

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT ANALYSIS/MODEL COVER SHEET

1. QA: N/A**Complete Only Applicable Items**

Page: 1 of 24

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Describe use: Used to support engineering design drawings and provide basis for design selection of the subsurface visual alarm system.	Describe use:						

4. Title:

Subsurface Visual Alarm System Analysis

5. Document Identifier (including Rev. No. and Change No., if applicable):

BABFAC000-01717-0200-00002 REV 00

6. Total Attachments:

None

7. Attachment Numbers - No. of Pages in Each:

N/A

	Printed Name	Signature	Date
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Remarks: Dennis W. Markman & William J. Reed are no longer with the company when the document was in the design review process.

**OFFICE OF CIVILIAN RADIOACTIVE WASTE
MANAGEMENT
ANALYSIS/MODEL REVISION RECORD**
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1. Page: 2 of 24

2. Analysis or Model Title:

Subsurface Visual Alarm System Analysis

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BABFAC000-01717-0200-00002 REV 00

4. Revision/Change No.

5. Description of Revision/Change

00

Issued for Approval

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ACRONYMS AND ABBREVIATIONS

AWG	American Wire gauge
CRWMS	Civilian Radioactive Waste Management System
M&O	Management and Operating Contractor
DH+	Data highway +
DOE	U.S. Department of Energy
ECRB	Enhanced Characterization of the Repository Block
ESF	Exploratory Studies Facility
I/O	Inputs and outputs
PLC	Programmable logic controller
SSCs	Structures, systems, and components
UPS	Uninterruptible Power System

1. PURPOSE

The *Subsurface Fire Hazard Analysis* (CRWMS M&O 1998, page 61), and the document, *Title III Evaluation Report for the Surface and Subsurface Communication System*, (CRWMS M&O 1999a, pages 21 and 23), both indicate the installed communication system is adequate to support Exploratory Studies Facility (ESF) activities with the exception of the mine phone system for emergency notification purposes. They recommend the installation of a visual alarm system to supplement the page/party phone system

The purpose of this analysis is to identify data communication highway design approaches, and provide justification for the selected or recommended alternatives for the data communication of the subsurface visual alarm system.

This analysis is being prepared to document a basis for the design selection of the data communication method. This analysis will briefly describe existing data or voice communication or monitoring systems within the ESF, and look at how these may be revised or adapted to support the needed data highway of the subsurface visual alarm system. The existing PLC communication system installed in subsurface is providing data communication for alcove #5 ventilation fans, south portal ventilation fans, bulkhead doors and generator monitoring system. It is given that the data communication of the subsurface visual alarm system will be a digital based system. It is also given that it is most feasible to take advantage of existing systems and equipment and not consider an entirely new data communication system design and installation.

The scope and primary objectives of this analysis are to:

- Briefly review and describe existing available data communication highways or systems within the ESF.
- Examine technical characteristics of an existing system to disqualify a design alternative is paramount in minimizing the number of and depth of a system review.
- Apply general engineering design practices or criteria such as relative cost, and degree of difficulty and complexity in determining requirements in adapting existing data communication highways to support the subsurface visual alarm system. These requirements would include such things as added or new communication cables, added Programmable Logic Controller (PLC), Inputs and Outputs (I/O), and communication hardware components, and human machine interfaces and their software operating system.
- Select the best data communication highway system based on this review of adapting or integrating with existing data communication systems.

This analysis is being prepared in accordance with the requirements of the *Technical Work Plan for Test Facilities Design FY01 Work Activities* (CRWMS M&O 2000), The *Subsurface Fire Hazard Analysis* (CRWMS M&O 1998, page 61) and The Document *Title III Evaluation Report*

for the Surface and Subsurface Communication System (CRWMS M&O 1999@, pages 21 and 23).

2. QUALITY ASSURANCE

A subsurface visual alarm system is recommended for the ESF according to the *Title III Evaluation Report for the Surface and Subsurface Communication System* (CRWMS M&O 1999a). The system has been evaluated in the *Determination of Importance Evaluation for the Subsurface Exploratory Studies Facility* (CRWMS M&O 1999b), and has been found not to be quality affecting since no special controls have been identified.

This design activity has been evaluated in accordance with procedure AP-2.21Q and the *Technical Work Plan for Test Facilities Design FY01 Work Activities* (CRWMS M&O 2000), and has been determined not to be quality affecting subject to the requirements of the *Quality Assurance Requirements and Description* (QARD) (DOE 2000) since the activity does not affect items in the Q-List.

As specified in *Technical Work Plan for Test Facilities Design FY01 Work Activities* (CRWMS M&O 2000), no controls are required to control the electronic management of data as required by AP-SV.1Q.

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3. COMPUTER SOFTWARE AND MODEL USAGE

The Project standard suite of office software for word processing has been used in the preparation of this analysis. These are commercial off-the-shelf software programs, approved for the Project, with no special qualifications needed.

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4. INPUTS

The primary source documents for input information utilized in this analysis are the *Title III Evaluation Report for the Surface and Subsurface Communication System* (CRWMS M&O 1999a), TDR-CRW-SE-000008, Rev.0 ICN 01 "*Safety Basis Report*" and the *Determination of Importance Evaluation for the Subsurface Exploratory Studies Facility* (CRWMS M&O1999b).

4.1 PARAMETERS

There are no parameters.

4.2 CRITERIA

Specialty Engineering has determined that the Communications is NOT a life safety system (Gwyn 1998, page 8) (Used in Section 6.4.2).

4.2.1 General Criteria

Visual alarm strobe lights should be located at reasonable distance intervals so they can be viewed by working personnel from any location in the drifts, alcoves, and main tunnel (Used in Section 6.4.2.3). The strobe lights flashes shall not exceed 2 flashes per second or be less than 1 flash every second with a maximum pulse duration of 0.2 second and maximum duty cycle of 40 percent. The light source color shall be clear or nominal white and shall not exceed 1000 CD (effective intensity).

4.3 CODES AND STANDARDS

NFPA 70 National Electrical Code, 1999 Edition

NFPA 72 National Fire Protection Code, 1999 Edition

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5. ASSUMPTIONS

5.1 GENERAL ASSUMPTIONS FOR THIS ANALYSIS

- 5.1.1 In general engineering accepted practices, design of new data communication systems will require engineer designer in support of development of installation drawings, specifications and spare part list, a new cost expenditures for an operating facility. These expenditures would include new system operations functions, new maintenance functions, new procedures, new operator interface hardware and software (in a digital electronic based system), and new training. These requirements add direct expenditures on a regular or periodic basis to an operating facility as should be defined in their operating budgets (Used in 6.4.1 and 7.).
- 5.1.2 It is assumed that the ESF, and then repository enters its development and construction phase certain Structures, Systems, and Components (SSCs) will be installed, revised and expanded, or removed. This evolution of the facilities is predicated on the fact that many years are needed to construct the facilities and their support systems would require expansions and integrations. Therefore, it is a reasonable engineering practice to avoid expensive and new dedicated solutions for design and installation of SSCs during the ESF phase. Rather, use integration of new data communication of the visual alarm system to an existing installed data communication system.(Used in 6.4.1 and 7.).
- 5.1.3 In general engineering accepted practices, if an operating facility uses one type of monitoring and control system, it would normally design for and install the same type of systems for new or expanding requirements of existing systems. As a minimum benefit, this practice provides for ease of operations, maintenance, no new or additional operator training, minimal software impact, and fewer spare parts requirements (Used in 6.4.2 and 7.).

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6. ANALYSIS

6.1 INTRODUCTION

The main purpose of the analysis is to provide a recommendation for a data communication system for the subsurface visual alarm system and document the selected design basis. This analysis will look at the factors that will help make the comparison of the proposed design alternatives.

There are two basic approaches to design for and provide for a successful installation and operating visual alarm data communication system. These include:

- Select, design, and install a new dedicated data communication system
- Integrate the data communication requirements into the hardware and software of an existing data communication system

With these two approaches, there are engineering and physical factors or methods that achieve a workable system. Some of these affect each design with different, small, large, or no impacts. By reviewing these same factors in each design, a comparison to an acceptable approach and design alternatives is achievable.

6.2 EXISTING DATA COMMUNICATION SYSTEMS IN THE ESF

There are four main facility data communication system in the ESF. These are:

- Gai-Tronics Page/Party Telephone system.
- Mine/Outside phone communication system
- Conveyor PLC control system
- ESF Flow Through Ventilation PLC control system

6.3 ENGINEERING AND PHYSICAL FACTORS OR METHODS

The physical factors or methods used in this analysis were selected to primarily help bound the limits of possible designs and approaches of the visual alarm system alternatives reviewed for achieving a workable system. These include:

- Relative costs
- Ease of design
- Ease of construction and installation

- Very minimal existing control system software impact
- Length of additional communication highway cable to install
- Number of communication interface and I/O hardware components to add

6.4 ANALYSIS OF DATA COMMUNICATION SYSTEM ALTERNATIVES

6.4.1 Elimination of New Design Approach

The best way to look at the alternatives, is to begin by eliminating some obvious design approaches to the visual alarm data communication system. It is highly suggested that the approach for the design and installation of an entirely new dedicated data communication system be eliminated based on the general assumptions in Sections 5.1.1 and 5.1.2.

For the ESF to take on added periodic expenses to support a new system is not necessary at all because an integrated design approach will use existing hardware and software of existing systems. When you include the six factors and methods in Section 6.3, each one of them adds an additional complexity, periodic expenses, hardware components and software systems, including an initial capital expenditure. It also becomes evident that existing systems have hardware and software designs that are made and intended for expansion capability. These are discussed below.

6.4.2 Integration of Existing Systems With Visual Alarm Data Communication Requirements

The existing systems are listed in Section 6.2. Each one of these is briefly discussed and then analyzed based on the factors and methods from above.

Because of Criterion 4.2, that the Communications is not a Life Safety system, the integration of the new visual alarm system into existing hardware and software is acceptable.

Remote I/O data highway gathering, monitoring and control systems are used in the ESF now and are recommended as the preferred method of communication. Significant reasons for this is that they require a minimal amount of signal wiring, and it applies good engineering design practice based on the general assumption in Section 5.1.3.

6.4.2.1 Telephone Systems in the ESF

Based on section 6.4.2, there would be one way to investigate the existing telephone systems for use in supporting the visual alarm system in the ESF. This would be to integrate requirements of the visual alarm system into the telephone system as follows:

- Use of one of the spare phone lines as the data highway for the visual alarm system using a master PLC based remote I/O network with all the required communication remote I/O hardware and software. The system would also require an operator or man machine interface, and

PLC operating system software for the PLC platform (required for system configuration and alarm event data recording).

The telephone system in the ESF consists of two different systems. One is the Gai-Tronics page/warning or page/party system that is installed in the Enhanced Characterization of the Repository Block (ECRB) Cross Drift, and the other is designed for the main drift and not completely installed. This system consists of 59 stations. According to the manufacturer, Gai-Tronics, the addition of a visual strobe light at each station is done often. However, because of the overall distances and the number of stations, the electrical load on the dedicated Uninterruptible Power Supply (UPS) system and the system communication cable, are currently challenged. To add the lights, new power supplies would be needed. The communication cable through the 7 miles of tunnel is too long to entirely support a system communication signal with complete assurances to trip the visual alarm light relays. The installation of the Gai-Tronics system is also only 85% complete at the time of this analysis. These factors would add enough uncertainty to prohibit the use of the Gai-Tronics system to support the visual alarm system.

The second system, the Mine/Outside phone communication system, consists of different size wire conductor pairs supporting mine/outside phone locations in the main drift, alcoves, portals, and the ECRB Cross Drift.

Use of any existing pair of the six pair #16 American Wire Gauge (AWG) in the main drift or the 25 pair #22 AWG telephone cable in the ECRB Cross Drift is not allowable. The telephone wire does not meet the technical specifications for an Allen-Bradley Universal Remote I/O Link network, which is a Belden 9463 shielded cable, or a fiber optic cable. There is also a maximum highway length limit of 10,000 feet. The length of the visual alarm data highway needs to be about 42,000 feet.

6.4.2.2 Conveyor PLC Control System

There is an existing PLC based tunnel conveyor control/monitoring system. It is not recommended to use the data communication highway or the control hardware because it is a dedicated process control system that may continue to be used for tunnel drilling and excavation. It would be wise engineering practice that the visual alarm system not be integrated with a large process operation PLC system, especially one that is not a continuous operation, one whose current status is unknown, and one that may be dismantled and removed in the future.

Other drawbacks in using the system are that the data communication highway is reconfigured as tunneling operations continue and the conveyor system becomes longer. This could interrupt the operation of the visual alarm system. The blue hose cabling for the data highway software platform is subject to a five mile distance limit. Three miles of additional cabling would be needed, and several PLC processors would need to be added, one at each remote I/O rack node, with each one needing configuration.

6.4.2.3 ESF Flow Through Ventilation PLC Control System

This system is an Allen-Bradley PLC 5/40 processor with a fiber optic cable, non-healing data highway. The system can support up to 4-Data Highway + (DH+) or remote I/O communication ports over a Universal Remote I/O Link Network. Currently this system is installed, but has not

been completely connected or put into service. It consists of 2- PLC racks, one a local rack with 6-I/O cards or modules, and the other a remote I/O rack with 3-I/O cards or modules, all communicating over a Universal Remote I/O Link of a fiber optic cable. The system was installed in 1999.

There are three Phoenix Digital fiber optic Model No. OCM-DPR-13-D-ST communication modules that act also as repeaters in the data highway that runs through the main drift of the ESF. Two of the fiber optic repeaters or modems are in the I/O racks; the other one is mounted separately. They communicate with the Allen Bradley communication module that is in each rack and are the physical point for putting the field data signals onto the highway. They are also required as a booster for communication signal enhancement because of the approximate five mile length of the main drift. The distance limit on the Universal Remote I/O Link Network is 10,000 feet.

To use this control system for the visual alarm system would seem to be the best, if not the only real workable solution with existing equipment in the ESF. It requires the addition of about three miles or 15,880 feet of the same specification fiber optic cable running down and back up the ECRB Cross Drift. This brings the total highway distance to about 42,000 feet. With a vendor recommendation of 7,000 feet between fiber optic modems/repeaters, a total of 9-remote I/O racks and chassis are needed to support the design of an integrated system of the visual alarms to the ventilation system. Seven of these racks will be new. Each rack will require a communication module, a Phoenix Digital fiber optic modem/repeater, 2-I/O cards or modules, and a power supply module. No additional PLC(s) are needed beside the one currently in the I/O rack at the control panel located at the north portal area. Proper mountings and enclosures are also needed to protect the racks from the tunnel environment.

Signal wiring from the I/O module's rack location to the proposed 34 strobe lights on Main Drift and 10 strobe lights on Cross Drift shall meet the general and reasonable distance criteria in Section 4.2.1 as stated in CRWMS M&O 1998, page 11, for achieving appropriate distances and space between the lights. The use of this Universal Remote I/O Link Network of the ESF flow through ventilation monitoring system provides for a modular replacement of components as required for the Subsurface Communication System (CRWMS M&O 1999b, Section 6.11) for the visual alarm system.

There is an operating panel with appropriate system configuration devices and software by the control panel enclosure in the existing walker shack at the north portal. All system configuration and programming is done from here at the main data highway PLC processor. Each new I/O rack, I/O and communication modules, and I/O signal will be configured as part of the now expanded data highway.

Approximate costs are about, \$19,000 for the fiber cable, \$7,000 for the fiber cable installation, \$42,000 for the remote I/O hardware, and \$7,500 to install, configure, and startup the remote I/O system.

	ESF Flow Through Ventilation PLC Control System	Conveyor PLC Control System	Gai-Tronics Page/ Party Telephone System	Mine/Outside Phone Communicati on System
Control for Visual Alarm Capability	Yes	No	No	No
Capability to interface with other system	Yes	No	N/A	N/A
Cost	\$76 k	Not estimated	Not estimated	Not estimated
Ease of Design	Best	Second best	Design is indeterminate. Design issues are indeterminate.	Design is indeterminate. Design issues are indeterminate.
Ease of Construction	Best	Second best	Design issues are indeterminate.	Design issues are indeterminate.
Minimal Existing Control System	Use current system software	Use current system software	Design issues are indeterminate.	Design issues are indeterminate.
Software Impact			Design issues are indeterminate.	Design issues are indeterminate.
Length of additional Communication Cable to Install	15800 ft.	15800 ft.		
Number of Communication Interface to Add	Seven	Not estimated	Design issues are indeterminate.	Design issues are indeterminate.
Number of I/O Hardware Components to Add	Seven	Not estimated	Design issues are indeterminate	Design issues are indeterminate
Reliability	Yes	Future of conveyor system is uncertain.	Yes	No. System dependent on batteries.
Maintenance % of Currently Completed System	Low	Low	Low	High
Installation. % of Communication System Currently Operational	75%	80%	100%	100%
	100%	100%	100%	100%

COMPARISON CHART FOR DATA COMMUNICATION SYSTEM

7. SUMMARY AND CONCLUSIONS

This document briefly defines and supports an approach and method for the design of a visual alarm data communication system. It also briefly looked at and reviewed alternatives for the designs.

The analysis strongly suggests that there is really only one viable engineering design approach and only one alternative for the visual alarm system. It is recommended that the design approach be one of an integration of the new data communication of the visual alarm system to an existing data communication system. The alternative recommended is to integrate to the existing ESF flow through ventilation monitoring system. Criteria 4.2 and 4.2.1 are supported in the selection of this approach and alternative. Use of general assumptions concerning reasonable and practical engineering design methods in sections 5.1.1, 5.1.2, and 5.1.3 provided the basis for the recommendations.

Relative cost was also used a basis. That was that remote I/O equipment is needed to have compatibility and the least costly impact on current ESF operations. No new software is required, and approximately three miles of new fiber optic cable is needed. This cable cost is a relative fixed and equal cost for any solution.

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8. REFERENCES

8.1 DOCUMENTS CITED

CRWMS M&O 1998. *Subsurface Fire Hazards Analysis*. BABFAH000-01717-0200-00121 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980414.0448.

CRWMS M&O 1999a. *Title III Evaluation Report for the Surface and Subsurface Communication System*. BAB000000-01717-5705-00014 Rev 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990511.0201.

CRWMS M&O 1999b. *Determination of Importance Evaluation for the Subsurface Exploratory Studies Facility*. BAB000000-01717-2200-00005 Rev 07 ICN 03. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990728.0282.

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DOE 2000. *Quality Assurance Requirements and Description*. DOE/RW-0333P. Rev. 10. Washington, D. C.: U. S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20000427.0422.

Gwyn, D. 1998. "ESF Life Safety Systems – Seismic Event System Safety Evaluation." Interoffice correspondence from D. Gwyn (CRWMS M&O) to W.R. Kennedy, W.J. Reed, L.R. Morrison and J.S. Leak, July 7, 1998, LV.SA.DWG.07/98-072, with attachment. ACC: MOL.19980831.0082.

NFPA 70 National Electrical Code, 1999 Edition, Quincy, Massachusetts
National Fire Protection Association. TIC.240528

NFPA 72 National Fire Protection Code, 1999 Edition, Quincy, Massachusetts
National Fire Protection Association. TIC.247112

8.2 PROCEDURES

AP-2.21Q, Rev. 0. *Quality Determinations and Planning for Scientific, Engineering, and Regulatory Compliance Activities*. U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20000802.0003.

AP-SV.1Q, Rev. 0, ICN 2. *Control of the Electronic Management of Information*. U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20000831.0065.

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9. ATTACHMENTS

Not applicable.