TEST REPORT

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REPORT NO. 44908-01
OUR JOB NO. 44908
YOUR P. O. NO. Verbal
CONTRACT N/A
PAGE 1 of 250 PAGE REPORT
DATE October 23, 1996

QUALIFICATION TESTING
OF THE
ACCU-VOTE ES-2000
VOTE TALLY SYSTEM

For

Global Election Systems, Inc.
Albuquerque, NM 87107

STATE OF ALABAMA
COUNTY OF MADISON } AL Professional Eng. Reg. No. 16011

Joseph T. Hazeltine, PE being duly sworn, deposes and says: The information contained in this report is the result of complete and carefully conducted testing and is to the best of his knowledge true and correct in all respects.

Joseph T. Hazeltine

SUBSCRIBED and sworn to before me this 27 day of Nov 1996

Notary Public in and for the State of Alabama at large

My Commission expires Dec. 27 1998

Wyle shall have no liability for damages of any kind to person or property, including special or consequential damages, resulting from Wyle's providing the services covered by this report.

PREPARED BY 11/25/96
J. R. Dearman, Project Engineer

APPROVED BY 11-26-96
D. P. Sandlin, Engineering Supervisor

WYLE Q. A. 11-27-96
R. G. Thomas, Q.A. Manager

(pap)

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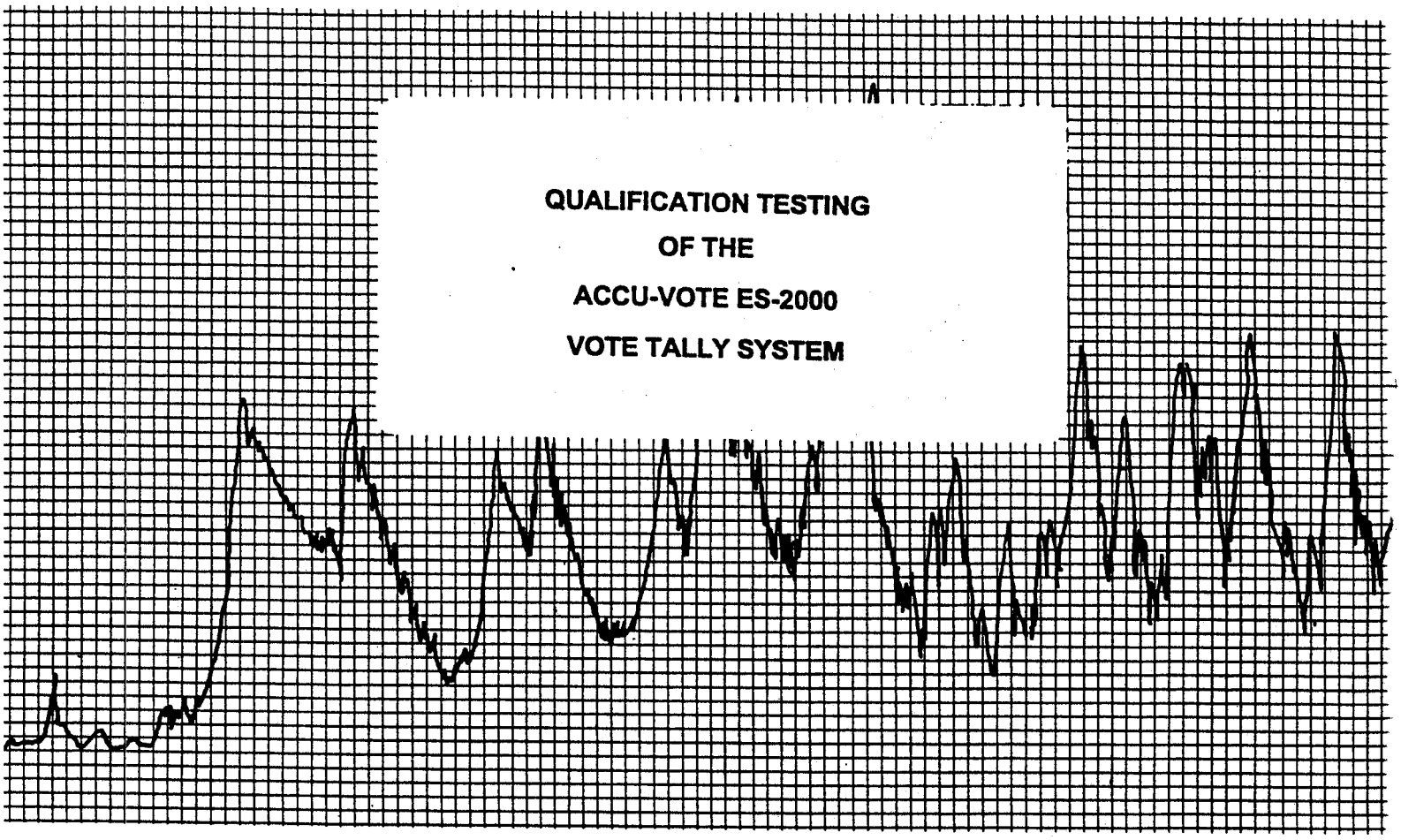

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1.0 INTRODUCTION

1.1 Scope

This report presents the Qualification Test Procedures and Test Results for the Global Elections Systems, Inc. Accu-Vote ES-2000 Vote Tally System.

1.2 Objective

The objective of this test program was to verify that the Accu-Vote ES-2000 Voting Machine, P/N 79810, and the associated Accu-Vote Operating Firmware, Version 1.94f, complied with the requirements of their own design specifications and with the guidelines of the Federal Election Commission (FEC) National Voting System Standards, January 1990.

1.3 Summary

Qualification testing includes the selective in-depth examination of software; the inspection and evaluation of system documentation; tests of hardware under conditions simulating the intended storage, operation, transportation, and maintenance environments; and operational tests verifying system performance and function under normal and abnormal conditions. Qualification testing is currently limited to the Voting Machine and associated resident machine firmware/software. Due to the varying requirements of individual jurisdictions, it is recommended by the FEC Standards that local jurisdictions perform pre-election logic and accuracy tests on all systems prior to their use in an election in their jurisdiction.

The Accu-Vote ES-2000, hereinafter referred to as the Accu-Vote, is a Marksense Electronic Voting System manufactured by Lynro Manufacturing of Honeoye Falls, NY, a wholly-owned subsidiary of Global Election Systems. The Accu-Vote accepts paper ballots inserted by the voter. Individual machine totals, including audit logs, are generated at the precinct level upon poll shutdown. Memory card technology allows for the transfer of vote totals to a central site for canvass report generation.

The Accu-Vote and associated Operating Firmware, Release 1.94f, was subjected to Environmental, Reliability, and System-Level Tests. It was demonstrated that the Accu-Vote and associated Operating Firmware successfully met the required acceptance criteria and, thus, meets the Qualification Test requirements of the Federal Election Commission Standards for Punchcard, Marksense, and Direct Recording Electronic Voting Systems, January 1990. Qualification testing (in-depth source code review and functional tests) did not include the Vote Tally System election management software which is run on a personal computer separate from the Accu-Vote. However, its use as an inherent part of the election management activities is discussed within the context of this report and the results observed during its required use (election definition, canvass report generation) are reported herein.

4.0 TEST HARDWARE/SOFTWARE DESCRIPTION

4.1 Hardware

4.1.1 Accu-Vote ES-2000

The Global Election Systems Accu-Vote Voting Machine is a Marksense Voting System used to read and tabulate ballot cards at the polling place. The Accu-Vote is capable of reading and processing ballots 8 1/2 inch wide and either 11 inch, 14 inch, or 18 inch long. Both ballot sides are read simultaneously by visible light sensors, in all possible orientations. The sensor circuit card on each side of the reader scans 34 columns on each ballot side. All voting marks of the printed ballot are aligned with these columns. The Accu-Vote requires ballots made of 90- to 110-pound paper stock.

The Accu-Vote is powered with a switching 5- and 14-volt power supply which also provides filtering and transient suppression. The Accu-Vote is supplied with a battery backup power in the event of an AC power failure.

The Accu-Vote is operated by the program (firmware) stored on EPROM chips within the machine. The firmware is upgraded by replacing ROM sets and the upgrade is reflected by ROM release numbers such as 1.94f.

The Accu-Vote has a 2 x 16 character LCD unit with an intelligent on-board controller. It is used to display messages and prompts in each of a memory card's election modes as well as diagnostic and setup information.

The Accu-Vote contains a light-weight, seven wire dot matrix M-180 Series EPSON printer controlled directly by the on-board CPU, which prints 24 columns on 2 1/4 inch wide paper. Both the ink cartridge and the paper roll are replaceable using basic changeout procedures.

A device for deflecting write-in or blank ballots to alternate compartment paths is driven directly from the on-board CPU. The deflector motor is driven with 14 volts DC power.

The Accu-Vote weighs approximately 15 pounds and requires 115 VAC, 60 Hz nominal power. A padded nylon carrying case is used for transporting the Accu-Vote on election day.

Memory cards are used to store precinct, ballot and election result information for each Accu-Vote. Memory cards are only required for precinct polling. The memory card interface accepts 32 Kbyte and optionally 64 Kbyte and 128 Kbyte credit-card sized EPSON memory cards. A memory card has 40 terminals covered by a spring-loaded shutter which is automatically pushed back upon insertion into the memory card interface. These terminals fit into the interface's 40-pin socket.

The manufacturer's data sheet states that the average life of the battery in the 32-Kbyte RAM card is approximately 10 years. The average battery life for the 64 Kbyte Ram card is approximately 8.5 years and the average battery life for the 128-Kbyte RAM card is about 5.7 years.

6.0 MATERIALS REQUIRED FOR TESTING (Continued)

6.4 Deliverable Materials

Global Election Systems provided the latest versions of all hardware and software specifications and poll-worker hardware and software user/maintenance manuals. All manuals were associated with an identifiable version number. Reference Paragraph 2.0 for a listing and version of the applicable documentation provided.

7.0 TEST SPECIFICATIONS

Qualification testing and a documentation review were performed to ensure that the Accu-Vote and associated resident firmware were in compliance with the design and functional requirements contained within the following paragraphs. The Election Management Software (Vote Tally System), where required for Qualification testing (e.g., defining an election, Memory Card programming, generation of canvass reports), was observed for proper functionality within the Accu-Vote system environment.

7.1 Environmental Subsystem

7.1.1 Shelter Requirements

The Accu-Vote can be operated or stored in any enclosed and habitable facility ordinarily used as a warehouse or polling place.

7.1.2 Space Requirements

The Accu-Vote unit and associated Ballot Box requires a 24 inch by 24 inch area for installation. It is recommended that a clear area be provided in front of the unit, large enough to allow easy access by voters (including wheelchair access).

7.1.3 Electrical Supply Requirements

The Accu-Vote operates on a standard electrical supply of 115 Vac, 60 Hz, Single Phase power. The unit is provided with a battery (1.2 Vdc, 1.2 Ahr) for power backup in the event of a facility power failure. A fully-charged battery will allow for operation of the unit for a period of approximately two hours at a rate of one ballot read per minute. The battery powered period of operation does not include the printing of any output reports. If reports are printed under battery power, the period of operation will be reduced.

7.2 Ballot Definition Subsystem

7.2.1 Administrative Database

The administrative database is maintained by the Vote Tally System Software (VTS) that is installed on a personal computer used at a central location. It allows for the defining of jurisdictional information, creating elections, performing test elections, defining security parameters, archiving election results and other various administrative type procedures.

7.0 TEST SPECIFICATIONS (Continued)

7.2 Ballot Definition Subsystem (Continued)

7.2.5 Election Programming (Continued)

During Qualification testing, several simulated elections were defined using the Electronic Precinct Manager software. These contests included various logical definitions of the ballot, including the number of allowable choices for each office and contest. Additionally, the presence of political subdivisions for voters of different geographical boundaries was demonstrated through the use of distinct ballots assigned to individual precincts. The defined elections were downloaded onto the Memory Cards and transported to the Accu-Vote where they were uploaded. The machines were then successfully voted.

7.2.6 Ballot Printing or Display

The VTS can print sample ballots for any preferred layout from a laser printer. These sample ballots can be reviewed for layout proofing.

The ballots created during Qualification testing were reviewed to ensure that the proper allocation of space and type fonts used for each active voting position was not perceived as showing favoritism toward one candidate/issue over another. All ballots observed were judged to be appropriate.

7.2.7 Ballot Validation

Tests can be performed on each memory card to validate the correctness of election programming and the correspondence of the ballot display with the installed election data. Ballot card testing is performed in Pre-Election Mode after a memory card has been programmed. The Accu-Vote prompts "Test Ballots" on its menu display. When this is selected, the operator can proceed to test either unvoted or fully-voted ballots of each style produced for the election and produce associated test reports.

7.3 Control Subsystem

7.3.1 Equipment Preparation

The preparation of the equipment consists of the Diagnostic Mode operations detailed in the Accu-Vote Operator's Guide. The Diagnostic Modes include tests for the machine's LCD display, printer, system memory, ballot deflector, as well as setting the system clock and other equipment preparation activities and tests. Hardware oriented activities (i.e., pre-election maintenance and repair activities) are further detailed in the Accu-Vote Hardware Guide.

7.0 TEST SPECIFICATIONS (Continued)

7.3 Control Subsystem (Continued)

7.3.4 Opening the Polling Place

The Accu-Vote is readied for voting by powering the unit on. It then proceeds to go through a startup diagnostics, and if successful, proceeds to print out a Zero Totals Report. At this time, the machine is ready and can be voted.

7.3.5 Error Recovery

Non-catastrophic errors and malfunctions are recoverable and within the operator's ability to correct. Any unaccepted ballot errors are explained, with probable cause and solution comments, in the Accu-Vote Operator's Guide under the Analyzing Unaccepted Ballots Chapter.

Other errors that could be displayed on the Accu-Vote's LCD are explained with probable cause and solution comments in the Accu-Vote Operator's Guide under the Accu-Vote Messages Chapter.

Also available is an election day trouble shooting guide that explains error messages that could appear on election day. This information can be found in the Accu-Vote Operator's Guide under the Election Day Chapter, Election Day Trouble Shooting section.

If the Accu-Vote unit becomes inoperable, a new device can be substituted in its place. All voting data is stored on the memory card. When the memory card is inserted into the replacement unit and the unit's power switch is turned on, ballot counting can resume.

During Qualification testing, there were no errors encountered which resulted in a non-recoverable situation (i.e., machine shutdown/lockout which precluded the ability to read votes already recorded).

7.3.6 Closing the Polling Place

Closing the Polls is performed by inserting an Accu-Vote Ender Card into the ballot reader. At this time, the Accu-Vote will automatically print an Election Results Report. Additional ballots cannot be read.

7.3.7 Polling Place Reports

The Accu-Vote can produce two types of election results reports, the Short Report and the Long Report. The short report includes the election title, the election date, the election type, the voting center number, and the time and date of the report. It includes the number of non-absentee and absentee ballots read, if applicable to the precinct, and the results of each participating race including the race title, the race number, the number of write-ins and candidates, and polling results. The long report includes all of the information contained in the short report as well as the ballot rejection parameters as specified during election definition, including overvoted races, blank voted races, undervoted races, all blank races, straight party

7.0 TEST SPECIFICATIONS (Continued)

7.4 Recording Subsystem (Continued)

7.4.3 Ballot Boxes

The Ballot Box produced for use with the Accu-Vote is a plastic container which incorporates locks on every door or plate which allows access to the voted ballot areas. The Ballot Box contains a separate compartment for the segregation of unread ballots and a separate compartment for write-in voted ballots. The segregation of write-in voted ballots is an option chosen by the jurisdiction during the programming of the election using the VTS Software. The Ballot Box includes a temporary storage compartment which retains ballots in the event of a machine failure. This compartment would be used to place voted ballots during the election until a replacement machine could be brought in.

Inspection of the temporary storage compartment revealed that the compartment door, with enough force, could be bent back far enough to allow unauthorized access. Consideration to the design of this particular door and possible modification to its design should be considered in future versions of the ballot box.

7.5 Conversion Subsystem

7.5.1 Ballot Handling

The actions of the P&M Conversion Subsystem (reader) are controlled by the CPU board and its program. The length of the reader's paper path is four inches. With the Accu-Vote unit installed in a Ballot Box, the description of the handling of a ballot by the reader is as follows.

An infrared sensor (PAPER IN), positioned forward of the drive mechanism, detects the presence of a ballot entering the reader. The PAPER IN detection starts the reader drive motor. The reader drive motor is engaged by pulleys and an 0-ring to two drive shafts that are positioned fore and aft of the sensing circuitry. Each of the drive shafts has a rubber pinch roller positioned in the center of the ballot width which bears down onto an idler bearing. When the leading edge of the inserted ballot reaches the forward pinch roller, it is pulled into the reader causing the voter to release the ballot. The ballot is drawn through the sensing circuitry where the timing marks and voting positions are scanned. As the leading edge of the ballot proceeds past the sensing circuitry, it reaches the aft pinch roller. The aft pinch roller engages the ballot and continues to pull the ballot through the sensing circuitry. Once the leading edge of the ballot passes the aft pinch roller, another infrared sensor (PAPER OUT), positioned rearward of the aft drive mechanism, detects the presence of the ballot. When timing marks along the ballot's top left edge are no longer detected by the sensing circuitry for a specific period of time, the motor is instructed to continue running for a finite period of time based on the sensed speed of the ballot. When this finite period of time expires, the sensing circuitry will have read all timing marks and voting positions for that ballot and the ballot will still be held by the aft pinch rollers. While the CPU board's program decides upon the ballot's acceptance or rejection, the motor is instructed to reverse its direction for another finite period of time based on the sensed ballot speed. If the ballot is

7.0 TEST SPECIFICATIONS (Continued)

7.6 Ballot Reading

7.6.1 Reading Accuracy

All potential voting positions on a ballot can be tested with a Diagnostic Test ballot card.

During Qualification testing, the Accu-Vote was subjected to a large volume Vote Reading Accuracy/Reliability Test. Over a minimum 163-hour period, 100 ballots (containing 65 cast votes out of 95 possible within 8 races) were fed through four individual Accu-Vote machines on an hourly basis. By the end of the 163 hours, each machine had accumulated approximately 312,000 votes. Upon inspection of the machine totals, it had been observed that some readings had been recorded in error. This anomaly was also observed during System Level testing. After further analysis and tests, it was concluded that the miscount was occurring because the leading edge of the candidate's name, combined with inherent ballot skewing as the ballot is pulled through the machine, was resulting in the leading edge of the candidate's name being picked up as a vote. This resulted in a change in the Global Elections Ballot Specification Guide. Previously, the voting zone, the area designated as the voting position, was defined as 0.125 inch to either side of the center of each oval by 0.100 inch above and below the center of the oval. The leading edge of the candidate's name on the ballots initially provided for Qualification testing was found to be within approximately 0.010 inch of the edge of the oval. As a result of the findings, new ballots were printed with the leading edge of the candidate's name no closer than approximately 0.125 inch to the edge of the oval. The four Accu-Vote machines were again subjected to the high volume ballot reading test. The results of three of the four machines, upon surpassing the minimum required 297,589 votes, were found to have recorded each voted position accurately. However, a fourth machine had recorded one miscount which was attributed to one of the older type ballots being inadvertently mixed into the new ballot test deck. The fourth machine was subjected to reading an additional 456,342 votes. Upon completion, the fourth machine totals were reviewed and found to be correct. As a result of the anomaly, Global Election Systems revised their Ballot Specification Guide to reflect an increase in the voting zone. The revised voting zone measures 0.185 inch to either side of the center of the oval by 0.100 inch above and below the center of each oval. The new voting zone parameters are contained in the revised Ballot Specification Guide, Revision D, August 27, 1996.

Notice of Anomaly No. 2 documents the occurrence of the aforementioned anomaly.

7.0 TEST SPECIFICATIONS (Continued)

7.7 Processing Subsystem (Continued)

7.7.1 Processing Accuracy (Continued)

During Qualification testing, no anomalies associated with the processing accuracy were observed.

Global Election Systems reports that during in-house testing performed on the processing system, Global has had Diagnostic Memory Card Tests running on three Accu-Vote machines for a period of approximately four months. Two machines had 32 kB memory cards installed and one machine had a 64 kB memory card installed. Each pass of the Diagnostic Memory Card Test performs four read and four write operations on each byte of memory in the memory card. At the time of the Technical Data Package submittal of this report, five million passes had run continuously with no errors (half that many passes for the 64 kB memory card). The tests are still running at this time with no errors being experienced.

The number of bits processed per Accu-Vote as reported in Global Election System's Technical Data Package is calculated as follows:

$$32 \text{ kB} \times 8 \text{ bits/byte} = 262{,}144 \text{ bits}$$

$$8 \text{ operations/bit} \times 5{,}000{,}000 \text{ passes} = 40{,}000{,}000 \text{ operations/bit}$$

A total of 10,490,000,000,000 data bits have been processed in each of three Accu-Vote units without error (the 64 kB memory card would have half the test passes but twice the number of bits as a 32 kB memory card).

The Diagnostic Memory Card Test exercises the CPU ALU, the read/write controls, the memory control logic, the data bus, the address bus, the EPROM, the memory locations in the memory card, and the memory card status logic.

The CPU is operated at a speed of 7.5 MHz with the memory card access at two wait states plus a READY signal.

7.7.2 Memory Stability

The voting data is stored on the removable memory card which resides in the Accu-Vote during election day voting. The battery life in a 32 kB memory card is 10 years. The battery life in the 64 kB memory card is 8.5 years and 5.7 years for the 128 kB memory card per the manufacturer's specifications based upon storage in an ambient controlled environment.

7.0 TEST SPECIFICATIONS (Continued)

7.9 Voter Data Management Subsystem (Continued)

7.9.1 Data File Management (Continued)

The Accu-Vote uses a proprietary Basic interpreter built into the firmware for report generation except for the audit report. The source code is developed on the VTS host using a proprietary version of Basic known as Accu-Basic. Accu-Basic uses Basic-like constructs with database extensions to extract and format election data as required. The source is then compiled using the Accu-Basic compiler ab194. The object is then programmed onto the memory card, along with the other election data, during the memory card programming operation. The format for the audit report is fixed in the firmware and is generated directly from the C code.

Accu-Basic has no provisions for modifying election parameters, ballot information, or vote counters. It is designed to support variations in report format according to the particular report being printed and according to user responses to prompts. It is able to print detailed reports with results broken down as far as the counters provide and it can produce summary reports as needed.

8.0 PHYSICAL CHARACTERISTICS

8.1 Size

The Accu-Vote unit measures 16 inches x 14 inches x 3 inches. The Ballot Box which it rests upon during elections measures 37.5 inches x 24 inches x 24 inches.

8.2 Weight

The Accu-Vote is a "portable" unit that weighs 15 pounds. It is intended to be hand carried by one person using its carrying case. It can be operated on a table top, for demonstration purposes, or in the recess provided for in the top of the Ballot Box.

The Ballot Box is a "movable" unit that, when empty of ballots, weighs approximately 45 pounds. The Ballot Box is intended to be handled by one or two persons. A dolly or hand truck can be used to move the Ballot Boxes.

8.3 Transport and Storage

When transporting the Accu-Vote unit by hand carrying, it is intended that the Accu-Vote carrying case (PN 341-1111) be used. The Accu-Vote unit does not have any handles to facilitate hand carrying, but the carrying case does have handles and a shoulder strap.

When transporting the Accu-Vote by surface and/or air freight services, an Accu-Vote shipping container must be used. This container provides packaging materials that allow the Accu-Vote to withstand impact, shock and vibration loads, and stacking loads.

9.0 DESIGN, CONSTRUCTION, AND MAINTENANCE CHARACTERISTICS (Cont'd)

9.4 Durability

Global states that the design life of the Accu-Vote and Ballot Box is at least 10 years. The Accu-Vote's printer ribbon, paper roll, the power supply battery, and the memory card battery are all considered consumables. The Clock Chip IC is a Dallas Smartwatch ROM chip that resides below the "B" EPROM. This part is also considered a consumable. It has a battery embedded inside the chip package which has a life expectancy of 10 years.

9.5 Reliability

A Mean-Time Between Failure of a minimum of 245 hours was demonstrated during Qualification testing. A minimum 163 hours of failure-free operation is required by the FEC standards to demonstrate an adequate minimum Mean Time Between Failure threshold. However, in the event of an observed failure, the operating time is increased to 245 hours. During Reliability testing of the Accu-Vote, it was observed that one of four machines under test ceased to function. This was caused by a failure of the Visible Light Read Head. The affected part was replaced and testing was continued until the revised threshold, 245 hours of operation, had been obtained without any further operational failures. Notice of Anomaly No. 1 documents the anomaly and resulting disposition.

Global Election Systems included within the Technical Data Package, in-house reliability studies performed on the Accu-Vote and associated mechanical components based upon Manufacturer's MTBF data. The Global Election derived MTBF based upon these analyses resulted in an MTBF for the Accu-Vote System of 6786 hours and is based upon the Ballot Box Motor.

9.6 Maintainability

Maintenance actions can be performed on any aspect of the Accu-Vote or Ballot Box. Operational status of the Accu-Vote and Ballot Box systems and their elements can be determined by the Diagnostic Test routines which are described in the Accu-Vote Operator's Guide under Diagnostics Mode.

There are no adjustments available on the Accu-Vote except for the contrast adjustment of the LCD which is factory set with no need for adjustment after shipping to the customer.

The Ballot Box has a deflector mechanism that is adjustable. This is usually factory set with no need for adjustment after shipping to the customer. If it is necessary to adjust the Ballot Box deflector, the procedure is described in the "Accu-Vote Hardware Guide" under the Maintenance and Repair chapter.

The components having a specified operating life (e.g. the consumable items) are accessible through the Accu-Vote printer access cover. Replacement of these components is described in the Accu-Vote Operator's Guide under the Maintenance chapter and Repair chapter.

9.0 DESIGN, CONSTRUCTION, AND MAINTENANCE CHARACTERISTICS (Cont'd)

9.9 Maintenance Ratio (MR) (Continued)

The total maintenance man-hours (MMH) for the system, as stated by Global Election Systems, is 0.33 hours (20 minutes).

The operating time for the system is the time for pre-election testing and the time it is operated at the polling place. These functions consist of pre-election testing, opening the polling place, ballot counting, closing the polling place, and uploading the election results to the central computer.

The total operating hours (OH) for the system as stated by Global Election Systems is 13 hours.

The Maintenance Ratio (MR) is MMH/OH = 0.33 hr. /13 hr. = 0.025

9.10 Availability

The Availability (Ai) of the system is based upon the Global Election System provided MTBF and the MTTR.

System MTBF = 6786 hours System MTTR = 0.05 hours

Ai = (MTBF)/(MTBF + MTTR) = 6786 hr./(6786 hr. + 0.05 hr.) = 0.999993

9.11 Electromagnetic Radiation

In accordance with the FEC Standards, the Accu-Vote must meet the limits for FCC Part 15, Class B computing devices. A verification scan of the Accu-Vote was performed, and it was verified that the unit met the acceptance criteria for Class B operation.

The Open-Area Test Site used to collect the data is located on the grounds of Wyle Laboratories' Huntsville, Alabama Test Facility. The Accu-Vote was configured for test as it would be used during an election.

Attachment B contains the associated Electromagnetic Test Data.

9.12 Product Marking

A label attached on the rear of the Accu-Vote unit identifies the following items:

- Product Name
- Product Model Number
- Product Manufacturer (by means of a suffix on the model number)
- -01 indicates manufacture at Global Election Systems Inc., 1562 Rand Avenue, Vancouver, B.C. Canada V6P 3G2
- -02 indicates manufacture at Lynro Manufacturing Inc. (Division of Global Election Systems Inc.), 10 Carriage Street, Honeoye Falls, NY, USA 14472

9.0 DESIGN, CONSTRUCTION, AND MAINTENANCE CHARACTERISTICS (Cont'd)

9.15 Human Engineering (Continued)

9.15.1 Controls and Displays (Continued)

The LCD displays all status, control, and precinct ballot count information during operation of the Accu-Vote. The LCD has large legible characters that are readily viewable. When the Accu-Vote is attached to a Ballot Box, the Ballot Box height and the LCD mounting angle allow for viewing by voters and operators in wheelchairs. The YES and NO buttons are conveniently located below the LCD for responding to questions displayed on the LCD. The LCD is a reflective display and, as such, requires a minimum level of ambient light that would be typically present in a voting environment. The LCD displays a flashing "POWER FAIL" message when AC power has been lost. When the 12.0 VDC battery falls below a voltage level of 10.5 Vdc, the LCD displays a "BATT LOW" message in place of the "POWER FAIL" message, and the CPU automatically stops the processing of any more ballots.

10.0 SOFTWARE STANDARDS

10.1 Software Design and Coding

The Accu-Vote firmware was subjected to a source code review. The source code was inspected for how well it followed the recommended programming guidelines as contained in the FEC standards. This included a review for:

- **Simplicity:** the straightforwardness of the design, such as avoidance of complex structure and obscure algorithms.
- **Understandability:** the ease with which the intent and function of the code can be ascertained and verified.
- **Testability:** the construction of code so as to incorporate implicit or explicit points or features to the flow of data and control within modules and at module interfaces.
- **Robustness:** a property of software design that is enhanced by editing and range specification, by the incorporation of controls or traps for immediate detection of errors to prevent their propagation throughout the rest of the code, and by providing a means of recovery without loss of control or data.
- **Security:** the inclusion of provisions to prevent unauthorized access, or to detect and control it, should it be attempted.
- **Usability:** the ability of the Voting Machine to be operated without recourse to excessive or obscure control procedures (e.g., text messages rather than numerical error codes which require the user to consult a table).
- **Installability:** the ease with which a Voting Machine can be made fully operational after delivery.

10.0 SOFTWARE STANDARDS (Continued)

10.2 Configuration Management (Continued)

- the EPROM checksum used to verify the correctness of the code on the ROM, and,
- the date the release was made.

Prior to Release 1.92o, labels lacked the release type, the application, and the base language sections and, therefore, each variation required a separate release number. Details of the characteristics of each release are contained in associated release notes.

Global states that all firmware is developed in-house. The original prototype was developed under contract by the engineering firm that designed the processor board and then was passed to Global Election Systems in 1989. Since then, Global states that all aspects of the code have been substantially modified.

Ballots (and occasionally the associated election databases) are kept on file after being used to test new features. However, for the last few years Global states that they have had the ability to print ballots on demand and, thus, intended to keep a base set of election databases that were modified as needed to test particular features. These modified databases are kept on file for a reasonable time and then purged.

10.3 Data Quality Assessment

Assessment of data quality consists of real-time monitoring of power conditions combined with extensive validation of stored data each time a ballot is read. Power monitoring consists of hardware generated signals indicating A/C power failure and battery low conditions. An internet to the main processor is generated upon a power failure condition.

10.4 Vote Recording Accuracy and Integrity

10.4.1 Power Stability Validation

Power monitoring consists of hardware-generated signals indicating A/C power failure and battery low conditions. The battery low condition indicates imminent failure and causes the system to abort any current ballot and to not read ballots until the power situation is corrected. The transition to the A/C failure condition indicates possible power instability and causes the system to abort processing any current ballot. Normal processing then continues on battery power.

10.0 SOFTWARE STANDARDS (Continued)

10.4 Vote Recording Accuracy and Integrity (Continued)

10.4.3 Valid Mark Validation

Every voting position of every ballot is analyzed to determine whether it is blank, marked, or undefined. A mark is undefined if the machine detects that a mark is present but the mark is not strong enough to be certain that the voter intended to mark it. Should an undefined mark be detected in any position that could influence the interpretation of the votes, then the ballot is returned with the error "INVALID MARK."

10.4.4 Voting Validation

Reject parameters are defined for each election before the memory cards are programmed. These may be used to validate many local voting restrictions. Global recommends that, unless this conflicts with local requirements, blank voted ballots be rejected. Any reject parameter may be overridden for a specific ballot by holding the YES button on the Accu-Vote when the ballot is read.

10.4.5 Memory Card Data Validation

Memory card validation checks are performed every time a memory card is inserted (or the Accu-Vote is powered on with a memory card installed) or a ballot is read. This is to verify that no data has been modified either accidentally or maliciously through the use of a set of checksums.

The checksums are divided into three categories: precinct, counter, and text.

The precinct data checksums verifies that the structural information on the memory card has not been changed. This includes any information that is used to properly process ballots and maintain the counters. It is not possible to process ballots if a precinct data error has been detected.

The count data checksums verifies that the counters have not been modified except in the normal processing of ballots. It is not possible to process ballots if a count data error has been detected; however, the operator will be given the option of clearing the counters and restarting the count.

The text data checksums verifies that no change has occurred in the data used only for generating reports. This data includes race titles, candidate names, and report formatting information. These checksums are encoded to detect changes in text position as well as spelling, thus preventing simple swapping of text. Text data errors do not prevent the processing of ballots; however, any reports printed by the Accu-Vote will be flagged and must be suspect. The information transmitted back to the host system cannot be affected by text data.

10.0 SOFTWARE STANDARDS (Continued)

10.5 Data and Document Retention (Continued)

The ballots will normally be boxed and sealed following an election. Thus, they are available for review or recount purposes. Similarly, the voter lists and other records would normally be sealed and stored.

The normal election procedure involves printing a final audit report following the successful transmission of election results to a central host computer. This audit report, which may be printed at any time after the memory card is programmed, records a detailed history of the operations performed on that memory card. Provided that a working real-time clock chip is installed in the Accu-Vote, the history includes time stamps on every record plus date stamps for the insertion (session start) of the memory card.

The Accu-Vote automatically prints a zero totals report on initialization before the opening of the polls and a results report following the ender card at the close of polls. These reports are to be certified by the officials at the polls and normally form the official results of the tally. Additional printed copies of the results report and the results transmitted to the host are normally considered unofficial results subject to verification against the official results report.

The memory cards may be stored as additional records of the election results. The audit log and the reported checksums may be used to ensure that the results are not altered from the time of the official results report. In addition, memory cards may be duplicated, possibly to store records at multiple sites) and the audit logs will record the duplication. The memory cards may be expected to maintain their data for at least five years following the installation of the battery. The memory cards provide a battery low signal that the Accu-Vote checks every time it displays a message to its internal LCD and if the memory card battery is low, a symbol resembling a telephone pole will be displayed on one side of the display. Operators are trained to recognize the symbol and to have the memory card serviced if the battery is low. Jurisdictions need to track the elapsed time between battery changes to ensure that data will be retained for sufficient periods.

10.6 Ballot Interpretation Logic

Through simulated elections performed during Qualification testing, the Accu-Vote demonstrated proper ballot interpretation of the following:

1. Closed and Open Primary
2. Partisan and Non-Partisan Offices
3. Straight Party Voting
4. Rotation of Names within an Office
5. Recall Issues, with Options
6. Split Precincts
7. Vote for N of M
8. Write-In Voting
9. Totally Blank Ballots

The Ballot Logic Test Cases and results are contained in Attachment E.

11.0 SYSTEM AUDIT (Continued)

11.5 Pre-election Audit Records

The VTS system is used for ballot preparation activities and Global states that extensive logging capabilities are embedded into the package. The VTS ballot preparation capabilities were not subjected to in-depth functional testing and verification testing. Thus, it is recommended that the logging capabilities of the VTS system be reviewed during jurisdiction acceptance testing.

11.6 System Readiness Audit Records

The memory card maintains a card status that is indicated indirectly to the operators by the nature of the prompts displayed. These include:

- 0=> memory card formatted - ready for programming
- 1=> memory card programmed - ready for testing
- 2=> memory card set for election - ready for counting
- 3=> counting completed - ready for transmission of results
- 4=> results successfully transmitted - ready for auditing
- 5=> memory card audited - ready for storage and/or clearing and re-use.

The Accu-Vote performs system memory testing on power up, validation of the memory card data on insertion and for each ballot processed, validation of the ballot image, monitoring of the power supply, and monitoring of the memory card battery. The system must pass the System Memory Tests and the memory card validation before the session start audit log record is generated. Errors in the ballot image and power supply problems prevent the processing of ballots.

Report labels normally specify the release number of the ROM set installed at the time the report was generated. In addition, the label specifies the election ID, the precinct ID, the download version and the copy number which, together, identify the memory card being reported. Finally the labels include a precinct checksum that can be used to verify the contents of the memory card and a counter checksum that may be used to determine if the counters have changed between reports.

11.6.1 Ballot Format Testing

The number to vote for in each race may be verified from a long format zero totals or results report and is most easily tested if the election administrator has set the system to reject overvoted ballots.

The long format reports identify the configuration parameters that have been programmed on the memory card. These determine what voting patterns are to be accepted and how to handle those accepted and those rejected. Testing these requires the creation of test decks specific to the particular situation.

11.0 SYSTEM AUDIT (Continued)

11.8 Vote Tally Data

The memory card records the number of ballots cast by precinct/card number combination.

The memory card records the vote totals for each race.

The memory card records the number of ballots read within each precinct by card number and separated by in-person and absentee ballots. For closed primary ballots, the card number identifies the party. For open primary ballots, the party votes must be determined from the race results.

The memory card records the number of ballots processed. Non-processed ballots are not accepted. Races with improper voting are recorded as appropriate for the situation. For multiple card ballots, the number of each card type is recorded.

The memory card records overvotes and undervotes separately for each race.

12.0 SECURITY

Global Election Systems performed extensive analysis in identifying potential threats to the security of the Accu-Vote and how such could be compromised. The resulting report, very lengthy and detailed, was included as a part of the Global Election Systems Technical Data Package. A review of this report suggests that to compromise the integrity of the Accu-Vote election day results would be extremely difficult and would take an inherent knowledge in the workings of the machine and associated operating system software. Global states that attempts by the Accu-Vote developers to modify the contents of an individual memory card proved very difficult even when armed with source code, data structure diagrams, and experience.

Due to the very proprietary nature of this analysis, the report has not been included as a part of the Qualification Test Report.

13.0 QUALITY ASSURANCE

13.1 Quality Control

Global Election Systems Inc. has adapted as its own, a quality assurance standard originally created by IBM. This manual addresses all aspects of the manufacturing process.

13.2 Responsibility for Tests

Lynro Manufacturing Inc. Is responsible for the performance of all Quality Assurance Tests.

14.0 SOFTWARE SYSTEM FUNCTIONAL TESTS (Continued)

14.1 Software System Functional Test Procedures (Continued)

- Procedures applicable to equipment used in the polling place for;

  (a) opening the polling place and enabling the acceptance of ballots,
  (b) maintaining a count of processed ballots,
  (c) monitoring equipment status,
  (d) verifying equipment response to operator input commands,
  (e) generating real-time audit messages,
  (f) closing the polling place and disabling the acceptance of ballots, and
  (g) generating election data reports.

14.2 Software System Functional Test Results

The Accu-Vote Version 1.94f operating software was successfully subjected to the above System Software Functional Tests. Additionally, the Vote Tally System Election Management Software was also observed for proper functionality, where required, for defining the elections and canvass reporting of election results.

The Accu-Vote was subjected to five different test elections. Four of the five elections were created to verify ballot logic operation of the Accu-Vote and are depicted in Attachment E. A fifth election was presented to the Global Election Systems' Representative during ITA Qualification testing as a yet-to-be seen election. This was done to subject the system to an election in which the Global Elections Systems' personnel had not previously had the opportunity to define and test. The test election was a Primary and included 10 precincts with two state congressional districts and five county districts divided among the 10 precincts. The ballots created for the fifth test election, Ballot Type E, are also depicted in Attachment E.

Ballots were created for each of the elections. The polls were opened and the machines were enabled for reading of ballots. Various votes were cast for each of the ballot styles defined. Following completion of the test election, the polls were closed and election results and audit log trails were generated. The election results were compared against the predetermined votes cast to ensure that proper ballot logic and accuracy in recording the votes had been obtained. Notice of Anomaly No. 2 documents an anomaly observed with the totals results during system-level testing which was also observed during the high-volume accuracy voting performed during the Operating Environmental Test. Notice of Anomaly No. 2 documents the observations made and the resulting disposition. Additional discussion of the anomaly are discussed in Paragraph 17.0. The anomalous condition was resolved and ballot logic testing was repeated to verify the correction.

The Accu-Vote was additionally subjected to a high-volume-vote Reliability/ Accuracy Test during the operating Environmental Test. The test and results are discussed in further detail in Paragraph 17.0.

Attachment E contains a Functional Summary Data Sheet, a Test Script, and Ballot Cases, Ballot Types, and Election results.

15.0 SYSTEM LEVEL TESTS (Continued)

15.6 Performance

As detailed in other sections of this report, the Accu-Vote was subjected to several simulated elections to verify poll opening, voting, and poll closing sequences as well as voter recording accuracy and correct ballot logic interpretation.

16.0 NON-OPERATING ENVIRONMENTAL TESTS

The Accu-Vote was subjected to various Non-Operating Environmental Tests. Prior to and immediately following each test environment, the Accu-Vote was powered and subjected to operability functionals to verify continued proper operation. The Accu-Vote was not powered during the performance of any of the tests below.

16.1 Vibration Test

The Accu-Vote was subjected to Vibration Tests. The Accu-Vote (S/N 72152) was subjected to a Baseline Operability Test. Upon the completion of such, the Accu-Vote was placed within its shipping carton and strapped to a Ling 340 electrodynamic shaker. One control accelerometer was affixed to the shaker table. Vibration and control was performed with an HP5427 Shock/Vibration controller. The Accu-Vote was subjected to the Basic Transportation, Common Carrier profile as depicted in MIL-STD-810D, Method 514.3, Category. The Accu-Vote was subjected to vibration for 30 minutes in each orthogonal axis. Upon test completion, the Accu-Vote was removed from its shipping carton and inspected for any obvious signs of degradation and/or damage. None were observed. The Accu-Vote was subjected to a post-test operability checkout and the results were in agreement with those previously established during the baseline checkout.

Attachment G contains Vibration Test Data Sheets and Data Plots.

16.2 Humidity Test

The Accu-Vote was subjected to Humidity Tests. The Accu-Vote (S/N 72152) was subjected to a baseline operability to verify system readiness. Upon the completion of such, the Accu-Vote was placed within its carrying case and placed within a Thermotron Humidity Chamber. The Accu-Vote was subjected to a 10-day humidity cycle in accordance with the procedure as found in MIL-STD-810D, Method 507.2, Procedure I - Natural Hot Humid. Upon completion of the first 120 hours of test, the Accu-Vote was removed from the chamber and subjected to an interim operability functional. No anomalies were observed. The Accu-Vote was returned to the humidity chamber for the remainder of the five days of humidity cycling. Upon test completion, the Accu-Vote was removed from its shipping container and inspected for any obvious signs of degradation and/or damage. None were observed. The Accu-Vote was subjected to a post-test operability checkout and the results were in agreement with those previously established during the baseline checkout.

Attachment H contains Humidity Thermal Circular Charts.

17.0 OPERATING TEST (Continued)

17.1 Operating, Environmental Test (Continued)

17.1.1 Operating Environment Test Results (Continued)

miscount during its first 297,589 cast. This error, as documented in the anomaly, was attributed to the older style ballot being inadvertently used during the retest on the fourth machine. Upon completion of the additional 465,342 votes, it was observed that the additional votes had been recorded correctly.

Attachment I contains the Environmental Operating Accuracy Test Reports generated throughout the test program.

18.0 TEST EQUIPMENT AND INSTRUMENTATION

All instrumentation, measuring, and test equipment used in the performance of this test program were calibrated in accordance with Wyle Laboratories' Quality Assurance Program, which complies with the requirements of ANSI/NCSL Z540-1, ISO 10012-1, and Military Specification MIL-STD-45662A. Standards used in performing all calibrations are traceable to the National Institute of Standards and Technology (NIST) by report number and date. When no national standards exist, the standards are traceable to international standards or the basis for calibration is otherwise documented.

19.0 QUALITY ASSURANCE

All work performed on this program was completed in accordance with Wyle Laboratories' Quality Assurance Program.

ORIGINAL **NOTICE OF ANOMALY** DATE: August 1, 1996

NOTICE NO: 1 P.O. NUMBER: Verbal CONTRACT NO: ----

CUSTOMER: Global Election Systems WYLE JOB NO: 44908

NOTIFICATION MADE TO: Jim Dearman NOTIFICATION DATE: July 23, 1996

NOTIFICATION MADE BY: Charlie Conrad VIA: Verbal

CATEGORY: ■ SPECIMEN □ PROCEDURE □ TEST EQUIPMENT DATE OF ANOMALY: July 23, 1996

PART NAME: Accu-Vote Vote Tally System PART NO. ES-2000

TEST: Environmental Test, Operating I.D. NO. ----

SPECIFICATION: Wyle Test Procedure 44908-10 PARA. NO. 15.1.9

REQUIREMENTS:

System level reliability for all types of voting systems shall be measured as Mean Time Between Failure (MTBF). Mean Time Between Failure is defined as the value of the ratio of operating time to the number of failures which have occurred in the specified time interval. For the purpose of demonstrating compliance with the FEC Standards, a failure is defined as any event which results in the loss or unacceptable degradation of one or more of the system functions. The MTBF demonstrated during qualification testing in accordance with the FEC Performance Standards For Punchcard, Marksense, and Direct Recording Electronic Voting Systems shall be at least 163 hours.

DESCRIPTION OF ANOMALY:

During the Environmental Test, Operating, one of the four voting machines (S/N 72028) ceased to function. It was observed that the unit would no longer accept ballots. The top of unit was removed to examine the drive belt and it was noted that the "Power On Test" indicator was on, indicating an anomaly present within the ballot reader.

DISPOSITION - COMMENTS - RECOMMENDATIONS:

The Global Election Systems' Technical Representative was present and witnessed the anomaly. The unit had successfully completed 25 hourly ballot counting cycles prior to the occurrence of the anomaly. The unit was removed from the test chamber and the affected part (Visible Light Read Head, P/N 4421111A) was changed out by the Technical Representative, taking approximately 15 minutes. The unit was subjected to a successful baseline checkout and returned to the test chamber. In accordance with the FEC Standards, the demonstrated MTBF was increased to 245 hours due to the occurrence of the observed failure. At the time of failure, 100 hours of error-free operation had been accumulated among four machines.

Testing was continued until the total number of hours accumulated among the four machines under test exceeded the minimum 245 hours required. No additional hardware anomalies were encountered during the MTBF demonstration.

RESPONSIBILITY TO ANALYZE ANOMALIES AND COMPLY WITH 10 CFR PART 21: ■ CUSTOMER □ WYLE

VERIFICATION:

TEST WITNESS: Charlie Conrad

REPRESENTING: Global Election Systems

QUALITY ASSURANCE: [signature] 8-5-96

PROJECT ENGINEER: [signature] 8/5/96 J.R.Dearman

PROJECT MANAGER: [signature] 8-5-96 J. H. Powell

INTERDEPARTMENTAL COORDINATION:

ORIGINAL

NOTICE OF ANOMALY

DATE: September 27, 1996

NOTICE NO: 3 P.O. NUMBER: Verbal CONTRACT NO: ----

CUSTOMER: Global Election Systems WYLE JOB NO: 44908

NOTIFICATION MADE TO: Charlie Conrad NOTIFICATION DATE: July 22, 1996

NOTIFICATION MADE BY: Jim Dearman VIA: Verbal

CATEGORY: ■ SPECIMEN ☐ PROCEDURE ☐ TEST EQUIPMENT DATE OF ANOMALY: July 22, 1996

PART NAME: Accu-Vote Vote Tally System PART NO. ES-2000

TEST: Outstacking I.D. NO. ----

SPECIFICATION: Wyle Test Procedure 44908-10 PARA. NO. 9.12.1

REQUIREMENTS:

The voting machine shall be inspected for its ability to divert cards when they are not read or when a condition is detected requiring the card to be segregated. This requirement shall be verified by voting premarked ballots and observing the machine's proper handling of such.

DESCRIPTION OF ANOMALY:

During System Level and Reliability Testing, it was observed that, on occasion, a write-in ballot would be incorrectly delivered to the regularly voted ballot compartment or a regularly voted ballot would be delivered to the write-in compartment by the voting machine's diverter system.

DISPOSITION - COMMENTS - RECOMMENDATIONS:

The Global Election Systems' Technical Representative was present and witnessed the anomaly. The anomaly was attributed to the diverter system since the votes cast during each occurrence had been correctly counted and, thus, was not deemed to be an anomaly associated with the ballot interpretation logic software. After further analysis, it was concluded that the diverter was not delaying itself long enough (and thus allowing the ballot to clear itself of the diverter) before engaging and changing position to deliver the next ballot to the regular compartment, or vice-versa. A code change to add in a delay to the engagement before its cycling over to another position was added to the Accu-Vote firmware by the Global Election Systems' technical personnel. Additional ballots were voted throughout the remainder of the test program with no additional diverter anomalies observed.

RESPONSIBILITY TO ANALYZE ANOMALIES AND COMPLY WITH 10 CFR PART 21: ■ CUSTOMER ☐ WYLE

VERIFICATION:

PROJECT ENGINEER: 9-27-96
J. P. Dearman

TEST WITNESS: Charlie Conrad

PROJECT MANAGER: 09/27/96
R. L. Porter

REPRESENTING: Global Election Systems

INTERDEPARTMENTAL COORDINATION:

QUALITY ASSURANCE: 9-28-96