AMERICAN INSTITUTE OF FORMATION EVALUATION

SPECIALISTS IN PRESSURE DATA ANALYSIS & COMPUTERIZATION

Data for over

170,000 Analyzed Drill Stem Tests

in the Continental U.S.

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History of Drill Stem Testing

- Working in El Dorado, Arkansas, in the 1920s, E.C. Johnston and his brother M.O. Johnston developed the first drill stem tester and ran the first commercial drill stem test in 1926. In April 1929, the Johnston Formation Testing Corporation was granted a patent (U.S. Patent 1,709,940) and they subsequently refined the testing system in the early 1930s.

- In the 1950s, Schlumberger introduced a method for testing formations using wireline. The Schlumberger formation-testing tool, placed in operation in 1953, fired a shaped charge through a rubber pad that had been expanded in the hole until it was securely fixed in the hole at the depth required. Formation fluids flowed through the perforation and connecting tubing into a container housed inside the tool. When filled, the container was closed, sealing the fluid sample at the formation pressure. The tool was then brought to the surface, where the sample could be examined. In 1956, Schlumberger acquired Johnston Testers.

- Throughout the years numerous testing companies were formed and several differing methods of testing have evolved, including digital recorders and closed chamber tests. Sadly, DST testing has pretty well ceased in North America as of 2018.

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Origins of the AIFE File

- The initial days of the AIFE file began at Lynes United Services (a division of Baker Industries) in 1978. Grant Ward, Larry Prier and Wayne Cox made up the hydro team and Steve Misner supervised the data analysis team which were tasked with creating a computerized DST database in Canada. The entire group disbanded in 1981 when Baker elected to get out of the 'high tech' end of the business, with Steve Misner continuing with the file through CIFE.

- CIFE, Canadian Institute of Formation Evaluation Ltd., continued with the construction of the Canadian database and initiated the American DST data library through its subsidiary, AIFE, American Institute of Formation Evaluation Ltd.

- Grant and Steve worked together again in 1986, with Grant heading the Hydrodynamics division of CIFE, Canadian Institute of Formation Evaluation Ltd., where they would provide several regional hydrodynamic studies to the industry. The CIFE database covering Canada was sold to IHS Canada in 2000 and is considered the industry standard for Drill Stem Test data.

- Steve Misner has continued to construct the U.S. DST database, and has been personally responsible for the collection of over 110,000 individual tests, from petroleum resource firms, DST testing companies and private individuals.

- In 1988 Canadian Hunter identified the Ring Border field, a Triassic discovery in British Columbia with estimated reserves at the time of 1.4 TCF. This discovery was made utilizing the CIFE drill stem test data file. The DST, which was tight and identified as potentially damaged on the CIFE file, led to the discovery by the highly regarded team at Canadian Hunter, including, but certainly not limited to, Murray Grigg, Janelle Davison, and Ian van Staaldinen.

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Ring Border 1.4 TCF

Open Hole Testing Techniques I

Wednesday, A.M.
MacLeod 'C'

DRILLSTEM TEST ANALYSIS - PROBLEMS OF DST EVALUATIONS IN LOW PERMEABILITY HYDROCARBON SYSTEMS

Grigg, Murray, Canadian Hunter Exploration Ltd., 2000 605-5th Avenue S.W., Calgary, Alberta, Canada, T2P 3H5

Quantitative drillstem test analysis is often the key technology used to judge the flow capability of a well prior to casing a well. Quantitative drillstem test analysis is capable of estimating insitu flow capacity and formation damage. Initial post completion flow rates of oil, gas and water can be estimated from drillstem test data analysis. We find this technique is reliable for fair to excellent permeability reservoir rocks for the Western Canada Sedimentary Basin. The low permeability reservoir rocks systems (0.1 mD to 10 mD) tend to be underestimated especially in the Deep Basin hydrocarbon saturated areas. Several case histories will be examined to demonstrate the severity of this wellbore evaluation problem. The underestimation of permeability can be 10 fold to as much as 100 fold. It is possible to condemn commercial rock quality based on drillstem test information which was interpreted as tight rock. This drillstem test misinterpretation phenomenon has been used to locate economic bypassed hydrocarbons and was one of the keys to the discovery of the Ring Border Montney Field, N.E. British Columbia.

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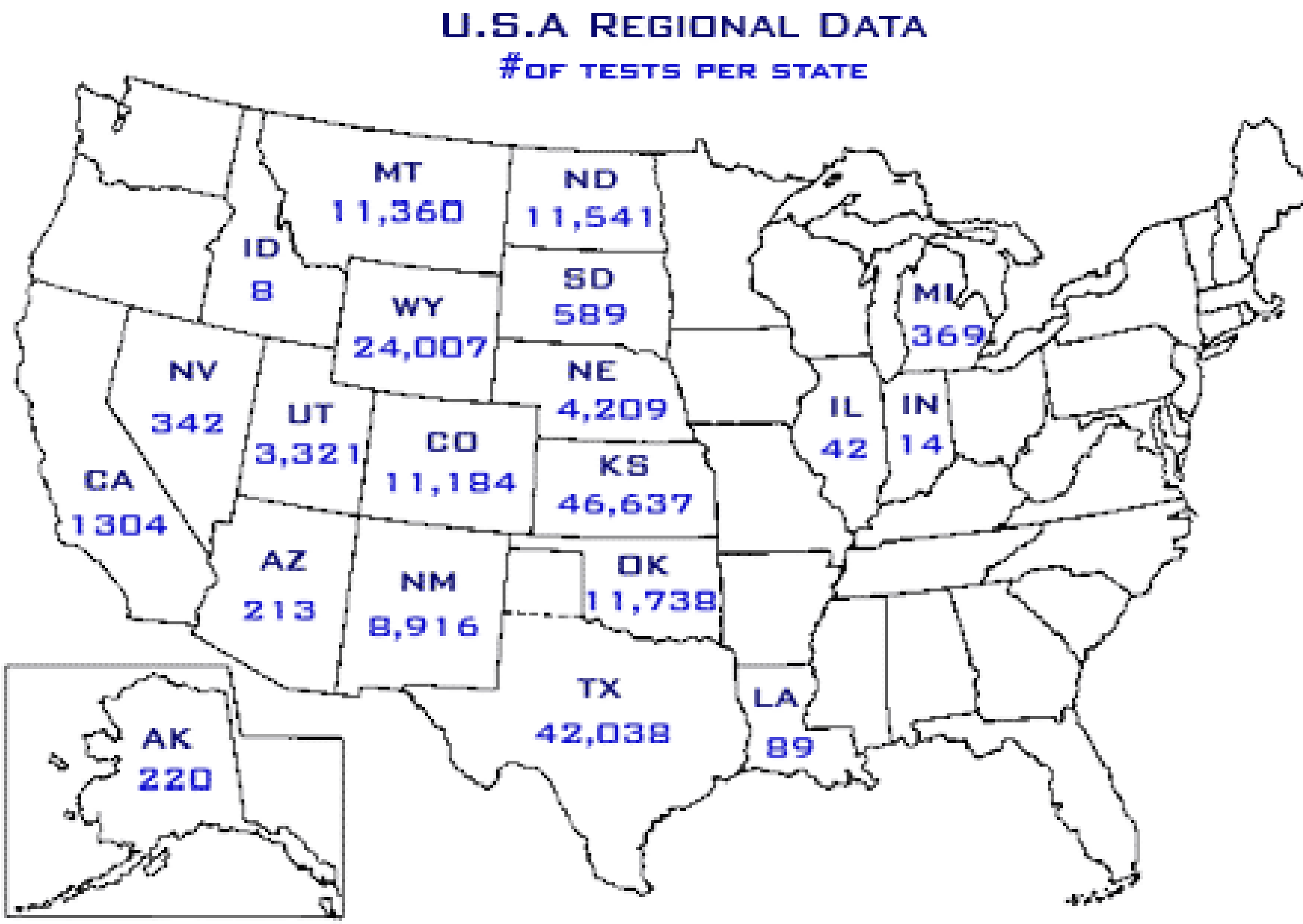
Historical DST Coverage by State



Historical drill stem test data has not, for the most part, been available in the United States, as no regulatory authority existed historically to collect this important information. AIFE has invested over $1.0 million to assimilate the raw data file, and over $4.0 million to analyze and computerize this information.

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AIFE Data Sources

- AIFE's drill stem test (DST) database contains over 170,000 analyzed tests for the United States covering the period 1948 to present.
  - Each analysis is derived from the original drill stem test report, not transcribed from scout or field data.
  - The DST data includes permeability, quality codes, drill collar and drill pipe data, incremental detail, HORNER extrapolated pressures and slopes, PMAX, Detailed blow descriptions, Formation DAMAGE and recoveries.
- The file was constructed over a 20 year period from the original DST reports at a cost exceeding $5.0 million.
  - Much of this investment was made in the 1980s and would be considerably more expensive to recreate today. The file represents the largest single collection of drill stem test reports available and surpasses any individual state record compilations.
  - A large percentage of the DST reports collected by AIFE could not be duplicated at any price, most testing companies are now out of business and have destroyed their records in contemplation of legal liability.

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AIFE Data Sources

- The original sources, (many of which have sadly been destroyed)for the data file include:
  - The internal records of Amoco Production Co., Arco and the numerous companies they had each acquired over the years.
  - Tests from individual testing companies (including Baker).
  - Petroleum Research Corporation who collected data from 1948 to 1983 (57,000 tests).
  - State records where available. Unfortunately the States that require DST's to be filed have not, for the most part, required filing of the digital recorder information so the incremental detail on the build-up curves has been lost.
  - It is arguably the only comprehensive database of historical DST information available in the United States.
  - AIFE has collected historical DST data from over 120 testing companies

Tests Collected top 20 testing companies

Halliburton	33384 tests
Johnston	24887 tests
Lynes	16631 tests
Miller	13177 tests
Virg's	12798 tests
Western	11885 tests
Foster	8536 tests
Tew	7665 tests
Rig	6716 tests
Sun	6187 tests
Superior	5497 tests
Permian	3852 tests
Star	3448 tests
B & B	3112 tests
Star Hughes	2721 tests
Miller-Donel	2680 tests
Big E	2512 tests
B & S	2068 tests
Oilwell	2057 tests
Sun Oil Well	1688 tests

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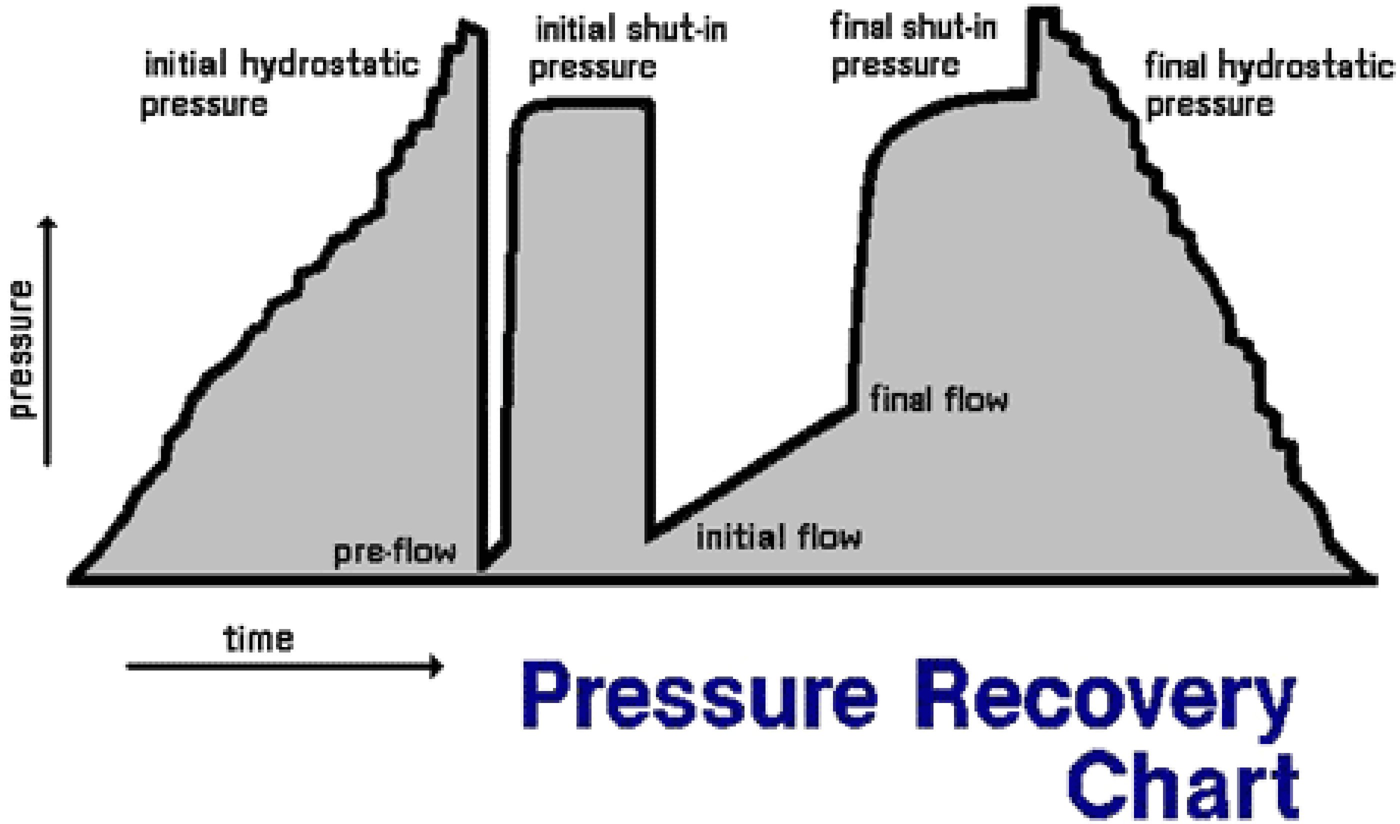
Drill Stem Testing



Drill Stem Testing is a basic oilfield evaluation tool. DST's are essential in determining the disposition of current wells and providing reservoir data which can aid in predicting productivity and appropriate well completion techniques.

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DST Testing

- The primary objective of Drill Stem Testing is to determine the type and rate of production, formation characteristics and conditions.
- Detailed interpretative analyses of drill stem tests provides vital information such as reservoir characteristics, permeability, virgin reservoir pressures and temperatures, reservoir drawdown and hydrocarbon recoveries.
- The incorporation of such data into an exploration program proves to be invaluable and essential for an overall perception of fluid migration.

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DST Data

- To the explorationist, evaluation of individual DST's is important to determine if potential zones were fully evaluated or if by-passed hydrocarbons are present.
- Virgin reservoir pressures as determined by DST's can be compared to post-stimulation results to determine stimulation effectiveness. The application of DST's in petroleum hydrodynamics is invaluable in delineating reservoir continuity, fluid gradient analysis, fluid migration pathways and pressure regime interpretation.
- Applications of DST's encompasses direct involvement in exploration, exploitation, reservoir engineering, hydrodynamics and drilling analysis.

DST Data

- The best type of DST data available is data taken directly from the original DST report, not transcribed or copied from field reports.
- Transcribed or field data is often unreliable at best.
- To have reliable DST data the original DST report should be obtained, the test reviewed for mechanical success and incremental detail on the shut-ins obtained to complete Horner extrapolation(s).
- This process is lengthy and requires a degree of skill in DST analysis to identify problems which if not recognized can lead to serious errors.

AIFE Analysis Overview

- AIFE provides the petroleum industry with over 170,000 DST reports in the United States, and has analyzed over 430,000 DSTs worldwide.
- Our team of professional analysts transform the raw data into high-grade form by calling upon their experience analyzing tens of thousands of tests.
- Pressure curves often need to be digitized so that incremental detail is available for performing various reservoir calculations which are a part of the high-grade data set.
- The DST’s are also coded according to unique time tested quality criteria making it possible to conclude facts about test reliability, reservoir permeability and damage etc., simply by glancing at our reports.

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AIFE Quality Coding System

- AIFE's expert personnel have re-evaluated each drill stem test from the source documents according to criteria identified over forty years of experience, providing a newly comprehensive and reliable base for decision making.
- The following is a brief look at the methods by which this re-evaluation was accomplished. A fully detailed study of how these standards were arrived at is available upon request.
- These Quality Codes grade drill stem tests according to the following signatures:

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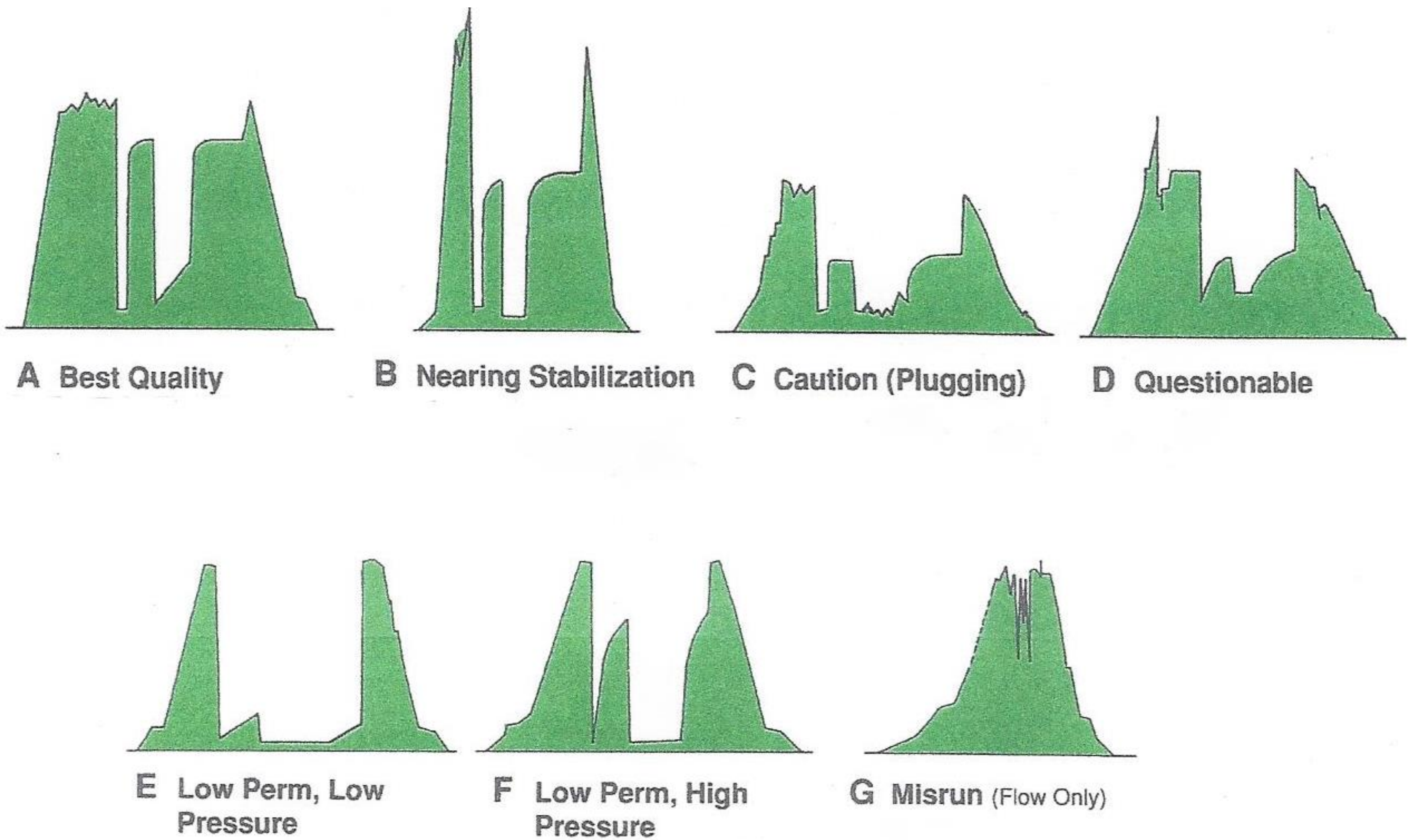
AIFE Quality Codes



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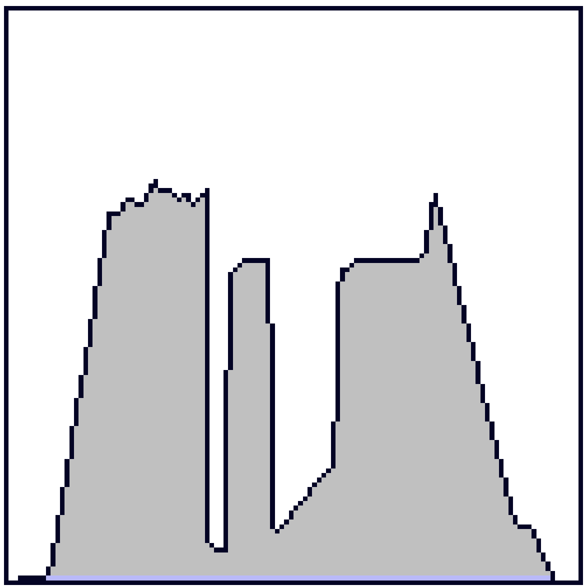
AIFE Quality Codes

- "A" Quality Test



- 1. Test mechanically sound - No Plugging/No Skidding
- 2. Recorder used-chart good, pressures compare
- 3. Flow pressures verify recoveries and/or flow rates
- 4. Bottom packer held on straddle tests
- 5. Recorder depths given
- 6. Recorder within interval tested
- 7. ISI stabilized, or nearing stabilization with increments
- 8. Preflow time long enough to release hydrostatic head
- 9. KB elevation given
- 10. Two good shut-ins required
- 11. PMAX Range of approximately 1 to 10 lbs. (7 to 69 kPa) from read shut-in pressure
- 88. Fluid to surface on flows (irregularities)
- 99. Flows incremented

Note: Quality code information is programmed into the data base, as listed, by both letter and number, e.g. B13, G64. This is done to enhance the reliability of the data base. Should a user wish to investigate any specific coding instance classification details are retrievable.

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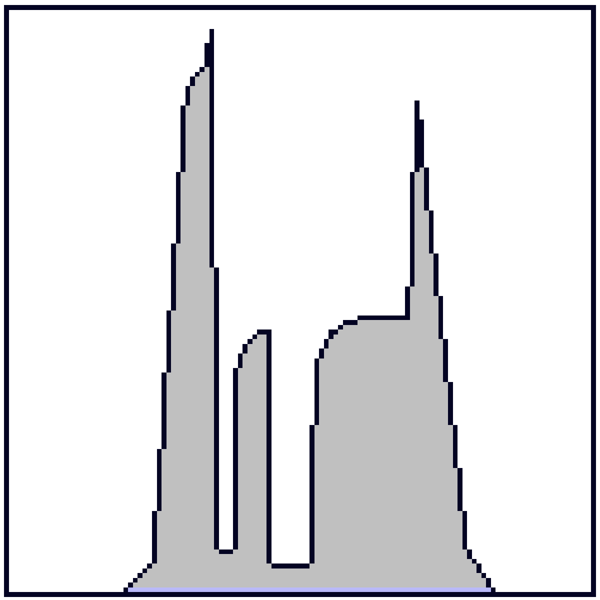
AIFE Quality Codes

- "B" Quality Test



- 12. Slight mechanical difficulties, but does not affect the test
- 13. Shut-ins not fully stabilized
- 15. Recorder pressures disagree from 1 to 19 PSI (7 to 131 kPa) after recorder drag and depth difference
- 17. PMAX range of approximately 20 to 35 lbs. (138 to 241 kPa) from read shut-in pressure
- 48. Flow pressures do not verify recoveries
- 88. Plugging, fluid to surface, resets on flows (irregularities)
- 99. Flows incremented

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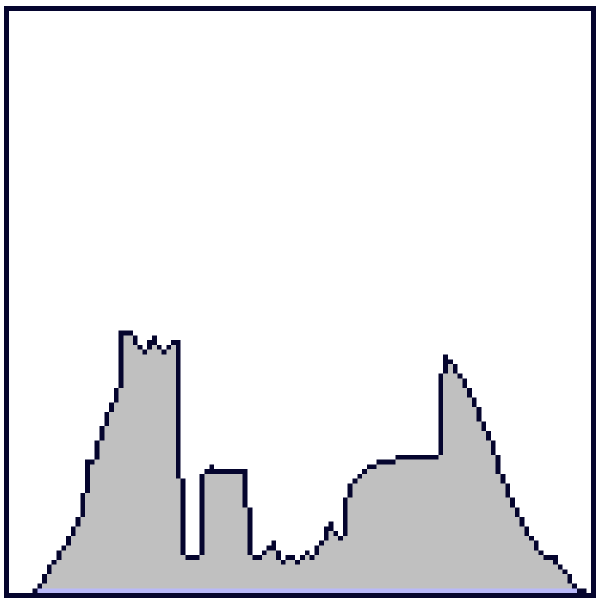
AIFE Quality Codes

- "C" Quality Test



- 18. Some mechanical difficulties evident on chart, however, does not appear to affect pressure data
- 19. Recorders run above the interval
- 21. Preflow not opened long enough, possibly slightly supercharged
- 22. Packer may have leaked slightly
- 24. Recorder pressures disagree from 20 - 29 PSI (138 to 200 kPa) after recorder drag and depth difference
- 25. Only one recorder, must be within interval
- 26. PMAX range of approximately 30 to 85 lbs.(207 to 586 kPa) from read shut-in pressure
- 27. Only one good shut-in
- 88. Plugging, fluid to surface, resets on flows (irregularities)
- 99. Flows incremented

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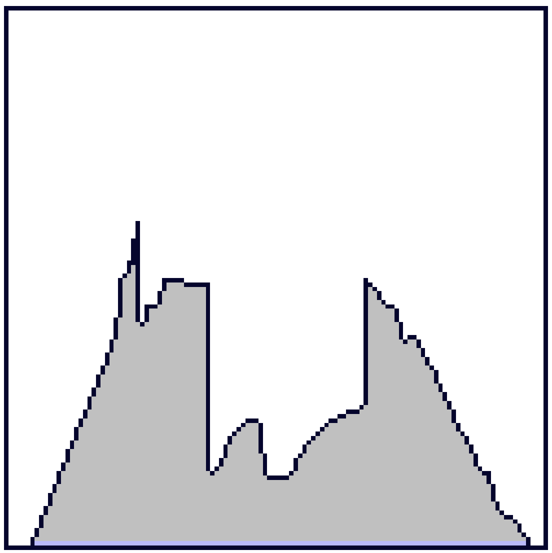
AIFE Quality Codes

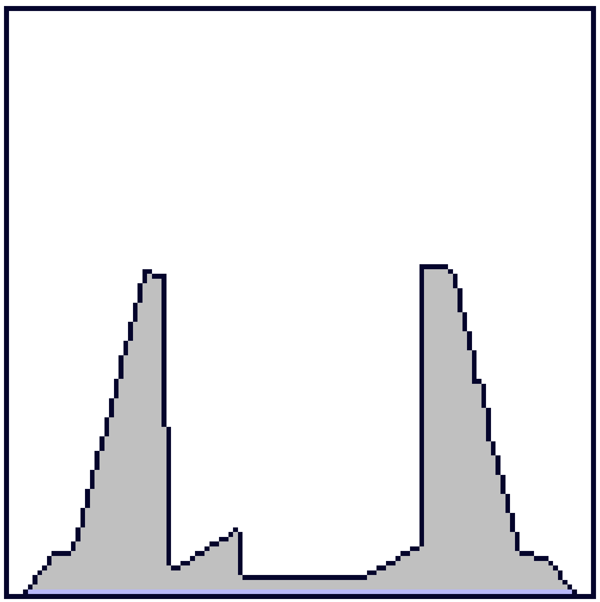
- "D" Quality Test



- 28. Not totally mechanically sound
- 29. Only one recorder, run inside above the interval
- 30. No recorder depth or questionable
- 31. No KB elevation
- 33. Questionable interval depths.
- 34. Supercharged ISI, FSI follows long valve open period
- 35. No chart from below bottom packer
- 36. Recorder pressures disagree from 30 PSI (206.8 kPa) and over after recorder drag and depth difference
- 37. PMAX range of approximately 80 to 150 lbs.(552 to 1034.2 kPa) from read shut-in pressure
- 79. Cannot define a valid P-Max (test indicates definite drawdown) P-Max filled with the initial shut-in pressure
- 88. Plugging, fluid to surface, reset on flows (irregularities)
- 99. Flows incremented

AIFE Quality Codes

- "E" Quality Test



Low Permeability, Low Pressure

- 38. Covers all requirements of Code A, however, low permeability and low pressure, unable to extrapolate
- 39. Low permeability, low pressure, but problems encountered throughout test
- 46. Low permeability, relatively high pressure for "E" Code
- 88. Plugging, fluid to surface resets on flows (irregularities)
- 99. Flows incremented

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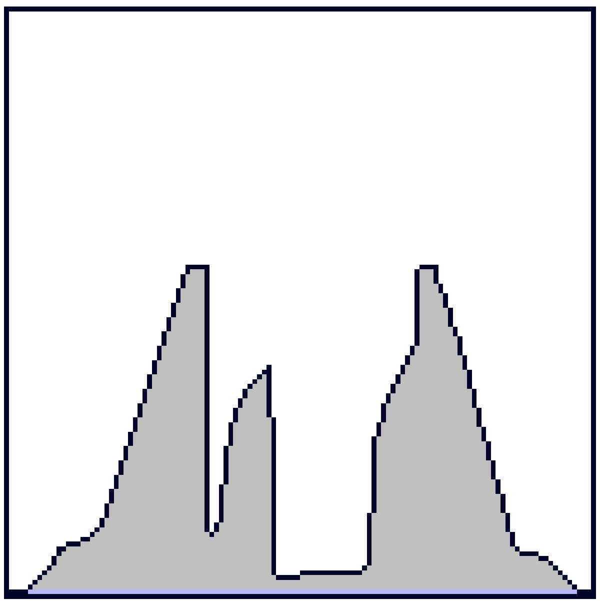
AIFE Quality Codes

- “F” Quality Code

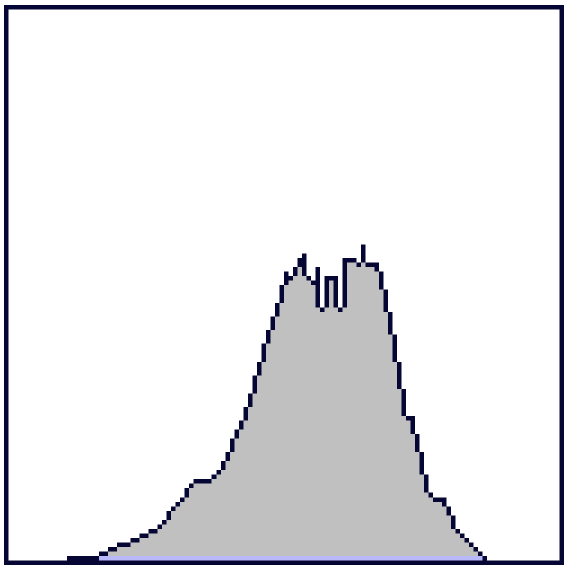


Low Permeability, High Pressure

- 40. Covers all requirements of Code A, however, low permeability and high pressure (CAUTION: Watch for Cushion)
- 41. Low permeability, high pressure. but problems encountered throughout test
- 47. Low permeability. relatively low pressure for "F" code
- 88. Plugging, fluid to surface, resets on flows (irregularities)
- 99. Flows incremented

AIFE Quality Codes

- "G" Quality Code Misrun or Flow Only



- 42. No shut-ins taken
- 43. No useable pressures
- 44. No useable data
- 45. Flow only
- 63. Unable to obtain initial packer seat
- 64. Lost seat after tool opened
- 65. No elements ruptured
- 66. Top elements ruptured
- 67. Bottom elements ruptured
- 68. Both elements ruptured
- 69. Plugged tool
- 70. Unable to reach test depth
- 71. Tool failure
- 72. Personnel failure
- 73. Belly spring turning
- 74. No reason available
- 75. Other
- 76. Mud dropped in annulus when tool opened (seat held)
- 77. Skidding tools when opening or during flow
- 90. Front page only, misrun

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Why Should I care about Misruns ?

- DST's are mechanically complicated, particularly in the case of older tests which are subject to mechanical failure.
- Historically, testing companies reported a 5% misrun rate on tests run. In the analysis of the original DST reports by AIFE the rate of misruns is actually 12%. AIFE believes this is partially owing to the substantial difference in the fee charged historically for a successful test versus a misrun by the testing companies.
- Other data vendors who provide DST data have not examined the original reports nor analyzed the tests and relied only on the testing company to report misruns. Based on the statistics from the AIFE file one out of every 14 tests looked at through other data sources is, in fact, a misrun with no indication that the pressures or recoveries reported are erroneous. There are many causes of misruns, to name a few;
- Tool plugging
- Communication during shut-in periods
- tool skidding
- loss of bottom packer seat (in event of straddle test)
- To illustrate this deficiency and for the purposes of a Client proposal AIFE pulled at random from its database in Adams and Arapahoe Counties, Colorado 11 misruns run between 1970 to 1980. These tests were rated by AIFE as Quality Code 'G', all had pressure data reported for flows and shut-ins which were unuseable owing to packer seat failures, tool plugging or the shut-in tool not functioning properly.
- Of these 11 tests analyzed by AIFE as 'G' Code, misrun only one (1) was identified by the second data source as being a misrun.

Using AIFE DST Quality Codes on a Regional Basis

- *"The interpretation of DST charts is a science in itself somewhat similar to log analysis. It is of prime importance to obtain the most reliable and accurate representation of virgin reservoir pressure possible."* I. Larry Prier, "Theory and Application of Hydrodynamics", 1978

- The AIFE Quality Codes enable the user to complete layers of pressure maps based on the pmax from A, B, C and D ratings and to then add low pressure or high pressure zones if desired from the E and F rated tests. Each DST has the actual depth of the pressure measuring device, both from surface and subsea elevations.

- With the coding system the user is ensured that 1. Misruns are eliminated, 2. The pmax (or extrapolated reservoir pressure) is an accurate representation of the virgin reservoir pressure, and

- 3. The actual depth at which the pressure was measured was utilized as opposed to using the mid point or other reference point of the interval tested.

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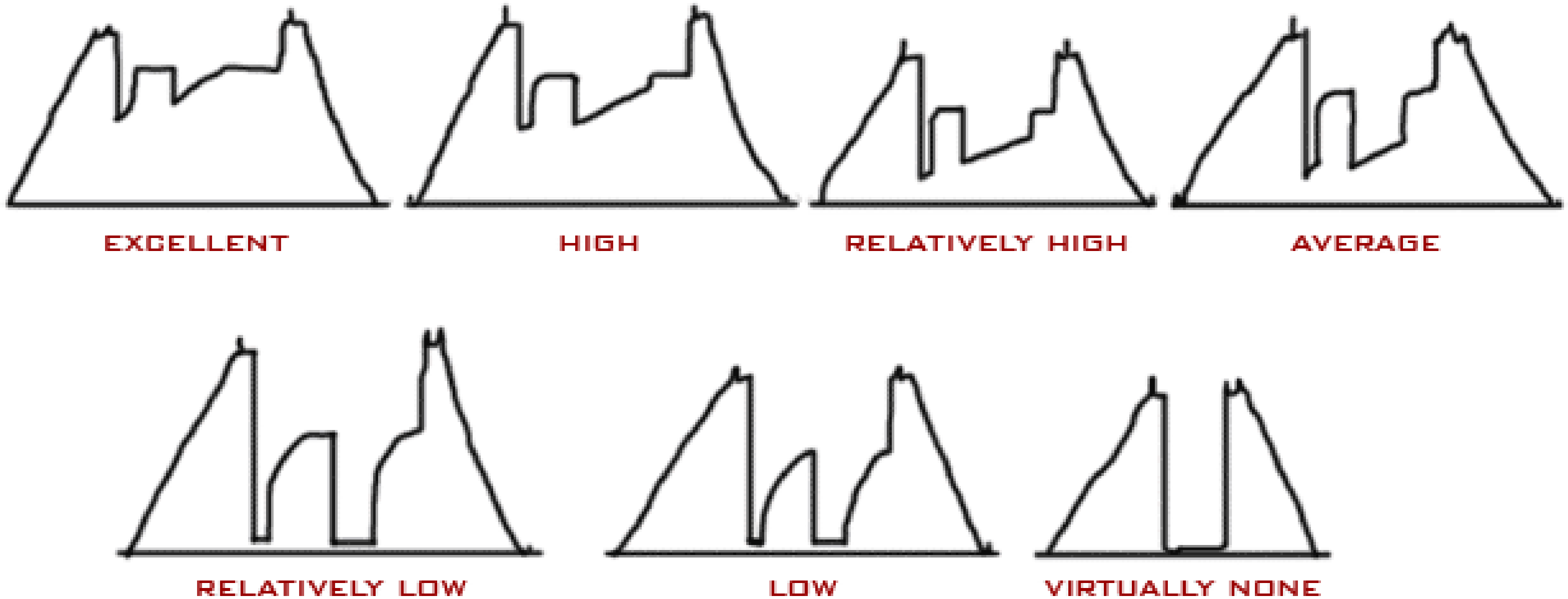
AIFE Permeability Ratings



From a drill stem test, the average effective permeability can be calculated to reservoir conditions using a set mathematical formula.

In a practical sense, one of the required formula parameters, such as viscosity of the fluid, may not always be readily available. Reliable ratings, however, have been qualitatively assigned from the Pressure/Recovery Charts based on the nature of the build-up curves related to flow and pressure data.

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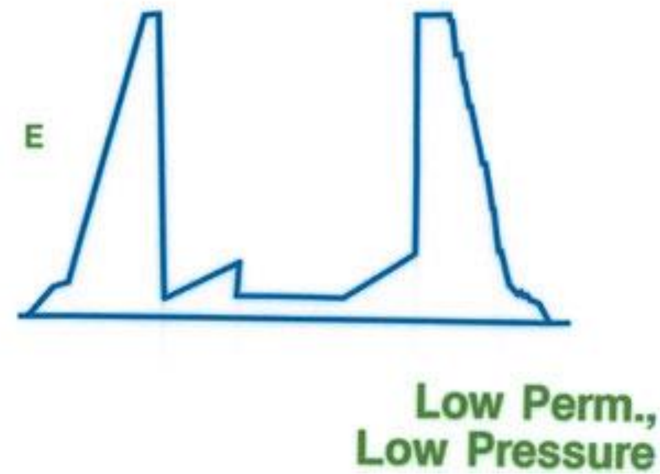
AIFE Permeability Ratings

By assigning a numerical value to the Permeability Ratings regional Permeability Maps can be constructed *



* e.g. EX – 60, HI -50, RH – 40, AV – 30, RL – 20, LO – 10, VN - 00

AIFE Damage Ratings

- Perhaps the most valuable determination to be made from test data is in estimating the presence and magnitude of Well Bore Damage. This is particularly true of tests resulting in low fluid recovery. In the absence of recognition of degrees of damage, this has often been read as poor production potential, resulting in the needless abandonment of commercial producers.

- In the USDST file, damage ratings have been qualitatively assigned to each drill stem test based on the nature of the build-up curve compared to the recovery.

- Types of damage have been categorized as follows:

- CLASS I DE Definite Damage
- CLASS II PO Possible Damage
- CLASS III NO No Damage
- b Cannot Be Determined

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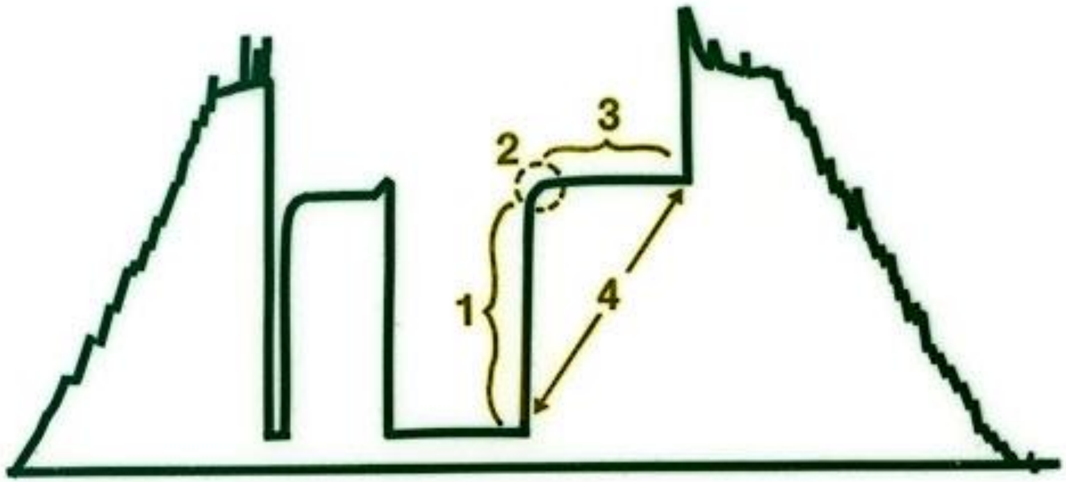
AIFE Damage Ratings



1 Very sharp rise after final flow.

2 Short radius of curve.

3 Reasonably flat slope.

4 High differential pressure between final shut-in and final flow pressure.

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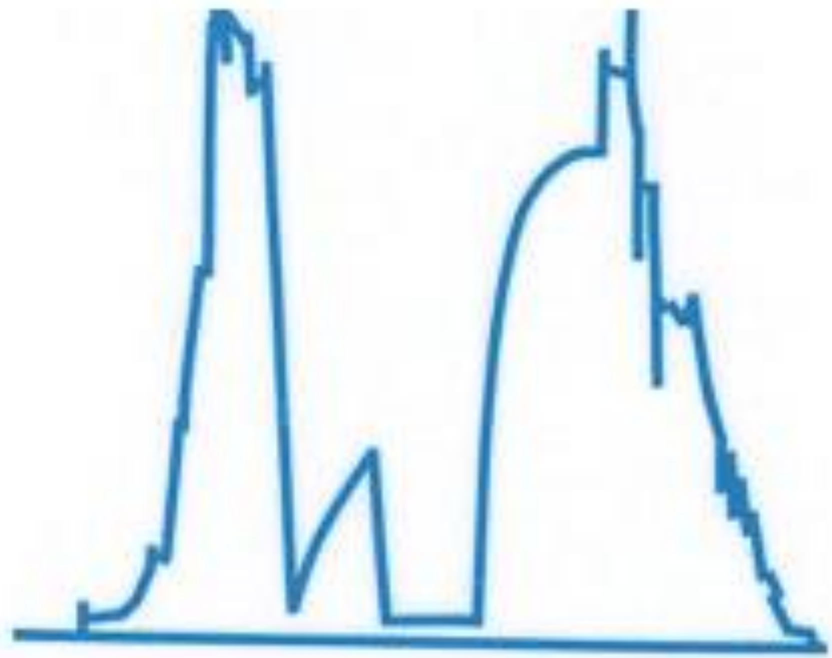
AIFE Damage Ratings



Definite Damage (deep)

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AIFE Incremental Detail

- Incremental detail is captured on each shut-in with a radius of curvature. Increments from the original report are preferred, however, in the event that increments are not provided or appear incorrect the shut-in(s) are digitized.
- Horner analysis is completed on each shut-in with a build-up curve to determine extrapolated pressure (P * or Pmax) and slope (for use in reservoir calculations). The best extrapolation/build-up curve is identified as the Pmax for that test.

AIFE Horner Plots

- Horner plots/extrapolated pressure are completed on each shut-in with a radius of curvature

- The Horner plot and build-up curves are included in the AIFE on-line report where applicable, including the p* and Horner Slope for each curve

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AIFE Temperature Data

- Both the bottom hole temperature and recorder temperature (when taken separately from the bottom hole temperature) are recorded in the database

- Temperature data can be accessed for regional mapping

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AIFE Salinity Data

- When provided, the reported Salinity and Chloride content are recorded from the original DST report in the database

- Salinity data can be accessed for regional mapping

AIFE DST Recoveries

- All recoveries are captured from the original DST report and are reported with a fully detailed description; additionally, recoveries are verified against flowing pressures and any anomalies noted
- Gas rates are captured including the gas measuring instrument, the choke size utilized, the Psi reading and the calculated production rate
- On the DST reports the first, last and maximum gas rates during the test are provided

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AIFE Formation Tops

US Formations

WAPANUCKA-UNION VALLEY	IWKUV 0692100402
WAPANUCKA-UNION VALLEY	RWKUV 0692100402
WARDEN	FWRDN 0570000451
WARDEN	IWRDN 0570000451
WARDEN	RWRDN 0570000451
WARNER	FWRNR 0653340404
WARNER	IWRNR 0653340404
WARNER	RWRNR 0653340404
WARREN POINT	FWRNP 0671400403
WARREN POINT	IWRNP 0671400403
WARREN POINT	RWRNP 0671400403
WARREN RANCH	FWRRC 0650000404
WARREN RANCH	IWRRC 0650000404
WARREN RANCH	RWRRC 0650000404
WARSAW	FWRSW 0754200353
WARSAW	IWRSW 0754200353
WARSAW	RWRSW 0754200353
WARTSBURG	FWRBG 0671400403
WARTSBURG	IWRBG 0671400403
WARTSBURG	RWRBG 0671400403
WASATCH	FWSTC 0245200652
WASATCH	IWSTC 0245200652
WASATCH	RWSTC 0245200652
WASATCH MARKER-1	FWSTC10245200000
WASATCH MARKER-1	IWSTC10245200000
WASATCH MARKER-1	RWSTC10245200000
WASATCH MARKER-2	FWSTC20245200000
WASATCH MARKER-2	IWSTC20245200000
WASATCH MARKER-2	RWSTC20245200000
WASATCH TONGUE	FWSTCT0244920652
WASATCH TONGUE	IWSTCT0244920652
WASATCH TONGUE	RWSTCT0244920652
WASHBURN	FWSBR 0671400403
WASHBURN	IWSBR 0671400403
WASHBURN	RWSBR 0671400403
WASHITA	FWSHT 0331000602
WASHITA	IWSHT 0331000602
WASHITA	RWSHT 0331000602
WATCHORN	FWCRN 0630000405
WATCHORN	IWCRN 0630000405
WATCHORN	RWCRN 0630000405
WATROUS	FWTRS 0431000000
WATROUS	IWTRS 0431000000
WATROUS	RWTRS 0431000000
WATTENBERG L	FDKJWL0315000000
WATTENBERG L	IDKJWL0315000000
WATTENBERG L	RDKJWL0315000000
WATTENBERG U	FDKJWU0315000000
WATTENBERG U	IDKJWU0315000000
WATTENBERG U	RDKJWU0315000000
WAYAN	FWAYN 0290100603
WAYAN	IWAYN 0290100603
WAYAN	RWAYN 0290100603

Each DST is assigned a Formation top. Historically when the database was constructed AIFE had access to the Amoco well-data database, the tops are identified with standard formation abbreviation tables and have the prefix of “I”, “F” or “R”, the I denoting the Amoco top pick, the F the front page of the microfilm and the R denoting the formation given on the original report, the formation table is available to users upon request

AIFE Pressure/Depth Data

- Each recorder run on the test is reviewed as to its mechanical performance and the best recorder is utilized for the pressure information, pressures must also compare between recorders within recorder capacity and depth difference guidelines, this serves as a check on tool plugging and recorder performance
- All pressures are taken from the original report unless not provided and are that event are estimated, with comments indicating which pressures were estimated
- Recorder depths are the depths as reported on the DST report or taken from the tool string diagram, not the top or bottom of interval
- The recorder depth allows for calculation of pressure/depth ratios and construction of pressure/elevation and pressure/depth charts

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AIFE DST Data Captured

The following data elements are captured in the DST-Data segment of the Database when provided on the original DST report (page 1 of 2):

CPA-NO	Location
COORDINATES	Bottom Hole Coordinates
API-NO	American Pet. Assn Unique well identifier
DST-NO	Drill Stem Test Number
LAT	Latitude
LONG	Longitude
WELL-NAME	Original Well Name
KB	Kelly Bushing Elevation
GR	Ground Elevation
DRILLING-FLOOR	Drilling Floor Elevation
OPERATOR	Original Well Operator
TEST-CO	Test Company Name
TEST-DATE	Test Date "YYMMDD"
PACKER-DIAM	Packer Diameter
PACKER-LENG	Packer Length
PACKER-NO	Number of one type of packer
TOTAL#PACKERS	Total Number of Packers Used
BH-CHOKE-SIZE	Bottom Hole Choke Size
CAL-HOLE	Was the Hole calipered
RAT	Rat hole diameter
HOLE-LENGTH	Rat hole Length
MUD-TYPE	Mud type
MUD-WT	Mud weight
REC-TEMP	Recorder temperature
BH-TEMP	Bottom Hole temperature
HOLE-COND	Hole condition
HOLE-SIZE	Diameter of the well bore
DC-SIZE-ID-UP	Upper drill collar size I.D.
DC-SIZE-ID-LW	Lower drill collar size I.D.
DC-SIZE-OD-UP	Upper drill collar size O.D.
DC-SIZE-OD-LW	Lower drill collar size O.D.
DC-TYPE-UP	Upper drill collar type
DC-TYPE-LW	Lower drill collar type
DC-LENG-UP	Upper Drill Collar length
DC-LENG-LW	Lower Drill Collar length
DP-SIZE-ID-UP	Upper Drill Pipe I.D.
DP-SIZE-ID-LW	Lower Drill Pipe I.D.
DP-SIZE-OD-UP	Upper Drill Pipe O.D.
DP-SIZE-OD-LW	Lower Drill Pipe O.D.
DP-TYPE-UP	Upper Drill Pipe type
DP-TYPE-LW	Lower Drill Pipe type
DP-LENG-UP	Upper Drill Pipe Length
DP-LENG-LW	Lower Drill Pipe Length
DP-WGT-UP	Upper Drill Pipe Weight
DP-WGT-LW	Lower Drill Pipe Weight
CUSH-AMT-F	Fluid Cushion Amount
CUSH-AMT-G	Gas Cushion Amount
CUSH-AMT-I	Inhibitor Cushion Amount
CUSH-TYPE	Cushion type
TOT-DEPTH	Total Depth
INT-F	Top tested interval
INT-T	Bottom tested inverval
FORMATIONS	Tested formations (3)
START-TIME	DST start time
OPENED-TIME	Tool open time
TIMES (Period 1)	Times for flow/shut-in period one
TIMES (Period 2)	Times for flow/shut-in period two
TIMES (Period 3)	Times for flow/shut-in period three

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AIFE DST Data Captured

The following data elements are captured in the DST-Data segment of the database when provided on the original DST report (page 2 of 2)

- TIMES (Period 4) Times for flow/shut-in period four
- BLOW-DESCR Blow description (4 lines max, 78 char. per line)
- TEST-TYPE Test type
- MULT? Was the test a multiple
- MULT-NO Multiple sequence number
- MULT-OF Number of multiple tests
- DAMAGE Formation damage
- PERM Permeability of the test
- HF Hydrodynamic factor (predominant recovery)
- RCV-OF— Descr. of recovery (6 lines, max 64 char. per line)
- RCV-AMTS-CHAR Amount recovered
- RCV-CODES Recovery codes
- REV-OUT Was the recovery reversed out
- COMMENTS Analysts comments on the test
- QC-ORIG Quality code of test
- MISRUN-CODES Reasons for the quality code
- REC-USED Recorder used for pressures
- P-MAX Extrapolated Pressure maximum
- GAS-INSTR Gas measuring instrument type
- GAS-RISER Gas riser size
- GM-CNT (Period 1) Gas measurement counter for flow period one
- GM-CNT (Period 2) Gas measurement counter for flow period two
- GM-CNT (Period 3) Gas measurement counter for flow period three
- GM-CNT (Period 4) Gas measurement counter for flow period four
- GAS-COMMENTS Gas comments (4 lines, max 78 char. per line)
- GAS-COM-FLAGS Gas comment flags
- API-GRAV'L Api-gravity-liquid
- COMPRESS'L Compressibility ratio-liquid
- PH-FLUID PH Level-liquid
- RES-WATER Resistivity of water
- RES-WATER-TP Testing temp. for Resistivity
- SPEC-GRAV'L Specific gravity-liquid
- SPEC-GRAV'L-TP Testing temp for Specific gravity
- VISC'L Viscosity-liquid
- VISC'L-TP Testing temp for viscosity
- WATER-GRAD Water gradient
- COMPRESS'G Compressibility ratio-gas
- DST-GAS-RATE'G Maximum gas flow rate
- SPEC-GRAV-G Specific gravity-gas
- SPEC-GRAV'G-TP Testing temperature for specific gravity
- VISC'G Viscosity-gas
- VISC'G-TP Testing temperature for viscosity
- Z'FACTOR'G Z Factor
- POROSITY Porosity of interval tested
- NET-PAY Net pay of interval tested
- REL-DENSITY Relative density
- REL-DENSITY-TP Testing temperature for relative density
- SALIN Salinity content
- CL-CONTENT Chloride content

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AIFE Gas/Recorder Data Captured

- Gas Measurement Data

CPA-NO	Location
COORDINATES	Bottom hole Coordinates
API-NO	API unique well identifier
DST-NO	DST number
BLK-NO	Block sequence counter
GAS-MEASUREMENTS*	Gas measurements block

- *20 quadruplets of gas measurements per record, each Quadruplet: TIME, SURFACE CHOKE, READING, FLOW VOLUME

- Recorder Data

CPA-NO	Location
COORDINATES	Bottom hole coordinates
API-NO	API unique well identifier
DST-NO	DST number
REC-NO	Recorder serial number
REC-PERF	Recorder performance code
REC-TYPE	Abbreviated recorder type
REC-DEPTH	Recorder depth
REC- I/O	Inside/Outside recorder
REC-CAPACITY	Recorder pressure capacity
REC-TEMP	Recorder temperature
REC-TEMP-HI	Recorder high temp. range
REC-TEMP-LO	Recorder low temp. range

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AIFE Recorder Data Captured for Recorder Used in Pressure Analysis

CPA-NO	Location
COORDINATES	Bottom hole coordinates
API-NO	API unique well identifier
DST-NO	DST number
REC-NO	Recorder serial number
INC-MODE	How shut-in increments obtained
SI-CNT (Period 1)	Tally for first shut-in
SI-CNT (Period 2)	Tally for second shut-in
SI-CNT (Period 3)	Tally for third shut-in
SI-CNT (Period 4)	Tally for fourth shut-in
PRESSURES (Period 1)	Press. For 1st flow/shut-in period
PRESSURES (Period 2)	Press. For 2nd flow/shut-in period
PRESSURES (Period 3)	Press. For 3rd flow/shut-in period
PRESSURES (Period 4)	Press for 4th flow/shut-in period
USE-IGNORE (Period 1)	Used/ignored points for 1 shut-in horner
USE-IGNORE (Period 2)	Used/ignored points for 2nd shut-in horner
USE-IGNORE (Period 3)	Used/ignored points for 3rd shut-in horner
USE-IGNORE (Period 4)	Used/ignored points for 4th shut-in horner
SEG-ID (Period 1)	ID's for first flow/shut-in period
SEG-ID (Period 2)	ID's for second flow/shut-in period
SEG-ID (Period 3)	ID's for third flow/shut-in period
SEG-ID (Period 4)	ID's for fourth flow/shut-in period
SEG-QC (Period 1)	QC's for first flow/shut-in period
SEG-QC (Period 2)	QC's for second flow/shut-in period
SEG-QC (Period 3)	QC's for third flow/shut-in period
SEG-QC (Period 4)	QC's for fourth flow/shut-in period
HS-I	Initial hydrostatic pressure
HS-F	final shut-in pressure

ANAL-TYPE	Analysis type – L or G
SLOPE'L (Period 1)	Horner slope shut-in one (liquid)
SLOPE'L (Period 2)	Horner slope shut-in two (liquid)
SLOPE'L (Period 3)	Horner slope shut-in three (liquid)
SLOPE'L (Period 4)	Horner slope shut-in four (liquid)
EXTRAP'L (Period 1)	Extrapolated press. Shut-in one (liquid)
EXTRAP'L (Period 2)	Extrapolated press. Shut-in two (liquid)
EXTRAP'L (Period 3)	Extrapolated press. Shut-in three (liquid)
EXTRAP'L (Period 4)	Extrapolated press. Shut-in four (liquid)
SLOPE'G (Period 1)	Horner slope shut-in one (gas)
SLOPE'G (Period 2)	Horner slope shut-in two (gas)
SLOPE'G (Period 3)	Horner slope shut-in three (gas)
SLOPE'G (Period 4)	Horner slope shut-in four (gas)
EXTRAP'G (Period 1)	Extrapolated press. Shut-in one (gas)
EXTRAP'G (Period 2)	Extrapolated press. Shut-in two (gas)
EXTRAP'G (Period 3)	Extrapolated press. Shut-in three (gas)
EXTRAP'G (Period 4)	Extrapolated press. Shut-in four (gas)
FLOW-CNT (Period1)	Tally for first flow
FLOW-CNT (Period 2)	Tally for second flow
FLOW-CNT (Period 3)	Tally for third flow
FLOW-CNT (Period 4)	Tally for fourth flow
FLOW-MODE	How flow increments obtained

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AIFE Incremental Data Captured

Each shut-in with a radius of curvature has incremental detail, either from the original DST report or digitized, flow data is captured when provided on the original DST report

• Shut-in Build-up Data

CPA-NO	Location
COORDINATES	Bottom hole coordinates
API-NO	API unique well identifier
DST-NO	DST number
REC-NO	Recorder serial number
BLK-NO	Block sequence counter
PT-INC	Shut-in increment block

- Note: 30 time/pressure pairs per record

• Flow Data

CPA-NO	Location
COORDINATES	Bottom hole coordinates
API-NO	API unique well identifier
DST-NO	DST number
REC-NO	Recorder serial number
BLK-NO	Block sequence counter
PT-INC	Flow increment counter

- Note: 30 time/pressure pairs per record

AIFE Utilization of DST Data

The below highlights information available and potential uses of AIFE analyzed DST Data

- Individual Test
  - Indication of near wellbore reservoir characteristics
  - Detailed assessment of Quality of test
  - Drill Pipe & Drill collar data
  - Horner extrapolation and slopes
  - Permeability assessment
  - Damage assessment
  - Detailed recoveries and blow description
  - Horner plot and build up curve charts
  - Data for detailed reservoir calculations
  - Incremental Detail on Shut-in Build-ups

- Regional Utilization
  - Permeability maps to highlight potential stratigraphic traps
  - Temperature maps
  - Potentiometric surface maps to indicate flow potentials, determine directions for preferential migration of hydrocarbons
  - Salinity maps
  - Pressure/Elevation Charts to determine continuity of reservoirs, estimate gas/oil/water contacts
  - Pressure/Depth Charts
  - Pressure/Depth ratio maps to locate abnormal and subnormally pressured reservoirs

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Accessing AIFE DST Data

- AIFE DST Data can be accessed by individual or regional data requests made directly through AIFE or through AIFE's online server
- Online access is provided to clients who have licensed a particular data set and provides for an unlimited number of users and unlimited data retrievals in the licensed geographic region
- Clients who license a geographic data set receive online access and a copy of the data for in-house loading in MS Access format

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AIFE Sample Data

- To view sample DST reports online go to **www.aifeonline.com** , enter the **user** name of **demo**, the **password** of **demo**, and then go to the “Search” prompt, select the State of Montana, then select the County of Golden Valley, you can then view all of the tests in that County.
- Each Drill Stem Test has been analyzed from the original DST report by AIFE’s experienced personnel in a consistent and detailed fashion for mechanical soundness, qualitative permeability and damage, extrapolated pressure, and assigned a final test Quality Code.
- The Quality Codes are copyrighted by AIFE and enable the user to quickly assess the test results with a high degree of confidence.

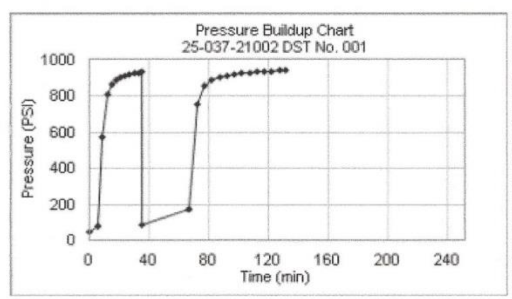
BURLINGTON NORTHERN 25-1 6/25 005N 021E 25 — **DST No: 001**

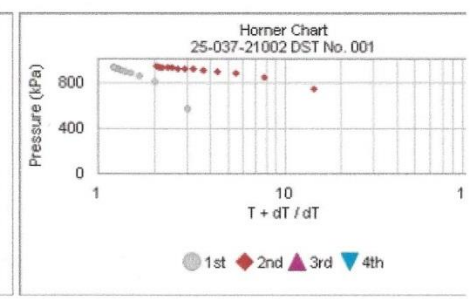
MONTANA GOLDEN VALLEY — API No: 25-037-21002-00
Ground: 3833 — Latitude: 46.153640
KB: — Longitude: 109.045600
Interval: 1604.0 to 1648.0 ft — Total Depth: 1648.0 ft
Operator: EMPIRE — Test Co.: JOHNSTON
Formations: IFRNR FFRNR — Type: CBH
Date: 701012
Quality Code: C
Recorder No: J355 — Recorder Type:
Recorder Depth: 1640.0 ft Outside — Recorder Temp: F
SubSea: — Temp Depth: 1640.0 ft
Capacity: 1600 psi — Bottom Hole Temp: 108.0 F

	Times (min)	Pressure (psi)	Horner Extrap (L) (psi)	Slope (L) (psi/cycle)
		48.0		
Preflow:	6.0	80.0		
Inital SI:	29.0	935.0	973.31	472.8116
		85.0		
2nd Flow:	32.0	174.0		
Final SI:	64.0	944.0	975.07	154.1368

Perm: AV
Damage: NO
HF: W
Gas Flow
MAX: mcf/d
FIRST: mcf/d
LAST: mcf/d

Inital Hydrostatic: 876.00 — Assigned P-Max: 975.07
Final Hydrostatic: 932.00 — Pressure/Depth: 0.608 psi/ft
Recovery Description: 300.00ft Muddy water.
Blow Description: Strong blow 12 inches blow in water on pre-flow increasing off bottom of bucket. Moderate blow 4.75 inches blow in water increasing to 8.5 inches at 1505 decreasing to 3 inches at 1524 on final flow.
Comments:
Drill Pipe Type:
Length: ft — Cushion Type:
Weight: lb/ft — Liquid Cushion:
Outer Diameter: in — Gas Cushion:
Internal Diameter: in — Inhibitor:
Drill collar Type: — Mud Type: GEL CHEM
Length: 509.00 ft — Mud Weight: 9.70 lb/gal
Outer Diameter: in — Salinity: 6700 ppm
Internal Diameter: 2.50 in — Chloride Content:





View Increment data Export Increment data

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AIFE Online Access

In addition to the individual DST test reports users can create a downloadable Excel file of data (sample below) and export the increment data for loading into reservoir calculation software

API_NO	CPA_NO	COORDINA	LAT	LON	KB	DST#	DATE RUN	FORM1	FORM2	FORM3	INT_F	INT_T	TEST_TYPE	P_MAX	REC_DEPT	REC_USED	REC_TEMP	BH_TEMP	HF	QC_ORIG	PERM	DAMAGE	SALIN
A250370500100	625005N020E31	C NW SE	46.13538	109.2668	3933	1	540822	ICCRT	FCCRT3		1935	1962	CBH1P		1923	192		100.0	G	F	20		
A250370500800	625005N019E23	SE SE	46.16003	109.3013	3905	1	560625	ICCRT	FCCRT3		2143	2183	CBH		2143	223		100.0	W	E	10		
A250370500800	625005N019E23	SE SE	46.16003	109.3013	3905	001A	560704	IAMSD	FTYLR		2880	2900	CBH1P		2899	B144			M	E	0		
A250370500800	625005N019E23	SE SE	46.16003	109.3013	3905	2	560626	ICCRT	FCCRT3		2213	2235	CBH1P		2213	223		100.0	M	F	10		
A250370500800	625005N019E23	SE SE	46.16003	109.3013	3905	3	560627	IMRSN	FNONE	RCCRT3	2275	2315	CBH1P	1210	2275	222		100.0	M	D	40	DE	
A250370501200	625005N018E09	C NE SE	46.19493	109.4698	4357	1	580130	IFRNR	FFRNR		1962	1980	CBH1P	823	1979	R851		98.0	W	C	50		
A250370501800	625006N022E27	SE NW	46.24174	108.9599	3723	1	560125	IFRNR	FFRNR		1601	1641	CBH1P		1584	195		100.0	M	E	0		
A250370501800	625006N022E27	SE NW	46.24174	108.9599	3723	2	560209	IAMSD	FAMSD		3790	3834	CBH1P	1962	3791	195		100.0	W	C	50		
A250370501800	625006N022E27	SE NW	46.24174	108.9599	3723	3	560219	IFRNR			1790	1860	CBH1P	973	1773	379		100.0	W	C	30		
A250370502300	625007N019E18	NW NE N	46.37185	109.3859	4077	1	531003	IAMSD	FSWFT		2952	2970	CBH1P	1407	2952	195		100.0	W	D	40		
A250370502300	625007N019E18	NW NE N	46.37185	109.3859	4077	2	531019	ICRLS	FCRLS		4371	4391	CBH1P	2044	4361	239		100.0	W	D	30		
A250370502800	625008N021E29	C SE SE	46.41112	109.1158	3864	1	530907	IODVC	FODVC	RNONE	4310	4348	CBH1P	2020	4310	195		100.0	W	D	30		
A250370502800	625008N021E29	C SE SE	46.41112	109.1158	3864	3	530915	ICRLS			3025	3075	CBH1P		3025	224		100.0	M	E	0		
A250370503900	625008N020E14	SW SW	46.4472	109.1919	3908	1	650312	IMRSN	FNONE	RDKOT	1896	1921	CBH	972.7	1918	317		80.0	W	B	40	NO	
A250370504200	625008N020E09	NE SE	46.46459	109.2163	3963	1	570801	ICCRT3	RCCRT3		1505	1520	CBH1P	771	1490	331		100.0	W	A	50	NO	
A250370504200	625008N020E09	NE SE	46.46459	109.2163	3963	2	570802	IMRSN			1675	1695	CBH1P	888.1	1645	T390		85.0	W	D	40		
A250370504200	625008N020E09	NE SE	46.46459	109.2163	3963	3	570804	ISWFT	RSWFT		1824	1864	CBH1P	898	1810	331		100.0	W	D	50		
A250370504200	625008N020E09	NE SE	46.46459	109.2163	3963	4	570806	IAMSD			1972	1986	CBH1P	941	1965	331		100.0	W	D	50		
A250370504400	625009N020E31	SE NW	46.4992	109.2535	4185	1	650224	IAMSD			3247	3257	CBH	1469	3254	317		120.0	M	B	40	DE	
A250370504400	625009N020E31	SE NW	46.4992	109.2535	4185	2	650226	IAMSD			3247	3272	CBH	1473	3269	317		130.0	W	A	40	DE	
A250370504700	625009N021E19	NE NW	46.53201	109.1281	4143	1	571202	IAMSD			4215	4266	CBH	1896	4209	T390		136.0	W	C	40		
A250372100200	625005N021E25	SE SW NV	46.15364	109.0456	3833	1	701012	IFRNR	FFRNR		1604	1648	CBH	975.1	1640	J355		108.0	W	C	30	NO	6700
A250372100300	625010N021E01	C SE SW	46.65391	109.0219	4202	1	711119	ITYLRA	FHETH	RNONE	1575	1783	CBH2P	744	1560	4153		128.0	O	D	30	DE	
A250372101000	625005N022E26	NW SW S	46.14954	108.9344	4063	2	740301	IFRNR	FNONE	RNONE	2404	2505	CBH1P	1288	2501	36		88.0	W	B	30	NO	
A250372102300	625004N018E02	SE NW N\	46.12688	109.4544	4370	1	750723	IFRNR	FFRSCL	RNONE	2211	2233	CBH	987	2229	12324			W	C	50	NO	
A250372102600	625007N019E09	C SW NE	46.38164	109.348	3969	1	751112	ICCRT2	FCCRT	RCCRT	2428	2536	IS	1230	2438	12165			W	C	50	NO	
A250372102600	625007N019E09	C SW NE	46.38164	109.348	3969	2	751112	IMWRY	FMWRY	RNONE	1259	1375	IS	618.1	1269	12165			M	C	30	DE	
A250372102600	625007N019E09	C SW NE	46.38164	109.348	3969	3	751113	IAMSD	FAMSD	RNONE	2975	3012	CBH	1456	2975	12165			W	D	50		
A250372102600	625007N019E09	C SW NE	46.38164	109.348	3969	4	751121	IMWRY	FMWRY	RMWRY	1301	1375	IS	631.4	1315	12165		64.0	M	C	30	NO	
A250372102700	625007N022E24	E2 SW NV	46.3445	108.9228	3576	1	600817	IMDDY	FMDDY		2445	2533	CBH	890.7	2437	293		120.0	M	D			
A250372102700	625007N022E24	E2 SW NV	46.3445	108.9228	3576	2	600821	ILKOT	FLKOT		3072	3103	CBH	1616	3064	331		100.0	W	A	50	NO	
A250372102700	625007N022E24	E2 SW NV	46.3445	108.9228	3576	3	600825	ICRLS	FCRLS		3856	3879	CBH	2044	3846	331		110.0	W	A	50	NO	
A250372102900	625005N020E36	SW NE NI	46.14235	109.1578	4285	2	760309	ICCRT3	FCCRT	RNONE	2800	2860	CBH	1285	2860	12324			W	B	40	NO	
A250372102900	625005N020E36	SW NE NI	46.14235	109.1578	4285	004B	760316	IPIPR	FAMSD	RNONE	3424	3499	IS	1562	3432	12324		110.0	W	B	50	NO	2500
A250372103000	625010N019E07	SE NE NW	46.64722	109.3781	5323	2	760920	ISWFT	FSWFT	RNONE	6819	6840	CBH		6825	12811			M	G			
A250372103000	625010N019E07	SE NE NW	46.64722	109.3781	5323	3	760926	IVGLL	FEGLE	RNONE	4000	4010	IS	1211	4008	12767		119.0	W	C	20		
A250372103300	625010N021E01	SW SE SV	46.65298	109.0229	4222	1	770623	IHETH	FHETH	RNONE	1600	1640	IS		1605	12324	84.0	84.0		E	0	NO	
A250372103800	625004N018E13	SW NE NI	46.09749	109.4215	4229	1	790912	IBGEK	FBGEK	RNONE	1834	1847	CBH	886.2	1845	9857		83.0	W	B	40	NO	3100
A250372104000	625005N019E14	SE NW NI	46.18543	109.3057	4000	1	790829	ICCRT	FCCRT3	RNONE	2433	2478	CBH	1237	2442	12773			W	C	50	NO	3093
A250372104100	625008N021E28	NW NW S	46.41565	109.1119	3910	1	790922	IKBBY	FKBSD	RNONE	2157	2170	CBH		2146	12624		114.0	O	E	0		
A250372104100	625008N021E28	NW NW S	46.41565	109.1119	3910	2	790923	IKBBY	FKBSD	RNONE	2170	2213	CBH	1079	2159	12624		114.0	O	D	20		6600

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AIFE Database Interesting Statistics

- In the AIFE Database the following Quality Codes have be assigned:
- "A" Quality – 4012 tests
- "B" Quality – 8388 tests
- "C" Quality – 31,243 tests
- "D" Quality – 38,336 tests
- "E" Quality – 36,952 tests
- "F" Quality – 32,195 tests
- "G" Quality – 20,577 tests
- A Horner extrapolation greater than 150 psi from the read shut-in pressure is generally considered unreliable
- Based on this guideline 18.7% of the tests ("F" Quality) looked at on raw data sources have unreliable shut-in pressures
- Tests falling in the "C" and "D" Quality codes can have extrapolated pressures (true formation pressure) ranging from 30 to 150 psi above the shut-in pressure reported through raw DST data sources
- Testing Companies historically reported 5% of tests run as misruns, the AIFE database indicates that 12% of tests were in fact misruns, in most cases the difference owing to bottom packer seat failure on straddle tests or plugged tools, the additional 7% not being reported as misruns on raw data sources
- Over 5900 tests in the AIFE database have a Damage classification of "DE" (Definite Damage)
- Over 7200 tests in the AIFE database have a Damage classification of "PO" (Possible Damage)
- The AIFE database contains historical Drill Stem Tests dating as far back as 1948
- A large portion of the Historical Drill Stem tests were collected by Petroleum Research Corp. in the late 1950's and early 1960's, whom AIFE acquired
- Construction of the AIFE database commenced in 1981, at one point AIFE and its Canadian counterpart CIFE employed over 40 individuals involved in database construction and Hydrodynamics
- CIFE Hydrodynamics personnel were the first in the industry to complete and sell regional Hydrodynamic studies
- The CIFE database covering the provincial and federal lands of Canada and containing over 260,000 analyzed Drill Stem tests has become the industry standard in Canada for computerized DST data
- CIFE was sold to IHS Canada in the early 2000's
- AIFE Principals have been associated with the Canadian/U.S. database since 1978
- AIFE has constructed Pressure related databases in a number of foreign countries, including Adam, Egypt and Qatar to name a few

General DST Industry Information

- The AIFE database contains tests from over 120 testing companies
- Drill Stem testing on new wells has diminished significantly in the United States and Canada
- AIFE successfully managed to obtain DST records from Baker Industries (after obtaining legal releases from well operators) and the firms it acquired over the years, including Lynes, Virg's and Star Hughes
- Most testing Companies have destroyed their historical records, Halliburton, one of the largest testing companies (AIFE has over 33,000 tests run by Halliburton), has indicated to AIFE that its historical records have been purged
- Most oil and gas Companies have destroyed their historical records that contained the original DST reports, usually during buy-outs or mergers
- AIFE personnel spent over 10 years collecting DST information from testing companies and oil and gas firms
- Most recently AIFE was able to source the original DST reports for tests run throughout the United States from 2002 to 2018 and is now adding these tests to the historical database

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Data for over

170,000 Analyzed Drill Stem Tests

in the Continental U.S.

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