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Early In-Situ Measurements Program for the Waste Isolation Pilot Plant

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Sandia Laboratories

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Printed June 1979

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Early In-Situ Measurements Program
for the
Waste Isolation Pilot Plant

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ABSTRACT

The technical basis and description of measurements for the early in-situ measurements program at the WIPP are described and a proposed organizational structure is presented. Measurements are needed for verification of design predictions and also for a prelude to the main experiment program. The design verification measurements will be concentrated in the first shaft and the underground support and access areas. Early experiments will be concentrated in the test drifts on the storage horizons. Recommendations are made to DOE for appropriate division of responsibility among Bechtel, the technical support contractor, the instrumentation contractor, and Sandia.

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Acknowledgment

I would like to acknowledge the important contribution to this report provided by E. V. Howes of Bechtel, Inc. Vince prepared the initial input describing the rock mechanics monitoring program. Inputs and comments were also received from Westinghouse and RE/SPEC, a consultant to Sandia. The comments and suggestions of A. J. Birkmyer at Bechtel, Inc., A. K. Kuhn at D'Appolonia Consulting Engineers, and J. R. Wayland and A. R. Sattler of Sandia Laboratories, were all helpful in the completion of this document.

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Early In-Situ Measurements Program for WIPP

1.0 Introduction

In November 1978, Sandia agreed to prepare a plan for the in-situ experiments to be performed during the initial development of the WIPP facility. The plan was to include requirements for Sandia's early experimental investigations as well as requirements of Bechtel and Westinghouse for facility design and operations. The information that follows presents the technical basis for the measurements program and a recommended organizational structure for implementation and execution. Measurements programs are described for the construction and initial operational phases of the WIPP. However, the instrumentation effort for the experimental areas of the WIPP (including any areas for storage of heat-producing wastes) has been specifically excluded. A description of these activities will be included in the draft experiment plan and preliminary design of experiments for WIPP which will be published in September 1979.

2.0 Types of Data Needed

The measurement program will be directed towards collection of the information necessary for verification of the engineering design by checking the validity of the structural interaction models and preliminary site-specific information for demonstrating the feasibility of radioactive waste disposal in the selected bedded salt deposit in southeastern New Mexico. For purposes of this

document the program has been divided into three general areas: information needed for verification of design predictions, measurements planned as a prelude to the main WIPP experimental program, and other measurements needed for the WIPP. Each area is explained in more detail in the following paragraphs.

2.1 Measurements for Design Verification - The proposed measurements are generally related to the verification of the short- and long-term stability predictions of the shafts and underground excavations. The behavior of the openings will be monitored with strain and stress gages of various designs. Design verification monitoring will include direct measurements of closure (roof to floor and pillar to pillar). In addition relative displacement across and along argillaceous seams will be measured. Preliminary information from the field measurements will be compared with the design calculations for the remainder of the underground development. It is expected that there will be some differences between the actual behavior observed and the design predictions. Laboratory measurements and review of similar underground designs can only approximate the actual in-situ behavior. Since the creep phenomena must be observed over a long period (90 days to 360 days for major fraction of transient creep and even longer for measurement of steady-state creep), the first measurements on each storage level are planned as early as

possible in the construction schedule. This early execution will allow feedback into the design process prior to commencement of the major portion of the underground support and access areas. Additional instrumentation will be installed during this major construction phase so that the design of the storage areas (which will have a room and pillar design similar to the access shifts) can be verified prior to commencement of storage operations. It should be noted that the early data collected will provide information mainly on the transient creep behavior. Continued measurements will be required to validate the assumptions made on the steady-state creep phenomena.

In addition to the measurement of structural response of the in-situ formations, instrumentation will be installed for monitoring the aquifers penetrated by the shafts, for measuring seismic response, and for accurately measuring the geometric configuration of the facility during its operating lifetime.

- 2.2 Early Experiment Program - The qualitative aspects of the measurements for design verification outlined in Section 2.1 are not much different than the measurement program for any major underground facility. The requirements for public review and acceptance of the project would perhaps dictate a more thorough program or a larger quantity of information but not anything which has not been done in other facilities. However, the radioactive waste disposal

and experimental activities proposed for the WIPP result in some rather unique, and in some cases, first-of-a-kind measurement requirements. A full-scale experimental program is planned for the lower storage horizon. The preliminary details of the experiments are not yet finalized, but the current scope includes waste experiments with the equivalent of twenty (20) canisters of high-level waste, twenty (20) spent fuel assemblies and numerous experiments to assess the response of the storage medium to heat producing radioactive waste. As a prelude to the main experimental program, the program described below will provide information for the finalization of the experiment designs and also serve as input to sections of the FSAR dealing with experiment safety. None of the early experiments will require the use of radioactive waste but nonetheless will provide much needed site specific data.

The in-situ thermal conductivity of the various rock types at the WIPP site will be measured. This physical property is needed as input for calculating the near and far-field thermal response of the geologic medium to heat producing radioactive waste and to provide more statistical data on this in-situ property. Laboratory size samples of site specific materials have been analyzed and full-scale experiments for measuring in-situ thermal conductivity will be completed during the pre-WIPP experimental program.

Data from measurement of this in-situ property during the early experiment program will be used as input to the final experiment designs, the design of the storage areas for heat producing wastes, and validation of the laboratory and full-scale non-site specific measurements.

Heater arrays will be installed in the test drifts to provide the thermal fields necessary to measure brine migration, drill hole closure, and salt decrepitation. The permeability of the heated and unheated formation will also be quantified. The scope of the heater array will limit measurements to the coupled region (the area within approximately 10' of a given heater where interactions between stress and temperature are likely). No attempt will be made to measure heated pillar behavior during the early experiment program since the test drifts will be too close to the shaft complex.

As a final operation in the heater array experiment, a retrieval demonstration of one or several hot salt cores will be accomplished. The data obtained from this demonstration will be invaluable for validation of the final design for retrieval equipment. Further, the demonstration will most likely be necessary prior to the emplacement of any heat-producing radioactive waste at the WIPP.

- 2.3 Other Measurements Needed - The information described below will be needed either to verify portions of the facility

design and/or operating procedures but is not directly related to waste handling operations or response of the geologic medium to the excavation and storage operation.

The radiation background of the underground areas will be measured. The information will serve as a baseline for calculation of operator dose rates and accumulated radiation exposures. The measurement program will consider areal variation in the dose rate, the effects of emanation on out-gassing, and the isotopic content of the background radiation environment.

Ventilation of the mine will provide the mechanism for solving the following problems. The first is movement of salt water (either from the construction or storage operation) to the surface. The dust effluent from the storage side ventilation system is of particular concern. If high quantities of particulates are entrained in this air stream then the maintenance of the HEPA filter systems which are on-line could be prohibitive. The other area of concern is the quantity and direction of moisture exchange between the ventilation air and the storage medium. The exchange of moisture to or from the storage medium will be measured and its impact assessed. Both of these ventilation-related measurements will be initiated as a typical, or near typical, underground ventilation pattern is established.

The integrity of the formation ahead of active mining operations and around the periphery of storage operations will be measured with mine face scanning equipment. The intent will be to identify any structural changes such as large voids, large brine inclusions or separations along bedding planes above the tunnel back. This measurement will yield further data on homogeneity and continuity of the storage horizons. The actual technique will be selected after completion of the pre-WIPP experimental program. Calibrations will be performed from the early test drifts and the initial drifts in the shaft pillar area.

3.0 Description of Measurements Program

The detailed description of the measurements program has been divided on the basis of locations within the WIPP facility. Four general regions have been identified; namely, the shafts, special test drifts, initial development areas, and operational development areas. The division of the program into areas of the facilities results in some duplication in the description. However, the divisions in this section match the proposed organizational structure presented in section four.

3.1 Shafts

Four shafts will be constructed between the surface and the lower horizon at WIPP. Each shaft will have a shaft

station at each horizon. The instrumentation program will be concentrated in the first shaft to be constructed - the construction exhaust and salt handling shaft. Detailed geologic mapping of the entire shaft will be performed with careful attention given to joints and fractures in the aquifer zones. Three of the shafts will be lined with concrete from the surface to a point shortly below the contact of the Rustler and Salado formations (approximately 860 feet below the surface). The fourth shaft will have a steel casing set in concrete. The types of instruments in the upper section of the shaft will differ slightly from those used in the unlined lower section of the shaft. A tabular summary of the individual measurement points in the first shaft is given in Table 3.1 and a section through the first shaft is shown in Figure 3.1. Descriptions of each type of sensor array and their locations is given below. The systems described in 3.1.1 and 3.1.2 will be installed in each shaft. The remaining instruments will be installed only in the first shaft constructed.

- 3.1.1 Convergence and Radial Motion Measurements. Measurement points will be established at various depths inside the shaft for monitoring the movement of four points on the perimeter of the shaft. The stations (each with four convergence points) will be established approximately every 200 feet in the lined section and approximately every 300 feet within the unlined section. Movement will be measured

Table 3.1

Instrumentation Arrays in First WIPP Shaft

<u>Type of Measurement</u>	<u>Location</u>	<u>Configuration</u>	<u>Readout</u>	<u>Frequency of Readout</u>
Convergence and radial motion	Every 100' in lined section, every 300' in unlined section	4 points on diameter	Manual	Weekly to monthly in lined and in unlined
Piezometers	Every 50' between -520 and -730 and at rock salt interface	2 points on diameter	Remote electrical	Weekly
Thermal conductivity	Every 50' or each major formation (smaller interval) plus every 5' within 100' of storage horizons	1 point at each level	Local electrical	One-time measurement
Lining key strain	Eight locations in liner key	Embedment strain gages	Local electrical	Weekly to monthly
Single point series or multipoint extensometers	-900', -1500' and -2400'	5', 10', 20' and 30', depth perpendicular to shaft wall	Manual	Weekly to monthly
Stressmeters	-900', -1500' and -2400'	5', 10', 20' and 30', depth perpendicular to shaft wall	Local electrical	Weekly to monthly
Seismic monitor	-27', -830', -1800', -2700'	At shaft 1/4 points embedded in rock	Remote electrical	Continuous with triggered recording
Geometric grid points	Every 400' and at shaft stations	To be determined	-	Monthly

ROCK MECHANICS INSTRUMENTATION FOR FIRST WIPP SHAFT

FIG. 3.1

with a portable convergence tape along three chords and the two diameters. Initially the convergence points will be checked weekly and eventually only on a monthly basis throughout the operational life of the facility. The schedule for increase in monitor intervals will be determined by the magnitude of movements. No connection to the automatic data recording system is anticipated for the convergence measurements.

3.1.2 Piezometers. The regions immediately above, in, and below the Magenta dolomite (approximately 570 feet below surface), the Culebra dolomite (approximately 680 feet below surface), and the interface of the Rustler and Salado formations will be instrumented with piezometers to monitor any pressure build-up behind the shaft liner. Ten sensors (two at each level) will be positioned between 520 and 730 feet at fifty foot intervals. An additional four to six sensors will be installed near the Rustler-Salado interface. Provisions will be made for additional measurement locations to be established as required by the conditions encountered during construction. However, it is not anticipated that additional water bearing formations will be found. As with the radial and convergence measurements, the piezometers will be monitored initially at weekly intervals until the trend of pressure build-up versus time is established. Less frequent measurements will be made throughout the operational life of the facility. Design of

the instrument system will incorporate the capability for remote readout and eventual connection into the WIPP central monitor and control system.

- 3.1.3 Thermal Conductivity. A one-time measurement of the in-situ thermal conductivities will be made from the first shaft. Measurements will be made in each major formation or every fifty feet (whichever occurs more frequently) from the surface to the bottom of the shaft. Near each storage horizon (above and below 100 feet) the measurements will be made more frequently. The instrumentation for the thermal conductivity measurements is being developed by Sandia Laboratories and will be field tested during the pre-WIPP experiment program. The measurements will be made after completion of the shaft construction.

- 3.1.4 Lining Key Instrumentation. The shaft lining will be keyed into the interface between the Rustler and Salado formations. The response of this reinforced concrete key will be monitored with embedment strain gages located at four to eight different combinations of elevation and depth. The gages will be designed for remote readout by the central monitor and control system on a monthly basis. Initially the gages will be read from a local meter on a more frequent schedule.

3.1.5 Strain and Stress Measurements in Unlined Section of Shaft. The internal creep of the unlined section of the first shaft will be measured by three groups of extensometers installed at depths of approximately 900, 1500, and 2400 feet below the surface. The information gathered by these arrays will supplement the convergence data measured for the interior surface of the shaft opening. The pattern of creep motion as a function of distance from the shaft wall will also be measured. Each level will consist of a series of single point extensometers or a multipoint extensometer with attachment points at 5, 10, 20, and 30 feet from the shaft wall. The gages will be installed as soon as possible after excavation and will be read manually on a weekly basis initially and with decreasing frequency as the magnitude of the readings diminish. Eventually the readings will be made only once a month.

The state of stress in the salt at the same locations from the shaft where extensometer measurements are made will be measured with single point stress meters. Thus four stress meters will be installed at 5, 10, 20, and 30 feet from the shaft wall at each of three levels. In-situ state of stress will also be measured at several locations. Consideration will be given to differences in the state of stress caused by the presence of anhydrite layers. The instrumentation currently being considered for the stress

measurements is compliant pressure bladders. However, consideration will be given to borehole inclusion stress meters which are stiff devices having an elastic modulus much greater than that of the host rock. Installation of the gages will follow the construction operations as closely as possible. All stress gages will be designed for manual readout although provisions for remote readout could be included. The monitor schedule for the stress measurements will match that for the internal creep readings.

3.1.6 Seismic Monitors. The variation of response to seismic activity as a function of depth below the surface will be quantified by broadband accelerometers located at four depths in the rock near the walls of the first shaft. Arrays will be installed at the quarter points at 27, 880, 2100, and 2700 feet below surface and connections will be made to a recorder located on the surface. Monitoring will be done continuously on a temporary memory and permanent records will be made for any activities above a pre-determined level. All four locations will be set to record permanent information if the trigger level is exceeded at any of the four locations.

3.1.7 Geometric Grid Points. The overall geometric configuration of the shafts will be monitored by a high order survey net during the life of the WIPP facility. Exact design of this system has not yet been established.

3.1.8 Sample Collection and Other Measurements. Provisions will be made for collection of large samples (perhaps 1 m³) during construction of the first shaft. Possible locations for these sample collection activities are the aquifer zones and each of the storage horizons. Other zones will be identified as necessary. Additional measurements that might be included in the first shaft monitoring program could include more detailed analysis of the characteristics of the aquifers, monitoring of shear displacements along joints or bedding places, and more extensive monitoring of the shaft lining (especially at joints in the liner). Details of these items are not available now and some flexibility will be included in the fielding program for additional measurements as they become necessary.

3.2 Special Test Drifts - Two drifts will be excavated on each storage horizon as soon as possible after completion of the shaft stations for the first shaft. The special drifts will be instrumented for observations of the response of the openings and the included pillar under ambient conditions. Early experiments will also be fielded to obtain in-situ information needed for the final design of the WIPP experiments. Horizontal core holes will be drilled in four directions on each level to obtain more information on the nature of the storage horizons. The test drifts should be excavated with the multipurpose

alpine miners planned for each level. Excavation by the drill and blast technique will fracture the formation near the drift walls and complicate or possibly invalidate the collection of some of the rock mechanics data. The orders for these mining machines will need to be scheduled such that they will be available for the test drift mining. Since the adequacy of the underground mine design will depend in a large part on the accuracy of the data obtained from the test drift measurements, the costs that might be associated with an early equipment purchase are more than justified.

A plan view of the CH level including the two test drifts on the upper horizon is shown in Figure 3.2. A detailed plan view of the test drifts is shown in Figure 3.3 and a listing of the instrumentation arrays is given in Table 3.2. Each drift will be scaled to have approximately the same aspect ratio as the proposed CH storage rooms. The cross section of the test drifts is planned to be 8 ft high by 23 ft wide and the length of each will be approximately 100 ft. The intervening pillar will be approximately 50 ft wide. These dimensions may change after the Title II design effort is completed. At the end of one of the test drifts on the upper horizon a room will be mined which has constant height and incrementally increasing width (up to 10 to 1 ratio of width to height). The purpose of this room will be to provide an area where comparative measurements can be made.

CH LEVEL TEST DRIFT & ROCK MECHANICS INSTRUMENTATION ARRAY LOCATION MAP

FIG. 3.2

PLAN VIEW OF TEST DRIFTS ON CH LEVEL
FIG. 3.3

Table 3.2

Instrumentation Arrays in CH and RB Level Test Drifts

<u>Type Measurement</u>	<u>Location</u>	<u>Configuration</u>	<u>Readout</u>	<u>Frequency of Readout</u>	<u>Comments</u>
Quasi-static large-scale testing	Zone I, drift 1	To be determined	-	-	-
Support structures	Zone II, drift 1	To be determined	-	-	-
Convergence meter	Station 0+70, in drift 1; 1+00 and at 25' intervals thereafter in drift 2	Horizontal and vertical	Local electrical	Continuous	Expanding drift section on CH level only
Single point series or multipoint extensometers	Arrays at 0+70 and 1+00 plus 10 additional single points	At 2, 5, 10, 15, 20 and 30' depth in all four directions at 0+70, and in one direction at 1+00 plus selected depths for other points	Local manual/electrical	Daily to monthly	-
Stressmeters	Same as extensometers	Same as extensometers	Local manual/electrical	Daily to monthly	-
Thermal sensor	End of drift 1	1 point at maximum distance from end of drift	Remote electrical	Monthly	Connected to CMCS
Thermal array experiments	Drift 2	Maximum 10 kw/array, exact configuration to be determined	Local electrical/manual	As required	Power to be supplied by facility electrical system
Radiation background	Drift 2	To be determined	Local electrical	Continuous	Connected to CMCS at later date

Two similar test drifts will be mined on the lower horizon. The test drifts will have a 10 ft wide by 10 ft high cross section and the intervening pillar will be approximately 50 ft wide. This will provide the section aspect ratio and extraction percentage planned for the main storage areas on this level. Each drift will be approximately 100 ft long. The expanding width expected for the upper horizon test area will not be included on the lower horizon. The reason is that the storage of RH waste is not controlled by maximizing storage space but rather by the amount of heat input and the clearance requirements for emplacement and retrieval equipment. The layout of the shaft pillar for the lower horizon has not been completed but the drifts will be located similar to the layout shown in Figure 3.2 for the upper horizon. A detailed plan of the test drifts on the lower horizon is shown in Figure 3.3.

Descriptions of the instrumentation arrays planned for the upper and lower horizon test drifts are provided in the following paragraphs.

3.2.1 Rock Mechanics Measurements Under Ambient Conditions

The first test drift on each level will be divided into three zones. Zone I (0' to 20') will be used for large-scale quasi-static rock mechanics testing and data collection. Zone II (20' to 40') will be devoted to

- ① ----- THERMISTORS
- ② ——— STRAIN GAGE
- ③ | SINGLE POINT EXTENSOMETER
- ④ T SINGLE POINT PRESSURE CELL
- ⑤ H SINGLE OR MULTI-POINT EXTENSOMETERS
- ⑥ H SINGLE OR MULTI-POINT PRESSURE CELLS
- ⑦ ——— CONVERGENCE METER

PLAN VIEW OF TEST DRIFTS ON RH LEVEL
FIG. 3.4

testing of effects of creep on permanent supports or structures and testing of various rock bolts. The final zone, Zone III (40' to 100'), will be used for strain and stress measurements. Instrumentation will include extensometers, pressure cells, and convergence meters. Figure 3.3 shows that the majority of instrumentation in zone III will be concentrated at its mid-point. This placement will minimize the effects from the end of the drift and also from the shaft construction. Additional measurement points are provided for redundancy and establishment of trends as the end effects are approached. At the center of Zone III, multipoint extensometers and pressure cells will be installed in all four walls of the test drifts at depths of 2, 5, 10, 15, 20, and 30 feet from the drift walls. Continuous reading micro-convergence meters (horizontal and vertical) and several pairs of pressure cells for differential pressurization will also be installed at this location.

The in-situ stress field will be measured at the end of Zone III. Instrumentation for this measurement will include pressure cells and single or multipoint extensometers installed horizontally at depths of 2, 5, 10, 15, 20, and 30 feet from the end wall of the test drift.

Gage installation will be accomplished as soon after the completion of mining as possible. This includes the

possibility of some gage installation near the advancing mine face prior to completion of the entire drift. Data collection will be accomplished by local reading and recording.

The 200-ft long expanding cross section test drift would be mined at the end of the second test drift on the CH level. The initial cross section at station 1+00 would be 8 ft high x 23 ft wide. At the end of the expanding drift at station 3+00 the cross section would be 8 ft high x 80 ft wide. This drift would be mined in increments and the entire length would be excavated only if the preceding sections behave in a stable manner. Response of the opening would be monitoring at 25-ft intervals with continuous reading convergence meters (both horizontal and vertical). Some strain extensometers and pressure gages might be installed to supplement the convergence meters. Ambient rock mechanics measurements taken in the second test drifts on each level (excluding the expanding drift on the CH level) will be limited to convergence points at 25-ft intervals. The remainder of these drifts will be devoted to the early WIPP experiments.

3.2.2 Thermal Array Experiments. Two thermal arrays will be installed in the second test drift on each level. A maximum power of 10 kw/array will be used to simulate the coupled region thermal effects of heat-producing

radioactive waste on the bedded salt formations. The thermal arrays will be used on both levels to determine the differences in response due to variations in the host formation. The arrays on the upper level will relate the in-situ WIPP experiments to the pre-WIPP program which will be conducted in a very similar formation.

One of the arrays on each level will be set up primarily to measure thermally activated creep, temperature dependent thermal conductivity, and hole closure. The second heater array on each level will be used to measure brine migration, coupon corrosion, and formation permeability at elevated temperatures. Formation permeability at ambient temperatures will be measured in another section of the test drift. Salt decrepitation as a function of temperature (either initial or maximum) and temperature gradients will be observed for all four arrays. Separate measurements of the decrepitation behavior may be required but can be accommodated within the 20 kw of electrical power supplied to each level for the test drifts. It should be noted that the power requirements for the test drift will not be needed after completion of the construction phase of the WIPP facility. Instrumentation required for the heater arrays and associate thermally induced phenomena will be compatible with the requirements for design verification measurements whenever practical.

- 3.2.3 Large Sample Collection. Provisions will be made for collection of large size "intact" samples from each test drift for use in bench-scale and laboratory tests.
- 3.2.4 Radiation Background Measurement. The initial station for the radiation background monitoring system will be installed in the second test drift on each level. Initially the monitoring stations will be read locally but eventually they will be tied into the facility grid on each level through the central monitor and control system. Early installation of these stations will allow time for system checkout and will also provide input for the facility operator dose rate calculations.
- 3.2.5 Retrieval of Hot Salt Cores. A demonstration of the retrieval of hot salt cores will be performed on the lower horizon after completion of the thermal array experiments. Retrieval equipment (or portions of some systems) being designed and fabricated by Sandia Laboratories will be used for the demonstration. It should be possible to complete at least one retrieval operation prior to completion of the WIPP construction phase. Eventually up to four heated cores could be recovered (two near each array).
- 3.2.6 Horizontal Core Holes. Core holes will be drilled along the directions of proposed access tunnels from the area of the shaft station and test drifts on each storage horizon.

The cores will be used to determine if the predictions of uniformity on the storage horizons is correct prior to proceeding with major underground development. Holes will probably be 2" to 4" in diameter and will be drilled as far as practical (up to 5000 ft).

- 3.3 Initial Development Zones - The measurements planned for the test drifts on each horizon will provide needed in-situ data for initial design verification. This information will be supplemented by data collected during the construction of the shaft pillar complex and access drifts on each level. The size of individual rooms and the proximity of several rooms and intervening pillars within these areas will provide a configuration very similar to the planned storage room configuration. Observation of the response of the formation during and after the excavation activities will provide a final design check of the underground design prior to commencement of storage operations. In addition to the rock mechanics measurements mentioned above instrumentation will be installed to monitor moisture exchange between the formation and the ventilation air, quantify the particulate entrained in the exhaust air and measure the radiation background throughout the underground development. The geometric survey grid will be extended as the construction proceeds and large samples will be collected. A final instrumentation effort will involve the use of mine face scanning equipment ahead of the excavation

operations. Each of these instrumentation efforts is described more fully in the paragraphs that follow.

3.3.1 Rock Mechanics Measurements Under Ambient Conditions.

Two main instrumentation arrays are planned for the central development area on the CH level. The location of these arrays is shown in Figure 3.2 and details of each array are shown in Figures 3.5 and 3.6. These measurements will be supplemented with convergence points set at various locations in the underground development. It should be noted that the actual location of these arrays will be dependent on the excavation sequence and the locations shown in Figure 3.4 are only approximate. The arrays for the lower horizon will be similar to the area shown in Figures 3.5 and 3.6. Actual locations will be selected after the shaft pillar and access drift layout for the lower horizon is completed. Additional information will be collected on the lower horizon from convergence points installed at selected locations.

The instrumentation arrays will be designed to measure salt creep and changes in stress in the material surrounding the excavated rooms. Multipoint extensometers will be anchored in the roof and central pillar at depths of 2, 5, 10, 20, and 40 feet. Multipoint stress meters will be installed at the same locations and depths and a single twin pressurized stress cell will be installed at each array location.

- ① SERIES OF SINGLE POINT OR MULTI-POINT INTERNAL EXTENSOMETERS.
- ② MULTI-POINT STRESSMETERS.
- ③ TWIN PRESSURIZED STRESS CELLS.
- ④ EXTERNAL CONVERGENCE POINTS.

CH LEVEL SHAFT PILLAR ROCK MECHANICS INSTRUMENTATION ARRAY
(SEE FIGURE 3.2 FOR LOCATION)

FIG. 3.5

- ① SERIES OF SINGLE POINT OR MULTI-POINT INTERNAL EXTENSOMETER.
- ② MULTI-POINT STRESSMETER.
- ③ TWIN PRESSURIZED STRESS CELLS.
- ④ EXTERNAL CONVERGENCE POINTS.

CH ACCESS DRIFT ROCK MECHANICS INSTRUMENTATION ARRAY
(SEE FIGURE 3.2 FOR LOCATION)

FIG. 3.6

Readings will be taken from each set of gages initially at daily intervals and eventually at three-month intervals as the magnitude of the readings decrease. All recordings of these arrays will be done on a local basis and connection to the central monitor and control system is not anticipated.

3.3.2 Moisture Exchange Measurements. After the ventilation system for the construction phase of the WIPP has been established, the moisture exchange between the ventilation air and the formation will be monitored. The dew point, pressure, and temperature will be measured at the inlet and exhaust and selected locations throughout the underground development. The intent will be to measure the net change in moisture content and the locations where this change occurs. The measurements made during the construction phase will serve as a prelude to the system needed during the operational phase. The early program will help to identify points that are important to monitor and serve as a test period for selection of the equipment needed for the final system.

3.3.3 Particulate Measurements. The amount and size range of particulate entrained in the ventilation exhaust will be measured during the latter stages of the underground construction phase. Initiation of the measurements will be delayed until a fairly routine ventilation pattern has been

established. The air stream will be sampled using high volume and Anderson impact samplers. As with the moisture exchange measurements, the purpose of this effort will be to quantify the measurement in general terms and gain experience for the system needed in the operating facility.

3.3.4 Radiation Background Measurements. The first few stations of the radiation background monitoring systems will be installed and connected to the central monitor and control system as the underground development proceeds. Exact design of the equipment and sensor locations will be finalized prior to completion of the Title II design effort.

3.3.5 Geometric Grid Points. Control points for the WIPP facility geometric configuration grid will be established as the underground development proceeds. The installation of each point will be rigidly controlled in order that the accuracy of the system is maintained. Final design and positioning of these points will be completed during Title II design effort.

3.3.6 Large Sample Collection. Provisions will be made for collection of large samples (1 m^3) from each level at various locations of the underground development. The samples will be used for lab and bench-scale tests needed as a prelude to commencement of the experimental and storage operations.

3.3.7 Mine Face Scanning. The integrity of the formation (presence of inclusions or structural discontinuities) ahead of the excavated rooms will be investigated with mine face scanning techniques.

The primary emphasis will be during the development of the storage and experimental areas. However, the initial development phase will allow implementation of the method with an immediate feedback from observations after excavation is completed. The techniques being considered include radar, RF, and electrical resistivity measurements between selected points. These techniques will be tried in the pre-WIPP program and calibrated for the site-specific effort during the WIPP construction phase.

3.4 Operational Development Zones (Storage Areas) - The measurements planned for the underground areas that will be developed during the operational phase of the WIPP are essentially extensions of measurements planned for the test drifts or initial development zones. The primary purpose of this phase of the instrumentation program will be measurement of the expected conditions predicted by the previous measurement activities. It is not anticipated that any additional types of measurements will be added during the operational phase. Brief descriptions of the instrumentation planned for the operational development zones are given in the following paragraphs. It should be

noted that the instrumentation for the operational development zones does not include any systems installed in the experimental areas or in storage areas used for heat producing radioactive waste.

3.4.1 Rock Mechanics Measurements Under Ambient Conditions.

The set of three rooms into the first storage panel on the CH horizon will be instrumented with the array shown in Figure 3.7. The second and subsequent storage panels will probably be monitored with smaller arrays assuming that acceptable formation response is observed in the access rooms to the first storage panel. The array for the first panel will include extensometers, stressmeters, and convergence points similar to the instrumentation described in previous sections of this report. Succeeding panels will be instrumented with convergence points as a minimum. Additional instrumentation will be added as dictated by conditions encountered.

Any rock mechanics instrumentation required on the RH horizon will be addressed in the preliminary experiment plan to be published by Sandia Laboratories in September 1979.

3.4.2. Moisture Exchange Measurements. Sensor locations will be established throughout the storage rooms on both horizons for measurement of dew point, pressure, and

- ① SERIES OF SINGLE POINT OR MULTI-POINT INTERNAL EXTENSOMETER.
- ② MULTI-POINT STRESSMETER.
- ③ EXTERNAL CONVERGENCE POINTS.

CH STORAGE PANAL ROCK MECHANICS INSTRUMENTATION ARRAY

temperature. The information gathered by this grid will be used as input for the assessment of any moisture exchange on long-term containment. The number and location of the sensor arrays will depend on the magnitude of the exchange and the particular ventilation pattern in operation.

3.4.3 Particulate Measurements. Additional measurement points will be added in active storage rooms to quantify the amount of airborne particulate generated by the activities associated with waste handling. Measurements will be made to determine what portions of the airborne particulate generated in the storage rooms actually reaches the surface. The impact on the HEPA filter systems will be assessed and changes in operational procedures will be made as required.

3.4.4 Radiation Background Measurements. Final stations in the radiation background monitoring system will be added as the storage rooms are developed. The monitors will be connected to the central monitor and control system.

3.4.5 Geometric Grid Points. Additional survey points will be established in the storage areas of the WIPP. These bench marks will be particularly important near storage areas for heat-producing radioactive waste.

3.4.6 Large Sample Collection. Samples will be collected from the storage rooms and experimental areas for bench scale

and laboratory testing. The size of samples collected will range from small diameter cores (2"-4") up to 1 m³ intact samples. Requirements for samples have not yet been determined, but the largest number will probably be collected from the first few storage rooms.

3.4.7 Permeability and Thermal Conductivity Measurements. Check measurements will be made to determine the variations in permeability and thermal conductivity of the salt near the storage rooms as compared with the measurements made during the test drift program.

3.4.8 Mine Face Scanning. If the mine face scanning operations during the construction phase of the WIPP prove to be feasible and practical, a routine survey program may be implemented ahead of the mining effort during the operational development phase of WIPP. The purpose of the program would be to identify and avoid any areas that contain large brine inclusion or structural voids. It is anticipated that the program would be a safety measure only and that significant imperfections in the formation will not be encountered.

4.0 Program Organization

The measurements program described in the preceding sections of this report will be implemented for DOE by a coordinated effort of

Sandia Laboratories, Westinghouse, and Bechtel Inc. The measurements program will be divided into two phases; construction phase and operations phase. A proposed division of responsibilities for each phase is given in the following paragraphs.

4.1 Technical Support Contractor (TSC) Responsibilities -

Westinghouse Inc. will be responsible for overall coordination and implementation of the measurements program. Specifically, the TSC would develop an implementation plan for the measurements in the shafts, the test drifts, the initial development areas, and the operational development areas. During the construction phase, the TSC responsibilities include the overview of the instrumentation contractor to insure technical compliance with the implementation plan, the analysis of data collected and publication of results. During the operations phase the TSC responsibilities include the specification of new instrumentation requirements, preparation of specifications, procurement, installation, calibration and operation of all standard, non-developmental instrumentation, analysis of data collected and publication of results.

4.2 Sandia Laboratories Responsibilities - Sandia Laboratories would specify the measurement program for the test drifts on each storage level that is required as a prelude to the experimental program. During the construction phase this includes the selection of measurements to be made, design and development, procurement for GFE to the instrumentation contractor, and

overview of the installation and operation by the instrumentation contractor, data reduction and analysis and report production. Standard instrumentation will be suggested with specification, procurement, etc., carried out by the TSC, Bechtel and the instrumentation contractor. Design interface information for construction of the test drift and supply of support utilities will be provided by Sandia to Bechtel Inc. During the operations phase, the same responsibilities apply except that the implementation will be carried out by the TSC rather than the instrumentation contractor.

4.3 Bechtel Inc. Responsibilities - The measurements required for design verification will be specified by Bechtel Inc. and submitted to the TSC for incorporation into their overall plan. The preliminary definition of these requirements has been incorporated in this document. In addition, Bechtel Inc. would incorporate the design interface requirements generated by Westinghouse and Sandia into the WIPP Title I and II design and provide inspection during Title III. This would include provisions for connection of permanent monitors into the central monitor and control system, design and construction contract preparation for mining of the test drifts, and interface of the shaft instrumentation program into the shaft construction schedule. Bechtel will prepare detailed technical specifications for the standard, non-developmental instruments with the input from the TSC and Sandia Laboratories. The technical specifications will be packaged in contract form for

the instrumentation contract. During the operational phase Bechtel will not have any responsibilities.

4.4 Instrumentation Contractor Responsibilities. During the construction phase the instrumentation contractor will be awarded a contract prior to the start of the first shaft to provide for procurement and installations of all non-developmental instruments. The instrumentation contractor will also install and operate all GFE development systems during this phase. During the operational phase the instrumentation contractor will have no responsibilities.