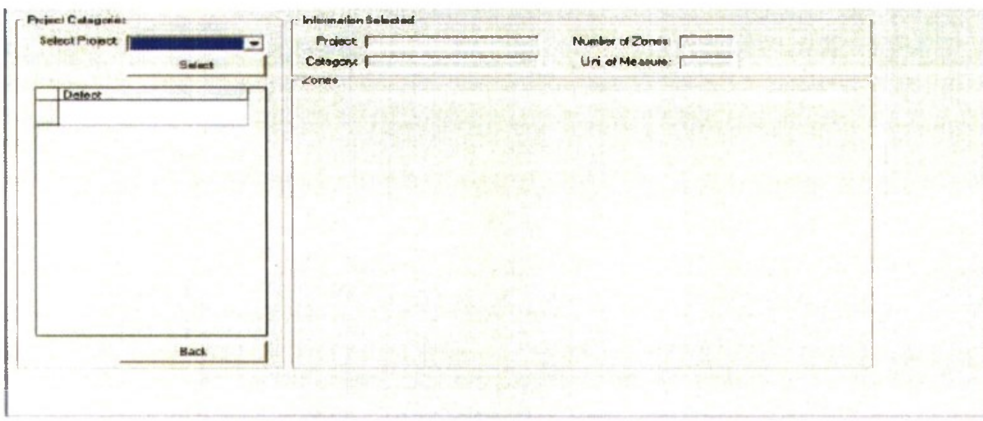


Figure A-18
X-ray parameter screen

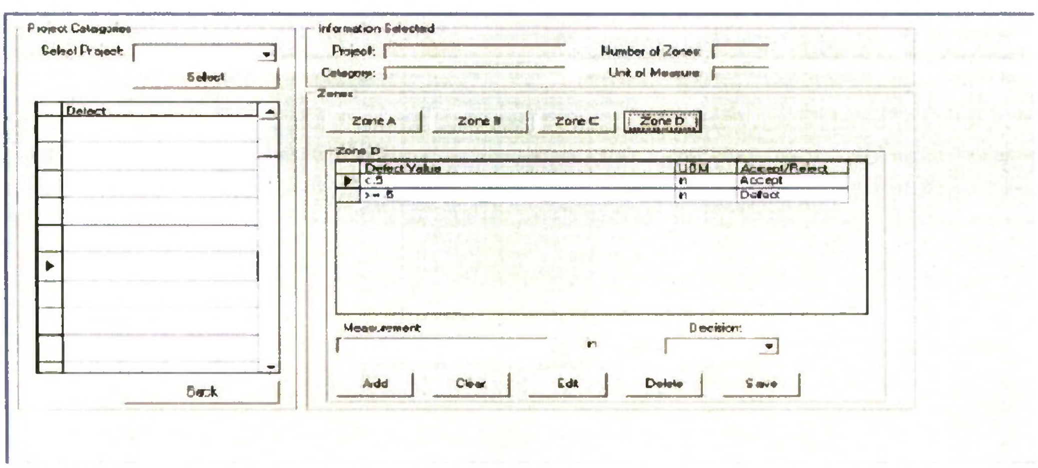


Figure A-19
X-ray parameter selection screen

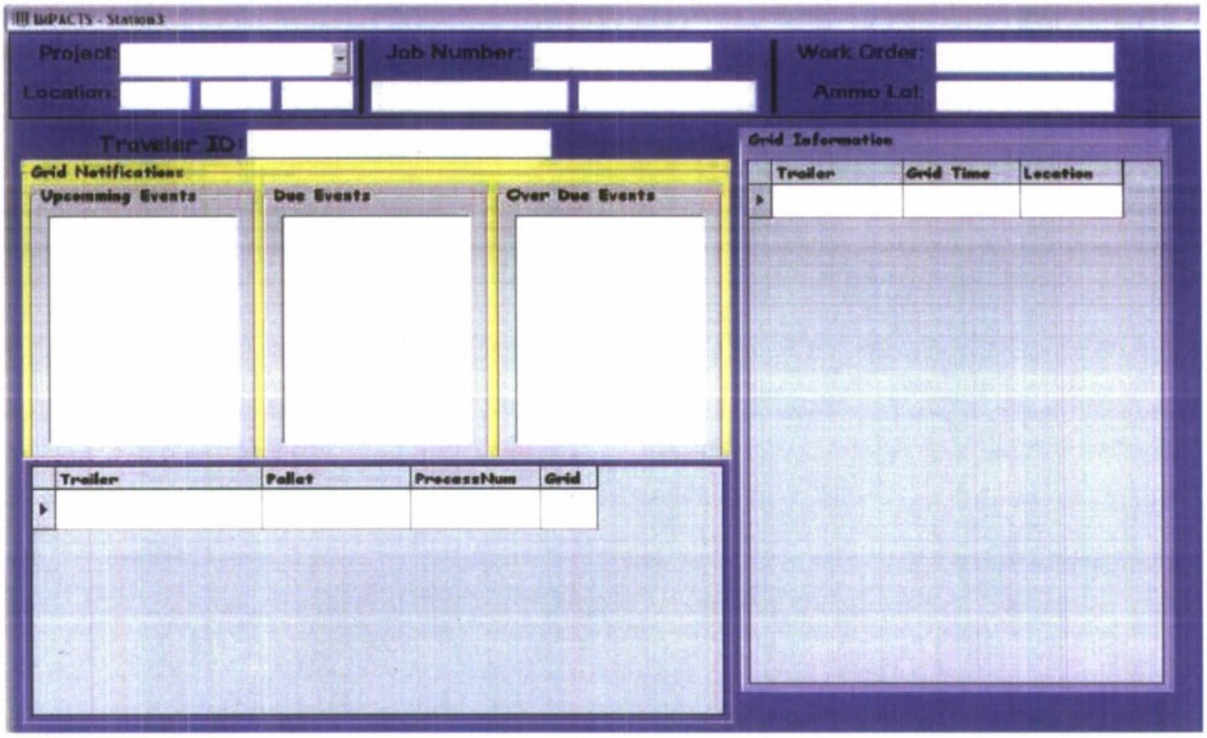


Figure A-20
Trailer tracking screen

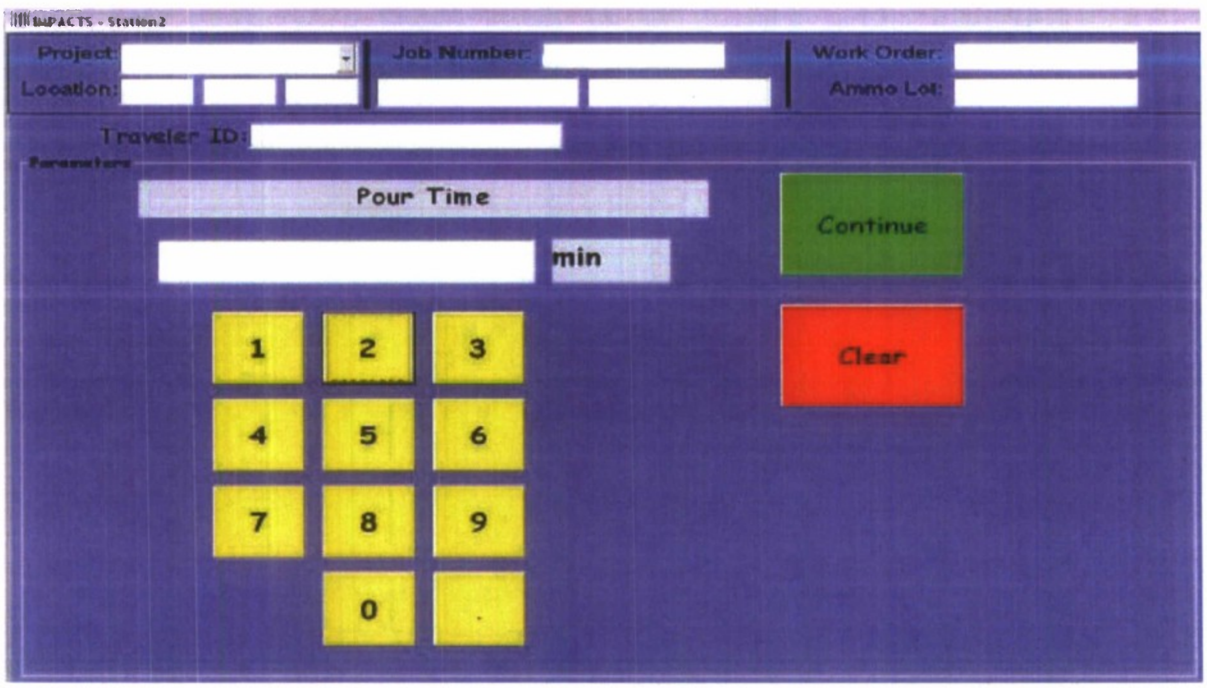


Figure A-21
Trailer tracking screen

APPENDIX B

PAD PRINTING AND LASER ETCHING RESULTS

Figure B-1
Pad printing machine

Figure B-2
Laser etching machine

Figure B-3
Pad printing of warning label

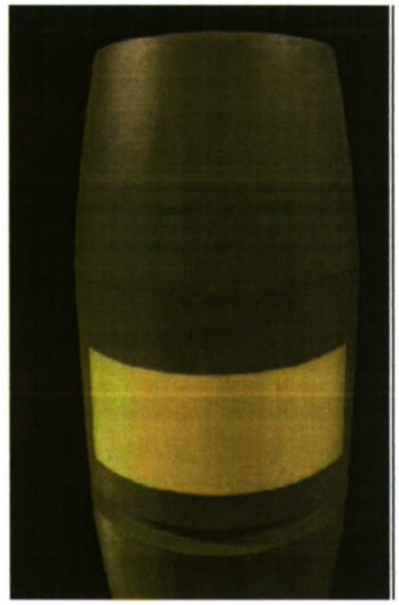


Figure B-4
Pad printing of yellow 'block'

Figure B-5
Laser etching of barcode and serial number

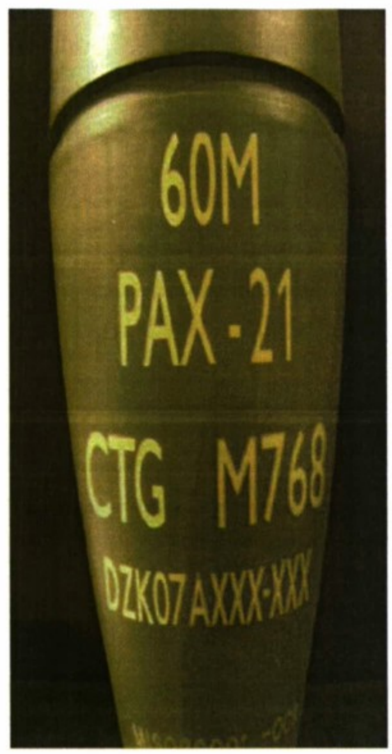


Figure B-6
Pad printing of final markings

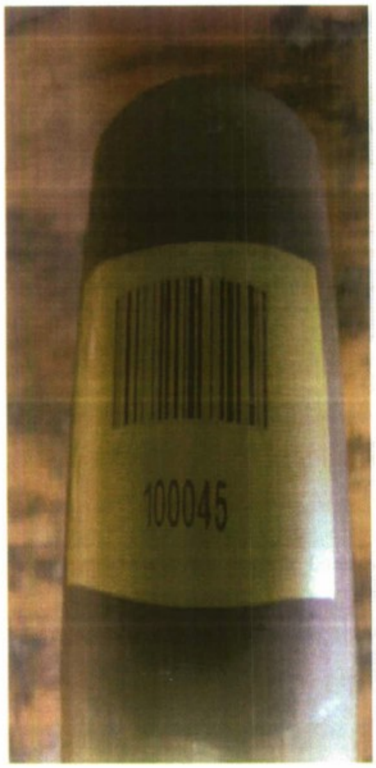


Figure B-7
Projectile showing oxidation

Figure B-8
Projectile showing oxidation

Figure B-9
Projectile showing no oxidation

Figure B-10
Projectile showing no oxidation

APPENDIX C
MATERIAL TRACKING AND BAR-CODING EQUIPMENT

EQUIPMENT	QUANTITY
Material Traceability	
Workstations	
- R100/460 Industrial Computer 1.5G	15
- Hope industrial system 17" Touch Panel	15
Barcode Readers	
- Scan Handle	15
- Intermec Terminal Class 1 Division 1 battery	15
Printers	
- Dell 1710n Laser Printer	1
- Intermec PM4i barcode Label Printer	4
Access Points	
- Cisco Wireless Access Points Removable Antennas	5
- Cisco 1728 Antenna	10
- 20 Foot Antenna Cable for Wireless Point	4
- 50 Foot Antenna Cable for Wireless Point	3
- 100 Foot Antenna Cable for Wireless Point	
Purge Units	
- Stainless Steel Enclosure	15
- Steel Panel for Enclosures	15
- Mounting Feet for Enclosures	15
- Bebco Air Purge Panel	15
Miscellaneous	
- Communications Adaptor	1
- Power Supply	1
- Line Cord	1
- Bebco Straight Vent with Spak Arrestor	15
- Bebco 1/4" 90 degree Connector	15
- Bebco 1/4" Straight Connector	15
- Bebco 1/4" Flush Connector	15
- Bebco 1/4" Bulkhead Connector	30
- Bebco 3/4" Pipe Connector	15
- Advantec 4port Ethernet to Fiber Optic Media Convertor	5
- Signamax Media Convertor Rack Mount	1
- Signamax Media Convertor Multi Mode	25
- RHINO 120W Power Supply	5
- Belkin 7 Outlet 885Joule Serge Protector	15
- 50M Optic Cable Multi Mode	1
Automatic Stencil & Barcode	
- Pad Printer	2
- Laser Etcher	1

APPENDIX D
MOCK PRODUCTION RUN X-RAY RESULTS

Serial:	Results:	View Date & Time	Remarks
	Accept	9/3/2008 10:39:37AM	
100,192	Accept	9/3/2008 10:42:52AM	
100,193	Accept	9/3/2008 10:43:30AM	
100,194	Accept	9/3/2008 10:37:35AM	
100,195	Accept	9/3/2008 10:39:31AM	
100,196	Accept	9/3/2008 10:40:09AM	
100,197	Accept	9/3/2008 10:39:20AM	
100,198	Accept	9/3/2008 10:41:06AM	
100,199	Accept	9/3/2008 10:37:44AM	
100,200	Accept	9/3/2008 10:40:47AM	
100,201	Accept	9/3/2008 10:39:01AM	
100,202	Accept	9/3/2008 10:43:48AM	
100,203	Reject	9/3/2008 10:45:22AM	Base Separation Defect / > .031 in / In Zone A
	Accept	9/3/2008 10:45:27AM	
100,204	Accept	9/3/2008 10:44:02AM	
100,205	Accept	9/3/2008 10:40:31AM	
100,206	Accept	9/3/2008 10:43:44AM	
100,207	Accept	9/3/2008 10:39:40AM	
100,208	Accept	9/3/2008 10:41:46AM	
100,209	Accept	9/3/2008 10:43:41AM	
100,210	Accept	9/3/2008 10:42:55AM	
100,211	Accept	9/3/2008 10:44:37AM	
100,212	Accept	9/3/2008 10:43:10AM	
	Accept	9/3/2008 10:43:19AM	
100,213	Accept	9/3/2008 10:39:23AM	
100,214	Accept	9/3/2008 10:39:26AM	
100,215	Accept	9/3/2008 10:37:32AM	
100,216			

Page 5 of 8

Figure D-1
X-ray report showing rejected projectile

Serial:	Results:	View Date & Time	Remarks
100,310	Accept	9/3/2008 10:36:51AM	
100,311	Accept	9/3/2008 10:33:02AM	
100,312	Accept	9/3/2008 10:33:07AM	
100,313	Accept	9/3/2008 10:32:44AM	
100,314	Accept	9/3/2008 10:32:49AM	
100,315	Accept	9/3/2008 10:32:25AM	
100,316	Accept	9/3/2008 10:32:21AM	
100,317	Accept	9/3/2008 10:36:46AM	
100,318	Accept	9/3/2008 10:36:42AM	
100,319	Accept	9/3/2008 10:32:56AM	
100,320	Accept	9/3/2008 10:32:59AM	
100,321	Accept	9/3/2008 10:36:28AM	
100,322	Accept	9/3/2008 10:36:31AM	
100,323	Accept	9/3/2008 10:32:38AM	
100,324	Accept	9/3/2008 10:32:29AM	
100,325	Accept	9/3/2008 10:36:39AM	
100,326	Accept	9/3/2008 10:36:35AM	
100,327	Reject	9/3/2008 10:36:01AM	Individual Cavity Accept / <= 5 sq in / In Zone A ; Cracks - Sum of Accept / <= 4 ea / In Zone A ; Base Separation Defect / > 031 in / In Zone A ,
100,328	Accept	9/3/2008 10:35:24AM	
100,329	Accept	9/3/2008 10:34:55AM	
100,330	Accept	9/3/2008 10:34:23AM	Piping Cavity Accept / <= 1 5 Long in / In Zone A,
100,331	Reject	9/3/2008 10:33:50AM	Piping Cavity Defect / > 25 Wide in / In Zone A,
100,332	Accept Accept	9/3/2008 10:33:34AM 9/3/2008 10:33:42AM	
100,333	Accept	9/3/2008 10:32:16AM	
100,334			

Figure D-1
(continued)

Non-Conforming Report for:
9/3/2008

Project:	Pour Trailer:	Serial Number:	Removed From:	Date / Time Removed:
60MM				
08090309471009	1009			
		100141	Production	9/3/2008 10:20:00AM
			Explosive on Threads	
		100185	Production	9/3/2008 10:19:00AM
			Explosive on Threads	
08090309561017	1017			
		100327	X-Ray	9/3/2008 10:36:00AM
			Individual Cavity Accept / <= .5 sq in / In Zone A, Cracks Sum of Accept / <= 4 ea / In Zone A, Base Separation Defect / > .031 in / In Zone A	
		100331	X-Ray	9/3/2008 10:34:00AM
			Piping Cavity Defect / > .25 Wide in / In Zone A	

Figure D-2
Report showing details on rejected projectile

Process List

Project:		Process:	Station:	Process Type:	Manual/Auto	Tracking Type	
		Parameter		*UOM*	*Low Range*	*High Range*	*Target Range*
60MM							
	1	**Trailer Setup** Create Serial Numbers and Place Projectiles in Trailer	1005A	Setup	Manual	Trailer Tracking	
	2	**Pour Prep** Prep Projectiles for Pour	1006C	Standard	Manual	Trailer Tracking	
		1 Number of Projectiles		seconds	63	65	64
	3	**Pour** Fill Projectiles with Explosives	1006A	Standard	Manual	Trailer Tracking	
	4	**Take to Cooling** Connect Trailer toBegin Cool Down Process	1006C	Grid	Manual	Trailer Tracking	
		1 Cooling		Minutes	9	11	10
	5	**Take off Shroud** Take Shroud off Pour Trailer	1006C	Standard	Manual	Trailer Tracking	
	6	**Facing** Do Facing on Projectiles	1006D	Standard	Manual	Trailer Tracking	
	7	**Inspection Station** Inspect Projectiles for fill	1006D	Quality Inspection	Manual	Trailer Tracking	
	8	**X-Ray Bomb Bodies** X-Ray Bomb Bodies	1019X	X-Ray	Manual	Trailer Tracking	
	9	**Wait for X-Ray Release** Wait for X-Ray to Release projectiles	1019G	X-Ray Inspection	Manual	Trailer Tracking	
	10	**Release To Assembly** Release Projectiles to the Assembly Process	1011Ew	Standard	Manual	Trailer Tracking	
	11	**Install fuze, adapter, and ta** Install fuze, adapter, and tailfin	1011E	Standard	Auto	Projectile Tracking	
	12	**Torque fuze, adapter, and t** Torque fuze, adapter, and tailfin onto body	1011F	Standard	Auto	Projectile Tracking	
	13	**Pass through the alignmen** Pass through the alignment gage	1011G	Standard	Auto	Projectile Tracking	
	14	**Install prop charge.**	1011H	Standard	Auto	Projectile Tracking	

Page 1 of 2

Figure D-3
Process List for Material Tracking

Project:	Process:	Station:	Process Type:	Manual/Auto	Tracking Type
	Parameter	*UOM*	*Low Range*	*High Range*	*Target Range*
	Install prop charge				
15	**Packaging** Projectile into tube	1011lw	Packaging	Manual	Projectile Tracking
16	**Packaging** Tube into can	1011le	Packaging	Manual	Projectile Tracking
17	**Packaging** Can into Box. Then place box on Pallet	1011K	Packaging	Manual	Projectile Tracking

Figure D-3
(continued)

APPENDIX E
SALT FOG TESTING PROCEDURES AND RECORDS

The procedure adhered to throughout all tests was ASTM B 117-07a:

"Standard Practice for Operating Salt Spray (Fog) Apparatus".

Our fog chamber apparatus used for all testing was from Industrial Filter & Pump Mfg. Co. Serial number S-2408; Type CA1.

Salt solution: for all tests: local tap water was used along with a 5% mix of salt. The salt used in all tests was: Salt (NaCl) from GFS Chemicals, lot # L821108. Purity was greater than 99.9%, therefore no test for halides was conducted per ASTM B 117-07a.

The scales used in mixing the 5% salt solution was a Fairbanks Morse, 250lb scale; ¼ lb graduation.

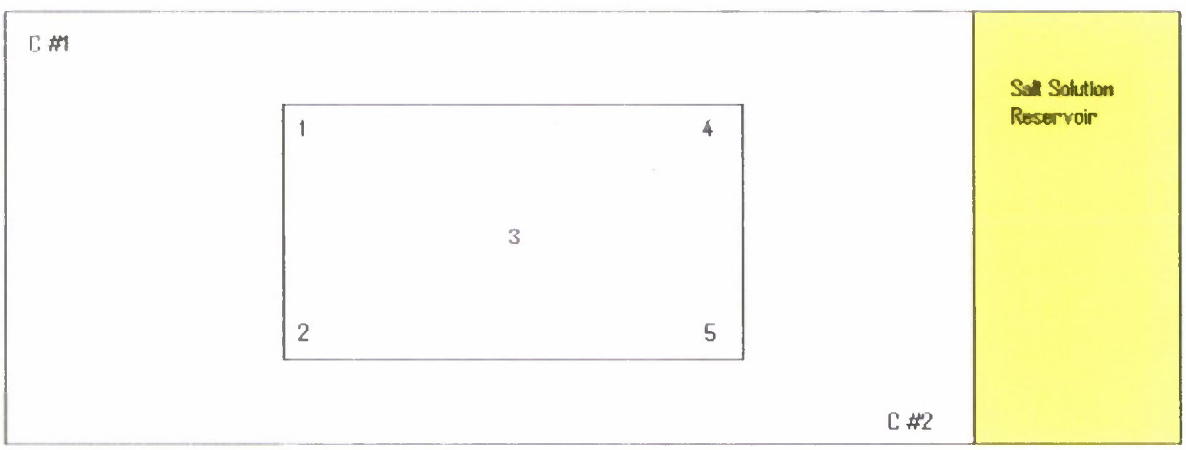
The pH meter used in all testing was from Fisher Scientific. Accumet pH meter 925.

Specific gravity was obtained in all testing with a hydrometer, measuring from 1.000 to 1.200 in .005 increments.

60-mm salt fog test records

Test #1: Started 15JUL08.

1220 hrs: Chamber air temp: 70°F.
pH at start: 7
Fog collecting cylinders #1 and #2: Empty
Parts tested and collectors were arranged as follows:



C #1=Cylinder #1 C #2=Cylinder #2
1=Serial #100046 2=100045 3=100047 4=100050 5=100054
Unit was started at this time with the temperature control on "HI".
Air regulator was set at 12psi.

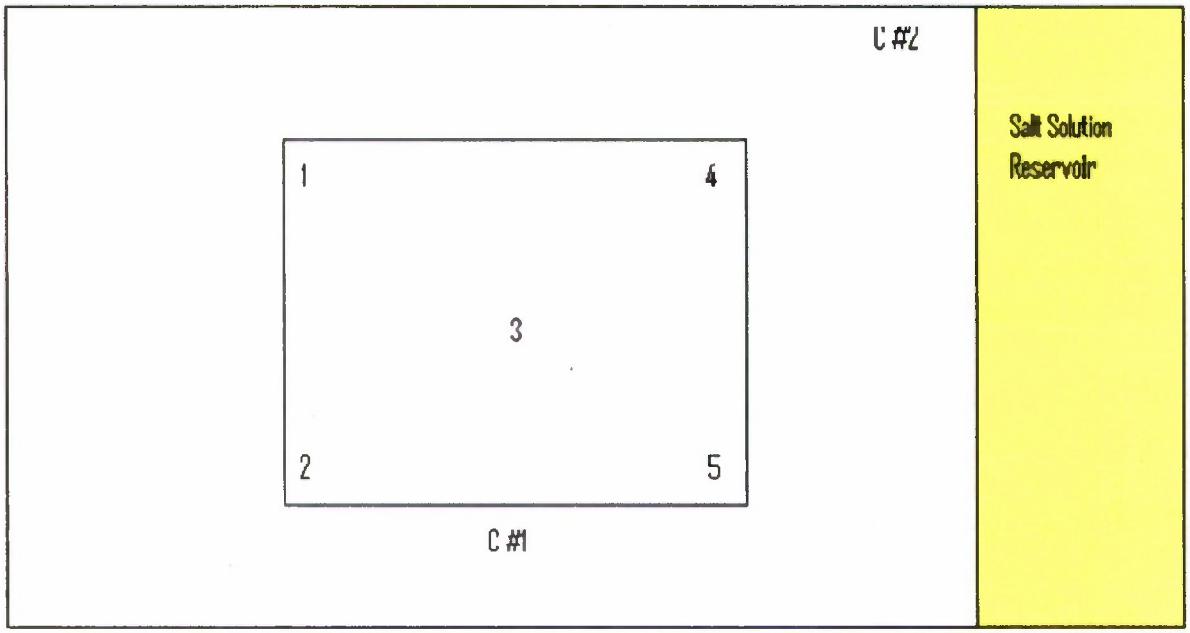
1420 hrs: Unit temperature switch set to "LOW".
Chamber air temp: 96°F.

1602 hrs: Stopped air flow to fill the heater reservoir.

1605 hrs: Started air flow. Chamber air temp: 97°F.

16JUL08

0639 hrs:	Chamber air temp: **96°F.**
1220 hrs:	Chamber air temp: **97°F.** Stopped air flow to fill heater reservoir and to allow the fog to settle. Turned unit power off.
1233 hrs:	Opened the unit and removed both collection cylinders. C #1 measured **68mL** with a pH of **4.4**. C #2 measured **70mL** with a pH of **4.4**. **10cc** of **Sodium Hydroxide** was added to the salt solution reservoir to raise the pH level. C #1 and C #2 were re-positioned as shown below:



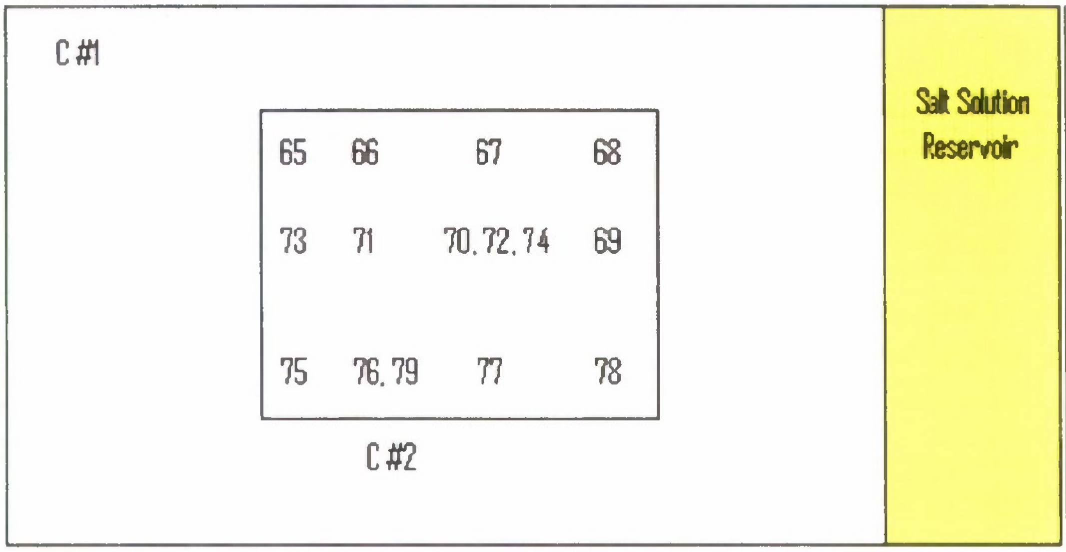
1256 hrs:	Started unit power on "HI". Chamber air temp: **90°F.**
1312 hrs:	Unit power set to "LOW". Chamber air temp: **94°F.**
1615 hrs:	Stopped air flow to refill heater reservoir.
1617 hrs:	Re-started unit on "LOW" power.

17JUL08

0630 hrs:	Chamber air temp: **97°F.**
1341 hrs:	Unit power and air turned off. Chamber air temp: **96°F.** C #1 measured **62mL** with a pH of **6.9** C #2 measured **89mL.** The pH level was not taken due to the presence of contaminants. Specific gravity measured **1.045.**

Test #2: Started 22JUL08

1435 hrs: Test bodies and collection cylinders were placed in the following order:



The above numbers are the last two of each body's serial number. "70, 72, 74" and "76, 79" are multiple barcodes and serial numbers on one body. "C #1 and #2" are collection cylinders.

Note: The following lists each serial number and the power the laser was set at While etching the barcode and serial number:

Serial number	% laser power used in etching
100065	35 (double yellow stamp on body)
100066	35
100067	35
100068	30
100069	30
100070	28
100071	28
100072	26
100073	26
100074	24
100075	24
100076	22
100077	22
100078	23
100079	23

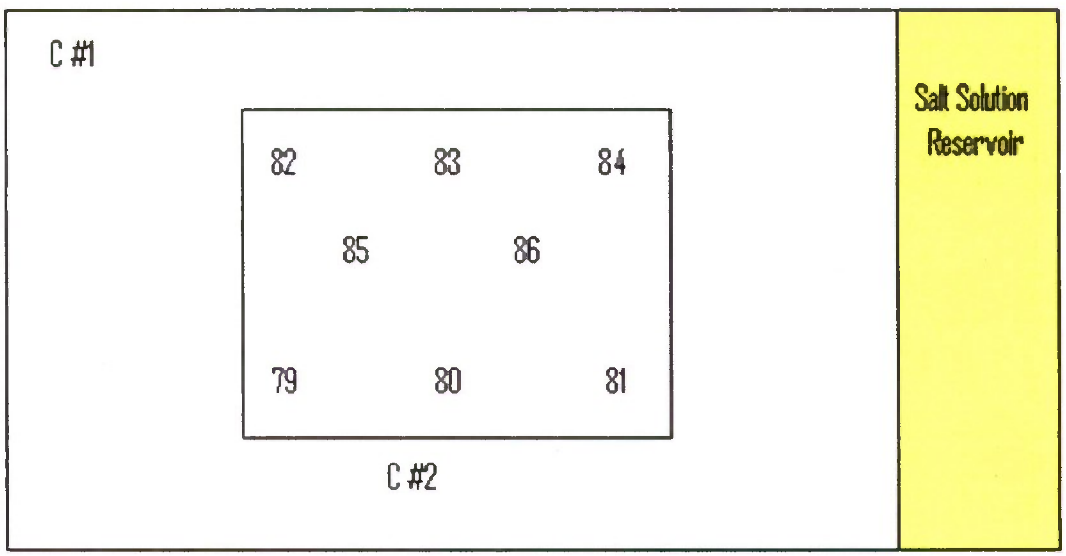
1453 hrs: Unit started on "HI" power. Air pressure regulator was set at 10psi. Specific gravity of solution measured **1.035**. The pH level was **7.2**. Chamber air temp: **78°F**.

1553 hrs: Unit power set to "LOW". Chamber air temp: **95°F**.

23JUL08
0652 hrs: Chamber air temp: **97°F**. Air flow stopped to fill heater tank.
0655 hrs: Re-started air flow at 10psi.
1455 hrs: Unit power and air were turned off to remove the collection cylinders. C #1 measured **48mL**. C #2 measured **50mL**. The pH level was **6.6**. Both cylinders were placed the same as above.
1505 hrs: Unit re-started on "LOW" power. Chamber air temp: **92°F**. Heater tank was re-filled and air pressure regulator was set to 9psi.

24JUL08
0640 hrs: Chamber air temp: **97°F**.
1457 hrs: Unit power and air were turned off. Test bodies and both collectors were removed. C #1 measured **42mL**. C #2 measured **47mL**. The pH level was **6.5**.

Test #3: **Started 28JUL08**
0945 hrs: Test bodies were arranged as follows:



"C #1 and #2" are collection cylinders.
The above numbers are the last two of each body's serial number.
The following is in reference to the laser power settings for the barcode and the serial number on each body:

Body	Barcode	Serial Number
100079	26%	30%
100080	26%	30%
100081	26%	30%
100082	27%	28%
100083	27%	28%
100084	27%	28%
100085	35%	35%
100086	35%	35%

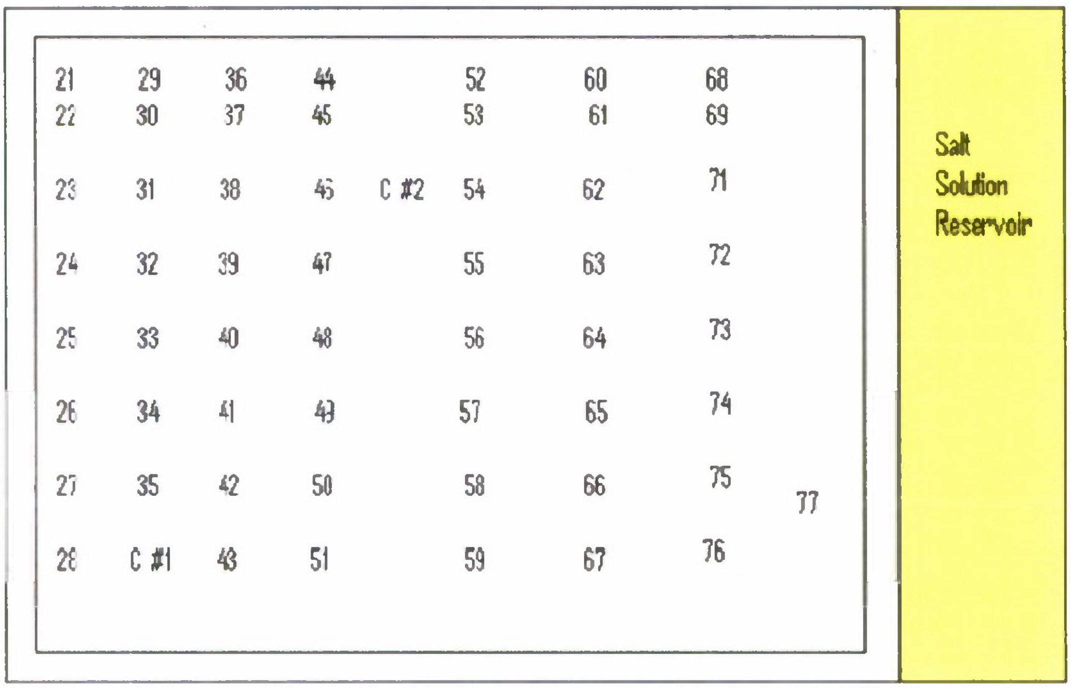
Unit power set to "HI". Air pressure regulator was set to 8psi. The pH level was **7.1** and the Specific gravity was **1.035**. Chamber air temp: **75°**.

1100 hrs: Chamber air temp: **95°F**. Unit power set to "LOW".
1554 hrs: Stopped air flow to re-fill the heater tank.
1556 hrs: Re-started air flow. Chamber air temp: **98°F**.

29JUL08
0945 hrs: Unit power and air were turned off to remove the collection cylinders. C #1 measured **40mL**; C #2 measured **45mL**. The pH level was **6.9**. Re-filled the heater tank.
1000 hrs: Unit re-started.
1600 hrs: Chamber air temp: **98°F**. No water was needed in the heater tank.

30JUL08
0730 hrs: Chamber air temp: **98°F**.
1000 hrs: Unit power and air was turned off. C #1 measured **39mL;** C #2 measured **44mL**. The pH level was **7.0**. Specific gravity was **1.035**.

Test started: 25AUG08
1030 hrs: The test bodies and collecting cylinders were arranged in the following manner:



"C #1 and #2" are collection cylinders. The numbers above are the last two numbers in each body's serial number.
*Serial Number "100070" was not used in this test.
Specific gravity measured **1.035** and the pH level was 7.1
Note: Due to a mechanical failure, the test was not started at this time.

26AUG08

0850 hrs: Unit power set to "HI"; air pressure was set at 7psi. Chamber air temp: **70°F**.
1005 hrs: Chamber air temp: **92°F**. Unit power set to "LOW".
1529 hrs: Air flow was stopped to re-fill the heater tank.
1531 hrs: Air flow was re-started at 7psi. Chamber air temp: **96°F.**

27AUG08

1100 hrs: Unit power and air turned off to remove collectors. C #1 measured **37mL**; C #2 measured **48mL**. The pH level was **7.1.**
1505 hrs: Chamber air temp: **98°F**. Water levels are OK.

28AUG08

1000 hrs: Unit power and air were turned off. C #1 measured **36mL**; C #2 measured **70mL** possibly catching a drip from an edge. The pH level was only tested From C #1 as C #2 had contaminants present. The pH level was **7.2**. Specific gravity measured **1.035.**

Serial	P/F	Barcode Laser Power	Number Laser Power	Barcode Read Attempts	Details
100065	F	35%	35%	2	Double stamp yellow pad to test effects of yellow paint thickness. Laser still too strong
100066	F	35%	35%	1	failed
100067	P	35%	35%	1	passed, possibly thicker green paint than others
100068	F	30%	35%	1	2 very small specs of iron oxide
100069	F	30%	35%	2	2 very small specs of iron oxide
100070	F	28%	35%	1	very small spec of iron oxide
100071	P	28%	35%	1	passed, slight dark areas, but doesn't look like oxidation
100072	P	26%	35%	1	pass, nonoticable oxidation
100073	P	26%	35%	2	pass, nonoticable oxidation
100074	P	24%	35%	5	Pass, laser power getting a little low, no noticable oxidation
100075	P	24%	35%	1	Pass, laser power getting too low, oxidation from runoff of numbers not the barcode
100076	P	22%	35%	1	Pass, laser power getting too low, no noticable oxidatior
100077	P	22%	35%	1	Pass, laser power getting too low, no noticable oxidatior
100078	P	23%	35%	2	needed 2 reads -yellow paint remaining in corner, oxidation from run off not barcode
100079	P	23%	35%	NoRead	Pass because no oxidation, NoRead because overlap of yellow paint, error on DZI part

Figure E-1
Report of salt fog testing for 7-24-08

Serial	P/F	Barcode Laser Power	Number Laser Power	Barcode Read Attempts	Details
100079		26%	30%	1	no noticable oxidation
100080		26%	30%	1	oxidation in barcode & number block, large quantity of oxidation on entire bomb body. Speculate green coating not to spec
100081		26%	30%	1	slight indication of oxidation in barcode
100082		27%	28%	1	no noticable oxidation
100083		27%	28%	1	slight indication of oxidation in barcode
100084		27%	28%	1	no noticable oxidation
100085		35%	35%	1	no noticable oxidation
100086		35%	35%	1	no noticable oxidation

Figure E-2
Report of salt fog testing for 7-30-08

Figure E-3
First salt spray result, laser power 30%

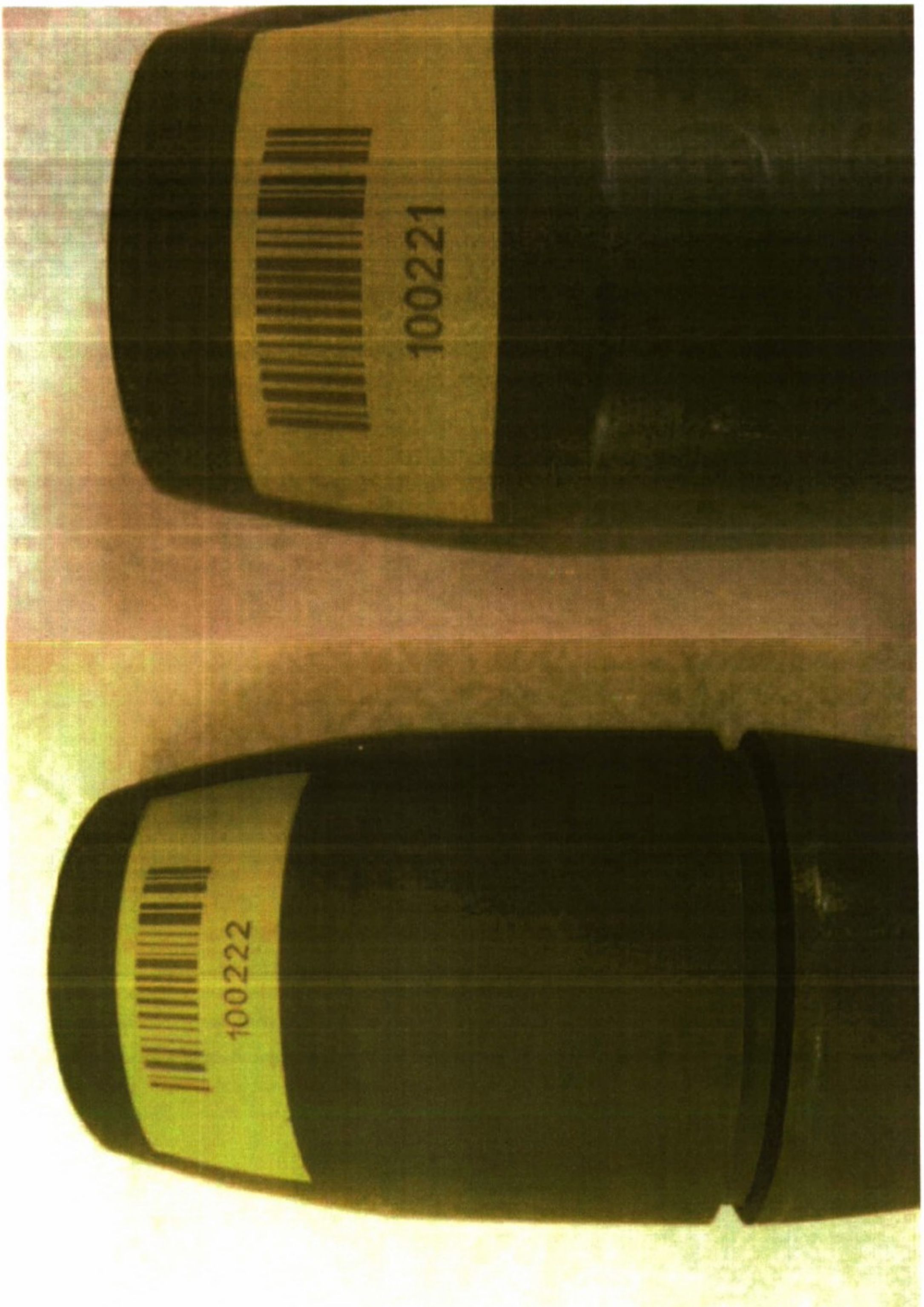


Figure E-4
Final salt spray test, laser power 27%

APPENDIX F
SYSTEM REQUIREMENTS FOR MATERIAL TRACKING SYSTEM

The minimum system requirements for workstations are as follows:

- Pentium-class processor running at 233 MHz or better
- 128 MB RAM
- 1.5 GB hard drive
- CD or DVD-Rom drive
- Keyboard and mouse
- SVGA (800x600) resolution monitor
- A connection to a server
- A bar code reader or reader/writer

Minimum system requirements for the server are as follows:

- Windows Server 2003 standard edition
- SQL Server 2005
- Pentium-class processor running at 133 MHz
- 128 MB RAM
- 2.9 GB hard drive
- SVGA (800x600) Monitor
- CD or DVD-ROM drive

In addition to the above minimum software and hardware requirements, Label Matrix V.7.0.0 is required to be available on any workstation that will be printing barcodes and Crystal Reports v. 11.0.0 is required on any station that needs to access the reports generated from the data received. A bar code printer is required as well however the type and number of printers required will depend on the individual product line logistics and configuration.

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