U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: AIR-PERMEABILITY TESTING PROGRAM

PRESENTER: GARY LeCAIN

PRESENTER'S TITLE AND ORGANIZATION: HYDROLOGIST
U.S. GEOLOGICAL SURVEY
DENVER, COLORADO

PRESENTER'S TELEPHONE NUMBER: (303) 236-5020

REGISTRY HOTEL, DENVER, COLORADO
JUNE 25-27, 1991

U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: AIR-PERMEABILITY TESTING PROGRAM

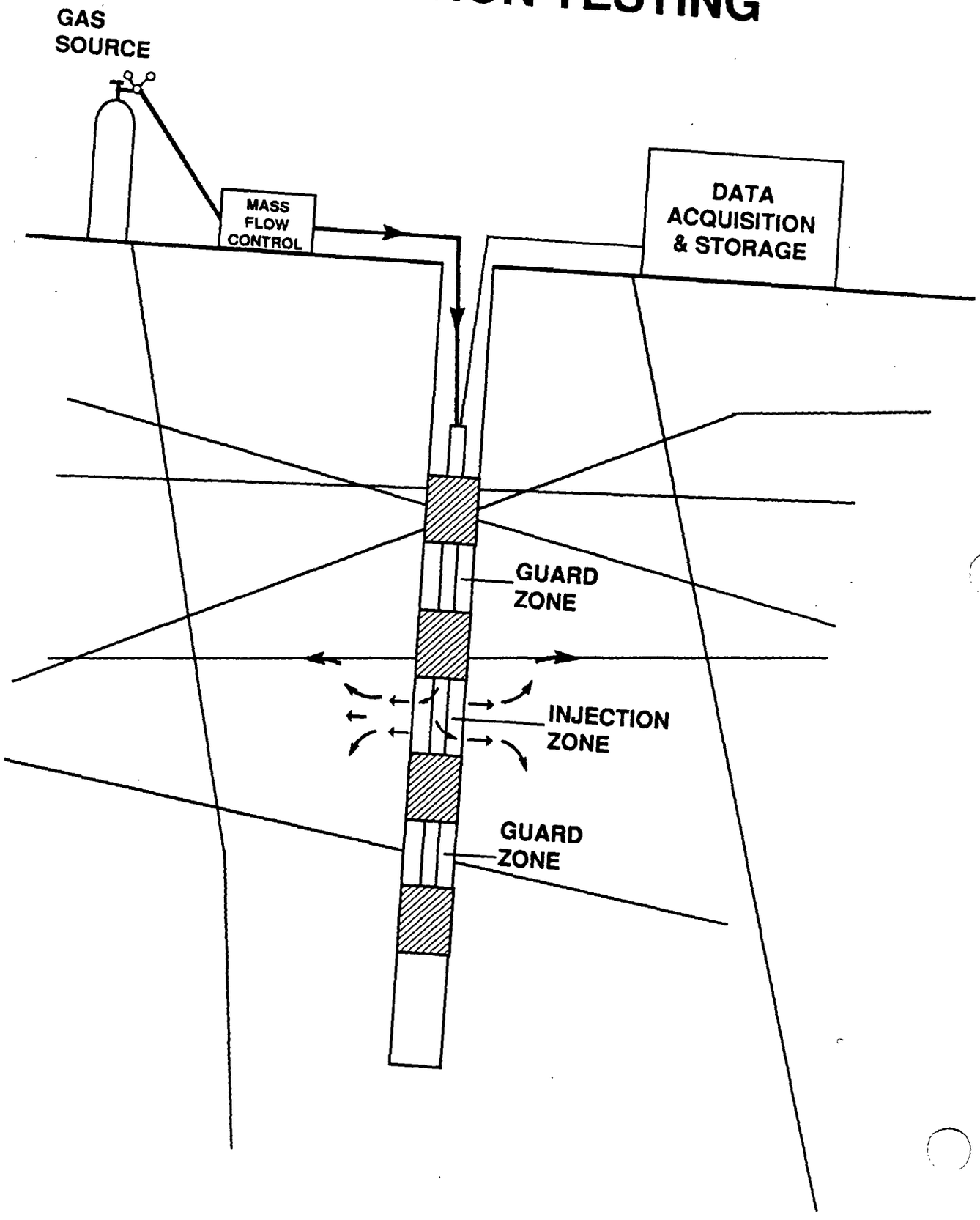
PRESENTER: GARY LeCAIN

PRESENTER'S TITLE AND ORGANIZATION: HYDROLOGIST
U.S. GEOLOGICAL SURVEY
DENVER, COLORADO

PRESENTER'S TELEPHONE NUMBER: (303) 236-5020

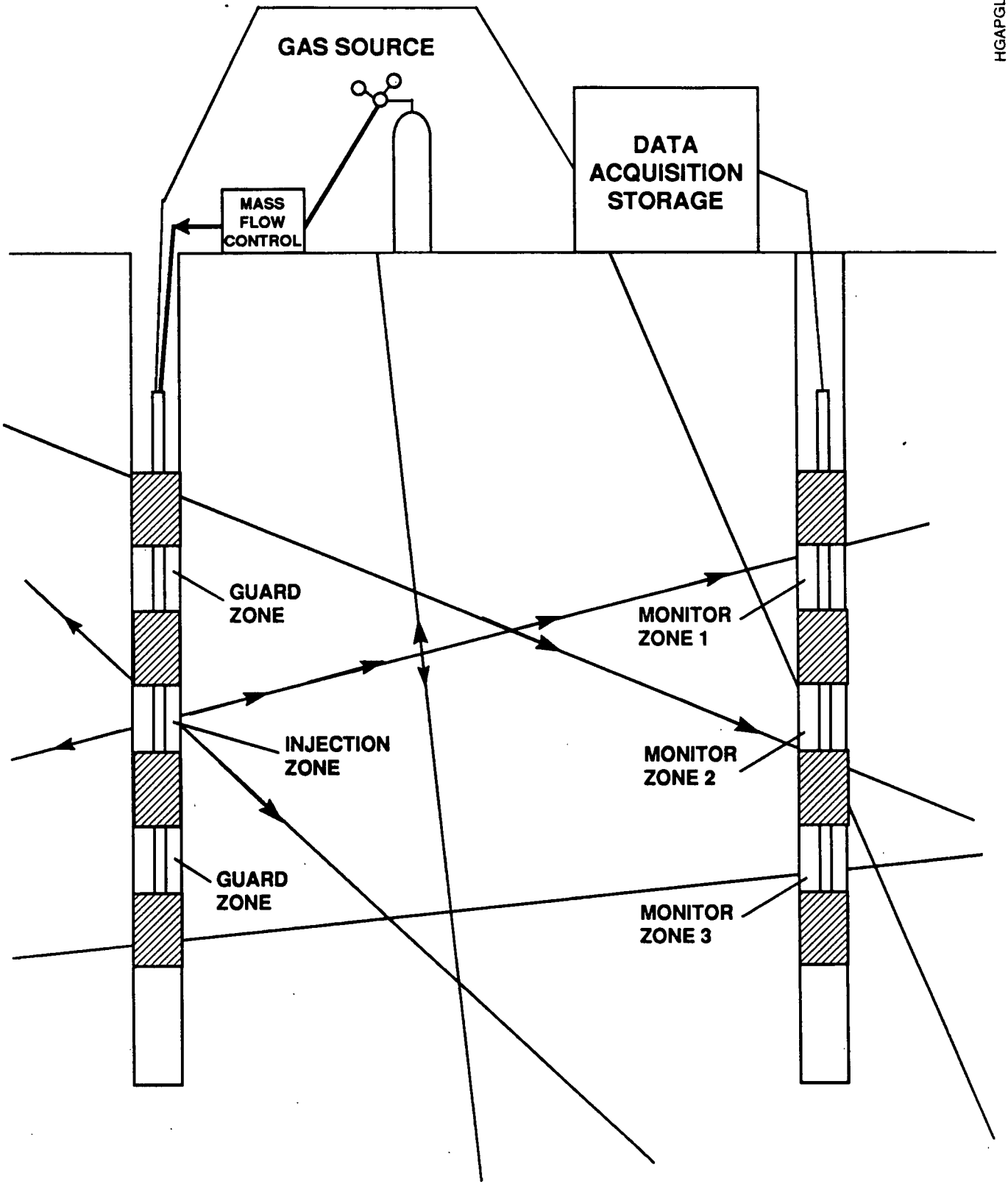
REGISTRY HOTEL, DENVER, COLORADO
JUNE 25-27, 1991

SCHEMATIC OF SINGLE HOLE INJECTION TESTING



HGAPGLFP.125.NWTRB\6-25,27-91

SCHEMATIC OF CROSS-HOLE TESTING



AIR PERMEABILITY TESTING PROGRAM

1. SURFACE-BASED TESTING

- MEASURE PERMEABILITY AND ANISOTROPY
- SINGLE AND CROSS-HOLE TESTING
- AIR AND/OR NITROGEN
- 12.25 INCH DIAMETER VERTICAL HOLES
  * CHARACTERIZE THE GEOLOGIC UNITS AT YUCCA MOUNTAIN

2. EXPLORATORY STUDIES BOREHOLE TESTING

- MEASURE PERMEABILITY AND ANISOTROPY
- SINGLE AND CROSS-HOLE TESTING
- AIR AND/OR NITROGEN
- 4.25 INCH DIAMETER HORIZONTAL HOLES
  * TEST CONTACTS AND FAULTS

OPTION 30

- RAMPS GIVE ACCESS TO MORE OF THE FORMATIONS, CONTACTS AND FAULTS
- INCREASED PROPOSED TESTING

AIR PERMEABILITY TEST GOALS

1. MEASURE THE YUCCA MOUNTAIN VOLCANIC TUFF IN SITU MATRIX AND FRACTURE AIR PERMEABILITY
2. QUANTIFY THE VOLCANIC TUFF HETEROGENEITY AND ANISOTROPY
3. MEASURE THE AIR PERMEABILITY OF THE YUCCA MOUNTAIN FAULTS
4. QUANTIFY THE ANISOTROPY OF THE FAULTS
5. ESTIMATE THE MATRIX AND FRACTURE IN SITU EFFECTIVE POROSITIES

OVERALL

6. PROVIDE EFFECTIVE PERMEABILITIES AND POROSITIES THAT WILL AID IN ESTIMATING WATER VAPOR AND GAS STORAGE AND TRANSPORT AT YUCCA MOUNTAIN

PROTOTYPE AIR PERMEABILITY TESTING

PROTOTYPE AIR PERMEABILITY TEST GOALS

1. DEVELOP AND/OR MODIFY PNEUMATIC EQUIPMENT AND TEST PROCEDURES FOR CONDUCTING SINGLE-HOLE AND CROSS-HOLE AIR INJECTION TESTS. (PACKERS, PRESSURE TRANSDUCERS, THERMISTORS, TCPs, DATA LOGGERS)

2. DEVELOP AND/OR MODIFY EXISTING PROCEDURES FOR PNEUMATIC TEST ANALYSIS FOR SINGLE AND CROSS-HOLE TESTING

3. COMPARE SATURATED AIR INJECTION TESTING VS. DRY NITROGEN INJECTION TO EVALUATE POSSIBLE DRYING IMPACTS

PROTOTYPE AIR PERMEABILITY TEST GOALS

(CONTINUED)

4. DETERMINE IF THE ISOTHERMAL ASSUMPTIONS ARE REASONABLE

5. DETERMINE IF THE CALCULATED PERMEABILITIES ARE INDEPENDENT OF THE INJECTION RATES AND PRESSURES

6. TEST ALONG AND ACROSS A GEOLOGIC CONTACT *

7. TEST ALONG AND ACROSS A FAULT *

8. CONDUCT CROSS-HOLE GAS TRACER TESTING *

* ITEM POSTPONED DUE TO CLOSURE OF G-TUNNEL

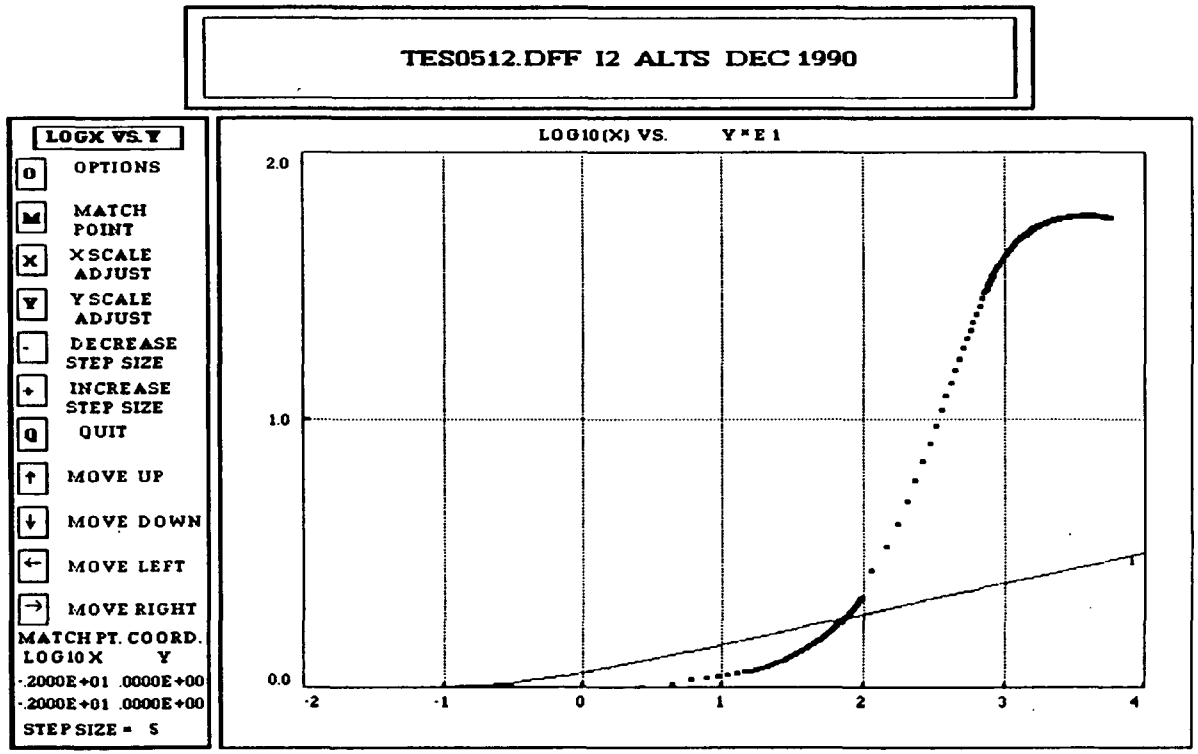
PROTOTYPE SINGLE HOLE INJECTION TESTING

- INJECTION WITH SATURATED AIR AND DRY NITROGEN
- INJECTION AT VARIABLE FLOW RATES
- TEST INTERVAL IS 3.1 METERS LENGTH

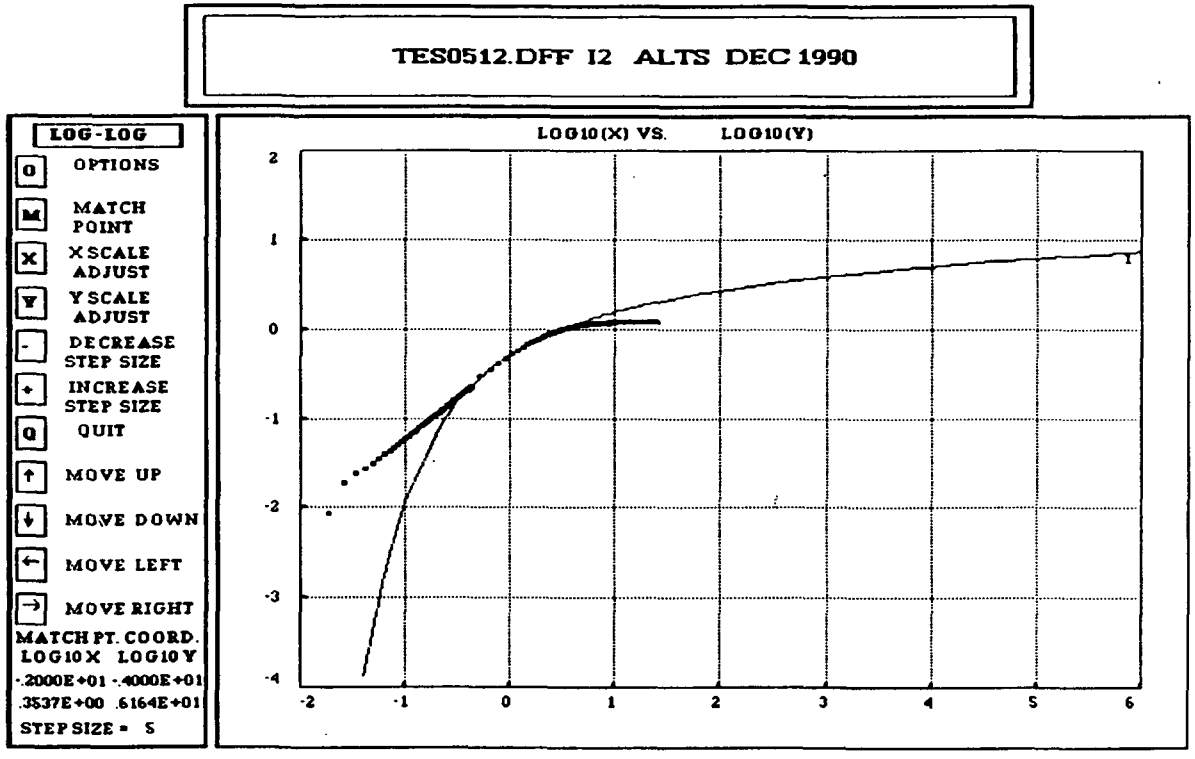
GOALS OF DECEMBER 1990 TESTING

1. COMPARE THE CALCULATED PERMEABILITIES USING SATURATED AIR VS. DRY NITROGEN
2. DETERMINE IF THE CALCULATED PERMEABILITIES ARE DEPENDENT ON INJECTION RATE
3. MONITOR THE INJECTION AND MONITOR INTERVALS TO SEE IF THE SYSTEM IS ISOTHERMAL

SINGLE-HOLE
$(p_i^2 - p^2)$ SEMILOG PLOT



SINGLE-HOLE
$(p_i^2 - p^2)$ LOG - LOG PLOT



RESULTS OF PROTOTYPE SINGLE HOLE INJECTION TESTS

- RADIAL FLOW MODEL
- SEMILOG ANALYSIS
- TEST INTERVAL 3.1 METERS LENGTH
- TESTS CONDUCTED ON INTERVAL WITHOUT VISIBLE FRACTURES
- PERMEABILITIES ARE IN METERS SQUARED
- FLOW RATES IN STANDARD LITERS PER MINUTE (SLPM)

	FLOW (slpm)	k (m**2)
SATURATED AIR INJECTION		
Tes0112	5.0	6.4 E-16
Tes0212	1.0	6.4 "
Tes0312	3.0	6.8 "
DRY NITROGEN INJECTION		
Tes0412	1.0	5.6 E-16
Tes0512	3.0	6.5 "
Tes0612	5.0	8.1 "
Tes0712	8.0	8.1 "

CONCLUSIONS FROM SINGLE HOLE TESTS

1. TESTING SHOWED SMALL PERMEABILITY DIFFERENCES BETWEEN SATURATED AIR VS DRY NITROGEN TESTS

2. THE SATURATED AIR INJECTION TESTS WERE INDEPENDENT OF INJECTION RATE. THE DRY NITROGEN TESTS SUGGEST AN INCREASE IN CALCULATED PERMEABILITIES FOR THE 1 TO 5 slpm RANGE BUT THE INCREASE WAS NOT CONTINUOUS TO THE 8 slpm TEST

3. TEMPERATURE CHANGES WERE LIMITED TO LESS THAN 0.2 DEGREE CELSIUS

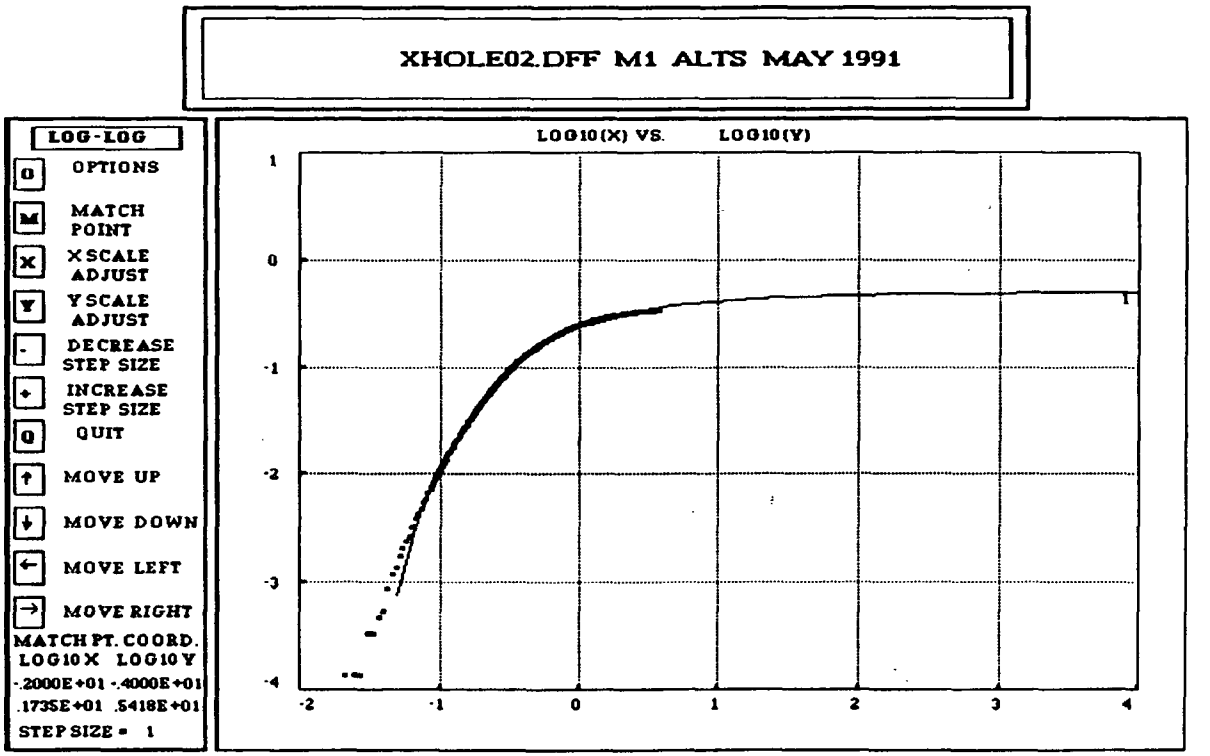
PROTOTYPE CROSS-HOLE FRACTURE FLOW TESTING

- INJECTION WITH AIR AT AMBIENT TEMPERATURE AND HUMIDITY
- INJECTION AT VARIABLE FLOW RATES
- TWO MONITOR ZONES AT 10.0 AND 10.1 METERS DISTANCE FROM THE INJECTION ZONE
- MONITOR ZONES AND INJECTION ZONES ARE 1.2 METERS LONG

GOALS OF MAY 1990 CROSS-HOLE TESTING

1. DETERMINE IF THE CALCULATED PERMEABILITIES ARE INDEPENDENT OF THE INJECTION RATE
2. MEASURE TEMPERATURE CHANGES TO DETERMINE IF THE SYSTEM IS ISOTHERMAL
3. EVALUATE THE TCPs ABILITY TO MONITOR THE HUMIDITY CHANGES DURING TESTING

CROSS-HOLE
$(p_i^2 - p^2)$ LOG - LOG PLOT

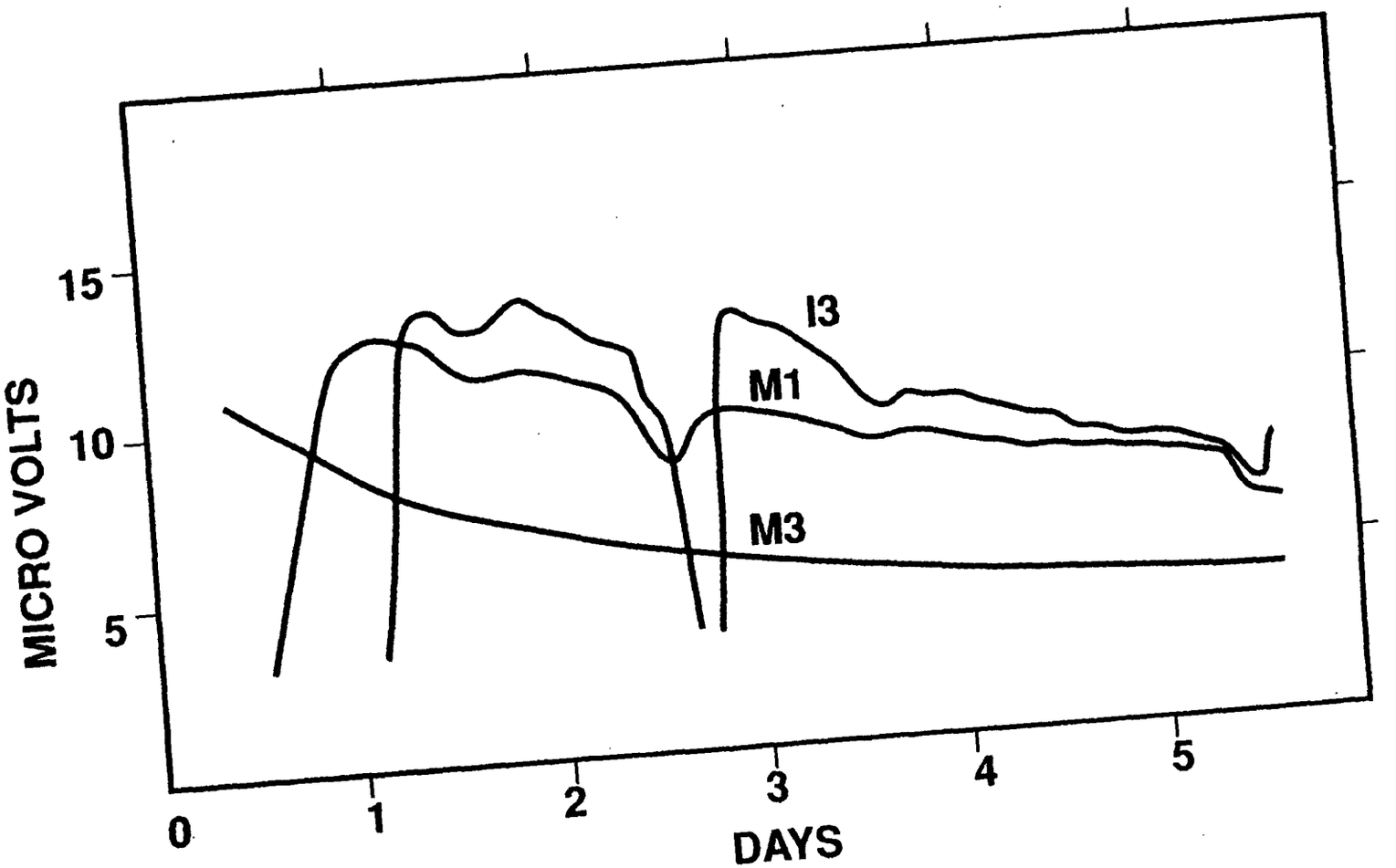


RESULTS OF PROTOTYPE CROSS-HOLE FRACTURE FLOW TESTING

- SPHERICAL FLOW MODEL
- AIR INJECTION
- PERMEABILITIES ARE IN METERS SQUARED
- POROSITIES ARE IN PERCENTS
- FLOW RATES ARE IN STANDARD LITERS PER MINUTE (slpm)

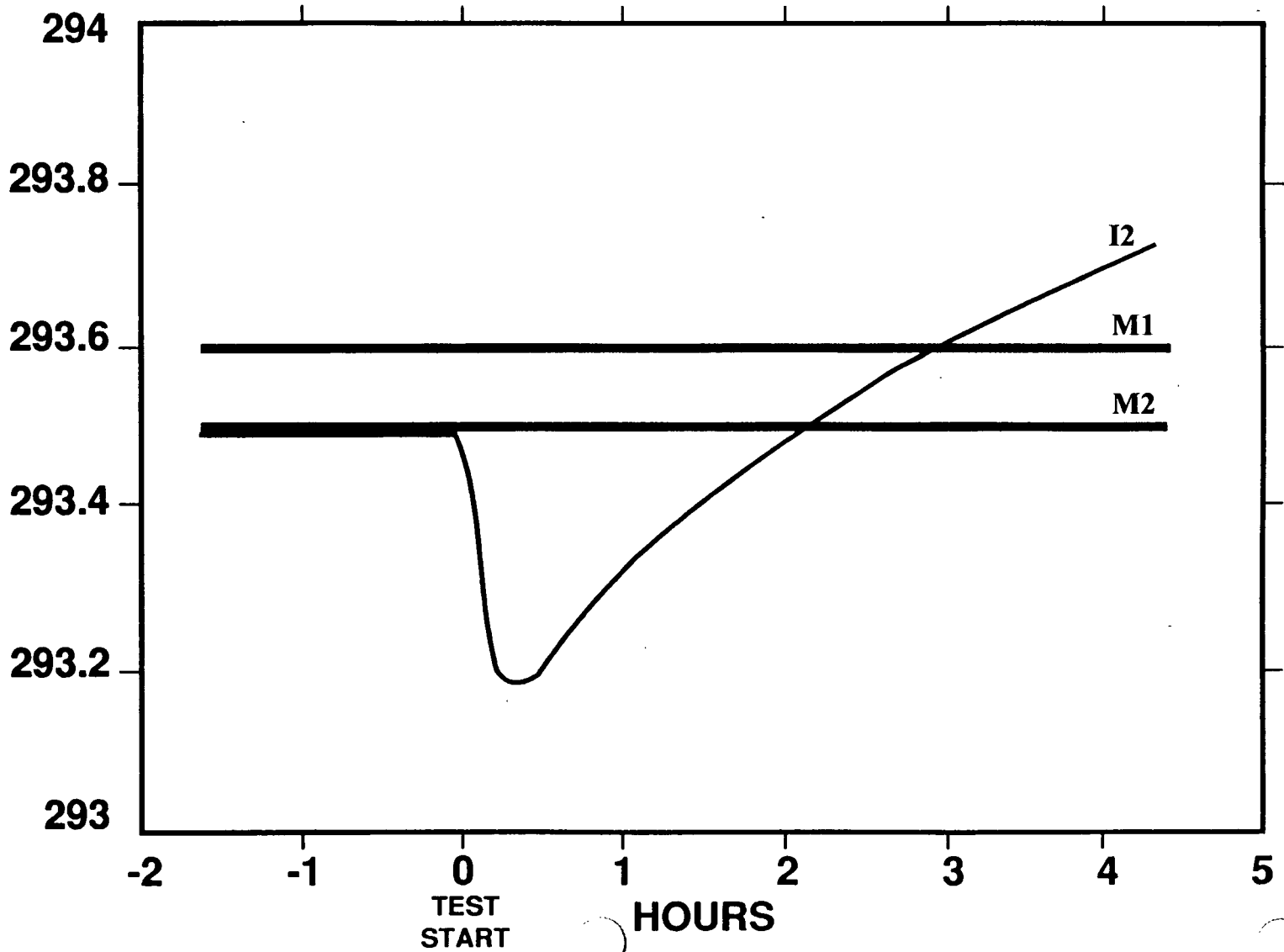
	FLOW (slpm)	MONITOR ZONE 1	MONITOR ZONE 2
XHOLE01	50.0	9.9 E-15 .25%	4.5 E-15 .11%
XHOLE02	23.4	9.9 E-15 .25%	4.7 E-15 .12%
XHOLE03	74.7	9.4 E-15 .23%	4.4 E-15 .11%
XHOLE05	13.0	10.2 E-15 .25%	4.6 E-15 .11%
XHOLE06	98.5	8.9 E-15 .24%	4.16 E-15 .11%

THERMOCOUPLE PSYCHROMETERS



HGAPGL5P.125.NWTRB/6-25,27-91

TEMPERATURES XHOLE06 (98.5 slpm)



CONCLUSIONS FROM CROSS-HOLE TESTS

1. THE CALCULATED PERMEABILITIES ARE INDEPENDENT OF THE INJECTION RATE FOR THE RANGE TESTED

2. TEMPERATURE CHANGES IN THE INJECTION ZONE WERE LESS THAN 0.5 DEGREES CELSIUS AND NO CHANGE WAS SEEN IN THE MONITOR ZONES; THE SYSTEM IS ISOTHERMAL

3. THE TCPs DID MONITOR THE GAS FRONT REACHING THE MONITOR ZONES HOWEVER NONE OF THE TCPs REACHED EQUILIBRIUM DURING THE SIX DAYS OF TESTING