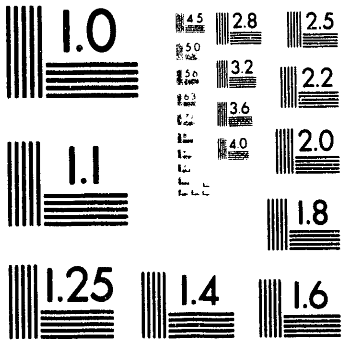
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GEOMECHANICAL MONITORING SYSTEM AT THE WASTE ISOLATION PILOT PLANT, CARLSBAD, NEW MEXICO

J.L. Francke, Dr. R.F. Cook, R.C. Carrasco
Westinghouse Waste Isolation Division, Carlsbad, New Mexico

B.C. Carney
International Technology Corporation, Albuquerque, New Mexico

ABSTRACT

This paper describes in detail the geomechanical instrumentation system and the data base that has been established from the geomechanical monitoring program. In addition, it describes the quality assurance and control measures that are in place to ensure that the data from the underground is accurate, traceable, and defensible.

The system is installed at the Waste Isolation Pilot Plant in Carlsbad, New Mexico. This facility is being developed for the disposal of transuranic nuclear wastes in underground excavations in salt 2150 feet below the surface. The purpose of the instrumentation system is to monitor the deformations and stress changes that are occurring in the rock with time. This information is needed to routinely assess conditions in the facility and to ensure that safe operating conditions are maintained.

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INTRODUCTION

The Waste Isolation Pilot Plant is a facility being developed in southeastern New Mexico to demonstrate the safe disposal of transuranic radioactive wastes. The disposal location is located 2150 feet below the surface in thick evaporite deposits of Permian age. As part of the demonstration and to show that the conditions underground are safe during the operations phase of the project, a comprehensive geomechanical instrumentation system has been established in the underground and a large data base that handles the ever increasing data from field observation is maintained. The system provides real-time output describing the structural conditions throughout the underground. The instruments are read both manually and remotely.

The geomechanical monitoring system is controlled by a 386-based IBM compatible personal computer. The system has been designed to poll ten dataloggers located at various locations underground from the surface and store readings collected manually and remotely from over 500 instruments.

A data base of the field measurements is maintained using programs developed from dBase IV software. Based on criteria provided by the user, the data can be sorted and manipulated on individual instruments. Through the system, the user can generate data plots and analyze data in a timely manner. For accuracy, quality control processing has been incorporated into the system. Furthermore, the system is continually being upgraded; current enhancements include the use of a bar code reader to import manually acquired data and an additional datalogger for future instruments.

The geomechanical monitoring system has provided data collection, quality control, and data base maintenance, all of which are of vital importance to monitoring the geomechanical performance of underground excavations.

All geomechanical data collected and processed is published annually in the Geotechnical Field Data and Analysis Reports.

BACKGROUND

The geomechanical monitoring program was started by the Architect/Engineer for the Project, Bechtel, during the construction phase. During this time, data was being collected for design validation of the underground workings. As part of the site and preliminary design validation process, a remote recording system was set up in the underground dedicated to the collection of geomechanical data. Following the completion of the construction phase, the geomechanical data collection was maintained, and more instruments were added to the system as the first part of the waste storage area was developed. Since the data is time related, each year more data is entered into the data base, and the data base expands (see Figure 1).

The additional data each year and the increase in number of instruments read each year has markedly increased the data contained in the data base. The original system, Stride 440, became overwhelmed in 1988 and was unable to be used subsequently. Therefore, a new master control computer was installed in 1988, and a new data base was developed using dBase IV software.

DATA ACQUISITION SYSTEM

Currently there are seven dataloggers located at various locations underground to poll remotely read instruments and approximately 400 manually read instruments as shown in Figure 2.

The data acquisition system consists of a surface datalogging PC computer, a surface and underground modem, datalink cable, underground dataloggers, and a number of under termination cabinets. The surface computer is programmed to communicate with all underground dataloggers. The surface computer sends a two-character address sequence down the datalink cable through a surface modem. Each datalogger then decodes the character sequence through its modem. Upon receipt of its address sequence, each datalogger will poll its instruments, perform any necessary data reduction, and send instrument readings back to the surface computer through the modem as a string of ASCII characters.

Through the modem, ASCII character data is exchanged over the datalink cable using a baud rate of 300 and even parity. The modem's 4-wire TELCO interface line terminates at a 20-position datalink cable termination block with the modem's RS-232 interface connected to the datalogger to ensure proper data communication.

The surface computer consists of an 80-megabyte hard drive and a 386 central processing unit. The computer utilizes a Hewlett-Packard Series II printer and is capable of plotting approximately 250 data plots in an eight-hour period. The software for plotting routines allows scales to be changed, notes to be added to the plot, and a small location map drawn up using Autocad software to be placed on the plot.

The dataloggers are custom built to meet the data collections with a particular area of the underground. Where possible, excess capacity of instrumentation is allowed so that additional instrumentation can be added. The dataloggers are connected in series and each is accessed by a two-digit identifying number.

Instruments

The geomechanical instrumentation includes a range of instruments that measure rock movements and rock pressure as well as the load that develops in the support systems. The types of instruments currently used at the site are given in Table 1. Remotely read instruments are read on a monthly basis unless indicated otherwise. They include multiple point borehole extensometers (MPBX), sonic probe convergence meters (CONV), spot-welded strain gages (SM2W), embedded strain gages (EM5), earth pressure cells (EPC), piezometers (PIEZ), rockbolt load cells (RBLC), and wire convergence meters (WCM). Manually read instruments, which are read on a monthly basis, include multiple point borehole extensometers (MPBX), convergence points (CVPT), rockbolt load cells (RBLC), jointmeters (JMTR), inclinometers (INCL), and wire convergence meters (WCM).

Manual readings are collected on a quarterly basis, at a minimum, by trained technicians in accordance with approved procedures and manually entered into the data acquisition system.

QUALITY ASSURANCE

To ensure quality control, data processing undergoes a number of checkprinting processes. Field data sheets are checked for erroneous readings prior to data entry. After data entry has been completed, a hard copy of the data is generated and checked for errors. Although two checkprinting processes have occurred, the possibility for errors is still there. The Geomechanical Instrumentation System (GIS) is programmed to check for duplicate records and records with an unidentified GISID number and to flag the user in such instances.

Erroneous readings or records which transfer into the master data base are corrected only if documentation is provided and if proof of the error is shown (i.e., a reading entered under the wrong GISID number).

DATALOGGING PROCESS

Incorporating Instruments into the GIS

The steps taken to incorporate a new instrument into the GIS is common to both remotely read and manually read instruments.

Upon completion of a new instrument installation, an initial reading is taken and recorded on a initial field data sheet. A copy of the data sheet is made and checked for possible errors, if any errors are found, corrections are indicated on the copy by the checker and changed on the original initial field data sheet by the technician. After checking is completed a GISID number is assigned to the new instrument; and the reading, date, time, fieldtag, and location of the new instrument is entered into the GIS data base.

To verify correct entry into the data base, a hard copy of the new reading is generated and checked for errors. Any errors are documented and corrected.

Entering Manually Read Data

Manually read data is recorded in the field on field data sheets. The data is entered into the computer on a dBase form. Upon completion of data entry, a hard copy of the entered data is generated and checked for errors. After checking, a transfer program is executed to reduce and transfer data to the master data base. To prevent duplicate records from transferring, the system is programmed to flag the user if a duplicate record is attempting to be processed or a record with an unidentified GISID number is attempting to transfer.

Remotely Read Data

After polling underground dataloggers, the system records and sends the polled data to a temporary data base for necessary editing. A hard copy of the polled data is generated and checked for erroneous readings. After checking is completed the data is reduced into appropriate units and transferred to the specific master data base files.

DATA MANIPULATION

The main analysis of the data is of the convergence data. On a routine basis, measured closure over yearly periods are compared with predicted values. The predictions are based on a statistical evaluation of selected data from openings of various geometries and ages that provides an empirical relationship between closure, room dimensions, and the age of excavations. Approximately 30 convergence locations are selected based on their typicalness. The empirical relationship is updated annually by the closure measurements from all convergence points (over 400) in the underground and compared with the prediction on a bimonthly basis. The prediction includes an allowance based on 95 percent confidence limits to provide an upper bounds estimate. Both the predicted closure rates and the tolerances can vary as new data is obtained and incorporated into the calculations. At the present time, the allowance above the average prediction is 0.5 inch per year. At locations at which measured closure rates exceed the upper bound predictions, investigations are initiated and explanations are sought. If no explanation can be found based on factors such as instrument malfunction or recent mining activity in adjacent openings, additional field studies may be initiated. The results of these comparisons of measured data with predicted values are documented in the annual Geotechnical Field Data and Analysis Reports.

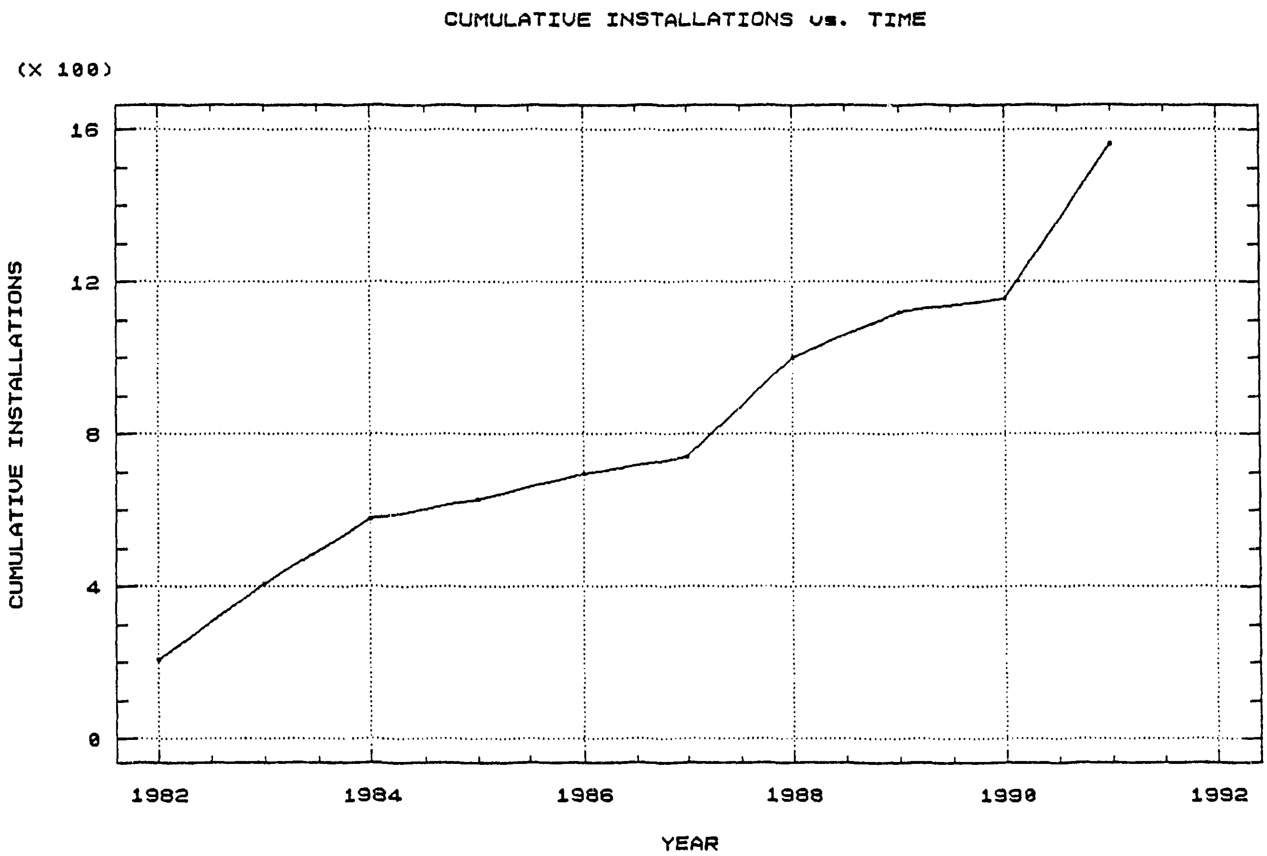

Figure 1. Installations from 1982 to the Present

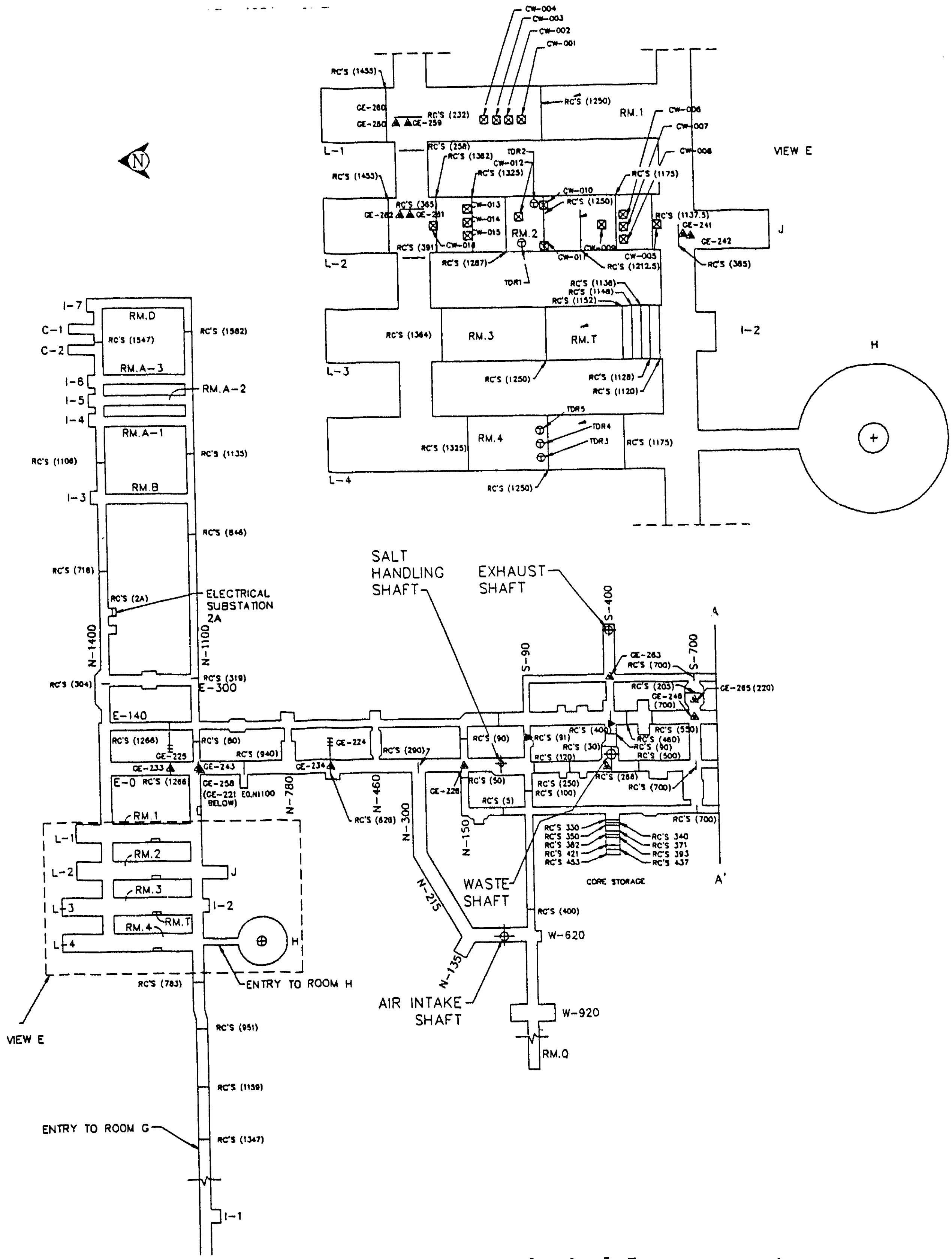

Figure 2. Underground Geomechanical Instrumentation

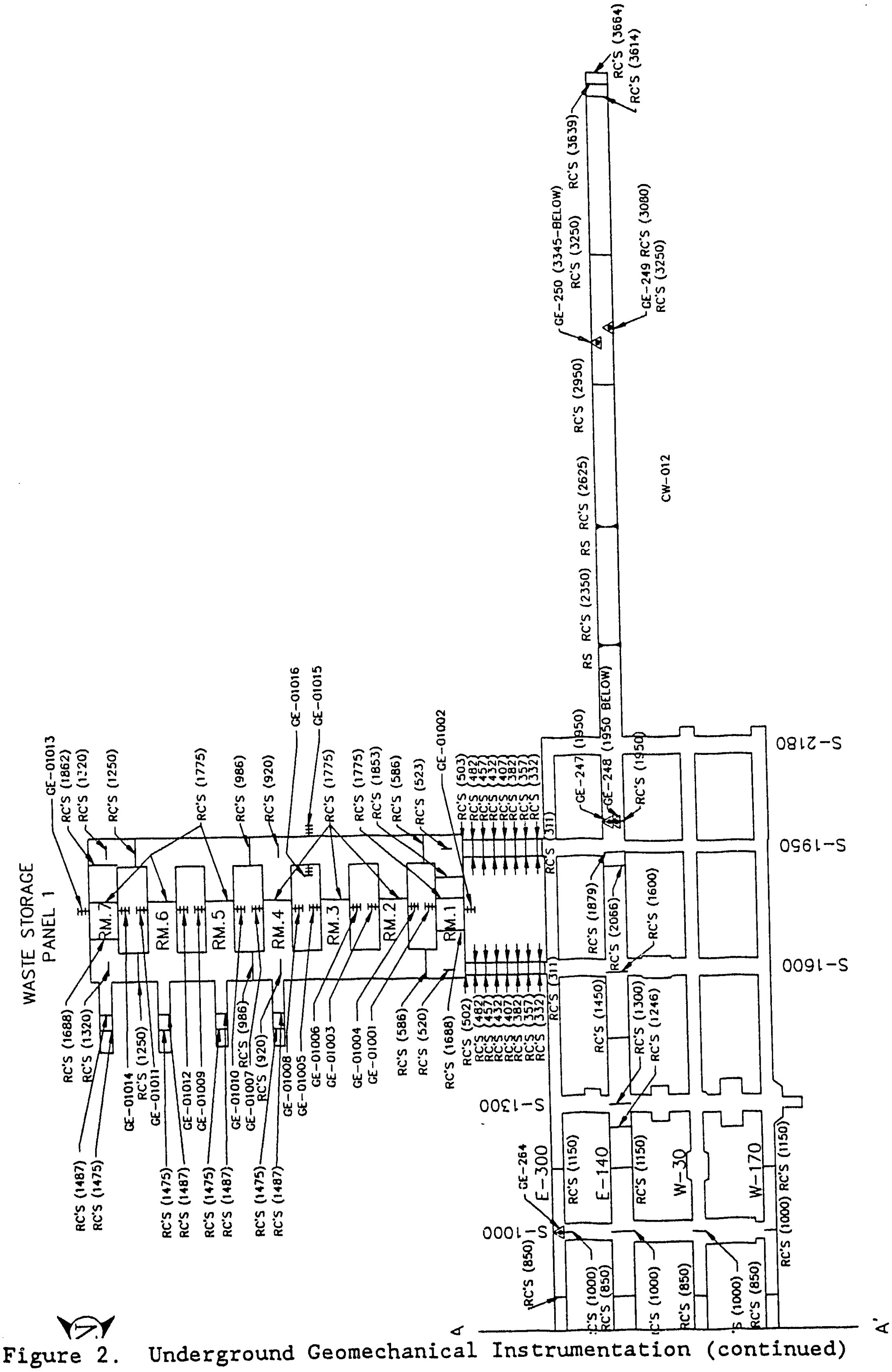

Figure 2. Underground Geomechanical Instrumentation (continued)

GEOMECHANICAL INSTRUMENT SPECIFICATIONS

Instrument Type	Measured	Range	Precision	Accuracy	Method
Borehole Extensometers	Cumulative Deformation	0-2 in.	+/- 0.001 in.	+/- 0.001 in.	Sonic Probe
Convergence Points	Cumulative Deformation	2-50- ft.	+/- 0.001 in.	+/- 0.001 in.	Tape Extensometer
Convergence Meters					
Probe	Cumulative Deformation	0-2.5 ft.	+/- 0.001 in.	+/- 0.001 in.	Sonic Probe
Wire	Cumulative Deformation	0-3 ft.	+/- 0.004 in.	+/- 0.032 in.	Rotary Potentiometer
Strain Gages					
Embedded	Cumulative Strain	0-3000 uin./in	+/- 1 uin./in.	+/- 2 uin./in.	Vibrating Wire
Spot Welded	Cumulative Strain	0-2500 uin./in	+/- 1 uin./in.	+/- 2 uin./in.	Vibrating Wire
Stressmeters	Stress	10000 psi	+/- 15 psi	+/- 15 psi	Vibrating Wire
Inclinometers					
Vertical	Cumulative Deflection	0-30 degrees	+/-0.001 in/ft.	+/-0.003 in/ft.	Accelerometer
Horizontal	Cumulative Deflection	0-30 degrees	+/-0.001 in/ft.	+/-0.003 in/ft.	Accelerometer
Rockbolt Load Cells	Load	0-50 tons	+/- 40 lbs	+/- 40 lbs	Strain Gage
Earth Pressure Cells	Lithostatic Pressure	0-10 psi	+/- 0.05 psi	+/- 0.05 psi	Vibrating Wire
Piezometers	Fluid Pressure	0-500 psi	+/- 0.5 psi	+/- 0.5 psi	Vibrating Wire

Table 1. Geomechanical Instrument Specifications

DATE

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