AMEND SWD 7/11/00

Mid-Continent Region
Production United States

Marathon Oil Company

P.O. Box 552
Midland, TX 79702-0552
Telephone 915/682-1626

June 20, 2000

New Mexico Oil Conservation Division
Attn: Mark Ashley
2040 South Pacheco Street
Santa Fe, New Mexico 87505

26

RE: Request to Amend Administrative Order SWD-705
Indian Hills Unit Well No. 12
UL "F", 2080' FNL & 2130' FWL, Section 33,
T-21-S, R-24-E, Eddy County, New Mexico

Dear Mr. Ashley:

The Indian Hills Unit No. 12 is currently permitted as a producing/disposal well per Administrative Order SWD-705. The order allows for the Upper Penn production to be separated downhole with the produced water disposed directly into the Devonian. However, due to ineffective downhole separation technology, the Devonian has been temporarily abandoned. The well is currently producing from the Upper Penn.

Marathon Oil Company is requesting an amendment to Order SWD-705 for the conversion of this well from an Upper Penn producer to a Devonian salt water disposal well. The high water volumes being produced from the Indian Hills Unit wells have made it necessary to increase the disposal capacity of the salt water disposal system in this field. The Indian Hills Unit No. 12 is located in the Indian Hills Unit, it has already been approved as a salt water disposal well, and it is completed in the Devonian zone. This makes it the most cost effective and sensible choice for an additional disposal well for the Indian Hills Unit area.

Marathon proposes to squeeze off the existing Upper Penn perfs, drill out the cast iron bridge plug at 8055' and the cement plug at 8422', and run 5", 18 lb., L-80 tubing. The tubing will connect directly with the existing 4 ½" liner. The attached wellbore diagrams show the current and proposed downhole configurations. Also attached is a map showing the location of the Indian Hills Unit and the locations of existing and proposed development wells in the unit.

If you need any other information or have any questions, please call me at (915) 687-8432, or the project engineer, Bryan Williams, at (915) 687-8442. Thank you for your consideration of this matter.

Sincerely,

Ginny Larke

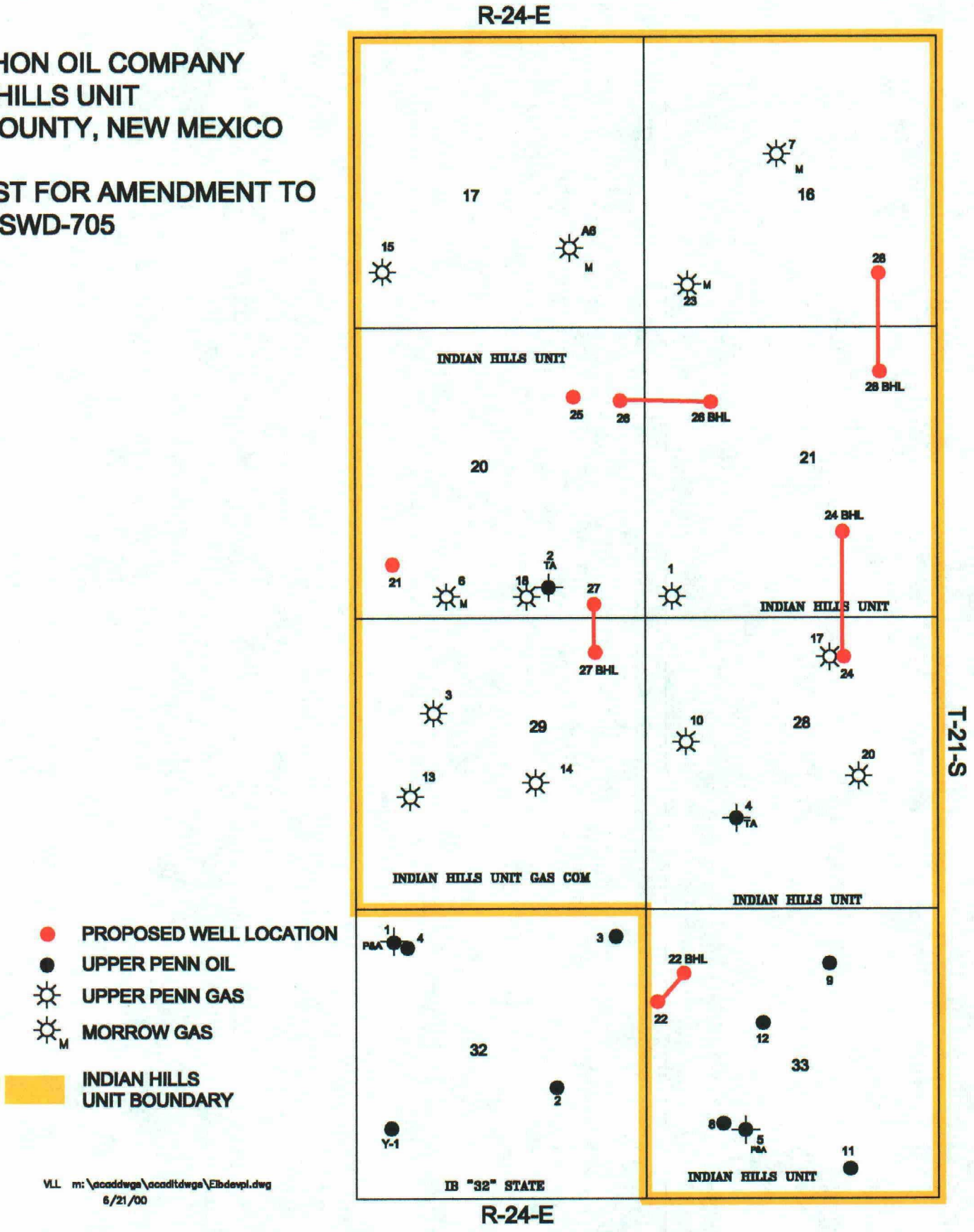
Ginny Larke
Engineer Technician

Attachments

vll/m:\winword\ihu12ltr.doc

MARATHON OIL COMPANY
INDIAN HILLS UNIT
EDDY COUNTY, NEW MEXICO

REQUEST FOR AMENDMENT TO ORDER SWD-705



PROPOSED WELL LOCATION

UPPER PENN OIL

UPPER PENN GAS

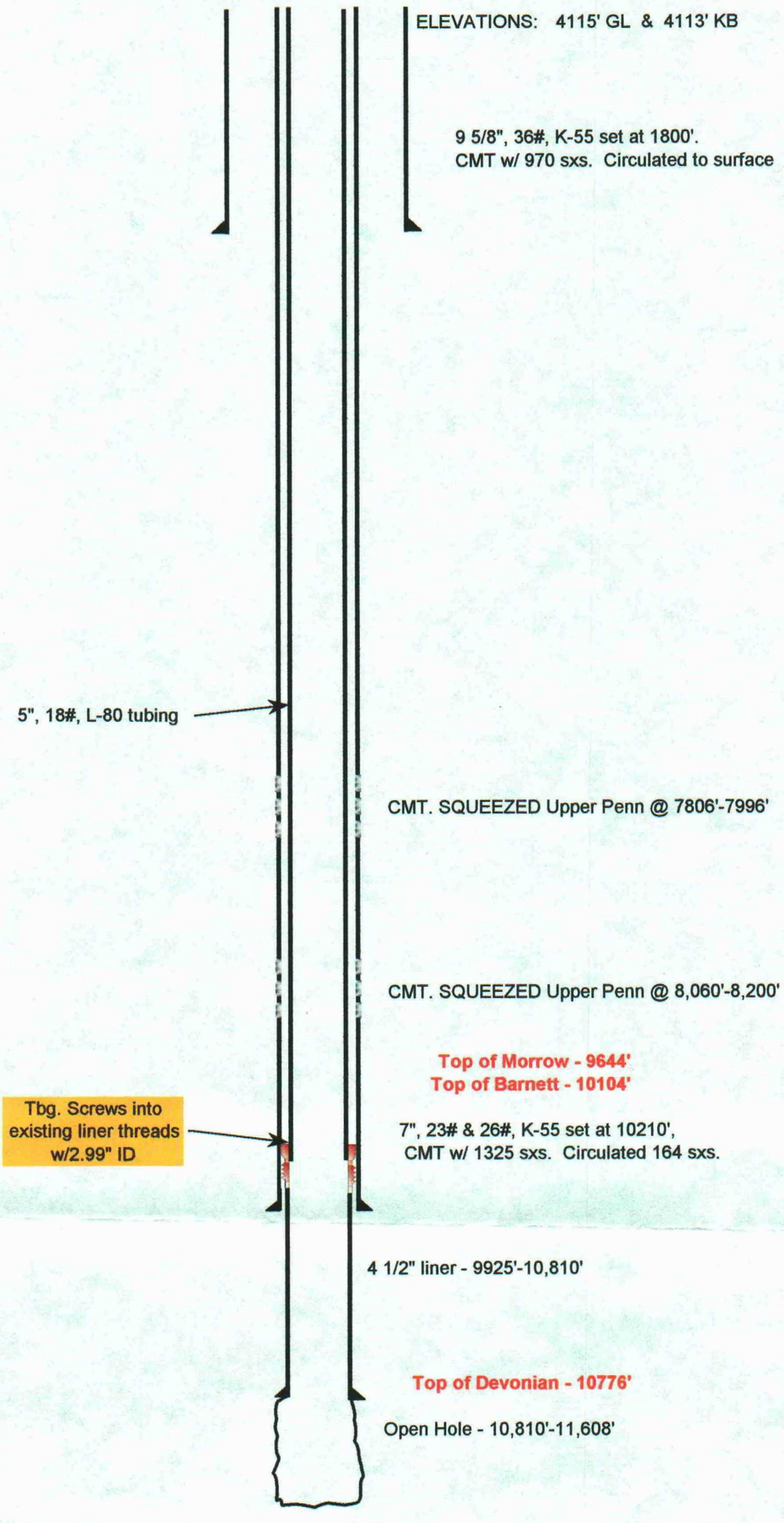
MORROW GAS

INDIAN HILLS UNIT BOUNDARY

VLL m:\acaddwgs\acaditdwgs\Elbdevpl.dwg
6/21/00

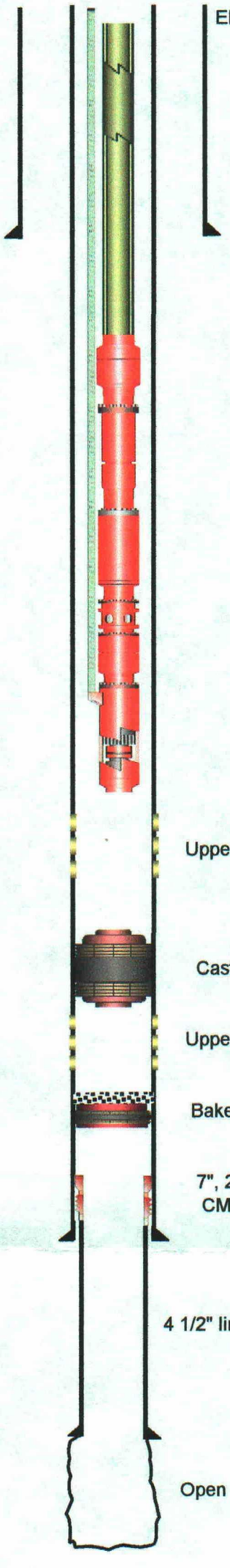
INDIAN BASIN FIELD
INDIAN HILLS UNIT #12
2080 FNL 2130 FWL, SEC. 33, T21S - R24E
EDDY COUNTY, NEW MEXICO

PROPOSED WELLBORE CONFIGURATION



INDIAN BASIN FIELD
INDIAN HILLS UNIT #12
2080 FNL 2130 FWL, SEC. 33, T21S - R24E
EDDY COUNTY, NEW MEXICO

CURRENT WELLBORE CONFIGURATION



ELEVATIONS: 4115' GL & 4113' KB

9 5/8", 36#, K-55 set at 1800'.
CMT w/ 970 sxs. Circulated to surface

Upper Penn @ 7806'-7996'

Cast Iron Bridge Plug @ 8055'

Upper Penn @ 8,060'-8,200'

Baker PIP @ 8460', TOC 8422'

7", 23# & 26#, K-55 set at 10210',
CMT w/ 1325 sxs. Circulated 164 sxs.

4 1/2" liner - 9925'-10,810'

Open Hole - 10,810'-11,608'

MARATHON OIL COMPANY
Mid-Continent Region

Telephone: 915/682-1626
FAX: 915/687-8431

P. O. Box 552
Midland, TX 79702

FAX/TELECOPY

DATE: 6/12/98 FAX NUMBER: 505-827-1389

TO: David Catanach

COMPANY: NMOCD

We are transmitting 2 pages, including cover page.

COMMENTS:

David,

Indian Hills Unit #12 stipulations as we discussed.

FROM: Ben Schoffmann

Indian Hills Unit Well No. 12
Proposed Downhole Separation and Disposal
Attachment to C-108
(Part VII)

Proposed Operations Continued

6. Prior to commencing production/injection operations the casing above the proposed producing interval and the casing and liner between the producing and injection interval in the subject well will be pressure tested according to rule 704 A.1 of the OCD rules and regulations.

7. During the course of normal operations the casing and liner in the subject well will be re-tested at resonable frequencies not to exceed five years according to rule 704 A.2.

8. The proposed injection system will be equiped with a downhole injection pressure and rate sensor that will monitor the injection pressure and rates into the proposed injection interval. The Artesia District office of the OCD will be notified in the event that this sensor fails.

9. Engineering data suggests that the maximum concentration of oil that could possibly be disposed downhole will be less than 500 ppm.

MIT Test

Can a standard MIT test be run Initially & Every 5 years thereafter? Will Submit

Annulus Fluid Level Readings? - N/A Won't work

Monitoring Monthly pressures & Volume - Pressure can be obtained.
Volume can be det by charts

Failure of downhole transducers - Ok with the proc.

Water-Oil Ratio -
1:1
50% oil/50% water

Correct
May require submit'l test results

STATE OF NEW MEXICO
ENERGY AND MINERALS DEPARTMENT

POST OFFICE BOX 2088
STATE LAND OFFICE BUILDING
SANTA FE, NEW MEXICO 87501

Revised 7-1-81

705 SWD 5/6/98

APPLICATION FOR AUTHORIZATION TO INJECT

I. Purpose: ☐ Secondary Recovery ☐ Pressure Maintenance ☒ Disposal ☐ Storage
Application qualifies for administrative approval? ☒ yes ☐ no

II. Operator: Marathon Oil Company

Address: P. O. Box 552 Midland, TX 79701

Contact party: A. B. Schoffmann Phone: 915/682-1626

III. Well data: Complete the data required on the reverse side of this form for each well proposed for injection. Additional sheets may be attached if necessary.

IV. Is this an expansion of an existing project? ☐ yes ☒ no
If yes, give the Division order number authorizing the project _____.

V. Attach a map that identifies all wells and leases within two miles of any proposed injection well with a one-half mile radius circle drawn around each proposed injection well. This circle identifies the well's area of review.

* VI. Attach a tabulation of data on all wells of public record within the area of review which penetrate the proposed injection zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of completion, and a schematic of any plugged well illustrating all plugging detail.

VII. Attach data on the proposed operation, including:

APR 21 1998

1. Proposed average and maximum daily rate and volume of fluids to be injected;
2. Whether the system is open or closed;
3. Proposed average and maximum injection pressure;
4. Sources and an appropriate analysis of injection fluid and compatibility with the receiving formation if other than reinjected produced water; and
5. If injection is for disposal purposes into a zone not productive of oil or gas at or within one mile of the proposed well, attach a chemical analysis of the disposal zone formation water (may be measured or inferred from existing literature, studies, nearby wells, etc.).

*VIII. Attach appropriate geological data on the injection zone including appropriate lithologic detail, geological name, thickness, and depth. Give the geologic name, and depth to bottom of all underground sources of drinking water (aquifers containing waters with total dissolved solids concentrations of 10,000 mg/l or less) overlying the proposed injection zone as well as any such source known to be immediately underlying the injection interval.

IX. Describe the proposed stimulation program, if any.

* X. Attach appropriate logging and test data on the well. (If well logs have been filed with the Division they need not be resubmitted.)

* XI. Attach a chemical analysis of fresh water from two or more fresh water wells (if available and producing) within one mile of any injection or disposal well showing location of wells and dates samples were taken.

XII. Applicants for disposal wells must make an affirmative statement that they have examined available geologic and engineering data and find no evidence of open faults or any other hydrologic connection between the disposal zone and any underground source of drinking water.

XIII. Applicants must complete the "Proof of Notice" section on the reverse side of this form.

XIV. Certification

I hereby certify that the information submitted with this application is true and correct to the best of my knowledge and belief.

Name: A. B. Schoffmann Title Indian Basin Asset Manager

Signature: A. B. Schoffmann Date: 4/20/98

* If the information required under Sections VI, VIII, X, and XI above has been previously submitted, it need not be duplicated and resubmitted. Please show the date and circumstance of the earlier submittal. _____

DISTRIBUTION: Original and one copy to Santa Fe with one copy to the appropriate Division district office.

III. WELL DATA

A. The following well data must be submitted for each injection well covered by this application. The data must be both in tabular and schematic form and shall include:

(1) Lease name; Well No.; location by Section, Township, and Range; and footage location within the section.

(2) Each casing string used with its size, setting depth, sacks of cement used, hole size, top of cement, and how such top was determined.

(3) A description of the tubing to be used including its size, lining material, and setting depth.

(4) The name, model, and setting depth of the packer used or a description of any other seal system or assembly used.

Division District offices have supplies of Well Data Sheets which may be used or which may be used as models for this purpose. Applicants for several identical wells may submit a "typical data sheet" rather than submitting the data for each well.

B. The following must be submitted for each injection well covered by this application. All items must be addressed for the initial well. Responses for additional wells need be shown only when different. Information shown on schematics need not be repeated.

(1) The name of the injection formation and, if applicable, the field or pool name.

(2) The injection interval and whether it is perforated or open-hole.

(3) State if the well was drilled for injection or, if not, the original purpose of the well.

(4) Give the depths of any other perforated intervals and detail on the sacks of cement or bridge plugs used to seal off such perforations.

(5) Give the depth to and name of the next higher and next lower oil or gas zone in the area of the well, if any.

XIV. PROOF OF NOTICE

All applicants must furnish proof that a copy of the application has been furnished, by certified or registered mail, to the owner of the surface of the land on which the well is to be located and to each leasehold operator within one-half mile of the well location.

Where an application is subject to administrative approval, a proof of publication must be submitted. Such proof shall consist of a copy of the legal advertisement which was published in the county in which the well is located. The contents of such advertisement must include:

(1) The name, address, phone number, and contact party for the applicant;

(2) the intended purpose of the injection well; with the exact location of single wells or the section, township, and range location of multiple wells;

(3) the formation name and depth with expected maximum injection rates and pressures; and

(4) a notation that interested parties must file objections or requests for hearing with the Oil Conservation Division, P. O. Box 2088, Santa Fe, New Mexico 87501 within 15 days.

NO ACTION WILL BE TAKEN ON THE APPLICATION UNTIL PROPER PROOF OF NOTICE HAS BEEN SUBMITTED.

NOTICE: Surface owners or offset operators must file any objections or requests for hearing of administrative applications within 15 days from the date this application was mailed to them.

Marathon Oil Company
Indian Hills Unit Well No. 12
Application for Authorization to Inject
(Proposed Downhole Separation and Disposal)
Attachments to C-108

Part III

Well Data

See attached proposed completion for Indian Hills Unit Well No. 12.

Part V

Attach a map that identifies all wells and leases within two miles of any proposed injection well with a one-half mile radius circle drawn around each proposed injection well. This circle identifies the well's area of review.

See attached map.

Part VI

Attach a tabulation of data on all wells of public record within the area of review which penetrate the proposed injection zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of completion, and a schematic of any plugged well illustrating all plugging details.

There are **no** wells within the "area of review" which penetrate the proposed disposal interval.

Part VII

Attach data on proposed operation

See attachment.

Part VIII

See attachment.

Part IX

Describe the proposed stimulation program, if any.

The proposed injection well will be completed open hole. The proposed open hole interval will be stimulated using 15% HCl acid (+/- 30,000 gallons).

Part X

Attach appropriate logging and test data on the well.

The appropriate forms, along with an inclination survey and logs were filed on this well July 1, 1996, when the well was initially completed.

Part XI

Attach a chemical analysis of fresh water from two or more fresh water wells (if available and producing) within one mile of any injection or disposal well showing location of wells and dates samples were taken.

There are no fresh water wells within one mile of this disposal well.

Part XII

Applicants for disposal wells must make an affirmative statement that they have examined available geologic and engineering data and find no evidence of open faults or any other hydrologic connection between the disposal zone and any underground source of drinking water.

Marathon Oil Company, as Operator of the proposed injection well, has reviewed and examined available geologic and engineering data and finds no evidence of open faults or any other hydrologic connection between the disposal zone and any underground source of drinking water.

Ben Schoffmann

Part XIII

Proof of Notice

See attachment. Marathon Oil Company is the only operator in the "area of review."

Indian Hills Unit Well No. 12
Proposed Downhole Separation and Disposal
Attachments to C-108
(Part III)

Proposed Completion for:

A. (1) Indian Hills Unit Well No. 12
Federal Lease No. NM07260
UL "F", 2080' FNL, 2130' FWL
Sec. 33, T-21-S, R-24-E
Eddy County, New Mexico

A. (2) CASING AND CEMENT

Surface Casing: 9-5/8", 36#, K-55 set at 1800'. Cmt w/970 sxs Circulated

Production Casing: 7", 23# & 26#, K-55 set at 10210', Cmt w/1325 sxs Circulated 164 sxs

Injection Liner: 4-1/2", 11.35#, L-80 FL-4S at 10,900'
Top of liner @ 10,000'

A. (3) Injection Tubing: 2-7/8" , 6.5#, L-80, Internally plastic coated tubing, attached to downhole separator discharge and set in seal assembly at ± 10,000'.

A. (4) Injection Packer: Polished bore receptacle and seal assembly attached to liner hanger @ 10,000'.

B. (1) Injection Formation: Devonian

B. (2) Injection Interval: 10,900' - 11,500'

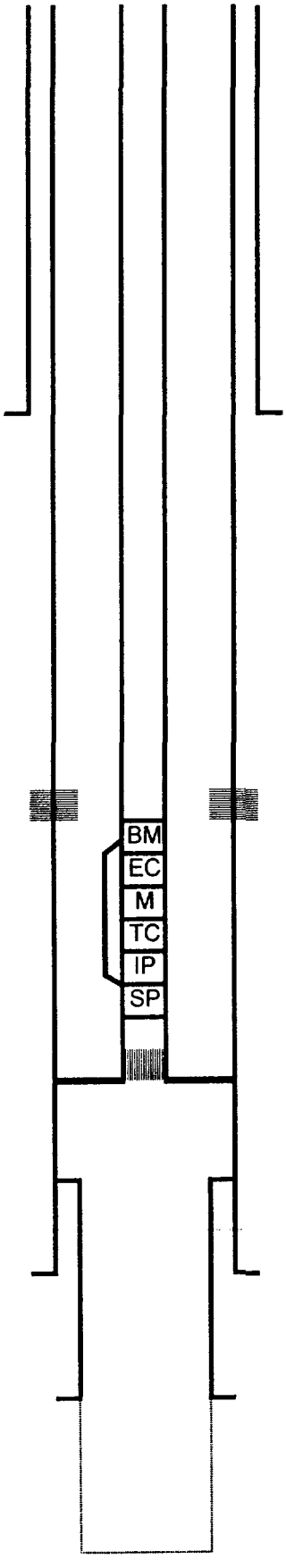
B. (3) The proposed deepening of this well is for the purpose of water disposal, although we intend to produce simultaneously from the Upper Penn formation.

B. (4) The next higher productive oil or gas zone is the Upper Penn at a depth of 8420' (Base).

B. (5) No formations below the Devonian have ever been produced in this area.

Indian Hills Unit Well No. 12
(Part III B)

PROPOSED DOWNHOLE SEPARATION AND INJECTION



FIELD: INDIAN BASIN
WELL: INDIAN HILL UNIT #12
LOCATION: 2080 FNL 2130 FWL, SEC. 33, T21S - R24E
COUNTY: EDDY
STATE: NM
STATUS: SHUT IN
DATE: 3/16/98
ELEVATIONS: 4115' GL & 4113' KB

9 5/8"
@ 1800'

SURFACE: 9 5/8", 36#, K-55 set at 1800'. CMT w/ 970 sxs Circulated

PRODUCTION: 7", 23# & 26#, K-55 set at 10210', CMT w/ 1325 sxs Circulated 164 sxs

LINER: 4 1/2" 11.35#, L-80 FL-4S @ 10,900'
TOL @ 10,000'

PRODUCING INTERVAL: 7804' - 8200'

SQUEEZE PERFS: 8,140'-8,164' [2 spf/49 holes]

DOWNHOLE EQUIP.: 2 7/8" 6.5# L-80 TBG, Bypass Manifold, Expansion Chamber, Motor, Thrust Chamber, Injection Pump, Oil-water separator, Injection Tubing, Seal Bore Asm. & Packer

PKR @ 9,200'

TOL @ 10,000'

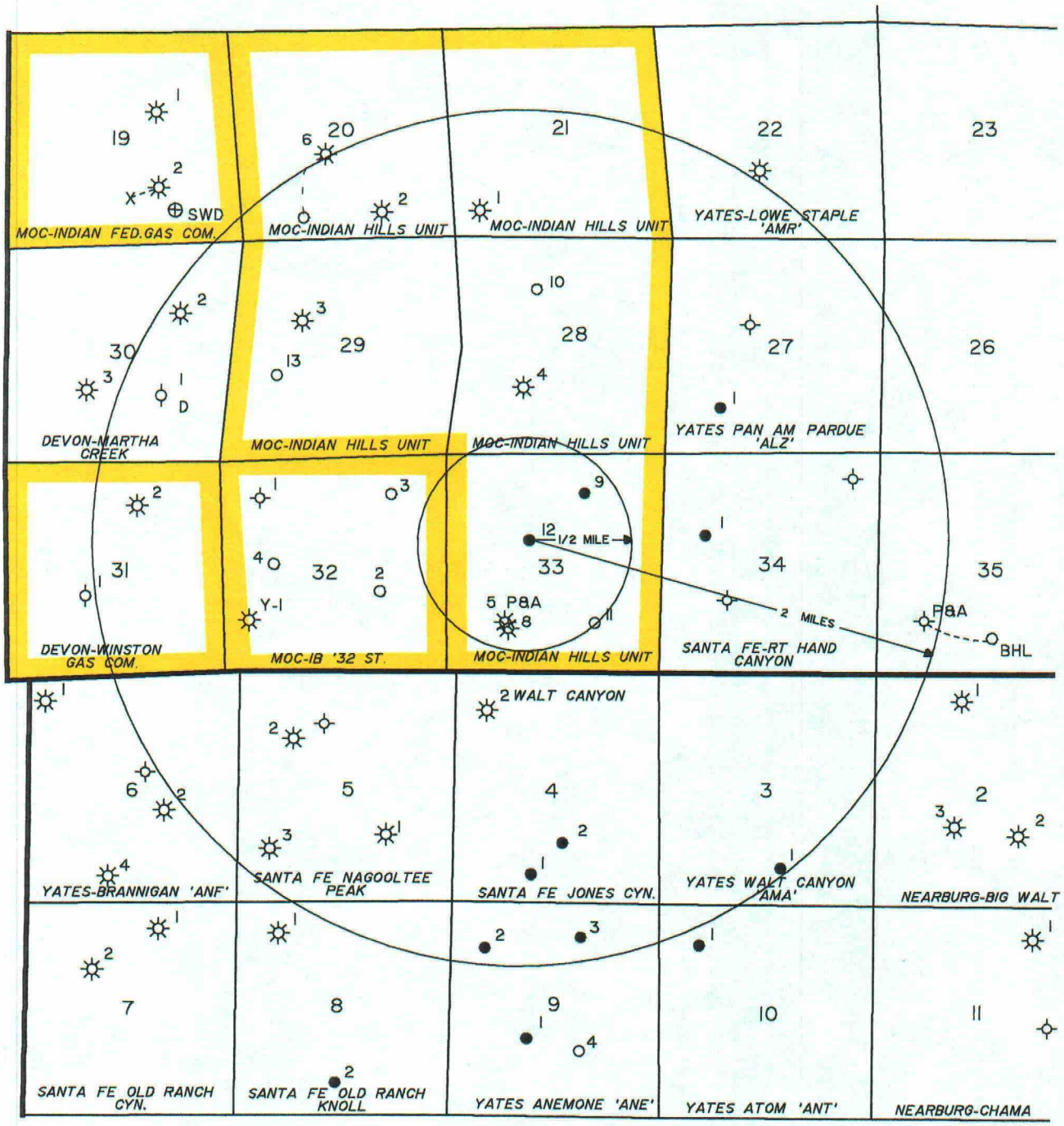
7" @ 10,210'

4 1/2" Liner @ 10,900'

INJECTION ZONE: 6 1/8" OPENHOLE

TD @ 11,500'

Indian Hills Unit Well No. 12
Proposed Downhole Separation and Disposal
Attachment to C-108
(Part V)



MARATHON OIL COMPANY
MID-CONTINET REGION

INDIAN BASIN

EDDY COUNTY, NEW MEXICO

IB398.DGN EXPL

3/98
G.LARKE

Indian Hills Unit Well No. 12
Proposed Downhole Separation and Disposal
Attachment to C-108
(Part VII)

Proposed Operations

1. ***Proposed average and maximum daily rate and volume of fluids to be injected.***

   Fluid: Produced Water

   Average Rate: 6,000 BWPD

   Maximum Rate: 10,000 BWPD

2. ***Whether the system is open or closed.***

   The proposed disposal system will be a closed system. Produced water will enter the downhole separator containing three hydrocyclones. The hydrocyclones will separate the oil and water. The oil will be produced to the surface with an approximate cut of 50%, then the remaining produced water will be reinjected into the Devonian formation.

3. ***Proposed average and maximum injection pressure.***

   Average Downhole Pressure: 4,800 psi

   Maximum Downhole Pressure: 5,000 psi (2,180 psi at surface)

4. ***Sources and an appropriate analysis of injection fluid and compatibility with the receiving formation if other than reinjected produced water.***

   The source of the injection fluid will be produced water from this well only.

   Formations: Upper Penn

   See attached water analysis for the above zone.

MITCHELL ANALYTICAL LABORATORY

2638 Faudree
Odessa, Texas 79765-8538
561-5579

Water Analysis

Upper Penn

Company.... Nalco/Exxon Energy Chemicals
Well # .... IHSC #7
Lease..... MARATHON
Location... Sec. 36, T-20-S, R-24-E
Date Run... 10/13/1997
Lab Ref #.. 97-OCT-N00769

Sample Temp... 70.0
Date Sampled.. 10/13/1997
Sampled by.... Mark Hermann
Employee # ... 27-011
Analyzed by... DANIEL

Eddy County, NM

Dissolved Gasses

		Mg/L	Eq. Wt.	MEq/L
Hydrogen Sulfide	(H2S)	340.00	16.00	21.25
Carbon Dioxide	(CO2)	0.00	22.00	0.00
Dissovled Oxygen	(O2)	0.00	8.00	0.00

Cations

Calcium	(Ca++)	341.70	20.10	17.00
Magnesium	(Mg++)	85.40	12.20	7.00
Sodium	(Na+)	3,714.25	23.00	161.49
Barium	(Ba++)	< .50	68.70	0.00
Manganese	(Mn++)	0.00	27.50	0.00

Anions

Hydroxyl	(OH-)	0.00	17.00	0.00
Carbonate	(CO3=)	12.00	30.00	0.40
Bicarbonate	(HCO3-)	928.72	61.10	15.20
Sulfate	(SO4=)	1,750.00	48.80	35.86
Chloride	(Cl-)	4,004.40	35.50	112.84

Total Iron	(Fe)	0.40	18.60	0.02
Total Dissolved Solids		11,176.87		
Total Hardness As CaCO3		1,200.00		
Conductivity MICROMHOS/CM		13,500		

pH 7.600 Specific Gravity 60/60 F. 1.008

CaSO4 Solubility @ 80 F. 40.28 MEq/L, CaSO4 scale is not likely

CaCO3 Scale Index

70.0	0.930
80.0	1.060
90.0	1.280
100.0	1.280
110.0	1.520
120.0	1.520
130.0	1.790
140.0	1.790
150.0	2.020

Nalco/Exxon Energy Chemicals

Indian Hills Unit Well No. 12
Proposed Downhole Separation and Disposal
Attachment to C-108
(Part VII)

Proposed Operations Continued

5. ***If injection is for disposal purpose into a zone not productive of oil or gas at or within one mile of the proposed well, attach a chemical analysis of the disposal zone formation water (may be measured or inferred from existing literature, studies, nearby wells, etc.***

Marathon Oil Company ran a DST on North Indian Basin Well No. 1 (Section 9, T-21-S, R-23-E, Eddy County New Mexico) in 1963. The DST tested the interval 10,009 ft to 10,100 ft. Based on the DST, the following analysis was reported:

Specific Gravity	1.109
pH	6.8
Resistivity	.285 @ 94° F
Chlorides (Cl)	11,000
Sulfates (SO_4)	1,500
Alkalinity (HCO_3)	610
Calcium (Ca)	1,080
Magnesium (Mg)	775
Iron (Fe)	20
Sodium (Na)	5,359
Sulfides (H_2S)	Negligible

Indian Hills Unit Well No. 12
Proposed Downhole Separation and Disposal
Attachment to C-108
(Part VIII)

Attach appropriate geological data on the injection zone including appropriate lithologic detail, geological name, thickness, and depth. Give the geologic name and depth to bottom of all underground sources of drinking water (aquifers containing waters with total dissolved solid concentrations of 10,000 mg/L or less) overlying the proposed injection zone as well as any such source known to be immediately underlying the injection interval.

Injection Zone

Geological Name: Devonian

Lithology: Dolomite

Thickness: 680'

Depth: 10,230' - 10,910'

Drinking Water - Overlying

Geological Name: Grayburg
Depth to Bottom: 650'

Above data is based on Geological data obtained from Ken Fresquez, Geologist, of the State Engineer's Office in Roswell, NM

Drinking Water - Underlying

NONE

Affidavit of Publication

№ 18378

State of New Mexico,
County of Eddy, ss.

Amy McKay,

being first duly sworn, on oath says:

That she is Business Manager of the Carlsbad Current-Argus, a newspaper published daily at the City of Carlsbad, in said county of Eddy, state of New Mexico and of general paid circulation in said county; that the same is a duly qualified newspaper under the laws of the state wherein legal notices and advertisements may be published; that the printed notice attached hereto was published in the regular and entire edition of said newspaper and not in supplement thereof on the date as follows, to wit:

March 21, 19 98
March 28, 19 98
April 4, 19 98
, 19
, 19
, 19

That the cost of publication is $ 63.84, and that payment thereof has been made and will be assessed as court costs.

Amy McKay

Subscribed and sworn to before me this

15th day of April, 1998

Donna Crump

My commission expires 8/1/98

Notary Public

March 21, 28, 1998
April 4, 1998

Marathon Oil Company, as operator, proposes to recomplete a well using downhole separation and downhole salt water disposal equipment. The location of the well is 2,080'FNL and 2130' FWL, Section 33, Township 21 South, Range 24 East, Eddy County, New Mexico. The zone to be used for water disposal is the Devonian from approximately 10,900 ft. to 11,500 ft. with a maximum expected injection rate of 10,000 BWPD. The expected maximum injection pressure at the disposal zone (10,900') is 5,000 psi, the maximum equivalent surface injection pressure expected is 2,180 psig. Any interested party with an objection or request of hearing should notify the Oil Conservation Division at 2040 S. Pacheco St., Santa Fe, New Mexico 87505, within 15 days of this notice. Any questions should be directed to Ben Schoffmann of Marathon Oil Company at P.O. Box 552, Midland, Texas 79702, or telephone (915) 682-1626.

RAILROAD COMMISSION OF TEXAS

OIL AND GAS DIVISION

TO: LORI WROTENBERY

AGENCY/DIVISION/LOCATION: N.M. OIL & GAS DIVISION

TELEPHONE #: **FAX #:** (505) 827-8177

FROM: FERNANDO DE LEON

SECTION: UIC

TELEPHONE #: (512) 463-6814 **FAX #:** (512) 463-6780

DATE/TIME: 12:55 pm 5/29/98

COMMENTS: DOWS PROCEDURES

PAGE COUNT (including cover): 10

Any problem with the transmission of this fax should be directed to Felicia at (512) 463-7542.

G:\DATA\PLANNING\WP\SCROGGIN\FAXCOVER.NEW

RAILROAD COMMISSION OF TEXAS

OIL AND GAS DIVISION

MEMORANDUM

TO: Chairman Charles R. Matthews
Commissioner Barry Williamson
Commissioner Carole Keeton Rylander

FROM: Lori Wrotenbery, Assistant Director for Environmental Services

DATE: July 8, 1997

SUBJECT: Use of downhole oil-water separators in simultaneous injection and production wells.

Underground Injection Control has drafted procedures for permitting the use of downhole oil-water separators (DOWS) in wells that simultaneously produce oil and dispose of produced water. The details about the operation of wells equipped with DOWS are described in the attached memorandum to David Schieck.

Baker Hughes Process Systems, which developed the DOWS, has been working very closely with Conoco, Inc. to seek approval for the use of DOWS in Texas. Conoco currently has pending approval the first injection well application of this type. For that reason, David has asked me to handle this item.

In addition, Conoco Inc. was sent a draft permit on June 2, 1997, with the provisions for testing, monitoring and reporting that we found appropriate for these injection operations. Conoco has provided no comments.

Unless you have questions, we will place the procedures for DOWS-equipped injection wells into effect on July 16, 1997 and approve Conoco's pending permit application administratively.

Please call me (3-4354) or Richard Ginn (3-6796) if you have any questions.

Attachment

cc: David Schieck

RAILROAD COMMISSION OF TEXAS

INTERNAL
ENVIRONMENTAL SERVICES
Lori Wrotenbery, Deputy Director

MEMORANDUM

TO: David Schieck, Director
Oil and Gas Division

THROUGH: Lori Wrotenbery, Assistant Director for
Environmental Services

FROM: Fernando De Leon, Engineering Supervisor
Environmental Services

DATE: June 18, 1997

SUBJECT: Use of downhole oil-water separators in simultaneous injection and production wells

Baker Hughes Process Systems has developed a downhole oil-water separator (DOWS) device to extend the economic viability of high water-cut operations. The device uses a downhole hydrocyclone to separate oil from the produced fluids. Most of the separated water is then injected without being brought to ground surface. The device reduces operating costs to the operator by reducing the volume of produced water that must be lifted to ground surface, separated at surface facilities, and later re-injected. Simultaneously, the risk of pollution is reduced.

Wells using DOWS can be divided into two basic configurations: those producing from a shallower zone and injecting into a deeper zone; and those producing from a deeper zone and injecting into a shallower zone.

The production above injection (P/I) configuration consists of tubing and packer set to the injection zone and a DOWS assembly set in the tubing string between the production and injection zones. A pump drives the produced fluids into the hydrocyclone separator. The majority of the produced brine is separated and spun out the bottom of the hydrocyclone by centrifugal force and then into the injection tubing. The separated oil

and remaining water are ducted into the tubing above the hydrocyclone where a lifting pump raises the mixture to ground surface. (See Figure A.)

The injection above production (I/P) configuration consists of tubing and packer set to the production zone, with isolation packers set immediately above and below the injection zone. A pump drives produced fluids into the hydrocyclone located opposite the injection zone. The majority of the produced brine is separated and spun into the tubing-casing annulus opposite the injection formation. The separated oil and remaining water are ducted into the tubing above the hydrocyclone where a lifting pump raises the mixture to ground surface. (See Figure B.)

The permitting of an injection well using a DOWS requires modifications to the standard permit requirements for mechanical integrity testing and injected fluid monitoring.

Baker Hughes proposed that annulus pressure monitoring and quarterly fluid level measurements be permitted in lieu of initial and subsequent mechanical integrity testing, that injection pressure and rate reporting be waived, and that DOWS wells be allowed to continue operating indefinitely without a requirement to repair a failed downhole pressure transducer. The Baker Hughes proposal would rely heavily on less reliable methods of demonstrating mechanical integrity and would not provide verifiable data with which to monitor performance and ensure compliance.

The following procedure is recommended for the permitting of DOWS wells. The procedure reduces the testing and monitoring requirements and associated compliance costs to a level consistent with the lower risk posed by these wells, while still providing information necessary to demonstrate proper operation. This procedure is summarized in the attached chart.

Recommended Application Requirements (for both configurations):

- A wellbore sketch showing the wellbore construction and DOWS configuration.
- Current fluid level or current "bottom hole" formation pressure of the proposed injection/disposal zone.
- Proposed water/oil ratio of the produced fluids raised to ground surface to be maintained by the DOWS equipment. (Except for the production above injection configuration where injection is into the same reservoir.)
- Proposed "bottom hole injection pressure" (BHIP) of the proposed DOWS completion.

Recommended Permit Requirements - Production Above Injection (P/I):

- An initial mechanical integrity test should be performed. This will be a conventional pressure test at 200 psi and will be performed in accordance with instructions on Form H-5. The test may be either a test with the packer set within 100 feet of the top of the perforations, OR a fluid level depression (Ada) test above the production perforations. The well should be retested after any workover that involves pulling the tubing out of the well but at least once every 10 years.

  Rationale:
  The mechanical integrity of the wellbore should be demonstrated prior to injection; however, because the environmental risk of a DOWS well is lower than a conventional injection well due to its mode of operation, subsequent MITs need to be performed only after each workover but at least once every 10 years.

- Quarterly fluid level readings by an echometer should be required. The readings should be reported on Form H-5 with the echometer chart attached.

  Rationale:
  The integrity of the packer and lower DOWS assembly can be determined by a rise in the fluid level in the tubing-casing annulus. Because the productive zone will be underpressured relative to the injection zone, production will be negatively impacted and should be noticed by a decline in oil production and an increase in water production caused by water recirculation. Whenever the pressure differential between the injection zone and the production zone is low, the negative effects may be less apparent, but determinable by a rise in fluid level in the annulus. When a loss of integrity or malfunction is indicated, the well should be shut in and tested, then corrective action taken, if necessary.

- The standard permit conditions on monitoring and reporting the injection volume and injection pressure should apply. The average and maximum monthly injection pressures and monthly injection volumes will be determined from transducer readings and reported annually on Form H-10. The operator should be required to report the failure of a downhole transducer within 24 hours and take corrective action within 3 months of transducer failure.

  Rationale:
  The downhole injection pressures will be measured by the downhole transducers, and the volumes will be derived by the operator from those readings. Pressures and volumes will be estimated if a transducer fails. The Commission will have no way to know if downhole pressure and volume information is unavailable unless notified of transducer failure.

- The maximum bottom hole injection pressure should be specified.

  Rationale:
  The maximum bottom hole injection pressure should not exceed the formation fracture pressure at the uppermost perforations. The formation fracture gradient is generally assumed to be 1.0 psi/ft.

- An application for amendment should be required if the well configuration will be changed.

  Rationale:
  A change in the configuration of the well, for example to conventional injection through tubing and packer arrangement, will necessitate changes in the permit conditions.

- The permit should include a minimum water/oil ratio no less than 1:1 for a single stage hydrocyclone. The permit should also require that the water/oil ratio be monitored monthly and reported annually as an attachment to Form H-10. This would not be required if the injection is into the same reservoir from which the well is producing.

  Rationale:
  The DOWS system should be designed so that some water is produced with the oil because it is more desirable to produce some water to the surface than to try to fine tune the system and run the risk that some oil is lost to the disposal zone. Economics will probably dictate that DOWS systems be installed primarily in high water-cut wells. According to Chris Shaw, Baker-Hughes, they recommend 50% water. Further, he stated that at 90% oil in the production stream, 0.5 % oil occurs in the disposal stream. Loss of oil back into the water leg of the same reservoir from which the well is producing is not cause for conservation concern because the oil is ultimately recoverable by the same well.

Recommended Permit Requirements - Injection Above Production (I/P):

- An initial mechanical integrity test on the tubing - casing annulus above the injection packer should be performed before injection begins. This will be a conventional pressure test, performed in accordance with instructions on Form H-5, with a test pressure of 200 psi. The pressure test should be repeated at least once every five years thereafter for wells that have surface casing that fully protects ground water. For wells with short surface casing, pressure tests should be required at least once every three years and the tubing-casing annulus should be monitored weekly. The tubing-casing annulus pressure should be monitored monthly for wells with full surface casing that have a permitted downhole injection pressure sufficient to reach ground water zones.

Rationale:
The risk to ground water for these wells will ordinarily be low because the produced water will be at a pressure sufficient only to move it into the disposal zone and that permitted "down-hole" injection pressure may not be sufficient to raise fluids to the ground water zones. In other cases, however, the formation pressure of the disposal zone may be high enough to require an injection pressure equivalent to that of surface injection operations, or at least sufficient to raise fluids to the ground water zones. In the event of a tubing or packer leak, the produced water may move under pump pressure into the tubing-casing annulus.

Considering the relatively low risk, wells with short surface casing should be tested once every three years, rather than annually, and the tubing-casing annulus pressures should be monitored weekly. Wells with full surface casing should be tested once every five years. Further, the tubing-casing annulus should be monitored monthly if the permitted injection pressure is sufficient to raise fluids to the ground water zones.

- The standard permit condition on monitoring and reporting the injection volume and injection pressure should apply. (see discussion under Production Above Injection case)

- The maximum bottom hole injection pressure should be specified. (see discussion under Production Above Injection case)

- An application for amendment should be required if a change in the well configuration is proposed. (see discussion under Production Above Injection case)

- The permit should include a minimum water/oil ratio no less than 1:1 for a single-stage hydrocyclone. (see discussion under Production Above Injection case)

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Downhole Oil-Water Separation

Application Requirements	Wellbore sketch	Current fluid level or formation pressure	Proposed water : oil ratio	Proposed bottomhole injection pressure
Production Above Injection (P/I)				
Both zones are within the same reservoir	✓	✓	-	✓
Injection zone is in different reservoir	✓	✓	✓	✓
Injection Above Production (I/P)				
Surface casing is set and cemented through entire zone of usable quality groundwater	✓	✓	✓	✓
Surface casing is not set and cemented through the entire zone of usable quality groundwater	✓	✓	✓	✓

Permit Requirements	Initial MIT	Subsequent MIT	Tubing casing annulus monitoring	Measure fluid level	Water : oil ratio
Production Above Injection (P/I)					
Both zones are within the same reservoir	PT/Ada	After each workover, at least every 10 years	-	Quarterly	-
Injection zone is in different reservoir	PT/Ada	After each workover, at least every 10 years	-	Quarterly	1:1 min
Injection Above Production (I/P)					
Surface casing is set and cemented through entire zone of usable quality groundwater	PT	5 Year	Monthly*	-	1:1 min
Surface casing is not set and cemented through the entire zone of usable quality groundwater	PT	3 Year	Weekly	-	1:1 min

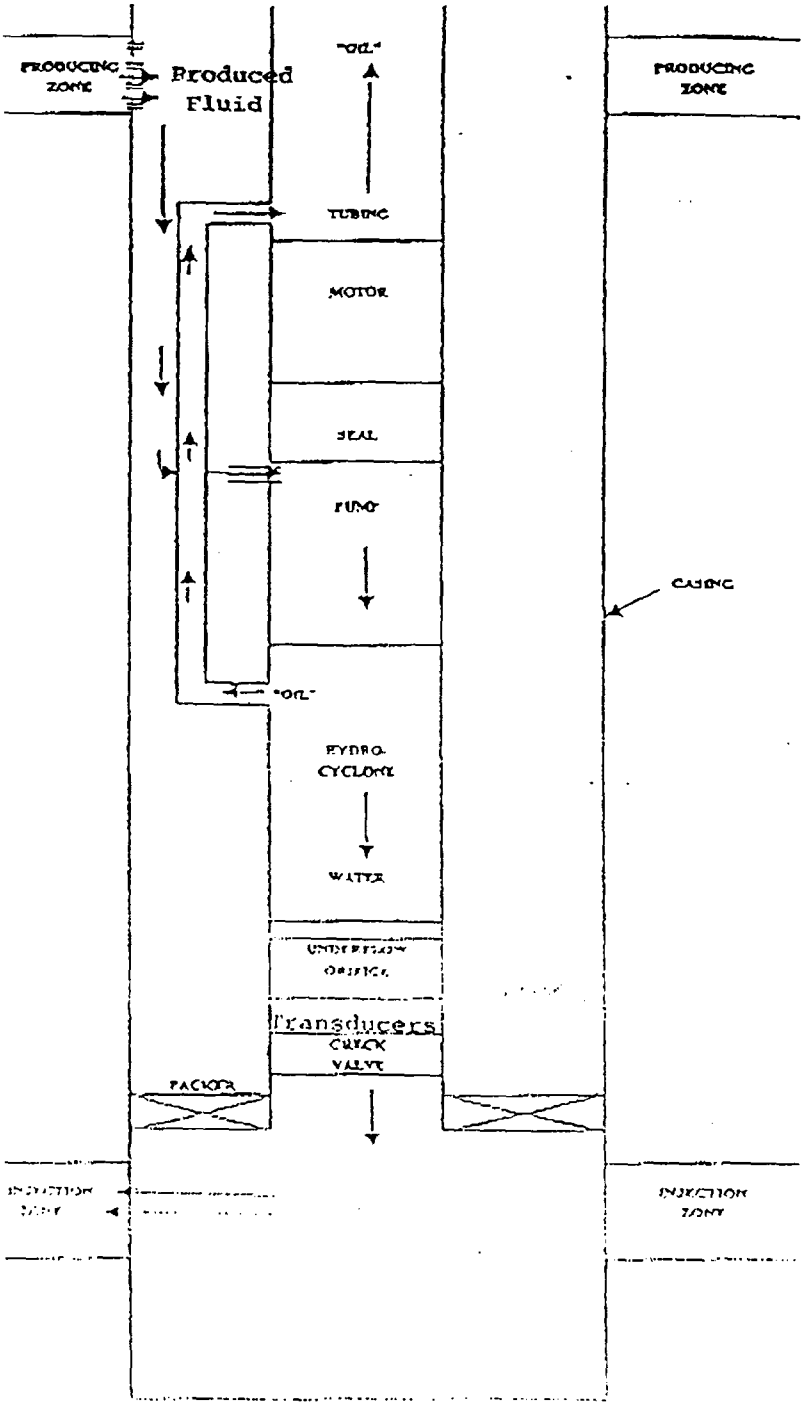
① Pressure Test (PT) is a conventional 200 psi test performed according to instructions on Form H-5 with the packer set within 100 feet of the perforations.
① Ada test is a fluid depression test that wells with production above injection (P/I) may use in lieu of the conventional pressure test.
① Quarterly fluid level measurements to be reported on Form H-5 with echometer chart attached.

* Monthly monitoring (on I/P) required only if the permitted injection pressure is sufficient to raise fluids to ground water zones.

Requirements Common To All Cases:

① Determine monthly injection pressures (average and maximum) and injected volumes from transducer readings and report annually on Form H-10.
① The operator must notify the district office of transducer failure within 24 hours, and repair the transducer within three months.
① Bottomhole injection pressure may not exceed fracture gradient (1.0 psi/ft at uppermost perforations).
① Any change in wellbore configuration will require a permit amendment.

DOWNHOLE OIL-WATER SEPARATOR (DOWS)
PRODUCTION ABOVE INJECTION (P/I)



DOWNHOLE OIL-WATER SEPARATOR (DOWS)
INJECTION ABOVE PRODUCTION (I/P)