NYE COUNTY NUCLEAR WASTE REPOSITORY

PROJECT OFFICE

TECHNICAL PROCEDURE

TITLE: Analysis of Pressure Transient Tests	Revision: Date: 2/23/1999 Page:
PROCEDURE No.: TP — 9.7	**SUPERSEDES**: Original Issuance
APPROVAL Project Manager Date 3.09.99	CONCURRENCE On-Site Geotechnical Representative Date 3-9-99 Principal Investigator Date 2/23/99 Project Quality Assurance Officer Date 2 MAR 1999

1. PURPOSE

The purpose of the procedure is to provide a set of consistent guidelines for the analysis of pressure transient tests. Numerous pressure tests are to be performed as part of Borehole Testing segment of the Nye County Nuclear Waste Repository Office

(NWRPO) Early Warning Drilling Program (EWDP). The implementation of these procedures and quality control guidelines will ensure accurate and consistent analysis of the pressure data and will yield results for use in formation characterization which will meet NWRPO quality assurance (QA) requirements for scientific data.

2. SCOPE

This procedure describes analysis methodology and quality control procedures for analysis of pressure transient tests.

2.1 APPLICABILITY

This procedure applies to the NWRPO principal investigators (PI) and designated contractors performing analysis of pressure transient test data as part of the Nye County independent scientific investigation program. These individuals shall be referred to herein as NWRPO personnel.

2.2 TRAINING

NWRPO personnel performing analysis described in this technical procedure shall be engineers or geoscientists with extensive prior experience in pressure transient analysis. Personnel involved in analysis shall have training and experience in the use of the computer spreadsheet and commercial analysis packages. A partial list of acceptable commercial analysis packages include: *Saphire* by Kappa Engineering, *We//test* by Fekete and Associates, and *Pansystem* by Edinburgh Petroleum Services. Personnel shall be trained in the use of this technical procedure and any other appropriate QA procedures before performing analysis and shall document that they have read and understand these procedures.

3. DEFINITIONS

PRESSURE TRANSIENT ANALYSIS: The term Pressure Transient Analysis ("PTA") is the analysis of variations in measured pressures caused by either naturally occurring events or intentionally induced flow rate changes for the purpose of defining reservoir or aquifer rock and flow parameters.

FLOW REGIME: The Flow Regime describes the geometry of fluid flow in the reservoir. This is typically Radial (Cylindrical), Linear, Bilinear, or Spherical.

WELLBORE STORAGE: The term Wellbore Storage is used to describe the period of time when flow continues from the reservoir after the surface flow rate has been discontinued. This is usually associated with changing fluid levels or the compression of wellbore fluids.

SKIN EFFECT: A numerical value that aids in describing the actual measured pressure drop in the near-wellbore area compared to what would be expected in the ideal unaltered case. A positive value indicates damage or a reduction in effective permeability near the well. A negative value indicates enhancement or stimulation.

EQUIVALENT SPHERICAL WELLBORE RADIUS: A calculated radius that converts the actual cylindrical wellbore configuration to a mathematically equivalent spherical shape.

RADIUS OF INVESTIGATION: The Radius of Investigation ("RI") is a measure of the amount of the reservoir investigated during the test. The RI is directly affected or increased by time and permeability and inversely affected or decreased by the porosity of the rock and the viscosity and compressibility of the fluid. The RI is an idealized measure, based on an engineering estimate of the distance influenced by a test within a particular test period, for an infinite, uniform, isotropic, porous medium.

4. RESPONSIBILITIES

The Project Quality Assurance Officer shall be responsible for the coordination of the internal review of this technical procedure.

The Principal Investigator shall be responsible for the preparation and modification of this procedure, as well as oversight of the performance of this procedure.
NWRPO personnel shall be responsible for the implementation of this procedure.

5. PROCESS

This procedure controls the analysis procedures performed by NWRPO personnel related to the analysis of pressure transient data. The performance of these procedures shall be documented in scientific notebooks or computer text files, as appropriate. All documentation shall meet the requirements of QAP-3.2, "Procedures for Documentation of Scientific Investigations." Any deviation from this procedure shall be documented in the scientific notebooks.

5.1 BACKGROUND

This Technical Procedure is intended as a guideline for the methodology to be employed while performing analysis of pressure transient data. It is not the intent of this document to provide a detailed handbook on the specific methods and calculations involved. Numerous good technical references exist on this subject.

5.2 DOCUMENTATION OF SOURCE DATA

A checklist to be employed while performing pressure analysis under this TP is attached as Attachment I. It is important the source of the rate and pressure data is documented. The name and location of the original pressure file should be noted on the form as well as in the scientific notebook.

5.3 DOCUMENTATION OF ASSUMPTIONS

The use of standard analysis calculations requires values to be estimated or determined for many rock and fluid properties such as porosity, thickness, viscosity, etc. These values have a direct effect on the analysis and are frequently subject to modification as information changes. For instance, for the thickness used in a permeability calculation, sometimes it is appropriate to use the total formation height based on petrophysical logs. For other tests, the height between the packers or the height determined from the pump-spinner log would be more appropriate. It is important the assumptions made and the sources of these assumptions are noted on the analysis checklist and the scientific notebook.

5.4 QUALITY CHECK OF PRESSURE DATA

In order to perform a cursory review of the pressure data, it is necessary to prepare a standard Cartesian plot of the measured pressure vs. time. This data should be visually checked for unexplained variations, undocumented shut-ins, and presence or absence of steady-state conditions. Ideally, both the pressure drawdown and recovery periods should be recorded. A copy of this plot should be attached to the analysis checklist.

5.5 DETERMINATION OF FLOW REGIMES

To aid in the determination of flow regimes, a standard Log-Log Plot should be prepared. This plot has pressure change and the derivative of pressure change on the Y-axis vs. delta Time on the X-axis. The analyst should note the flow regimes apparent on the plot. These may include Wellbore Storage, Bilinear Flow, Linear Flow, Spherical Flow, and/or Radial Flow. In most cases, only one or two flow regimes will be recognizable on the plot. The annotated plot should be included with the analysis.

5.6 DOCUMENTATION OF THE INTERPRETATION

The interpretation should be documented by including the following items:

- **Input Data Worksheet,** including the time, date and place of the test, the rate history, thickness, porosity, viscosity, temperature, compressibility, wellbore radius, and other data assumed for the analysis.

- **Analysis Graphs,** including the Log-log Diagnostic plot, a semi-log plot of pressure or head versus the logarithm of time (often called the Horner, Theis, Jacob, Miller-Dyes-Hutchinson, or MDH plot), a Cartesian plot of pressure or head versus time, and other relevant plots as needed (bilinear, linear, or spherical flow plots)

- **Match Results.** The match line or curve should be included as well as the actual data points on the plots.

- **Summary Results Sheet,** which should include the computed permeability, skin factor, extrapolated reservoir pressure, final flowing pressure, maximum buildup (recovery) pressure, radius of investigation, and other computed results.

6. DATA ACQUISITION METHODOLOGY AND LIMITATIONS

This procedure covers the interpretation and analysis of the pressure transient data but does not cover the actual acquisition of the pressure data or associated rock and fluid properties. The proper application of these procedures will allow for characterization of flow behavior in the area influenced by the test. As such, the information is only applicable to the area of influence or within the radius of investigation of the test. Care should be taken when applying the properties over larger areas.

Uncertainty attached to the methodology of pressure transient analysis includes the variability of the level of skill of the NWRPO personnel performing the analysis and individual professional judgment. Completed analysis documentation will be submitted to the NWRPO Quality Assurance Records Center (QARC) for capture in the project files.

7. REFERENCES

- NWRPO Quality Assurance Manual

- Matthews, C.S. and Russell, D.G., 1967, *Pressure Buildup and Flow Tests in Wells*, Society of Petroleum Engineers Monograph Volume 1, Dallas, Texas.

- Earlougher, R.C., Jr., 1977, *Advances in Well Test Analysis,* Society of Petroleum Engineers Monograph Volume 5, Dallas, Texas.

- Horne, R.N., 1995, *Modern Well Test Analysis, A Computer-Aided Approach,* Petroway, Inc., Palo Alto, California, 2nd ed.

8. RECORDS

A Pressure Transient Analysis Checklist is attached as Attachment I

9. ATTACHMENTS

- **ATTACHMENT 1: PRESSURE TRANSIENT ANALYSIS CHECKLIST**

10. TEST EQUIPMENT

There is no specific test equipment required to perform analysis under this Technical Procedure.

11. PERSONNEL REQUIREMENTS

There are no specific personnel requirements other than those described in Section 2.2

12. SPECIAL ENVIRONMENTAL TEST/STORAGE CONDITIONS

There are no special requirements for environmental test or storage conditions.

13. INSPECTION HOLD POINTS

There are no applicable inspection hold points.

14. ACCEPTABLE DETAIL AND ACCURACY LEVELS

Verification of calculations shall be made with a relative error of less than 1 in 1,000.

NYE COUNTY NUCLEAR WASTE REPOSITORY OFFICE
INDEPENDENT SCIENTIFIC INVESTIGATION
YUCCA MOUNTAIN, NEVADA

WELL TEST ANALYSIS QUALITY CONTROL CHECKLIST

Test Information

Borehole: _____ Interval Tested:_____
Test Date: _____ Datum:_____
Test Type: _____ ObservationWell(s)?:_____
Remarks:_____

Source of Data

Pressure File:_____ Source:_____
Type of Pressure Gauge:_____ Units:_____
Rate File:_____ Source:_____
Type of Flow Meter:_____ Units:_____

Assumptions

	Value	Units	Source	Comments
Height				
Porosity				
Viscosity				
Wellbore Radius				
Compressibility				
Temperature				

Results

Cartesian Plot Analysis: Attach Plot
Length of Flow: _____ Steady State? Y or N Pseudo-Steady State? Y or N
Remarks:_____

Log-Log Plot Analysis: Attach Plot
Flow Regimes Noted: (Circle Appropriate Types; Include Flow Regime Plot if Appropriate)
Wellbore Storage Bilinear Linear Radial Spherical Other
Remarks:_____

Analysis Procedures
Software Utilized: _____ File Name:_____Location:_____

Result Summary (Include Units)
Permeability: _____ Final Flowing Pressure: _____
Skin: _____ Extrapolated Reservoir Pressure: _____
Effective Flow Time: _____ Radius of Investigation: _____
Average Flow Rate: _____ Other: _____
Total Flow Volume: _____ Other: _____
Remarks:_____
_____

Analyzed by:_____ Analysis Date:_____