

STATE OF ALASKA
ALASKA OIL AND GAS CONSERVATION COMMISSION
333 West 7th Avenue, Suite 100
Anchorage, Alaska 99501

Re: THE APPLICATION OF BP) Area Injection Order No. 25A
EXPLORATION (ALASKA) INC. for)
modification of Area Injection) Prudhoe Bay Field
Order 25 to authorize underground) Polaris Oil Pool
injection of enriched hydrocarbon)
gas for enhanced oil recovery in)
Polaris Oil Pool, Prudhoe Bay Field,) November 28, 2005
North Slope, Alaska; and

**THE PROPOSAL initiated by the
Commission to amend underground
injection orders to incorporate
consistent language addressing the
mechanical integrity of wells**

IT APPEARING THAT:

1. By application dated August 23, 2005 BP Exploration (Alaska) Inc. (“BPXA”) in its capacity as Polaris Operator and Unit Operator of the Prudhoe Bay Unit (“PBU”) requested an order from the Alaska Oil and Gas Conservation Commission (“Commission”) modifying Area Injection Order 25 (“AIO 25”) to authorize the injection of enriched hydrocarbon gas for enhanced oil recovery purposes in the Polaris Oil Pool within the PBU.
2. The Commission published notice of opportunity for public hearing on BPXA’s application in the Anchorage Daily News on September 6, 2005.
3. The Commission received no comments or protests regarding BPXA’s application.
4. The Commission held a public hearing October 13, 2005 at the Alaska Oil and Gas Conservation Commission at 333 West 7th Avenue, Suite 100, Anchorage, Alaska 99501.
5. On its own motion the Commission proposed to amend the rules addressing mechanical integrity in all existing orders authorizing underground injection. The Commission published notice of opportunity for public hearing on the proposal in the Anchorage Daily News on October 3, 2004.
6. By e-mail dated October 15, 2004, BPXA suggested edits to the Commission’s proposed language addressing the mechanical integrity of injection wells.
7. No protests to the Commission’s proposal or requests for hearing were received, and the hearing was vacated.

FINDINGS:

1. Operator:

BPXA is Operator of the Polaris Oil Pool in the Prudhoe Bay Field, North Slope, Alaska.

2. Formations Authorized for Enhanced Recovery:

The currently approved strata for enhanced recovery injection are a subset of the Polaris Oil Pool defined in Conservation Order 484 and correlated with the N- and O-Sand interval between 5,603 feet and 6,012 feet measured depths ("MD") in Prudhoe Bay Unit well S-200PB1. BPXA has not requested changes to the approved strata for injection.

3. Proposed Injection Area:

BPXA requested authorization to inject fluids for the purpose of enhanced recovery on portions of lands within Umiat Meridian T11N-R12E, T11N-R13E, T12N-R12E, and T12N-R13E in the Prudhoe Bay Unit. The application for the AIO 25 modification provides information surrounding three injection wells. These proposed injectors are wells S-215i, W-209i, and W-215i.

4. Operators/Surface Owners Notification:

BPXA provided operators and surface owners within one-quarter mile of the proposed area with a copy of the application for injection. The only affected operator is BPXA, Operator of the Prudhoe Bay Unit. The State of Alaska, Department of Natural Resources is the only affected surface owner.

5. Description of Operation:

The contemplated operation is an enhanced oil recovery ("EOR") project using enriched gas from the Prudhoe Bay Central Gas Facility. The project involves the cyclical injection of water alternating with injection of hydrocarbon gas enriched with intermediate hydrocarbons, principally ethane and propane. Implementation of the Polaris EOR project will involve connection of Polaris injection wells to existing or new miscible gas injection distribution systems on M, S, and W Pads. Enriched hydrocarbon gas injection is expected to occur in late 2005.

6. Hydrocarbon Recovery:

The Polaris Oil Pool is estimated to contain 350 to 750 million barrels of original oil in place ("OOIP") based on exploratory drilling and seismic mapping. Combined primary and secondary recovery is estimated at 15-30% of the OOIP.

Preliminary evaluations suggest that the EOR project could yield an incremental recovery of up to 6% where implemented. These recovery estimates were obtained using an Equation of State ("EOS") developed for the Polaris reservoir fluid. Laboratory swell, multiple contact, and slimtube experiments were conducted using

Polaris oil and the PBU enriched gas and were used to develop a new Polaris EOS.

Fully compositional, mechanistic type pattern model simulations were conducted using the Polaris EOS for a W Pad reservoir description. In part of the project area where the reservoir oil has sufficient concentration of C7-C13, the enriched gas forms a miscible bank with the reservoir oil through exchange of hydrocarbon components, and displaces nearly all of the contacted oil. In areas where the oil lacks sufficient concentration of C7-C13 components to be miscible with the Prudhoe enriched gas at reservoir conditions, miscibility may not occur. Rather, a multiple contact condensing/vaporizing mass transfer mechanism between reservoir oil and the CO₂ and C2-C4 in the Prudhoe enriched gas causes a significant reduction in reservoir oil viscosity. BPXA states that the magnitude of tertiary oil recovery by this “viscosity reducing, immiscible enriched gas flood” is very close to that recovered with miscible gas injection. A fifty-fold reduction in viscosity of a 40 cp Polaris oil was found by contacting the PBU enriched gas in a single cell multiple-contact laboratory experiment conducted at reservoir conditions.

Gross utilization of Prudhoe enriched gas was estimated to be around 5.3 thousand cubic feet ("MCF") of enriched gas injected for every barrel of EOR oil. This is similar to the efficiency at other satellite Prudhoe projects and compares to an efficiency of about 15-20 MCF/barrel for enriched gas injection in the mature IPA EOR project area, which justifies the preferential injection of Prudhoe enriched gas into the Polaris Oil Pool.

7. Geologic Information:

- a. Stratigraphy: The Polaris Oil Pool encompasses reservoirs assigned to the Late Cretaceous-age Schrader Bluff Formation (“Schrader Bluff”) and the Early Tertiary-age Ugnu Formation (“Ugnu”). The approved injection interval is only the Schrader Bluff Formation. AIO 25 dated February 3, 2003 provides a full geologic description of the Polaris Oil Pool.
- b. Confining Intervals: Lower confinement for the Polaris Oil Pool is provided by the non-reservoir, laminated muddy siltstone that constitutes the base of the OBF interval and 1,100 feet of mudstone and silty mudstone assigned to the upper Colville Group.

The basal portion of the Schrader Bluff N-Sands interval consists of non-reservoir mudstone and siltstone that forms a regionally extensive hydraulic barrier. This barrier separates lighter, higher quality oil in the O-Sands from the heavier oil accumulations in the overlying N- and M-Sand intervals. The MC-Sand is separated from the underlying N-Sands by a silty mudstone that ranges in thickness from 15 to 25 feet.

Upper confinement is provided by a 14- to 25-foot thick mudstone that lies at the base of the MB2 interval and forms a regionally continuous hydraulic barrier. This mudstone layer separates oil-bearing MC-Sand from overlying, water-bearing MB2-Sand within the pool. A 9- to 15-foot thick silty mudstone overlies the uppermost MA-Sand and provides a regionally extensive barrier.

8. Well Logs:

The logs of existing injection wells are on file with the Commission.

9. Mechanical Integrity of Injection Wells and Wells within ¼ mile of injector:

Wells recently drilled into the Polaris Oil Pool have been constructed in conformance with Commission regulations. Three wells are currently proposed for enhanced gas injection service: Wells S-215i, W-209i, and W-215i. Mechanical integrity has previously been established for the subject wells and all wells within ¼ mile of these injectors have been reviewed. The Commission approved these wells for water injection.

Changes proposed by the Commission in the rules governing demonstration of mechanical integrity, well integrity failure and confinement, and administrative actions will improve clarity, reduce the potential for confusion, and better protect mechanical integrity of injection wells.

10. Type of Fluid / Source:

In addition to water for injection supplied from Gathering Center 2 and from the Seawater Treatment Plant, enriched hydrocarbon gas from the Prudhoe Bay Central Gas Facility will be injected. In addition, tracer survey fluids and well stimulation fluids will be injected periodically to ensure efficient operation of the water flood. Non-hazardous filtered water collected from Polaris Oil Pool well house cellars and well pads may also be injected.

11. Enriched Gas Composition and Compatibility with Formation:

The enriched gas proposed for injection is a hydrocarbon with similar composition to reservoir fluids in the Polaris Oil Pool and therefore no compatibility issues are anticipated. The compatibility of the injection waters was addressed in AIO 25 dated February 3, 2003.

12. Injection Rates and Pressures, Fracture Information:

The anticipated maximum gas injection requirements are 15,000 MCF per day. The requested maximum water injection rate is 50,000 barrels of water per day ("BWPD") in the project area. The individual well injection rates will range from 1000 to 5000 BWPD.

The surface injection pressure for the enriched gas will be around 3400 psi, with a maximum surface injection pressure of 4500 psi. Miscible gas and water injection operations are expected to be above the Schrader Bluff Formation parting pressure to enhance injectivity and improve recovery of oil. Miscible gas injection is not anticipated to cause fracture propagation through the confining intervals. Fracture propagation models and operations involving injection of highly viscous fluids at high rates have not created net pressures sufficient to exceed the integrity of the confining layers.

13. Rule 10 – W-17 Surveillance:

In the original AIO 25 the Commission ordered that temperature logs be run in W-17. This surveillance was required because well W-17 is within 255 feet of proposed injector W-212i and there was insufficient information at the time to demonstrate cement confinement across the Polaris Oil Pool in well W-17. The required temperature surveys indicate that the Polaris Oil Pool is isolated within W-17 and no further action is needed at this time.

CONCLUSIONS:

1. The application requirements of 20 AAC 25.402 have been met.
2. Enriched gas injection will significantly improve recovery.
5. The proposed injection operations will be conducted in permeable strata, which can reasonably be expected to accept injected fluids at pressures less than the fracture pressure of the confining strata.
6. Injected fluids will be confined within the appropriate receiving intervals by impermeable lithology, cement isolation of the wellbore and appropriate operating conditions.
7. Reservoir and well surveillance, coupled with regularly scheduled mechanical integrity tests will demonstrate appropriate performance of the enhanced oil recovery project or disclose possible abnormalities.
8. The findings and conclusions of AIO 25 dated February 3, 2003, are incorporated by reference to the extent not inconsistent with this order.
9. Revisions as proposed by the Commission are appropriate concerning the rules governing demonstration of mechanical integrity, well integrity failure and confinement, and administrative actions.
10. Rule 10 concerning surveillance requirements in W-17 is no longer necessary because BPXA has satisfied those requirements.

NOW, THEREFORE, IT IS ORDERED that:

1. Within the affected area, this order supersedes and replaces Area Injection Order 25 dated February 3, 2003.
2. The underground injection of fluids for enhanced oil recovery as described in BPXA's application is authorized, as modified by and subject to the following rules and the statewide requirements under 20 AAC 25 (to the extent not superseded by these rules) in the following affected area.

Umiat Meridian

Township / Range	Lease	Sections
T12N-R12E	ADL 28256	Sec 22 S/2 S/2 and NE/4 SE/4
	ADL 47448	Sec 23 S/2 NW/4 and SW/4
	ADL 28257	Sec 25 SW/4 NW/4 and SW/4 and SW/4 SE/4, 26, 35, 36
	ADL 28258	Sec 27, 33 SE/4 SE/4, 34 E/2 W/2 and SW/4 SW/4 and E/2
T12N-R13E	ADL 28279	Sec 31 SW/4 NW/4 and SW/4
T11N-R13E	ADL 28282	Sec 6 W/2 and SE/4 and S/2 NE/4 and NW/4 NE/4, Sec 7 N/2 and N/2 SW/4 and SE/4 SW/4 and SE/4, Sec 8 W/2 SW/4
T11N-R12E	ADL 28260	Sec 1, 2, 11 W/2 and NW/4 NE/4, 12 N/2 N/2 and SE/4 NE/4
	ADL 28261	Sec 3, 4 E/2 E/2, 9 NE/4 NE/4 and S/2 NE/4 and SE/4, 10
	ADL 28263-1	Sec 15, 16 E/2
	ADL 28263-2	Sec 21 NE/4 NW/4 and NE/4 SE/4 and NE/4, 22 N/2 and N/2 SW/4 and SE/4 SW/4 and SE/4
	ADL 47451	Sec 14 W/2 and W/2 SE/4, 23 W/2 and W/2 E/2 and SE/4 SE/4 and SE/4 NE/4
	ADL 28264	Sec 26 N/2 N/2
	ADL 47452	Sec 27 NE/4 NE/4

Rule 1 Authorized Injection Strata for Enhanced Recovery (AIO 25)

Authorized fluids may be injected for purposes of pressure maintenance and enhanced oil recovery into strata that are common to, and correlate with the N- and O-Sand interval between 5,603 feet and 6,012 feet MD in Prudhoe Bay Unit well S-200PB1.

Rule 2 Fluid Injection Wells (Revised this Order – AIO 25A)

The underground injection of enriched gas for enhanced oil recovery is authorized only in the following wells: S-215i, W-209i, and W-215i. Upon proper application, the Commission may approve additional wells for injection of enriched gas within the Polaris Oil Pool.

The application to drill or convert a well for injection must include a report on the cementing records, cement quality log or formation integrity test records of each well that has penetrated the injection zone within a one-quarter mile radius of the proposed injection well.

Rule 3 Authorized Fluids for Enhanced Recovery (Revised by this Order – AIO 25A)

Fluids authorized for injection are:

- a. produced water from the Polaris Oil Pool or Prudhoe Bay Unit production facilities for the purposes of pressure maintenance and enhanced recovery;
- b. tracer survey fluid to monitor reservoir performance;
- c. enriched hydrocarbon gas from the Prudhoe Central Gas Facility;
- d. source water from a sea water treatment plant;
- e. non-hazardous filtered water collected from Polaris Oil Pool well house cellars and well pads; and
- f. enriched hydrocarbon gas from the Prudhoe Bay Unit processing facilities.

Rule 4 Authorized Injection Pressure for Enhanced Recovery (AIO 25.003)

- a. Injection pressure must be maintained so that injected fluids do not fracture the confining zone or migrate out of the approved injection stratum.
- b. Within three months of start of injection in a new or converted injector, a step rate test and surveillance log must be run for detection of fluids moving out of the approved injection stratum. Results must be submitted to the commission.
- c. If fluids are found to be fracturing the confining zone or migrating out of the approved injection stratum, the Operator must immediately shut in the injector(s). Injection may not be restarted unless approved by the Commission.

Rule 5 Monitoring Tubing-Casing Annulus Pressure (Revised by this Order AIO 25A)

The tubing and casing annuli pressures of each injection well must be monitored at least daily, except if prevented by extreme weather condition, emergency situations, or similar unavoidable circumstances. Monitoring results shall be documented and made available for Commission inspection.

Rule 6 Demonstration of Tubing/Casing Annulus Mechanical Integrity (Revised by this Order AIO 25A)

A Commission-witnessed mechanical integrity test must be performed after injection is commenced for the first time in a well, to be scheduled when injection conditions (temperature, pressure, rate, etc.) have stabilized. Subsequent tests must be performed at least once every four years thereafter (except at least once every two years in the case of a slurry injection well). The Commission must be notified at least 24 hours in advance to enable a representative to witness mechanical integrity tests. Unless an alternate means is approved by the Commission, mechanical integrity must be demonstrated by a tubing/casing annulus pressure test using a surface pressure of 1500 psi or 0.25 psi/ft multiplied by the vertical depth of the packer, whichever is greater, that shows stabilizing pressure and does not change more than 10 percent during a 30 minute period. Results of mechanical integrity tests must be readily available for Commission inspection.

Rule 7 Multiple Completion of Water Injection Wells

- a. Water injectors may be completed to allow for injection in multiple pools within the same wellbore so long as mechanical isolation between pools is demonstrated and approved by the Commission.
- b. Prior to initiation of commingled injection, the Commission must approve methods for allocation of injection to the separate pools.
- c. Results of logs or surveys used for determining the allocation of water injection between pools, if applicable, must be supplied in the annual reservoir surveillance report.
- d. An approved injection order is required prior to commencement of injection in each pool.

Rule 8 Well Integrity Failure and Confinement (Revised by this Order AIO25A)

Whenever any pressure communication, leakage or lack of injection zone isolation is indicated by injection rate, operating pressure observation, test, survey, log, or other evidence, the operator shall notify the Commission by the next business day and submit a plan of corrective action on a Form 10-403 for Commission approval. The operator shall immediately shut in the well if continued operation would be unsafe or would threaten contamination of freshwater, or if so directed by the Commission. A monthly report of daily tubing and casing annuli pressures and injection rates must be provided to the Commission for all injection wells indicating well integrity failure or lack of injection.

Rule 9 Notification of Improper Class II Injection

Injection of fluids other than those listed in Rule 2 without prior authorization is considered improper Class II injection. Upon discovery of such an event, the operator must immediately notify the Commission, provide details of the operation, and propose actions to prevent recurrence. Additionally, notification requirements of any other State or Federal agency remain the operator's responsibility.

Rule 10 W-17 Surveillance (Revoked by this Order - AIO 25A)

Rule 11 Plugging and Abandonment of Fluid Injection Wells (AIO 25)

An injection well located within the affected area must not be plugged or abandoned unless approved by the Commission in accordance with 20 AAC 25.

Rule 12 Other conditions (AIO 25)

- a. It is a condition of this authorization that the operator complies with all applicable Commission regulations.
- b. The Commission may suspend, revoke, or modify this authorization if injected fluids fail to be confined within the designated injection strata.

Rule 13 Administrative Actions (Revised by this Order - AIO 25A)

Unless notice and public hearing are otherwise required, the Commission may administratively waive or amend any rule stated above as long as the change does not promote waste or jeopardize correlative rights, is based on sound engineering and geoscience principles, and will not result in fluid movement outside of the authorized injection zone.

DONE at Anchorage, Alaska and dated November 28, 2005.

John K. Norman
Chairman

Cathy P. Foerster
Commissioner

AS 31.05.080 provides that within 20 days after receipt of written notice of the entry of an order, a person affected by it may file with the Commission an application for rehearing. A request for rehearing must be received by 4:30 PM on the 23rd day following the date of the order, or next working day if a holiday or weekend, to be timely filed. The Commission shall grant or refuse the application in whole or in part within 10 days. The Commission can refuse an application by not acting on it within the 10-day period. An affected person has 30 days from the date the Commission refuses the application or mails (or otherwise distributes) an order upon rehearing, both being the final order of the Commission, to appeal the decision to Superior Court. Where a request for rehearing is denied by nonaction of the Commission, the 30-day period for appeal to Superior Court runs from the date on which the request is deemed denied (i.e., 10th day after the application for rehearing was filed).