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# REPORT on INTERPRETATION
# of
# TEST DATA
# from
# PROJECT RULISON
# in the
# RULISON FIELD, GARFIELD COUNTY, COLORADO

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# REPORT on INTERPRETATION of TEST DATA from PROJECT RULISON in the RULISON FIELD, GARFIELD COUNTY, COLORADO

## FOREWORD

On September 10, 1969, a nuclear explosive with a nominal yield of 40 kilotons was detonated at Project Rulison 8,246 feet below the surface of the Mesaverde formation of the Rulison field, Garfield County, Colorado.

The Rulison R-EX well was directionally drilled to intercept the fracture system created by the nuclear explosive and a successful penetration of the fracture zone near the top of the cavity was made in July 1970 and the well completed for production testing. Testing of the nuclear stimulated well was begun in October 1970 and after four intermittent flow periods the well was shut in April 23, 1971, and pressure observations at varying intervals of time have continued through September 27, 1971.

## Scope of Investigation

This report is an interpretation of observations made in the Rulison R-EX well during production testing, during shut-in periods between production tests, and during the shut-in period following the last production test. Using these test data and a mathematical model constructed and operated by Computer Technical Services, Inc., Dallas, Texas, interpretations of the test data have been made jointly by that firm and DeGolyer and MacNaughton. The object of these studies was to determine the permeability of the fracture zone, the permeability of the unstimulated reservoir rock, and the long-term capability of the well to produce gas.

Gas volumes in this report are expressed at standard conditions of 14.73 pounds per square inch absolute and 60 degrees Fahrenheit.

Authority

This report is prepared at the request of Mr. C. W. Leisk, Chairman and President of Austral Oil Company Incorporated.

Source of Information

Information used in this study was furnished by Austral Oil Company Incorporated. All information furnished was accepted as represented.

## PRODUCTION TESTING

Production testing of the nuclear stimulated well began October 4, 1970, at various rates in order to calibrate the U.S. Public Health Service off-site surveillance program and continued until October 7, 1970, at which time the well was shut in. No data were observed between October 7 and October 26, 1970, as the drilling rig which was used to complete the well was being removed from the well site. Production testing resumed October 26 and continued at rates from 11 to 15 million cubic feet per day until November 2, 1970, at which time the well was shut in. Pressure and temperature observations were recorded during this shut-in period through November 30, 1970. The well was reopened December 1 and produced at rates approximating 5 million cubic feet per day until December 20, on which date the well was again closed in. Pressure and temperature observations were again made in the shut-in period from that date through February 1. The well was reopened for a third production test beginning February 2 and continued at rates which declined from 10.4 million cubic feet per day at the beginning of the test to slightly under 1 million cubic feet per day at the conclusion of the test on April 23, 1971. Pressure and temperature measurements have been observed at various times during the subsequent shut-in period, the last subsurface pressure measurement being made September 27, 1971.

During the production testing, data concerning surface wellhead pressures, temperatures, separator gas gravity, gas, condensate, and water production were recorded. In addition, subsurface pressure and temperature measurements were made at various times as conditions permitted.

Observations were made at 2,059 times during the period between the opening of the well on October 4, 1970, and the latest subsurface pressure measurement on September 27, 1971. These data have been arranged in one-day time periods and the measured gas production reduced to dry-gas production by subtracting the volume of water produced. The mol fraction dry gas in the total stream of production is also reported. These data are shown in Table 1.

Observations of static and flowing subsurface pressure in the flow string at the beginning of the second and the third production tests indicated no pressure drop due to friction between the cavity and the flow string.

The composition of the reservoir gas prior to the nuclear detonation is shown in Table 2.

Twelve samples of gas produced during the production testing were collected and analyzed by Teledyne Isotopes. The analyses of these samples are reported in Table 3.

The analyses of the gas samples taken indicate that the hydrogen concentration in the produced gas declines linearly with cumulative production, however, the carbon dioxide concentration declined to a minimum value as indicated by the sample taken February 27, 1971, then increased. Since all of the hydrogen in the produced gas was generated at the time of the nuclear explosion, the hydrogen concentration represents the relative concentration of cavity gas versus time. The carbon dioxide concentration did not decline commensurately with the hydrogen concentration so it must be concluded that additional carbon dioxide was evolving either from solution in water or from the carbonates in the reservoir rock. These observations indicated the need for a mathematical model that would adequately treat these phenomena.

The water production as compared to the volume of dry gas produced progressively increased throughout the production testing until at the end of the third production test it amounted to some 56 percent of the flow from the well. It has been variously estimated that some 17 to 34 thousand barrels of water were in the cavity at the beginning of production testing. A total of 20,244 barrels was produced. The volume of water produced dictated a need for the model to properly treat volumetrically with the volume of production and also to account for the enlarged storage capacity of the cavity as the result of the vaporization of water.

It was not possible to measure the temperature of the cavity. Temperatures were observed in the flow string of the well as high as 438 degrees Fahrenheit. A change in the relationship between the water produced per unit of gas production versus cavity pressure occurred at about 400 pounds per square inch absolute. This corresponds to the vapor pressure of water at 445 degrees Fahrenheit. It was concluded from this that a temperature of 445 degrees Fahrenheit is representative of the cavity temperature.

## DESCRIPTION of MATHEMATICAL MODEL

The mathematical model constructed and operated by Computer Technical Services, Inc., to simulate the performance of the Rulison R-EX well is a one-dimensional, single-phase, radial-flow model. The model consists of a series of blocks, or in this case, concentric rings, each of which may be assigned varying values of porosity, permeability, thickness, and temperature. The geometry used in this simulation consists of 28 blocks. The first 8 blocks were used to describe the cavity. The next 7 blocks simulated the fracture zone. The remaining blocks were assigned values of the unstimulated porosity and permeability of the reservoir rock.

Due to the known variations in temperature existing in the system, it was necessary to construct a temperature overlay feature which would allow the introduction of this variable into the solution.

During the production testing of the R-EX well, considerable variations in produced gas composition were observed indicating that this phenomenon should be accounted for in the solution technique.

A special routine was written to handle the gas compressibility factor as function of temperature, pressure, and varying gas composition. Corrections for the compressibility of nitrogen were incorporated based on the work of Eilerts, Carlson, and Mullens.[1] As for corrections for the compressibility of carbon dioxide based on the work of Olds, Sage, and Lacy,[2] the method of applying these correction factors is described in "Petroleum Reservoir Engineering", by Amyx, Bass, and Whiting; McGraw-Hill, 1960, Pages 261 – 270. The routine also corrects for the effects of observed water-vapor content on the gas compressibility factor. Due to the high critical properties of water and the large mol fractions of water in the produced gas, reduced temperatures for the mixture at certain observed pressures were calculated to be less than 1.05. This is the lower limit of reduced temperature in available compressibility value correlations, and when this occurred the reduced temperature was set to the minimum value.

The routine just described was used for determining the compressibility factor for the gas in the cavity and the fracture system. Here the assumption is made that the produced gas composition represents the cavity gas and the mobile gas in the fracture system during the known producing history.

It was also necessary to develop a method for determining gas viscosity as a function of pressure, temperature, and varying composition. The work of Carr, Kobayashi, and Burrows[3] was utilized for this determination.

Vaporization and condensation of water and the evolution of carbon dioxide were handled in the model by material balance methods and the net effect applied to the wet-gas production rate and the cavity pore volume. In other words, the net effect of vaporization or condensation of water and evolution of carbon dioxide occurring during each time period was subtracted from the wet-gas producing rate to obtain the net effective producing rate for the model calculations. In addition, the cavity volume was increased or decreased each time-step as vaporization or condensation occurred to simulate the increase or decrease in volume of water in the cavity.

Two versions of the mathematical model were used in this simulation. The normal pressure solution case was used during the history-match portion of the simulation. This version solves for the potential or pressure in each block at each time period when production rate and composition are given.

The matrix solution in the model was rearranged to solve for the rate case during prediction runs. A minimum flowing pressure is assigned to Block 1 and a maximum rate calculated. The calculated rate is then used in the normal pressure case to solve for the pressure distribution in the system. This procedure allows the system to automatically decline when prescribed rate conditions can no longer be satisfied.

HISTORY MATCH

In order to attempt to match the observed pressure and production data, the model was configured with the cavity radius of 74 feet, a cavity height of 270 feet, on the theory that radial flow would not exist below the point of detonation because of glazing. The outer radius of the fracture zone was taken to be 220 feet and the outer radius of the model 3,000 feet, so that the total area represented by the model was approximately 640 acres.

The pay thickness and properties of the unstimulated reservoir rock were taken from analyses of electrical logs of the stimulated interval. The pay thickness was taken to be 75 feet and the porosity 7.1 percent, which is equivalent to the arithmetic mean of the values in the stimulated interval. The permeability was taken to be .05 millidarcys, which was the geometric mean permeability of the stimulated interval. The water saturation was estimated to be 50 percent.

The cavity temperature of 445 degrees Fahrenheit was decreased proportionately to the log of the radius until a value of 214 degrees Fahrenheit was reached at the outer radius of the fracture zone. The temperature of the unstimulated reservoir rock was taken to be 214 degrees.

The hydrocarbon gas composition was smoothed and interpolated between analyses in order that daily gas composition could be entered as input to the model.

Hydrogen and carbon dioxide content of the cavity gas was smoothed, as shown in Figure 1, and input to the model on a daily basis.

Pressure and production data in Table 1 were also used as input on a daily basis.

Successive material balance calculations during the early part of the production testing indicated the gas in place in the cavity to be 210 million cubic standard feet, which is in close agreement with the void space of 1.5 million cubic feet thought to be in the cavity.

The first observed subsurface pressure was obtained at the beginning of the first production test following the calibration flow period and was found to be 3,156 pounds per square inch absolute. The performance of the well to that point was matched with that pressure and it required an initial reservoir pressure of 3,251 pounds per square inch absolute to effect the match. Using the values for pressure and temperature cited in the foregoing, the gas in place in the fracture zone was taken to be 176 million cubic feet, and in the unstimulated reservoir rock lying outside of the fracture zone and within the 3,000-foot outer radius of the model the gas in place was 14,040 million cubic feet.

In order to match the observed pressures during the various periods of production, it was necessary to reduce the permeability of portions of the fracture zone to a value of .001 millidarcys and increase the permeability of the various blocks successively with time. The values of permeability used are shown in Table 4 and Figure 2. It was found that a permeability of .3 of a millidarcy at a radius of 88 feet, which is the outer radius of the first fracture block, was sufficient to allow flow from the well in those amounts experienced. The permeability was increased only to the extent that was necessary to allow flow to occur and match the pressure observed during the production testing. The permeability distribution used at various time periods is shown in Table 4 and Figure 2. This phenomenon could be caused by water filling the fractures at the beginning of the flow testing and being removed gradually as the well was produced. It was indicated that the fracture zone was not completely cleaned at the end of production testing. This phenomenon is frequently observed in conventionally completed and hydraulically fractured oil and gas wells.

During the production testing which ended with time period 202, there was produced some 430,243 thousand cubic feet of dry gas. The model indicated that some 143,836 thousand cubic feet of water vapor had evolved and 32,821 thousand cubic feet of carbon dioxide had evolved. During the closed-in period following the last production test, it was assumed no additional water vaporized or carbon dioxide evolved.

After a preliminary match was obtained, the value of the unstimulated permeability was varied to determine, if possible, whether or not the value of .05 millidarcys initially selected as a result of log interpretation was the best value. Values of .01, .025, .04, and .05 millidarcys were used. It was found that prior to the time the well was shut in at time period 202 the model was insensitive to the value of permeability for the unstimulated reservoir rock. A value of .04 millidarcys was indicated to be the best value of those used in this phase of the history match. The results of this are included as Table 5 and Figure 3.

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unstimulated
k

The entire history match was repeated using a value of .04 millidarcys for the permeability of the unstimulated reservoir rock. The resulting match of the observed and calculated pressures is shown as Figure 4.

PREDICTIONS

Using the geometry of the cavity and fracture zone established in the history match, several prediction cases were run with the model in order to assess the long-term productivity of the Rulison R-EX well. The phenomenon of increasing permeability in the fracture zone during the production testing was further studied. The average permeability of the fracture zone, as shown in Table 4, was plotted versus cumulative production, as shown in Figure 5. The postulated ultimate permeability distribution in the fracture zone is shown in Table 4 and also in Figure 2. A plot of average permeability versus cumulative dry-gas production, as shown in Figure 5, was extrapolated to the average permeability of the postulated ultimate distribution and this plot indicates that such a condition would be reached at a cumulative dry-gas production of 600 million cubic feet.

Case 1

In this instance, the well was allowed to remain shut in until June of 1972 then opened at a rate of 1 million cubic feet per day. During the shut-in period and subsequent producing period the composition was allowed to change as a result of influx during the shut-in period and removal of cavity gas as well as influx of reservoir gas during the producing period. At the end of the shut-in period the cavity pressure had built up to 1,232 pounds per square inch absolute. The permeability of the fracture zone was allowed to increase to the ultimate distribution at a cumulative production of 600 million cubic feet. When the well was put on production, as shown in Figure 6, it sustained a rate of 1 million cubic feet per day until the end of August 1974, from which time it declined over a 30-year period to a rate of 316 thousand cubic feet per day. The cumulative production during this 30-year period was 5,943,829 thousand cubic feet to which must be added the 433,243 thousand cubic feet during the production testing for a total cumulative production of 6,374,072 thousand cubic feet This represents a recovery of 44.2 percent of the gas in place under the 640 acres represented by the model.

Of interest in connection with this prediction case is the hydrogen concentration in the produced gas versus time. Figure 7 is a plot of the actual concentration and that projected during the shut-in period of the well and its subsequent producing period. During the production testing, the hydrogen concentration declined from 15 percent at the outset to 0.23 percent at the end of production testing and is calculated to decline during the shut-in period and the subsequent producing period until a value of 0.007 percent will be reached in August 1974, at which time the compositional change routine was discontinued.

Cases 2, 3 and 4

Both the history match and prediction Case 1 were run using a constant pay thickness of 75 feet. This implies perfect continuity in the Mesaverde formation throughout the 640-acre area studied in the modeling. It is a well known fact that the Mesaverde formation is composed of elongate sand lenses, interbedded in shales, which are not continuous over great distances. Knutson, Maxwell and Millheim published their findings with regard to the sandstone continuity in the Mesaverde formation.[4] In order to investigate the effect of sandstone continuity on gas recovery from the Rulison R-EX well, three prediction cases were run using in Case 2 a constant pay thickness of 75 feet; in Case 3 a pay thickness decreasing from 75 feet at the cavity radius to 1 foot at the outer radius of 3,000 feet, this according to the distribution found by Knutson, Maxwell and Millheim. The work of Knutson et al was concerned with studies of outcrops along the minor axis of the sand lenses and therefore depicts the sand discontinuity more pessimistically than the actual. Consequently, Case 4 was run using a distribution halfway between that of Case 2 and Case 3 wherein the pay thickness was decreased from 75 feet at the cavity radius to 38 feet at the outer radius of 3,000 feet. In each of these instances the starting pressure was set at the initial pressure of 3,251 pounds per square inch, the reservoir gas composition is used, and in all other respects the model configuration is the same as Case 1.

The results of Cases 2, 3 and 4 are shown in Figure 8. In Case 2 the well produced at a rate of 1 million cubic feet per day for 3 years and 9 months, declining thereafter to 329 thousand cubic feet per day after 30 years. The cumulative production at the end of the 30 years was 6,330,436 thousand cubic feet which represents a recovery of 43.9 percent of the gas in place under the 640 acres included in the model.

In Case 3, which illustrates the most serious discontinuity of sand, the well produced for 1 year and 7 months at 1 million cubic feet per day, declining to an economic limit of 50 thousand cubic feet per day in 8 years. The cumulative production was 866,657 thousand cubic feet or 6 percent of the gas in place under the 640 acres.

In Case 4 the well produced for 2 years and 4 months at 1 million cubic feet per day, declining to 175 thousand cubic feet per day over a 30-year period. Cumulative production was 4,133,712 thousand cubic feet or 28.7 percent of the gas in place under the 640 acres.

## SUMMARY and CONCLUSIONS

An interpretation of observations made in the Rulison R-EX well during production testing, during shut-in periods between production tests, and during the shut-in period subsequent to the last of the production tests has been made using a mathematical model which represents the various aspects of the physical phenomena occurring in the well. A reasonable history match with the observed data has been obtained. The most reasonable value of the permeability of the unstimulated reservoir rock was found to be .04 millidarcys, which agrees reasonably well with the geometric mean permeability of the stimulated interval of .05 millidarcys as determined from log analysis. If the well were allowed to remain shut in until June 1972, and then commenced to produce at 1 million cubic feet per day, the hydrogen concentration would decline from the initial value to about 1/15,000 of that value by August 1974. Assuming perfect continuity of the Mesaverde formation, the well would produce some 6.4 billion cubic feet of gas over a 30-year period, or 44.2 percent of the gas in place under 640 acres. Because of known discontinuity of the sandstones in the Mesaverde formation, it is more reasonable to conclude that the well would produce some 4.1 billion cubic feet over a 30-year period or 28.7 percent of the gas in place under the 640-acre area.

Submitted,

DeGolyer and MacNaughton
DeGOLYER and MacNAUGHTON

Computer Technical Services, Inc
COMPUTER TECHNICAL SERVICES, INC.

SIGNED: December 6, 1971

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3. Carr, N. L., R. Kobayashi, and D. B. Burrows: "Viscosity of Hydrocarbon Gases under Pressure", Trans. AIME, 1954, p. 201.

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# TABLE 1

## PROJECT RULISON
## PRODUCTION and PRESSURE DATA

| Date | Time Period | DRY GAS PRODUCTION – Mcf Cumulative | DRY GAS PRODUCTION – Mcf Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | TOTAL WATER PRODUCED Daily (Barrels) | TOTAL WATER PRODUCED Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 3,321 |
| 10-4-70 | 1 | 478 | 478 | 10 | 10 | 20.9 | 0.86647 | 2,993 |
| 10-5-70 | 2 | 6,192 | 5,714 | 133 | 123 | 21.5 | 0.86317 | 3,072 |
| 10-6-70 | 3 | 8,345 | 2,153 | 179 | 46 | 21.4 | 0.86372 | 3,168 |
| 10-7-70 | 4 | 11,342 | 2,997 | 244 | 65 | 21.7 | 0.86207 | 2,997 |
| No data observed between October 7, 1970 and October 26, 1970 | | | | | | | | |
| 10-26-70 | 23 | 15,153 | 3,811 | 270 | 26 | 6.8 | 0.95225 | 3,072 |
| 10-27-70 | 24 | 30,813 | 15,660 | 404 | 134 | 8.6 | 0.94037 | 2,921 |
| 10-28-70 | 25 | 45,917 | 15,104 | 536 | 132 | 8.7 | 0.93972 | 2,761 |
| 10-29-70 | 26 | 60,227 | 14,310 | 724 | 188 | 13.1 | 0.91192 | 2,625 |
| 10-30-70 | 27 | 73,744 | 13,517 | 914 | 190 | 14.1 | 0.90583 | 2,488 |
| 10-31-70 | 28 | 86,391 | 12,647 | 1,146 | 232 | 18.3 | 0.88111 | 2,373 |
| 11-1-70 | 29 | 98,144 | 11,753 | 1,445 | 299 | 25.4 | 0.84226 | 2,261 |
| 11-2-70 | 30 | 109,319 | 11,175 | 1,762 | 317 | 28.4 | 0.82686 | 2,163 |
| 11-3-70 | 31 | 115,705 | 6,386 | 1,955 | 193 | 30.2 | 0.81788 | 2,157 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION – Mcf Cumulative | DRY GAS PRODUCTION – Mcf Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | TOTAL WATER PRODUCED Daily (Barrels) | TOTAL WATER PRODUCED Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 11-4-70 | 32 | 115,705 | | 1,955 | | | | 2,158 |
| 11-5-70 | 33 | 115,705 | | 1,955 | | | | 2,165 |
| 11-6-70 | 34 | 115,705 | | 1,955 | | | | 2,178 |
| 11-7-70 | 35 | 115,705 | | 1,955 | | | | 2,188 |
| 11-8-70 | 36 | 115,705 | | 1,955 | | | | 2,196 |
| 11-9-70 | 37 | 115,705 | | 1,955 | | | | 2,207 |
| 11-10-70 | 38 | 115,705 | | 1,955 | | | | 2,216 |
| 11-11-70 | 39 | 115,705 | | 1,955 | | | | 2,220 |
| 11-12-70 | 40 | 115,705 | | 1,955 | | | | 2,230 |
| 11-13-70 | 41 | 115,705 | | 1,955 | | | | 2,234 |
| 11-14-70 | 42 | 115,705 | | 1,955 | | | | 2,241 |
| 11-15-70 | 43 | 115,705 | | 1,955 | | | | 2,248 |
| 11-16-70 | 44 | 115,705 | | 1,955 | | | | 2,256 |
| 11-17-70 | 45 | 115,705 | | 1,955 | | | | 2,262 |
| 11-18-70 | 46 | 115,705 | | 1,955 | | | | 2,265 |
| 11-19-70 | 47 | 115,705 | | 1,955 | | | | 2,272 |
| 11-20-70 | 48 | 115,705 | | 1,955 | | | | 2,277 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION – Mcf Cumulative | DRY GAS PRODUCTION – Mcf Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | TOTAL WATER PRODUCED Daily (Barrels) | TOTAL WATER PRODUCED Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 11-21-70 | 49 | 115,705 | | 1,955 | | | | 2,278 |
| 11-22-70 | 50 | 115,705 | | 1,955 | | | | 2,289 |
| 11-23-70 | 51 | 115,705 | | 1,955 | | | | 2,293 |
| 11-24-70 | 52 | 115,705 | | 1,955 | | | | 2,298 |
| 11-25-70 | 53 | 115,705 | | 1,955 | | | | 2,306 |
| 11-26-70 | 54 | 115,705 | | 1,955 | | | | 2,309 |
| 11-27-70 | 55 | 115,705 | | 1,955 | | | | 2,311 |
| 11-28-70 | 56 | 115,705 | | 1,955 | | | | 2,315 |
| 11-29-70 | 57 | 115,705 | | 1,955 | | | | 2,319 |
| 11-30-70 | 58 | 115,705 | | 1,955 | | | | 2,326 |
| 12-1-70 | 59 | 118,337 | 2,632 | 2,028 | 73 | 27.7 | 0.82989 | 2,315 |
| 12-2-70 | 60 | 123,681 | 5,344 | 2,185 | 157 | 29.4 | 0.82185 | 2,255 |
| 12-3-70 | 61 | 128,816 | 5,135 | 2,324 | 139 | 27.1 | 0.83346 | 2,197 |
| 12-4-70 | 62 | 133,874 | 5,058 | 2,467 | 143 | 28.3 | 0.82736 | 2,154 |
| 12-5-70 | 63 | 138,938 | 5,064 | 2,619 | 152 | 30.0 | 0.81887 | 2,108 |
| 12-6-70 | 64 | 143,996 | 5,058 | 2,775 | 156 | 30.8 | 0.81493 | 2,062 |
| 12-7-70 | 65 | 149,132 | 5,136 | 2,850 | 75 | 14.6 | 0.90281 | 2,018 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION – Mcf Cumulative | Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | Daily (Barrels) | Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 12-8-70 | 66 | 154,233 | 5,101 | 3,101 | 251 | 49.2 | 0.73380 | 1,977 |
| 12-9-70 | 67 | 159,357 | 5,124 | 3,269 | 168 | 32.8 | 0.80526 | 1,932 |
| 12-10-70 | 68 | 164,531 | 5,174 | 3,441 | 172 | 33.2 | 0.80335 | 1,886 |
| 12-11-70 | 69 | 169,712 | 5,181 | 3,610 | 169 | 32.6 | 0.80621 | 1,837 |
| 12-12-70 | 70 | 174,930 | 5,218 | 3,778 | 168 | 32.2 | 0.80813 | 1,798 |
| 12-13-70 | 71 | 180,135 | 5,205 | 3,949 | 171 | 32.9 | 0.80478 | 1,752 |
| 12-14-70 | 72 | 185,294 | 5,159 | 4,123 | 174 | 33.7 | 0.80098 | 1,707 |
| 12-15-70 | 73 | 190,472 | 5,178 | 4,296 | 173 | 33.4 | 0.80240 | 1,667 |
| 12-16-70 | 74 | 195,614 | 5,142 | 4,469 | 173 | 33.6 | 0.80145 | 1,627 |
| 12-17-70 | 75 | 200,810 | 5,196 | 4,646 | 177 | 34.1 | 0.79909 | 1,588 |
| 12-18-70 | 76 | 205,961 | 5,151 | 4,826 | 180 | 34.9 | 0.79534 | 1,548 |
| 12-19-70 | 77 | 211,108 | 5,147 | 5,011 | 185 | 35.9 | 0.79070 | 1,510 |
| 12-20-70 | 78 | 214,104 | 2,996 | 5,121 | 110 | 36.7 | 0.78703 | 1,486 |
| 12-21-70 | 79 | 214,104 | | 5,121 | | | | 1,492 |
| 12-22-70 | 80 | 214,104 | | 5,121 | | | | 1,505 |
| 12-23-70 | 81 | 214,104 | | 5,121 | | | | 1,509 |
| 12-24-70 | 82 | 214,104 | | 5,121 | | | | 1,517 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION – Mcf Cumulative | Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | Daily (Barrels) | Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 12-25-70 | 83 | 214,104 | | 5,121 | | | | 1,524 |
| 12-26-70 | 84 | 214,104 | | 5,121 | | | | 1,533 |
| 12-27-70 | 85 | 214,104 | | 5,121 | | | | 1,540 |
| 12-28-70 | 86 | 214,104 | | 5,121 | | | | 1,548 |
| 12-29-70 | 87 | 214,104 | | 5,121 | | | | 1,554 |
| 12-30-70 | 88 | 214,104 | | 5,121 | | | | 1,560 |
| 12-31-70 | 89 | 214,104 | | 5,121 | | | | 1,567 |
| 1-1-71 | 90 | 214,104 | | 5,121 | | | | 1,575 |
| 1-2-71 | 91 | 214,104 | | 5,121 | | | | 1,580 |
| 1-3-71 | 92 | 214,104 | | 5,121 | | | | 1,586 |
| 1-4-71 | 93 | 214,104 | | 5,121 | | | | 1,593 |
| 1-5-71 | 94 | 214,104 | | 5,121 | | | | 1,598 |
| 1-6-71 | 95 | 214,104 | | 5,121 | | | | 1,605 |
| 1-7-71 | 96 | 214,104 | | 5,121 | | | | 1,611 |
| 1-8-71 | 97 | 214,104 | | 5,121 | | | | 1,617 |
| 1-9-71 | 98 | 214,104 | | 5,121 | | | | 1,621 |
| 1-10-71 | 99 | 214,104 | | 5,121 | | | | 1,625 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION – Mcf Cumulative | DRY GAS PRODUCTION – Mcf Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | TOTAL WATER PRODUCED Daily (Barrels) | TOTAL WATER PRODUCED Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 1-11-71 | 100 | 214,104 | | 5,121 | | | | 1,628 |
| 1-12-71 | 101 | 214,104 | | 5,121 | | | | 1,631 |
| 1-13-71 | 102 | 214,104 | | 5,121 | | | | 1,636 |
| 1-14-71 | 103 | 214,104 | | 5,121 | | | | 1,642 |
| 1-15-71 | 104 | 214,104 | | 5,121 | | | | 1,647 |
| 1-16-71 | 105 | 214,104 | | 5,121 | | | | 1,652 |
| 1-17-71 | 106 | 214,104 | | 5,121 | | | | 1,656 |
| 1-18-71 | 107 | 214,104 | | 5,121 | | | | 1,660 |
| 1-19-71 | 108 | 214,104 | | 5,121 | | | | 1,665 |
| 1-20-71 | 109 | 214,104 | | 5,121 | | | | 1,669 |
| 1-21-71 | 110 | 214,104 | | 5,121 | | | | 1,672 |
| 1-22-71 | 111 | 214,104 | | 5,121 | | | | 1,677 |
| 1-23-71 | 112 | 214,104 | | 5,121 | | | | 1,681 |
| 1-24-71 | 113 | 214,104 | | 5,121 | | | | 1,683 |
| 1-25-71 | 114 | 214,104 | | 5,121 | | | | 1,686 |
| 1-26-71 | 115 | 214,104 | | 5,121 | | | | 1,690 |
| 1-27-71 | 116 | 214,104 | | 5,121 | | | | 1,695 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION – Mcf Cumulative | DRY GAS PRODUCTION – Mcf Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | TOTAL WATER PRODUCED Daily (Barrels) | TOTAL WATER PRODUCED Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 1-28-71 | 117 | 214,104 | | 5,121 | | | | 1,698 |
| 1-29-71 | 118 | 214,104 | | 5,121 | | | | 1,701 |
| 1-30-71 | 119 | 214,104 | | 5,121 | | | | 1,704 |
| 1-31-71 | 120 | 214,104 | | 5,121 | | | | 1,708 |
| 2-1-71 | 121 | 214,104 | | 5,121 | | | | 1,712 |
| 2-2-71 | 122 | 220,471 | 6,367 | 5,271 | 150 | 23.6 | 0.85178 | 1,606 |
| 2-3-71 | 123 | 230,905 | 10,434 | 5,477 | 206 | 19.7 | 0.87317 | 1,507 |
| 2-4-71 | 124 | 240,563 | 9,658 | 5,703 | 226 | 23.4 | 0.85285 | 1,438 |
| 2-5-71 | 125 | 249,440 | 8,877 | 5,934 | 231 | 26.0 | 0.83913 | 1,348 |
| 2-6-71 | 126 | 257,681 | 8,241 | 6,165 | 231 | 28.0 | 0.82888 | 1,298 |
| 2-7-71 | 127 | 265,423 | 7,742 | 6,411 | 246 | 31.8 | 0.81007 | 1,246 |
| 2-8-71 | 128 | 272,641 | 7,218 | 6,666 | 255 | 35.3 | 0.79348 | 1,173 |
| 2-9-71 | 129 | 279,364 | 6,723 | 6,927 | 261 | 38.8 | 0.77756 | 1,113 |
| 2-10-71 | 130 | 285,713 | 6,349 | 7,175 | 248 | 39.1 | 0.77622 | 1,067 |
| 2-11-71 | 131 | 291,684 | 5,971 | 7,423 | 248 | 41.5 | 0.76570 | 1,014 |
| 2-12-71 | 132 | 297,310 | 5,626 | 7,668 | 245 | 43.5 | 0.75715 | 984 |
| 2-13-71 | 133 | 302,635 | 5,325 | 7,907 | 239 | 44.9 | 0.75128 | 938 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION – Mcf Cumulative | Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | Daily (Barrels) | Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 2-14-71 | 134 | 307,686 | 5,051 | 8,141 | 234 | 46.3 | 0.74550 | 903 |
| 2-15-71 | 135 | 312,443 | 4,757 | 8,372 | 231 | 48.6 | 0.73619 | 865 |
| 2-16-71 | 136 | 316,933 | 4,490 | 8,598 | 226 | 50.3 | 0.72946 | 836 |
| 2-17-71 | 137 | 321,252 | 4,319 | 8,818 | 220 | 50.9 | 0.72712 | 799 |
| 2-18-71 | 138 | 325,311 | 4,059 | 9,035 | 217 | 53.5 | 0.71712 | 779 |
| 2-19-71 | 139 | 329,160 | 3,849 | 9,248 | 213 | 55.3 | 0.71036 | 749 |
| 2-20-71 | 140 | 332,894 | 3,734 | 9,468 | 220 | 58.9 | 0.69721 | 738 |
| 2-21-71 | 141 | 336,521 | 3,627 | 9,693 | 225 | 62.0 | 0.68626 | 704 |
| 2-22-71 | 142 | 340,012 | 3,491 | 9,907 | 214 | 61.3 | 0.68872 | 715 |
| 2-23-71 | 143 | 343,409 | 3,397 | 10,087 | 180 | 53.0 | 0.71902 | 669 |
| 2-24-71 | 144 | 346,493 | 3,084 | 10,293 | 206 | 66.8 | 0.67000 | 618 |
| 2-25-71 | 145 | 349,420 | 2,927 | 10,499 | 206 | 70.4 | 0.65830 | 616 |
| 2-26-71 | 146 | 352,348 | 2,928 | 10,711 | 212 | 72.4 | 0.65197 | 614 |
| 2-27-71 | 147 | 355,154 | 2,806 | 10,915 | 204 | 72.7 | 0.65103 | 576 |
| 2-28-71 | 148 | 357,712 | 2,558 | 11,121 | 206 | 80.5 | 0.62753 | 556 |
| 3-1-71 | 149 | 360,191 | 2,479 | 11,325 | 204 | 82.3 | 0.62235 | 543 |
| 3-2-71 | 150 | 362,574 | 2,383 | 11,528 | 203 | 85.2 | 0.61418 | 526 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION – Mcf Cumulative | DRY GAS PRODUCTION – Mcf Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | TOTAL WATER PRODUCED Daily (Barrels) | TOTAL WATER PRODUCED Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 3-3-71 | 151 | 364,835 | 2,261 | 11,730 | 202 | 89.3 | 0.60298 | 517 |
| 3-4-71 | 152 | 367,099 | 2,264 | 11,933 | 203 | 89.7 | 0.60191 | 507 |
| 3-5-71 | 153 | 369,275 | 2,176 | 12,129 | 196 | 90.1 | 0.60085 | 488 |
| 3-6-71 | 154 | 371,374 | 2,099 | 12,318 | 189 | 90.0 | 0.60111 | 476 |
| 3-7-71 | 155 | 373,352 | 1,978 | 12,509 | 191 | 96.6 | 0.58403 | 453 |
| 3-8-71 | 156 | 375,283 | 1,931 | 12,698 | 189 | 97.9 | 0.58078 | 454 |
| 3-9-71 | 157 | 377,148 | 1,865 | 12,886 | 188 | 100.8 | 0.57365 | 442 |
| 3-10-71 | 158 | 378,963 | 1,815 | 13,072 | 186 | 102.5 | 0.56956 | 429 |
| 3-11-71 | 159 | 380,718 | 1,755 | 13,256 | 184 | 104.8 | 0.56411 | 416 |
| 3-12-71 | 160 | 382,393 | 1,675 | 13,443 | 187 | 111.6 | 0.54859 | 409 |
| 3-13-71 | 161 | 384,037 | 1,644 | 13,629 | 186 | 113.1 | 0.54529 | 403 |
| 3-14-71 | 162 | 385,635 | 1,598 | 13,811 | 182 | 113.9 | 0.54354 | 394 |
| 3-15-71 | 163 | 387,197 | 1,562 | 13,995 | 184 | 117.8 | 0.53517 | 387 |
| 3-16-71 | 164 | 388,716 | 1,519 | 14,177 | 182 | 119.8 | 0.53098 | 380 |
| 3-17-71 | 165 | 390,219 | 1,503 | 14,352 | 175 | 116.4 | 0.53815 | 374 |
| 3-18-71 | 166 | 391,642 | 1,423 | 14,530 | 178 | 125.1 | 0.52019 | 363 |
| 3-19-71 | 167 | 393,061 | 1,419 | 14,702 | 172 | 121.2 | 0.52809 | 361 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION – Mcf Cumulative | DRY GAS PRODUCTION – Mcf Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | TOTAL WATER PRODUCED Daily (Barrels) | TOTAL WATER PRODUCED Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 3-20-71 | 168 | 394,421 | 1,360 | 14,880 | 178 | 130.9 | 0.50887 | 346 |
| 3-21-71 | 169 | 395,721 | 1,300 | 15,052 | 172 | 132.3 | 0.50621 | 345 |
| 3-22-71 | 170 | 397,010 | 1,289 | 15,230 | 178 | 138.1 | 0.49548 | 338 |
| 3-23-71 | 171 | 398,225 | 1,215 | 15,399 | 169 | 139.1 | 0.49368 | 320 |
| 3-24-71 | 172 | 399,370 | 1,145 | 15,571 | 172 | 150.2 | 0.47451 | 319 |
| 3-25-71 | 173 | 400,511 | 1,141 | 15,742 | 171 | 149.9 | 0.47501 | 312 |
| 3-26-71 | 174 | 401,633 | 1,122 | 15,912 | 170 | 151.5 | 0.47236 | 309 |
| 3-27-71 | 175 | 402,749 | 1,116 | 16,086 | 174 | 155.9 | 0.46524 | 308 |
| 3-28-71 | 176 | 403,897 | 1,148 | 16,255 | 169 | 147.2 | 0.47955 | 319 |
| 3-29-71 | 177 | 405,099 | 1,202 | 16,424 | 169 | 140.6 | 0.49100 | 316 |
| 3-30-71 | 178 | 406,288 | 1,189 | 16,595 | 171 | 143.8 | 0.48538 | 314 |
| 3-31-71 | 179 | 407,469 | 1,181 | 16,758 | 163 | 138.0 | 0.49567 | 309 |
| 4-1-71 | 180 | 408,628 | 1,159 | 16,922 | 164 | 141.5 | 0.48941 | 304 |
| 4-2-71 | 181 | 409,759 | 1,131 | 17,084 | 162 | 143.2 | 0.48643 | 303 |
| 4-3-71 | 182 | 410,881 | 1,122 | 17,253 | 169 | 150.6 | 0.47385 | 296 |
| 4-4-71 | 183 | 411,983 | 1,102 | 17,411 | 158 | 143.4 | 0.48608 | 293 |
| 4-5-71 | 184 | 413,069 | 1,086 | 17,572 | 161 | 148.3 | 0.47769 | 289 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION – Mcf: Cumulative | DRY GAS PRODUCTION – Mcf: Daily | TOTAL WATER PRODUCED: Cumulative (Barrels) | TOTAL WATER PRODUCED: Daily (Barrels) | TOTAL WATER PRODUCED: Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 4-6-71 | 185 | 414,140 | 1,071 | 17,728 | 156 | 145.7 | 0.48210 | 287 |
| 4-7-71 | 186 | 415,201 | 1,061 | 17,883 | 155 | 146.1 | 0.48142 | 286 |
| 4-8-71 | 187 | 416,251 | 1,050 | 18,037 | 154 | 146.7 | 0.48040 | 281 |
| 4-9-71 | 188 | 417,282 | 1,031 | 18,197 | 160 | 155.2 | 0.46635 | 280 |
| 4-10-71 | 189 | 418,310 | 1,028 | 18,353 | 156 | 151.8 | 0.47187 | 277 |
| 4-11-71 | 190 | 419,329 | 1,019 | 18,501 | 148 | 145.2 | 0.48296 | 276 |
| 4-12-71 | 191 | 420,329 | 1,000 | 18,655 | 154 | 154.0 | 0.46829 | 270 |
| 4-13-71 | 192 | 421,316 | 987 | 18,808 | 153 | 155.0 | 0.46668 | 271 |
| 4-14-71 | 193 | 422,294 | 978 | 18,958 | 150 | 153.4 | 0.46926 | 268 |
| 4-15-71 | 194 | 423,261 | 967 | 19,120 | 162 | 167.5 | 0.44743 | 265 |
| 4-16-71 | 195 | 424,215 | 954 | 19,266 | 146 | 153.0 | 0.46991 | 263 |
| 4-17-71 | 196 | 425,158 | 943 | 19,414 | 148 | 156.9 | 0.46364 | 262 |
| 4-18-71 | 197 | 426,087 | 929 | 19,566 | 152 | 163.6 | 0.45326 | 258 |
| 4-19-71 | 198 | 426,999 | 912 | 19,711 | 145 | 159.0 | 0.46034 | 255 |
| 4-20-71 | 199 | 427,909 | 910 | 19,858 | 147 | 161.5 | 0.45647 | 254 |
| 4-21-71 | 200 | 428,812 | 903 | 20,006 | 148 | 163.9 | 0.45281 | 252 |
| 4-22-71 | 201 | 429,697 | 885 | 20,151 | 145 | 163.8 | 0.45296 | 246 |
| 4-23-71 | 202 | 430,243 | 546 | 20,244 | 93 | 170.3 | 0.44334 | 248 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION – Mcf Cumulative | DRY GAS PRODUCTION – Mcf Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | TOTAL WATER PRODUCED Daily (Barrels) | TOTAL WATER PRODUCED Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 4-24-71 | 203 | 430,243 | | 20,244 | | | | 271 |
| 4-25-71 | 204 | 430,243 | | 20,244 | | | | 280 |
| 4-26-71 | 205 | 430,243 | | 20,244 | | | | 287 |
| 4-27-71 | 206 | 430,243 | | 20,244 | | | | 293 |
| 4-28-71 | 207 | 430,243 | | 20,244 | | | | 299 |
| 4-29-71 | 208 | 430,243 | | 20,244 | | | | 306 |
| 4-30-71 | 209 | 430,243 | | 20,244 | | | | 311 |
| 5-1-71 | 210 | 430,243 | | 20,244 | | | | 317 |
| 5-2-71 | 211 | 430,243 | | 20,244 | | | | 323 |
| 5-3-71 | 212 | 430,243 | | 20,244 | | | | 328 |
| 5-4-71 | 213 | 430,243 | | 20,244 | | | | 333 |
| 5-5-71 | 214 | 430,243 | | 20,244 | | | | 338 |
| 5-6-71 | 215 | 430,243 | | 20,244 | | | | 343 |
| 5-7-71 | 216 | 430,243 | | 20,244 | | | | 348 |
| 5-8-71 | 217 | 430,243 | | 20,244 | | | | 352 |
| 5-9-71 | 218 | 430,243 | | 20,244 | | | | 357 |
| 5-10-71 | 219 | 430,243 | | 20,244 | | | | 362 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION – Mcf Cumulative | DRY GAS PRODUCTION – Mcf Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | TOTAL WATER PRODUCED Daily (Barrels) | TOTAL WATER PRODUCED Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 5-11-71 | 220 | 430,243 | | 20,244 | | | | 367 |
| 5-12-71 | 221 | 430,243 | | 20,244 | | | | 371 |
| 5-13-71 | 222 | 430,243 | | 20,244 | | | | 376 |
| 5-14-71 | 223 | 430,243 | | 20,244 | | | | 380 |
| 5-15-71 | 224 | 430,243 | | 20,244 | | | | 385 |
| 5-16-71 | 225 | 430,243 | | 20,244 | | | | 390 |
| 5-17-71 | 226 | 430,243 | | 20,244 | | | | 394 |
| 5-18-71 | 227 | 430,243 | | 20,244 | | | | 398 |
| 5-19-71 | 228 | 430,243 | | 20,244 | | | | 403 |
| 5-20-71 | 229 | 430,243 | | 20,244 | | | | 407 |
| 5-21-71 | 230 | 430,243 | | 20,244 | | | | 411 |
| 5-22-71 | 231 | 430,243 | | 20,244 | | | | 415 |
| 5-23-71 | 232 | 430,243 | | 20,244 | | | | 420 |
| 5-24-71 | 233 | 430,243 | | 20,244 | | | | 423 |
| 5-25-71 | 234 | 430,243 | | 20,244 | | | | 427 |
| 5-26-71 | 235 | 430,243 | | 20,244 | | | | 431 |
| 5-27-71 | 236 | 430,243 | | 20,244 | | | | 435 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION – Mcf Cumulative | DRY GAS PRODUCTION – Mcf Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | TOTAL WATER PRODUCED Daily (Barrels) | TOTAL WATER PRODUCED Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 5-28-71 | 237 | 430,243 | | 20,244 | | | | 439 |
| 5-29-71 | 238 | 430,243 | | 20,244 | | | | 443 |
| 5-30-71 | 239 | 430,243 | | 20,244 | | | | 447 |
| 5-31-71 | 240 | 430,243 | | 20,244 | | | | 451 |
| 6-1-71 | 241 | 430,243 | | 20,244 | | | | 455 |
| 6-2-71 | 242 | 430,243 | | 20,244 | | | | 459 |
| 6-3-71 | 243 | 430,243 | | 20,244 | | | | 462 |
| 6-4-71 | 244 | 430,243 | | 20,244 | | | | 466 |
| 6-5-71 | 245 | 430,243 | | 20,244 | | | | 470 |
| 6-6-71 | 246 | 430,243 | | 20,244 | | | | 473 |
| 6-7-71 | 247 | 430,243 | | 20,244 | | | | 477 |
| 6-8-71 | 248 | 430,243 | | 20,244 | | | | 481 |
| 6-9-71 | 249 | 430,243 | | 20,244 | | | | 485 |
| 6-10-71 | 250 | 430,243 | | 20,244 | | | | 489 |
| 6-11-71 | 251 | 430,243 | | 20,244 | | | | 493 |
| 6-12-71 | 252 | 430,243 | | 20,244 | | | | 496 |
| 6-13-71 | 253 | 430,243 | | 20,244 | | | | 500 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION – Mcf Cumulative | DRY GAS PRODUCTION – Mcf Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | TOTAL WATER PRODUCED Daily (Barrels) | TOTAL WATER PRODUCED Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 6-14-71 | 254 | 430,243 | | 20,244 | | | | 504 |
| 6-15-71 | 255 | 430,243 | | 20,244 | | | | 507 |
| 6-16-71 | 256 | 430,243 | | 20,244 | | | | 511 |
| 6-17-71 | 257 | 430,243 | | 20,244 | | | | 515 |
| 6-18-71 | 258 | 430,243 | | 20,244 | | | | 518 |
| 6-19-71 | 259 | 430,243 | | 20,244 | | | | 522 |
| 6-20-71 | 260 | 430,243 | | 20,244 | | | | 526 |
| 6-21-71 | 261 | 430,243 | | 20,244 | | | | 529 |
| 6-22-71 | 262 | 430,243 | | 20,244 | | | | 533 |
| 6-23-71 | 263 | 430,243 | | 20,244 | | | | 536 |
| 6-24-71 | 264 | 430,243 | | 20,244 | | | | 540 |
| 6-25-71 | 265 | 430,243 | | 20,244 | | | | 544 |
| 6-26-71 | 266 | 430,243 | | 20,244 | | | | 547 |
| 6-27-71 | 267 | 430,243 | | 20,244 | | | | 551 |
| 6-28-71 | 268 | 430,243 | | 20,244 | | | | 554 |
| 6-29-71 | 269 | 430,243 | | 20,244 | | | | 558 |
| 6-30-71 | 270 | 430,243 | | 20,244 | | | | 561 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION -- Mcf Cumulative | DRY GAS PRODUCTION -- Mcf Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | TOTAL WATER PRODUCED Daily (Barrels) | TOTAL WATER PRODUCED Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 7-1-71 | 271 | 430,243 | | 20,244 | | | | 565 |
| 7-2-71 | 272 | 430,243 | | 20,244 | | | | 568 |
| 7-3-71 | 273 | 430,243 | | 20,244 | | | | 572 |
| 7-4-71 | 274 | 430,243 | | 20,244 | | | | 575 |
| 7-5-71 | 275 | 430,243 | | 20,244 | | | | 579 |
| 7-6-71 | 276 | 430,243 | | 20,244 | | | | 582 |
| 7-7-71 | 277 | 430,243 | | 20,244 | | | | 585 |
| 7-8-71 | 278 | 430,243 | | 20,244 | | | | 588 |
| 7-9-71 | 279 | 430,243 | | 20,244 | | | | 591 |
| 7-10-71 | 280 | 430,243 | | 20,244 | | | | 594 |
| 7-11-71 | 281 | 430,243 | | 20,244 | | | | 596 |
| 7-12-71 | 282 | 430,243 | | 20,244 | | | | 599 |
| 7-13-71 | 283 | 430,243 | | 20,244 | | | | 602 |
| 7-14-71 | 284 | 430,243 | | 20,244 | | | | 605 |
| 7-15-71 | 285 | 430,243 | | 20,244 | | | | 608 |
| 7-16-71 | 286 | 430,243 | | 20,244 | | | | 611 |
| 7-17-71 | 287 | 430,243 | | 20,244 | | | | 614 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION – Mcf Cumulative | DRY GAS PRODUCTION – Mcf Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | TOTAL WATER PRODUCED Daily (Barrels) | TOTAL WATER PRODUCED Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 7-18-71 | 288 | 430,243 | | 20,244 | | | | 617 |
| 7-19-71 | 289 | 430,243 | | 20,244 | | | | 619 |
| 7-20-71 | 290 | 430,243 | | 20,244 | | | | 622 |
| 7-21-71 | 291 | 430,243 | | 20,244 | | | | 625 |
| 7-22-71 | 292 | 430,243 | | 20,244 | | | | 628 |
| 7-23-71 | 293 | 430,243 | | 20,244 | | | | 631 |
| 7-24-71 | 294 | 430,243 | | 20,244 | | | | 634 |
| 7-25-71 | 295 | 430,243 | | 20,244 | | | | 637 |
| 7-26-71 | 296 | 430,243 | | 20,244 | | | | 640 |
| 7-27-71 | 297 | 430,243 | | 20,244 | | | | 643 |
| 7-28-71 | 298 | 430,243 | | 20,244 | | | | 645 |
| 7-29-71 | 299 | 430,243 | | 20,244 | | | | 648 |
| 7-30-71 | 300 | 430,243 | | 20,244 | | | | 651 |
| 7-31-71 | 301 | 430,243 | | 20,244 | | | | 654 |
| 8-1-71 | 302 | 430,243 | | 20,244 | | | | 657 |
| 8-2-71 | 303 | 430,243 | | 20,244 | | | | 660 |
| 8-3-71 | 304 | 430,243 | | 20,244 | | | | 663 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION – Mcf Cumulative | DRY GAS PRODUCTION – Mcf Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | TOTAL WATER PRODUCED Daily (Barrels) | TOTAL WATER PRODUCED Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 8-4-71 | 305 | 430,243 | | 20,244 | | | | 666 |
| 8-5-71 | 306 | 430,243 | | 20,244 | | | | 669 |
| 8-6-71 | 307 | 430,243 | | 20,244 | | | | 672 |
| 8-7-71 | 308 | 430,243 | | 20,244 | | | | 674 |
| 8-8-71 | 309 | 430,243 | | 20,244 | | | | 677 |
| 8-9-71 | 310 | 430,243 | | 20,244 | | | | 680 |
| 8-10-71 | 311 | 430,243 | | 20,244 | | | | 683 |
| 8-11-71 | 312 | 430,243 | | 20,244 | | | | 685 |
| 8-12-71 | 313 | 430,243 | | 20,244 | | | | 687 |
| 8-13-71 | 314 | 430,243 | | 20,244 | | | | 690 |
| 8-14-71 | 315 | 430,243 | | 20,244 | | | | 692 |
| 8-15-71 | 316 | 430,243 | | 20,244 | | | | 694 |
| 8-16-71 | 317 | 430,243 | | 20,244 | | | | 697 |
| 8-17-71 | 318 | 430,243 | | 20,244 | | | | 699 |
| 8-18-71 | 319 | 430,243 | | 20,244 | | | | 702 |
| 8-19-71 | 320 | 430,243 | | 20,244 | | | | 704 |
| 8-20-71 | 321 | 430,243 | | 20,244 | | | | 707 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION – Mcf Cumulative | DRY GAS PRODUCTION – Mcf Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | TOTAL WATER PRODUCED Daily (Barrels) | TOTAL WATER PRODUCED Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 8-21-71 | 322 | 430,243 | | 20,244 | | | | 709 |
| 8-22-71 | 323 | 430,243 | | 20,244 | | | | 711 |
| 8-23-71 | 324 | 430,243 | | 20,244 | | | | 714 |
| 8-24-71 | 325 | 430,243 | | 20,244 | | | | 716 |
| 8-25-71 | 326 | 430,243 | | 20,244 | | | | 719 |
| 8-26-71 | 327 | 430,243 | | 20,244 | | | | 721 |
| 8-27-71 | 328 | 430,243 | | 20,244 | | | | 724 |
| 8-28-71 | 329 | 430,243 | | 20,244 | | | | 726 |
| 8-29-71 | 330 | 430,243 | | 20,244 | | | | 728 |
| 8-30-71 | 331 | 430,243 | | 20,244 | | | | 731 |
| 8-31-71 | 332 | 430,243 | | 20,244 | | | | 733 |
| 9-1-71 | 333 | 430,243 | | 20,244 | | | | 736 |
| 9-2-71 | 334 | 430,243 | | 20,244 | | | | 738 |
| 9-3-71 | 335 | 430,243 | | 20,244 | | | | 740 |
| 9-4-71 | 336 | 430,243 | | 20,244 | | | | 743 |
| 9-5-71 | 337 | 430,243 | | 20,244 | | | | 745 |
| 9-6-71 | 338 | 430,243 | | 20,244 | | | | 748 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION – Mcf Cumulative | DRY GAS PRODUCTION – Mcf Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | TOTAL WATER PRODUCED Daily (Barrels) | TOTAL WATER PRODUCED Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 9-7-71 | 339 | 430,243 | | 20,244 | | | | 750 |
| 9-8-71 | 340 | 430,243 | | 20,244 | | | | 753 |
| 9-9-71 | 341 | 430,243 | | 20,244 | | | | 755 |
| 9-10-71 | 342 | 430,243 | | 20,244 | | | | 757 |
| 9-11-71 | 343 | 430,243 | | 20,244 | | | | 760 |
| 9-12-71 | 344 | 430,243 | | 20,244 | | | | 762 |
| 9-13-71 | 345 | 430,243 | | 20,244 | | | | 765 |
| 9-14-71 | 346 | 430,243 | | 20,244 | | | | 767 |
| 9-15-71 | 347 | 430,243 | | 20,244 | | | | 769 |
| 9-16-71 | 348 | 430,243 | | 20,244 | | | | 772 |
| 9-17-71 | 349 | 430,243 | | 20,244 | | | | 774 |
| 9-18-71 | 350 | 430,243 | | 20,244 | | | | 777 |
| 9-19-71 | 351 | 430,243 | | 20,244 | | | | 779 |
| 9-20-71 | 352 | 430,243 | | 20,244 | | | | 782 |
| 9-21-71 | 353 | 430,243 | | 20,244 | | | | 784 |
| 9-22-71 | 354 | 430,243 | | 20,244 | | | | 786 |
| 9-23-71 | 355 | 430,243 | | 20,244 | | | | 789 |

PROJECT RULISON

| Date | Time Period | DRY GAS PRODUCTION – Mcf Cumulative | DRY GAS PRODUCTION – Mcf Daily | TOTAL WATER PRODUCED Cumulative (Barrels) | TOTAL WATER PRODUCED Daily (Barrels) | TOTAL WATER PRODUCED Bbls/MMcf Dry Gas | Mol Fraction Dry Gas | Cavity Pressure Psia |
|---|---|---|---|---|---|---|---|---|
| 9-24-71 | 356 | | | | | | | |
| | | 430,243 | | 20,244 | | | | 791 |
| 9-25-71 | 357 | | | | | | | |
| | | 430,243 | | 20,244 | | | | 794 |
| 9-26-71 | 358 | | | | | | | |
| | | 430,243 | | 20,244 | | | | 796 |
| 9-27-71 | 359 | | | | | | | |
| | | 430,243 | | 20,244 | | | | 798 |

TABLE 2

PROJECT RULISON
COMPOSITION of RESERVOIR GAS

(Sample from Federal "A" No. 29-95 on June 8, 1966)

| Component | Mol* Percent |
|---|---|
| Carbon Dioxide | 1.29 |
| Nitrogen | 0.04 |
| Methane | 90.90 |
| Ethane | 5.14 |
| Propane | 1.58 |
| iso-Butane | 0.31 |
| n-Butane | 0.34 |
| iso-Pentane | 0.12 |
| n-Pentane | 0.10 |
| Hexanes | 0.11 |
| Heptanes plus | 0.07 |
| | 100.00 |

*As reported by Core Laboratories, Inc.

TABLE 3

PROJECT RULISON
COMPOSITION of PRODUCED GAS

(As Reported by Teledyne Isotopes)

| Date Sampled | 8-1-70 | 10-7-70 | 10-26-70 | 10-29-70 | 11-3-70 | 12-5-70 | 12-13-70 | 12-20-70 | 2-3-71 | 2-27-71 | 3-24-71 | 4-23-71 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | GAS COMPOSITION in MOL PERCENT | | | | | | | | | | | |
| Methane | 30.90 | 36.00 | 31.50 | 35.70 | 37.70 | 46.00 | 50.00 | 56.00 | 60.00 | 71.00 | 70.00 | 69.00+ |
| Ethane | 1.40 | 1.86 | 1.90 | 1.59 | 2.24 | 2.77 | 2.93 | 2.77 | 2.92 | 3.24 | 3.54 | 4.30 |
| Propane | 0.37 | 0.40 | 0.43 | 0.39 | 0.59 | 0.53 | 0.73 | 0.70 | 0.94 | 0.95 | 1.00 | 1.13 |
| Pentanes through Octanes | 0.27 | 0.247 | 0.22 | 0.23 | 0.32 | 0.51 | 0.53 | 0.55 | 0.63 | 0.86 | 0.70 | 0.90 |
| Carbon Dioxide | 45.00 | 46.00 | 47.00 | 44.00 | 43.00 | 38.70 | 34.30 | 31.70 | 27.20 | 19.00 | 21.30 | 22.40 |
| Nitrogen | 5.60 | 0.25 | 2.88 | 1.89 | 1.28 | 0.26 | 0.20 | 0.40 | 0.14 | 0.46 | 0.71 | 1.36 |
| Hydrogen | 15.60 | 14.60 | 15.10 | 14.90 | 14.92 | 10.90 | 10.60 | 7.70 | 7.40 | 3.30 | 2.10 | 0.50 |

TABLE 4

PROJECT RULISON

| Block No. | Outer Radius Feet | PERMEABILITY of FRACTURE ZONE – MILLIDARCYS Time Periods 1 – 30 | Time Periods 31 – 58 | Time Periods 59 – 68 | Time Periods 69 – 120 | Time Periods 120 – 359 | Postulated Ultimate |
|---|---|---|---|---|---|---|---|
| 9 | 88 | 0.100 | 0.300 | 0.300 | 0.300 | 0.300 | 0.300 |
| 10 | 107 | 0.010 | 0.150 | 0.170 | 0.260 | 0.260 | 0.261 |
| 11 | 129 | 0.001 | 0.021 | 0.060 | 0.140 | 0.215 | 0.219 |
| 12 | 156 | 0.001 | 0.006 | 0.020 | 0.050 | 0.1575 | 0.165 |
| 13 | 187 | 0.001 | 0.001 | 0.002 | 0.006 | 0.015 | 0.098 |
| 14 | 220 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.040 |
| Average Permeability | | 0.019 | 0.0798 | 0.0922 | 0.1262 | 0.1581 | 0.1805 |
| Cumulative Dry Gas Production at End of Period – Mcf | | 114,319 | 120,705 | 169,526 | 219,099 | 434,613 | |

TABLE 5

PROJECT RULISON

| Time Period | Reported Cavity Pressure psia | MODEL CALCULATED PRESSURES FOR VARIOUS VALUES of MATRIX PERMEABILITY | | | |
|---|---|---|---|---|---|
| | | 0.01 md. | 0.025 md. | 0.04 md. | 0.05 md. |
| 202 | 248 | 236 | 247 | 253 | 255 |
| 205 | 287 | 259 | 270 | 276 | 278 |
| 210 | 317 | 292 | 305 | 311 | 313 |
| 215 | 343 | 322 | 335 | 341 | 344 |
| 220 | 367 | 349 | 363 | 369 | 372 |
| 225 | 390 | 374 | 388 | 395 | 398 |
| 230 | 411 | 397 | 412 | 419 | 422 |
| 235 | 431 | 419 | 434 | 441 | 445 |
| 240 | 451 | 439 | 455 | 463 | 466 |
| 245 | 470 | 458 | 474 | 483 | 486 |
| 250 | 489 | 476 | 493 | 501 | 505 |
| 255 | 507 | 493 | 511 | 519 | 523 |
| 260 | 526 | 509 | 527 | 536 | 541 |
| 265 | 544 | 524 | 543 | 553 | 557 |
| 270 | 561 | 539 | 559 | 569 | 573 |
| 275 | 579 | 553 | 574 | 584 | 588 |
| 280 | 594 | 566 | 588 | 598 | 603 |
| 285 | 608 | 580 | 602 | 613 | 618 |
| 290 | 622 | 592 | 615 | 627 | 632 |
| 295 | 637 | 605 | 629 | 640 | 646 |
| 300 | 651 | 617 | 641 | 654 | 659 |
| 305 | 666 | 629 | 654 | 667 | 672 |
| 310 | 680 | 640 | 667 | 679 | 685 |
| 315 | 692 | 651 | 679 | 692 | 698 |
| 320 | 704 | 663 | 691 | 704 | 711 |
| 325 | 716 | 673 | 702 | 717 | 723 |
| 330 | 728 | 684 | 714 | 729 | 735 |
| 335 | 740 | 695 | 726 | 741 | 747 |
| 340 | 753 | 705 | 737 | 752 | 759 |
| 345 | 765 | 715 | 748 | 764 | 771 |
| 350 | 777 | 725 | 759 | 776 | 783 |
| 355 | 789 | 735 | 770 | 787 | 794 |
| 359 | 798 | 743 | 781 | 796 | 803 |

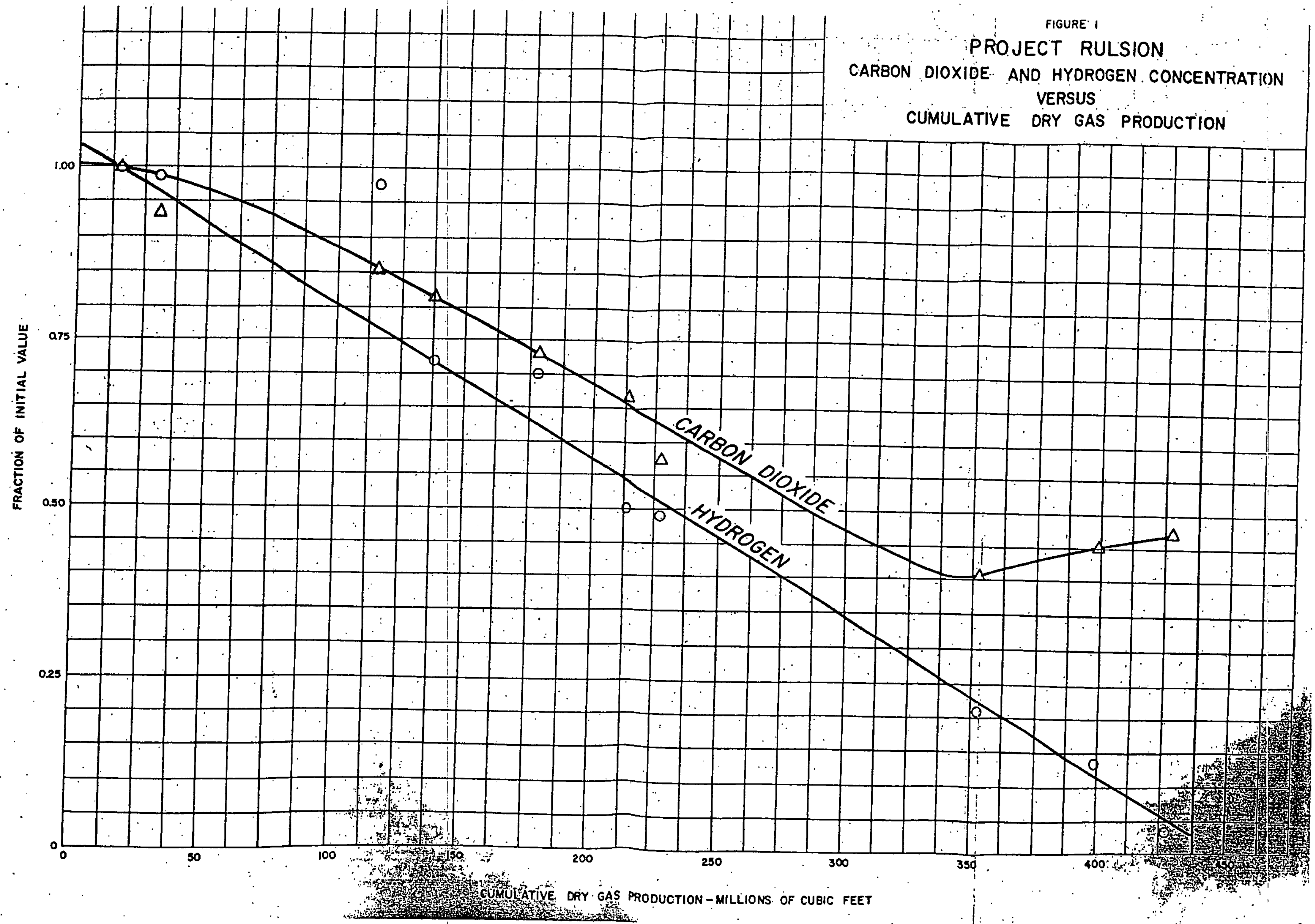


FIGURE I
PROJECT RULSION
CARBON DIOXIDE AND HYDROGEN CONCENTRATION
VERSUS
CUMULATIVE DRY GAS PRODUCTION
FRACTION OF INITIAL VALUE
1.00
0.75
0.50
0.25
0
0
50
100
150
200
250
300
350
400
450
CARBON DIOXIDE
HYDROGEN
CUMULATIVE DRY GAS PRODUCTION – MILLIONS OF CUBIC FEET

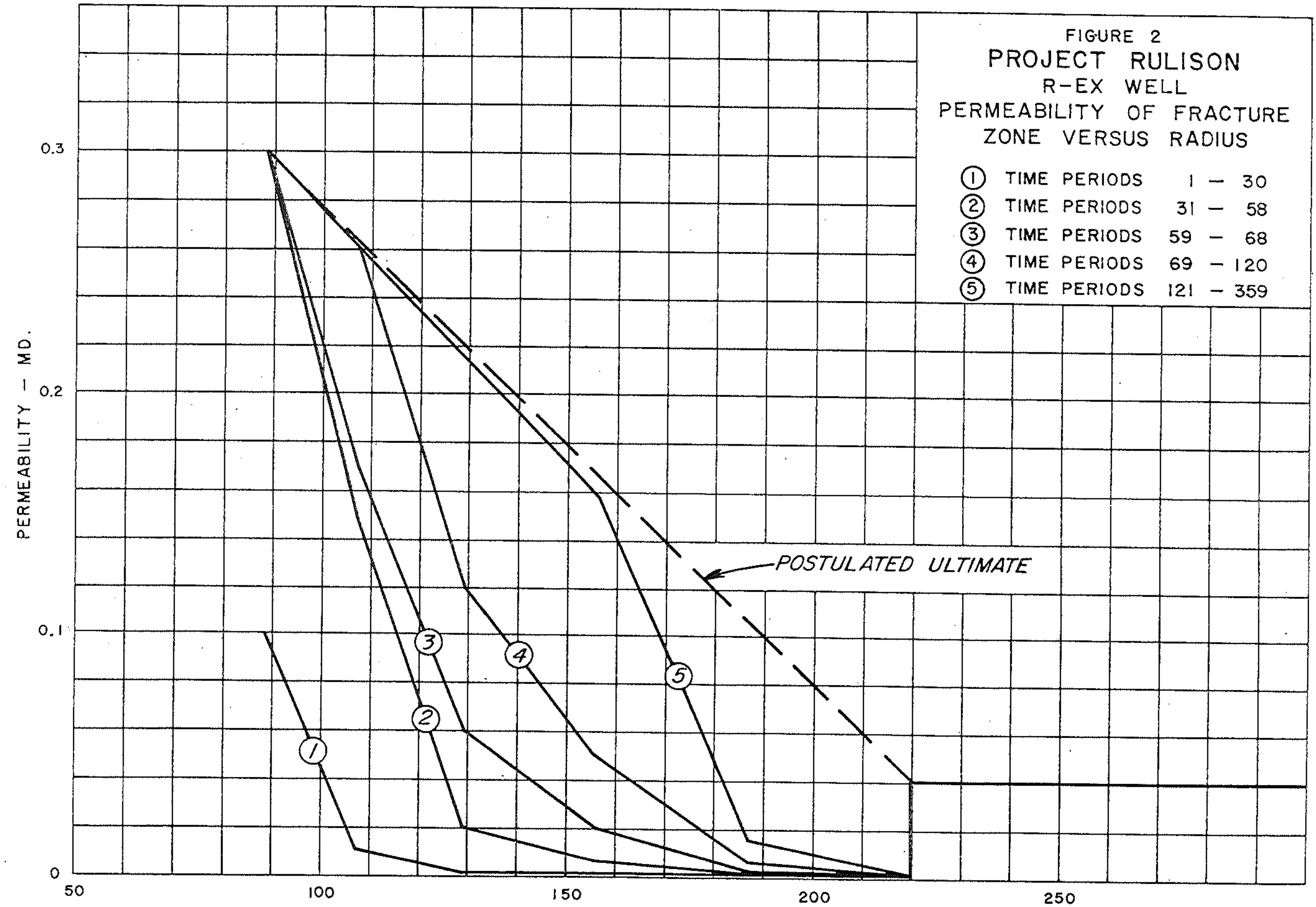


FIGURE 2
PROJECT RULISON
R-EX WELL
PERMEABILITY OF FRACTURE ZONE VERSUS RADIUS
① TIME PERIODS 1 — 30
② TIME PERIODS 31 — 58
③ TIME PERIODS 59 — 68
④ TIME PERIODS 69 — 120
⑤ TIME PERIODS 121 — 359
POSTULATED ULTIMATE
PERMEABILITY - MD.
0.3
0.2
0.1
0
50
100
150
200
250

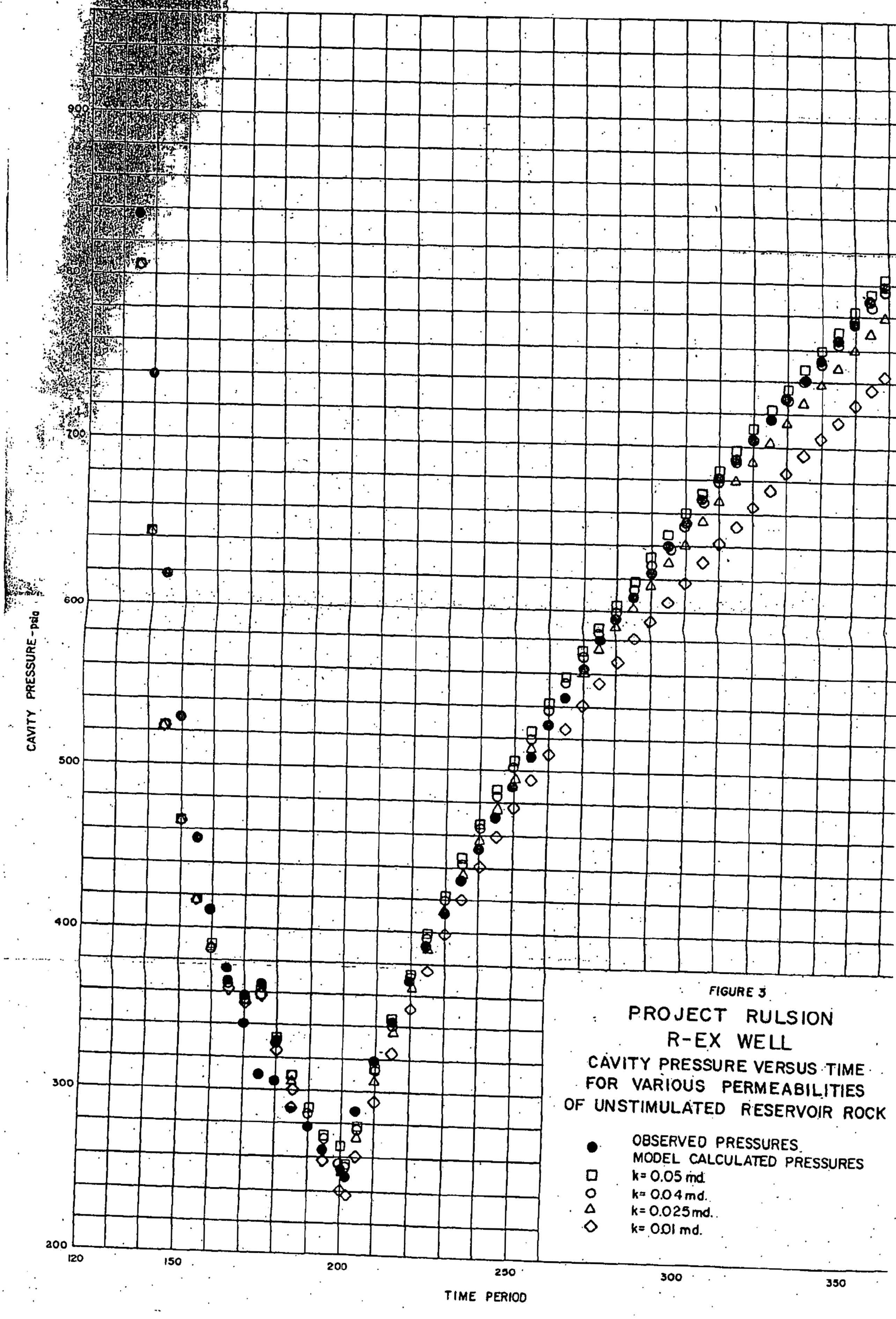



FIGURE 3

PROJECT RULSION

R-EX WELL

CAVITY PRESSURE VERSUS TIME FOR VARIOUS PERMEABILITIES OF UNSTIMULATED RESERVOIR ROCK

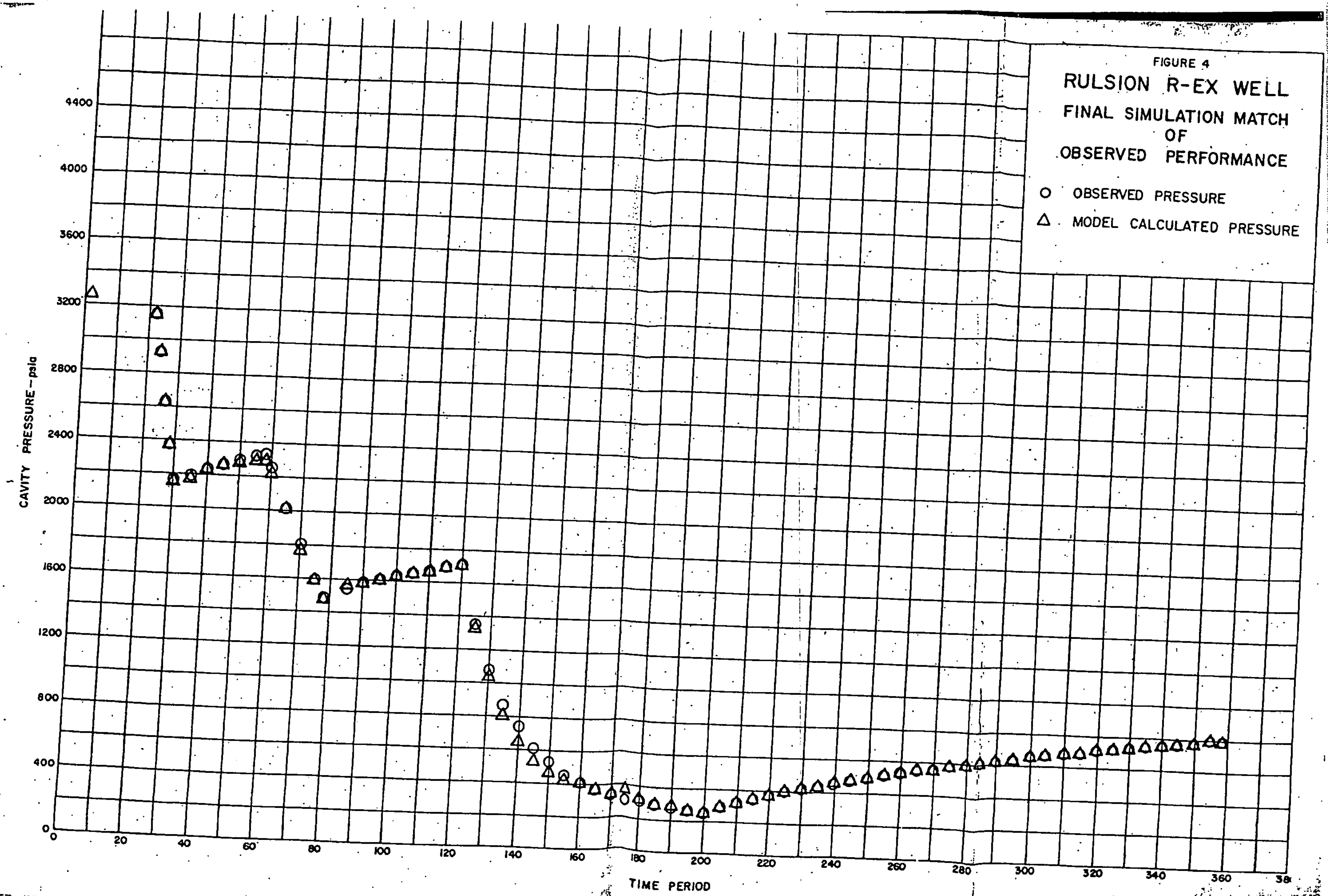


FIGURE 4
RULSION R-EX WELL
FINAL SIMULATION MATCH
OF
OBSERVED PERFORMANCE
O OBSERVED PRESSURE
Δ MODEL CALCULATED PRESSURE
CAVITY PRESSURE – psia
TIME PERIOD
4400
4000
3600
3200
2800
2400
2000
1600
1200
800
400
0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360

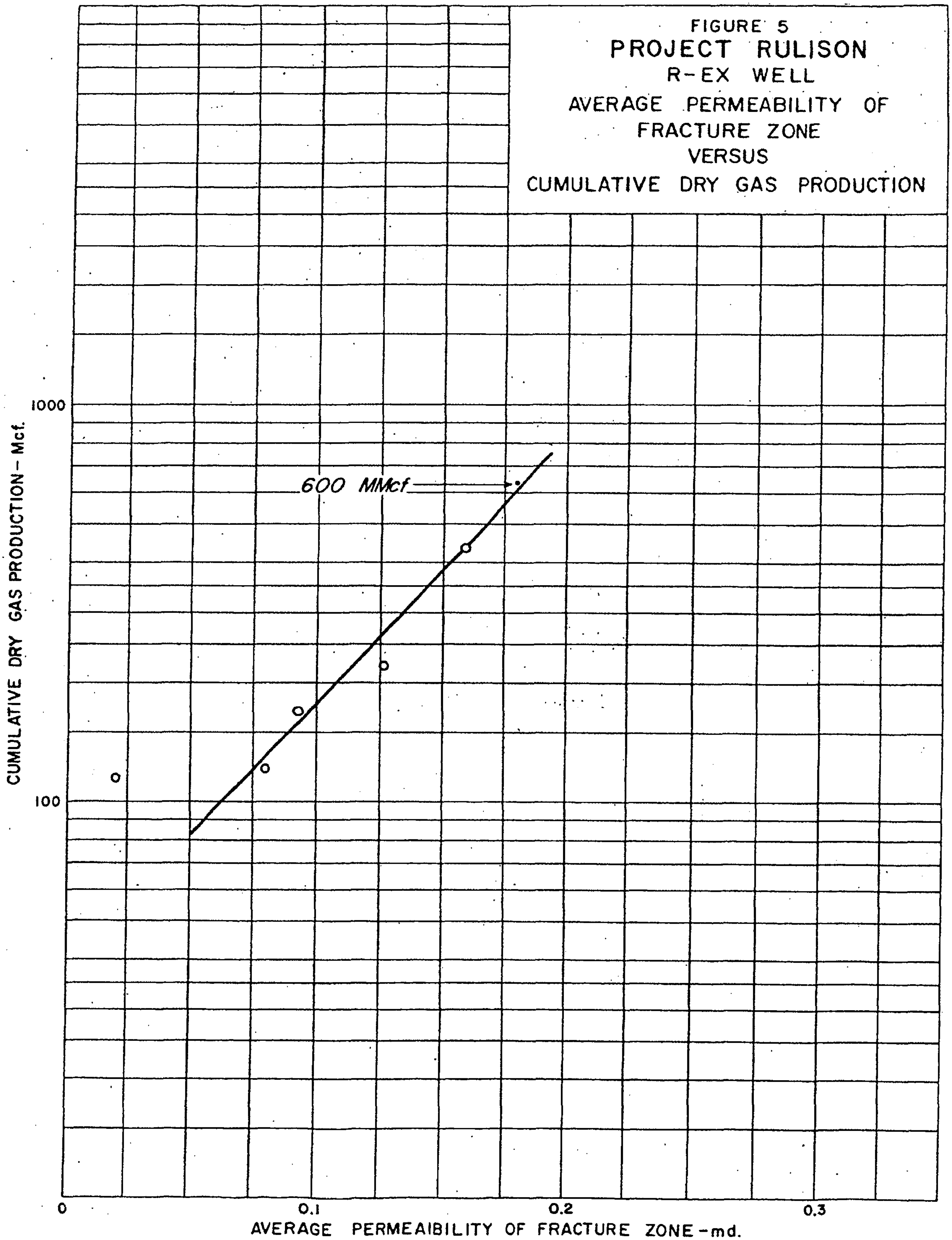


FIGURE 5
PROJECT RULISON
R-EX WELL
AVERAGE PERMEABILITY OF
FRACTURE ZONE
VERSUS
CUMULATIVE DRY GAS PRODUCTION
600 MMcf
1000
100
CUMULATIVE DRY GAS PRODUCTION - Mcf.
0
0.1
0.2
0.3
AVERAGE PERMEAIBILITY OF FRACTURE ZONE - md.

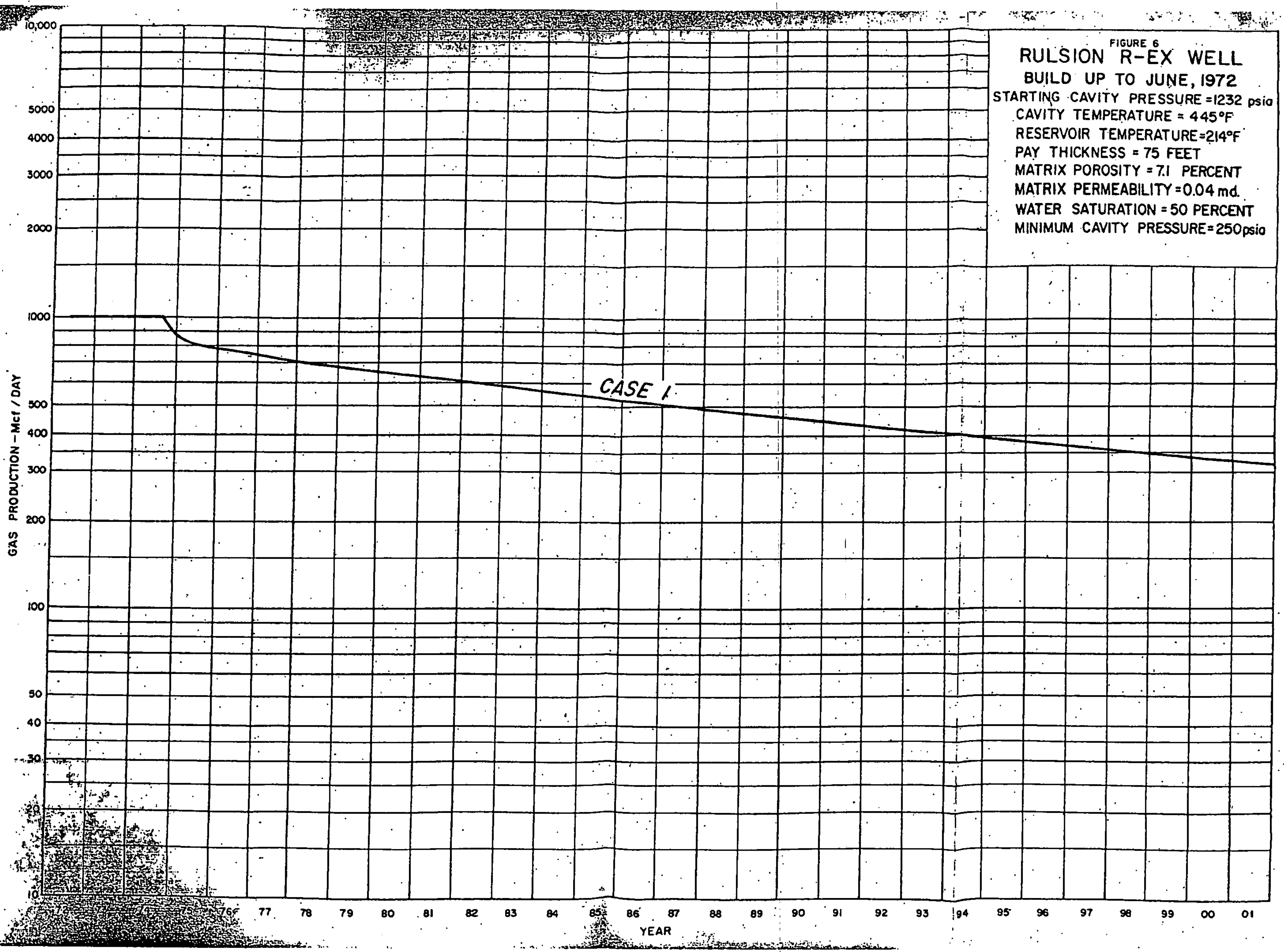


FIGURE 6
RULSION R-EX WELL
BUILD UP TO JUNE, 1972
STARTING CAVITY PRESSURE = 1232 psia
CAVITY TEMPERATURE = 445°F
RESERVOIR TEMPERATURE = 214°F
PAY THICKNESS = 75 FEET
MATRIX POROSITY = 7.1 PERCENT
MATRIX PERMEABILITY = 0.04 md.
WATER SATURATION = 50 PERCENT
MINIMUM CAVITY PRESSURE = 250 psia
CASE I
GAS PRODUCTION - Mcf / DAY
10,000
5000
4000
3000
2000
1000
500
400
300
200
100
50
40
30
20
10
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
00
01
YEAR

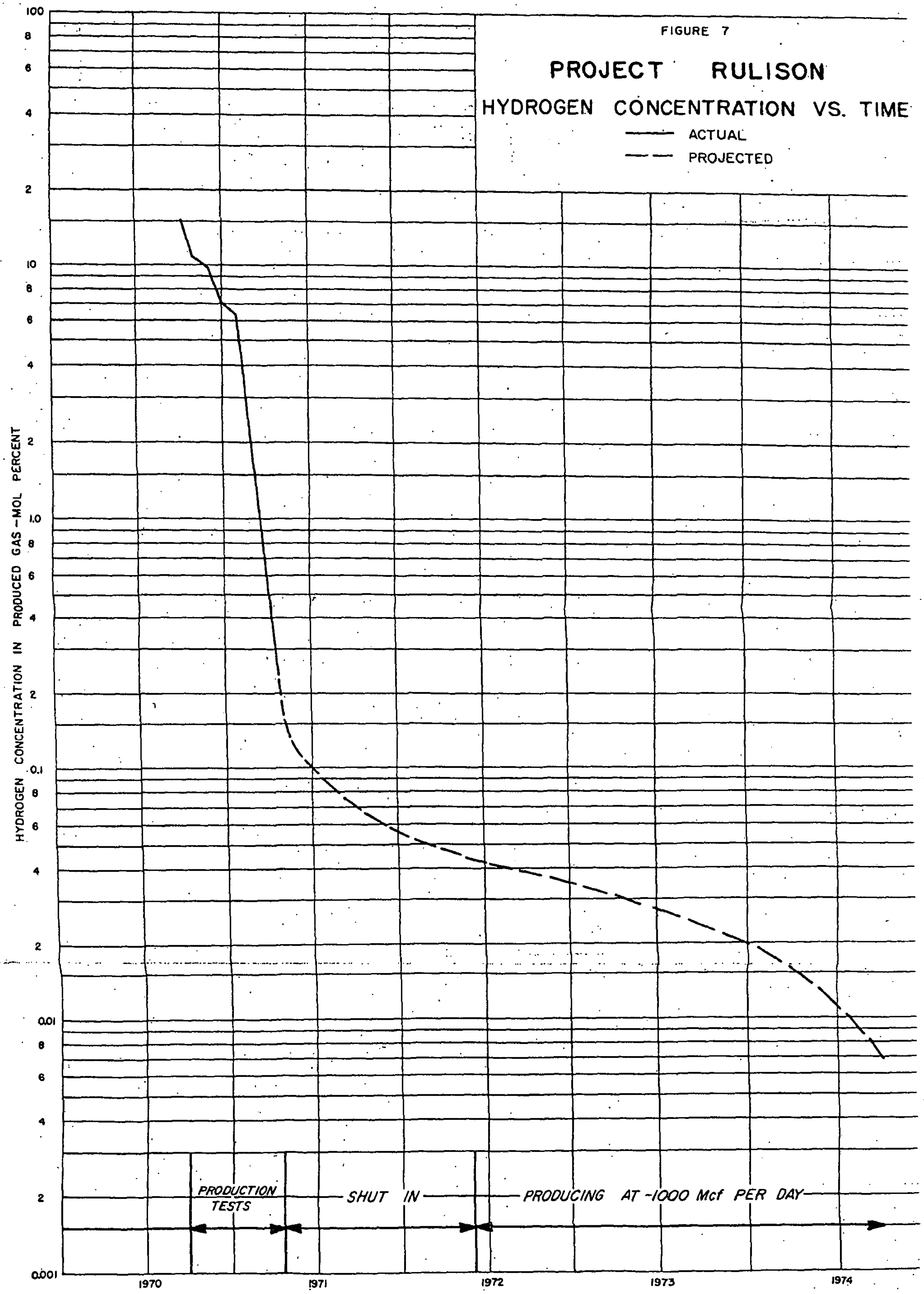
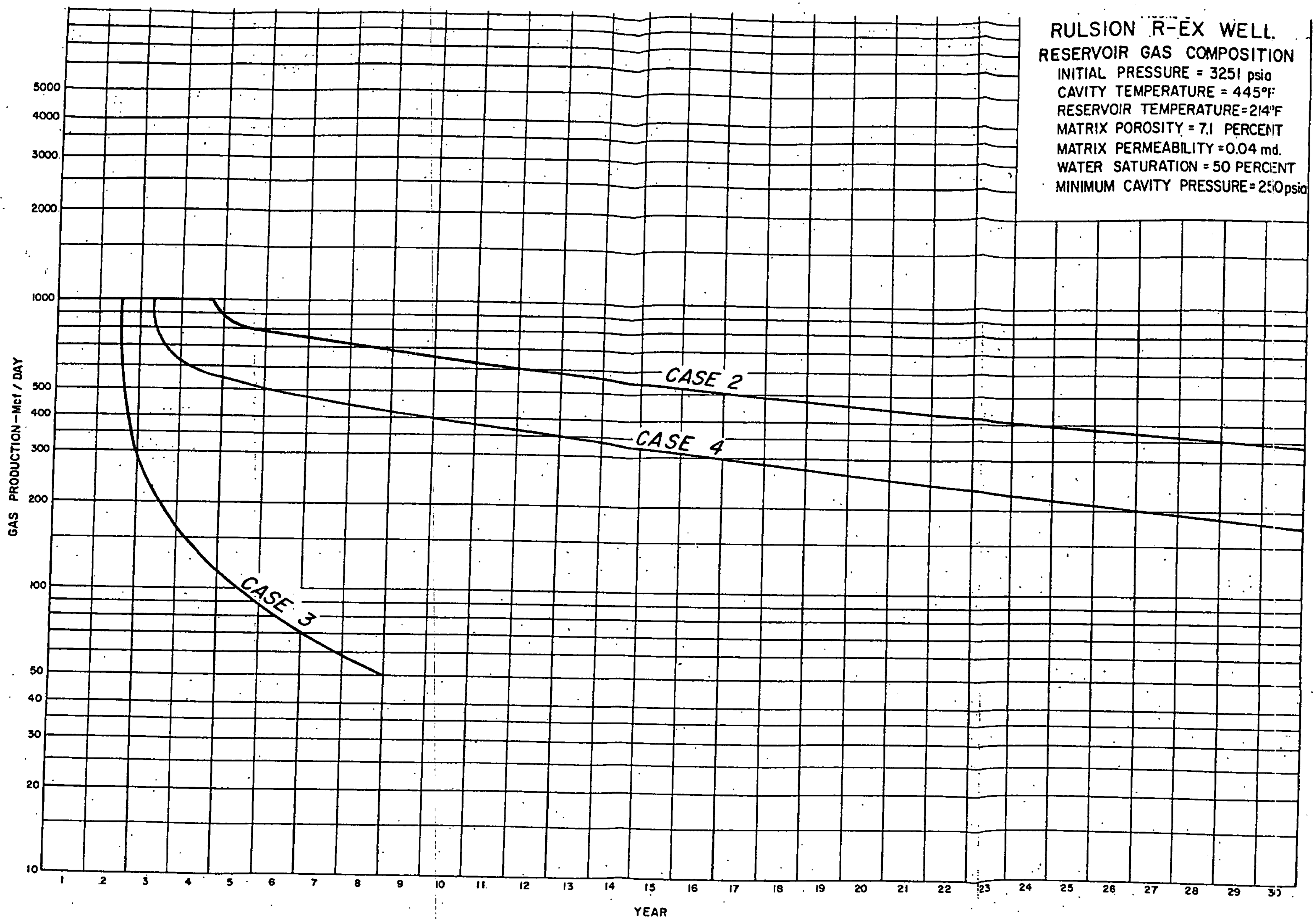


FIGURE 7
PROJECT RULISON
HYDROGEN CONCENTRATION VS. TIME
ACTUAL
PROJECTED
HYDROGEN CONCENTRATION IN PRODUCED GAS-MOL PERCENT
100
8
6
4
2
10
8
6
4
2
1.0
8
6
4
2
0.1
8
6
4
2
0.01
8
6
4
2
0.001
PRODUCTION TESTS
SHUT IN
PRODUCING AT ~1000 Mcf PER DAY
1970
1971
1972
1973
1974



RULSION R-EX WELL
RESERVOIR GAS COMPOSITION
INITIAL PRESSURE = 3251 psia
CAVITY TEMPERATURE = 445°F
RESERVOIR TEMPERATURE = 214°F
MATRIX POROSITY = 7.1 PERCENT
MATRIX PERMEABILITY = 0.04 md.
WATER SATURATION = 50 PERCENT
MINIMUM CAVITY PRESSURE = 250 psia
GAS PRODUCTION - Mcf / DAY
YEAR
CASE 2
CASE 4
CASE 3