memorandum

TO: Jim Hill/J981
FROM: Don Dreesen
SYMBOL: ESS-4-83-415
SUBJECT: PACKER TEST CALCULATIONS FOR
EXPERIMENT 2032 PRE-PUMP

DATE: November 17, 1983

MAIL STOP/TELEPHONE: J981/7-4318

In order to rapidly determine that the upper OTIS packer, 5-1/2 inch tubing 9-5/8 inch casing and wellhead assembly form a competent pressure vessel, calculations have been run to predict backside performance during the pre-pump. Using the flow rate history (Attachment #1) and average annulus temperature (Attachment #2), the mass of water required to maintain an annular volume of 523.5 bbls at 2000 psi surface pressure was calculated.

Two methods were used to calculate the mass. The assumptions made to do these calculations are summarized in Table I. Mass was determined using the average density method as outlined:

1. Input the average annulus temperature and the surface annulus pressure.
2. Assume an average density.
3. Calculate average pressure.
4. Use the equation of state for water to determine the average density.
5. Repeat steps 3 and 4.
6. The product of the volume of the annulus (523.5 bbl) and the density (grams/cm³) is the stock tank bbls or mass required to fill the annulus.

The integration of the hydrostatic column method uses a calculator program which calculates the hydrostatic pressure of 100 ft increments (measured depth) of wellbore and then calculates a new pressure and temperature at the bottom of the last increment. The equation of state is

used to determine the density of water in the next increment. The temperature was input from a temperature vs measured depth program. The geothermal gradient was used for the static wellbore and a linear relation between temperature and measured depth (using 5°C surface temperature and the average annulus temperature at 5650 ft) was used for injection down the tubing.

The results of the calculation are summarized in Table II. On Attachment #3, the backside pumping schedule as projected by both methods is plotted. Attachment #4 shows a plot of mass of water in the annulus versus average annulus temperature using the hydrostatic column method and a surface temperature of 5°C to calculate the mass.

It is recommended that a projection of pumping and venting required to maintain the annulus at 2000 to 2100 psi for the remainder of Experiment 2032 be completed with several contingencies including (1) unplanned shut downs at several points in the job (2) rate reduction to 40 BPM and 10 BPM (in lieu of ISIP) at various points in the job and (3) increasing the rate to 60 BPM half way through the job.

With the capability of pumping up to 60 BPM down the tubing, rapid cool down of the annulus is possible. The rate of cool down must be limited to allow the backside pumper to keep up with the contraction of the water in the annulus. The backside pumper also needs to be prepared to vent at high rates during the early part of the job if the pumping goes down - completely. If the backside truck cannot keep up, the vent system will have to be activated to maintain an annulus pressure below 2000.

TABLE I

Experiment 2032 Pre-Pump Packer Test Calculations

Assumptions

1. The upper packer is set at 11,300 ft measured depth with 5-1/2 inch OD tubing to the surface.
2. The temperature of annulus increases linearly with depth when significant wellbore cooling occurs as a result of injection.
3. The geothermal gradient background log is used for static calculations.
4. The average annulus temperature as calculated by the WBHT code is used as the temperature at 5660 ft and the surface annulus temperature is 5°C. Temperature increases linearly with measured depth.
5. The backside pumper will maintain a surface annulus pressure between 2000 and 2100 psi by injecting water during cool down and venting water during heat up of the annulus.
6. The backside is filled with water and CO₂ contamination is minimal
7. Effects from ballooning, helical buckling of the tubing and ballooning and thermal contraction of the casing are not considered.

TABLE II

Time (hours)	Operation	Annulus Surface Pressure	Average Temp	Mass of Water in Annulus (Stock Tanke Barrels)	
				Average Density	Hydrostatic
0	Initialize	0	Geothermal	494.2	493.4
0	Increase Pressure	500	"	495.2	494.3
0	Increase Pressure	1000	"	496.1	495.3
0	Increase Pressure	1500	"	496.9	496.2
0	Minimum Pressure	2000	"	497.8	497.1
0	Maximum Pressure	2100	"	498.0	497.3
1-1/2	End 1 BPM Injection	2000	109°C	505.4	504.0
2-1/2	End 2 BPM Injection	2000	90	512.2	511.7
3-1/2	End 4 BPM Injection	2000	59	521.6	522.4
4	Inject at 8 BPM	2000	38	526.6	528.0
6-1/2	End 8 BPM Injection	2000	26	528.7	530.5
6-1/2	Maximum Pressure	2100	26	528.9	530.6
7-1/2	End 4 BPM Injection	2000	35	527.2	528.7
8-1/2	End 2 BPM Injection	2000	46	524.9	526.0
10	End 1 BPM Injection	2000	63	520.6	521.2

Expt 2032 Pre-pump

Attachment # I

Attachment #2
11319 ft

Expt 2032 Pre-pump

Average Temperature from 0-3450m (annulus)

BACKSIDE PUMPING / VENT SCHEDULE

CUMULATIVE VOLUME PUMPED VS. TIME

Stock tank
Bbls. 22

AS-0011 -60

5 X 5 TO THE HALF INCH

SQUARE

Buffalo, New York

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SQUARE 5 X 5 TO THE HALF INCH AS-0811 -60

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MASS OF WATER
IN 9 5/8" X 5 1/2" Annulus
versus Average Annulus Temperature
for various surface pressures
as shown

Geothermal
Gradient

2000
1500
1000
500
0

140°

100°

50°

0°

Expt 2032 Pre-pump