

THE APPLICATION OF CRIMSON EXPLORATION INC. UNDER RULE 36 TO DISPOSE OF OIL AND WASTE CONTAINING HYDROGEN SULFIDE GAS INTO ITS ROGERS LEASE, WELL NO. 2D, MADISONVILLE (WILCOX H2S DISP) FIELD, MADISON COUNTY, TEXAS

Heard by: Margaret Allen, Technical Hearings Examiner

Procedural history

Applicant received: December 14, 2005
Hearing held: April 13, 2006

Appearances

<u>Applicant</u>	Representing
William Osborn	Crimson Exploration Inc.
Deborah Pennington	
Tracy Price	
Robert Tierney	
Tom Kaetzer	
Kerry Pollard	
 <u>Interested persons</u>	
Charles Holtgraves	Advanced Energy Recovery, Inc.
L.J. Horbach	

EXAMINER'S REPORT AND PROPOSAL FOR DECISION

STATEMENT OF THE CASE

Crimson Exploration, Inc. ("Crimson") is seeking to inject sour gas in its Rogers Lease, Well No. 2D, in the Madisonville (Wilcox H2S Disp) Field in Madison County. The application was originally protested but the protest has been withdrawn, and a disposal permit can be issued administratively under Statewide Rule 9. However, Statewide Rule 36(c)(10) requires that a public hearing be held before the injection of fluid containing hydrogen sulfide ("H₂S" or "sour gas"), when "injection fluid is a gaseous mixture...where the 100 ppm radius of exposure is in excess of 50 feet and includes any part of a public area except a public road; or, if the 500 ppm radius of exposure is in excess of 50 feet and includes any part of a public road; or if the 100 ppm radius of exposure is 3,000 feet or greater."

The Notice of Hearing indicated two issues to be discussed at the hearing:

1. At least one well (Marshall Exploration, Rogers Well No. 1) within 1/4 mile of the proposed injection well does not have the proposed injection interval isolated by cemented casing/borehole annulus [sic]. As the applicant seeks authority to inject fluids containing highly

hazardous concentrations of hydrogen sulfide, the Environmental Services staff recommends that the applicant be required to demonstrate that the existence of the Rogers No. 1, or any other well within the expected radius of influence, which does not have the proposed injection interval isolated with adequate cement plugs and/or cemented casing, does not represent a predictable threat of fluid migration from the injection interval due to the proposed acid gas disposal operation.

2. The applicant must prepare a Contingency Plan in accordance with the provisions of Statewide Rule 36(c)(9) for review and approval by the Field Operations Staff of the Oil & Gas Division. However a Contingency Plan has not yet been filed.

The applicant filed a Contingency Plan before the hearing, which was approved by the Field Operations section of the Railroad Commission. Representatives of Advanced Energy Recovery, Inc. appeared at the hearing as observers.

The applicant had requested a maximum surface pressure of 2500 psi, which is greater than the standard gradient of 0.5 psi per foot of depth. The applicant had no objection to limiting surface injection pressure to the standard gradient which is 2360 psi.

DISCUSSION OF THE EVIDENCE

In 2001, Redwood Energy Production, LP (“Redwood”) received a permit to dispose of fluids containing hydrogen sulfide into its Madisonville Disposal Well No. 1D. A treatment plant, now operated by MGP, to process (‘sweeten’) the gas was built west of Redwood’s Ruby Magness Well No. 1, the discovery well in the Madisonville (Rodessa) Field. MGP is expanding this plant to process the sour gas produced from Crimson’s proposed wells in the same field, however it is requiring Crimson to provide a disposal facility for the waste fluid which is estimated to be 45% H₂S and 55% CO₂.

During the past 2-1/2 years, the Ruby Magness No. 1 has produced 12.4 BCF from a depth of 11,864', and both Redwood and Crimson plan to produce additional wells in this reservoir. The field contains an estimated 100 BCF of gas that contains about 10% H₂S and 10-13% CO₂.

The waste gas from the MGP plant moves north by flow line to Redwood’s Madisonville Disposal Well No. 1D which injects it into the Wilcox and Poth Formations between 4934' and 5170'. Since June, 2003, a total of 650,000 barrels of acid liquid has been injected into this disposal well, at pressures up to 1000 psi. A special field designation of Madisonville (Wilcox H₂S Disp) Field was established in Final Order No. 03-0228949, to identify the non-productive disposal zone as a formation now containing hydrogen sulfide.

Because Redwood’s disposal well has operated without problems, Crimson has modeled its proposed disposal well on it. Crimson’s Rogers No. 2D will be drilled to 5500' and the applicant intends to inject through tubing set on a packer at 4700'. The total injection interval requested is between 4720' and 5200', with actual perforations expected to be between 5010' and 5090'. The base of usable-quality water has been determined to be 3450'. Crimson plans to set surface casing at 3500 feet and to cement the production casing from total depth to the surface. All of the equipment installed in the wellbore and well head, and flowlines from it, that might come in contact with H₂S, have been designed by

specialists to be of H₂S-resistant stainless steels and alloys that meet all Commission and industry standards for handling H₂S.

Redwood's disposal well uses 50' of net sandstone in the lowermost basal Wilcox and 15' of sandstone in the underlying Poth Formations for injection. The log of Redwood's well shows there are additional sandstones present above the permitted interval, and Crimson proposes to include this shallower section within its requested disposal interval. Most of Crimson's overall disposal section is therefore somewhat stratigraphically higher (though downdip) than Redwood's disposal section. The complete basal Wilcox disposal sandstone package in Crimson's well (which has not been drilled) is expected to be found between 4720' and 5200', which is stratigraphically equivalent to the sandstone package in the Redwood well occurring between 4664' to 5126'. Using sandstones for disposal in Crimson's well that are at least partially separate stratigraphically from those used in Redwood's well should reduce chances for interference between the two disposal wells' waste plumes.

Crimson believes that, above the 50' that Redwood's well uses, are an additional 146 net feet of sandstone in the basal Wilcox interval it has chosen (between 4720' and 5126') that are capable of accepting injected fluid. Crimson has assumed only 35' of total porous sandstone thickness in its calculations to be conservative. Using a thicker interval would result in a smaller plume area. These basal Wilcox sandstones are porous, permeable and extensive.

The initial source of the waste to be disposed of in the Rogers No. 2D, the Johnston No. 2, was issued a drilling permit in July of 2005. The MGP plant will absorb the CO₂ and H₂S from the gas stream produced by the Johnson No. 2, and the resultant waste known as acid gas will be compressed into a liquid. The estimated average daily injection rate is 2000 barrels per day with a maximum of 4000 barrels. The maximum surface injection pressure requested was 2500 psig (since amended to 2360 psig), though Crimson believes the average pressure will be only 1200 psi.

There are two wells within 1/4 mile of the proposed location of the Rogers Well No. 2D. The Nucorp Energy Johnston No. 1 was drilled to 9310' in 1985 and, although plugged according to Commission standards, it does not have H₂S rated cement across the disposal interval. The Marshall Exploration Rogers No. 1 was drilled to 9450' in 1983, and is an inactive well under the control of Crimson. Crimson is planning to recomplete the well which now has surface casing at 3500' and production casing cemented from 9448' to 8300'. Because there is no cement across the disposal interval of this well, Crimson has suggested that as a condition of the permit it will cement through this interval using H₂S rated cement. Crimson will also re-enter and replug the Johnston No. 1 using H₂S rated cement through the disposal interval.

The location of the proposed disposal well was chosen to provide at least a 1000' buffer to other wells in the area, while being relatively close to the MGP plant. It is on the same 213 acre unit as the proposed producing well, the Johnston No. 2. The Rogers No. 2D is located in a low-lying area, with a curtain of trees to isolate it from the public and landowners' view where possible. The well sites of both producing and disposal wells will be surrounded by fences with locked gates.

The subsurface injection plume, which remains a liquid at reservoir conditions, was modeled by Earthward Consulting, Inc. of Lovettsville, Virginia, specialists in the design of hazardous waste wells. The numerical model is known as the SWIFT model and it has been accepted nationally for hazardous waste wells by the EPA. The porosity is assumed to be 33% and the permeability to be 200 md.

The injection plume model depends on the number and timing of wells to be drilled in the Madisonville (Rodessa) Field which will affect the amounts of acid gas that will need to be disposed of. Injection rates into Redwood's disposal well are expected to reach a maximum of 9000 cubic feet per day in 2005-2006, while a maximum rate of 13,000 cubic feet per day (less than 2200 barrels) is expected in Crimson's proposed disposal well during 2008. Total injection into the Redwood well is anticipated to be 17.5 BCF of acid gas and into Crimson's proposed well is anticipated to be 21.5 BCF. Active injection is expected to cease in 2017.

If only 35' of net sandstone are conservatively assumed to be available to receive waste, the edge of the disposal plume (defined as 1% or less acid gas with at least 99% formation liquid in the pore space) will reach 1000'-1300' away from the Rogers No. 2D by 2017. This model shows the disposal plume of the Rogers No. 2D will be as close as 1660' to the equivalent disposal plume from Redwood's disposal well.

The initial pressure in the lower Wilcox sandstones is assumed to 2200 psi, and the current pressure at the site of the proposed Rogers No. 2D is now 30 psi higher due to injection from Redwood's disposal well. The radius of pressure influence in the existing saltwater in the basal Wilcox is much greater than the radius that H₂S will actually reach. The peak pressure in the lower Wilcox at the site of the Rogers No. 2D is expected to be 2365 psi in 2009, and the pressure increase will be dissipated by a year after disposal at this well ceases in 2016.

According to the Forms H-9 submitted by Crimson, the maximum escape rate during normal operations of the Rogers No. 2D, through tubing, is 15,300 MCFD. During drilling or work-over operations, the size of the casing is considered in determining the maximum escape rate and the maximum rate is therefor 187,000 MCFD. The calculated exposure radius ("roe") of 100 ppm H₂S, due to a catastrophic release during workover operations on the proposed injection well, is 5915' and of 500 ppm is 3175', assuming unfavorable weather conditions. This radius intersects FM Highway 1372 to the south. Most of the 100 ppm roe of Crimson's well is within the 100 ppm roe of Redwood's disposal well. Crimson will install additional signs indicating sour gas if necessary along the highway or any other public roads in the area.

Crimson used a dispersion model to determine the roe called CANARY by Quest. This model calculates release conditions and the initial dilution of the vapor (based on the release conditions) and subsequent vapor dispersion. The model accounts for thermodynamics, mixture behavior, transient release rates, gas cloud density, initial velocity of the gas and heat transfer effects. This model has been reviewed by the Minerals Management Service.

Crimson has drawn up an emergency response plan. It has held townhall meetings in Madisonville about its proposed sour gas operations and coordinated with local emergency responders such as volunteer fire departments. All part time and full time occupants of all structures within the radii of exposure will be notified about emergency procedures and evacuation routes. Within the 500 ppm roe of 3175' is one residence occupied by a deaf person and another occupied by a person without a telephone. There are five additional occupied residences, the MGP plant and other structures within 3175' of the Rogers No. 2D.

There are a total of 65 residences, businesses and unoccupied structures within 5915', which could be within the roe to 100 ppm during a catastrophic release from the Rogers No. 2D. A list of telephone numbers and other notification requirements will be maintained and updated annually or more frequently if necessary.

The system is designed with numerous safeguards and the injection well compressor will shut-down if a monitor detects any of a number of unusual conditions, such as abnormally low or high pressure to or from the compressor or wellhead. The tubing, casing, surface and line pressure and temperature will be monitored at all times. There will be equipment to detect immediately any release of H₂S. All personnel who will work at or near the facility will be trained in H₂S safety and safety drills will be performed frequently. Crimson's contingency plan, as proposed, satisfies the requirements of Statewide Rule 36.

FINDINGS OF FACT

1. Notice of this application to inject fluid containing hydrogen sulfide was issued to all surface owners, offset operators, and the Madison County Clerk on December 13, 2005.
2. Notice of this hearing was issued on March 15, 2006, to all interested persons.
3. Notice of the disposal application was published on October 12, 2005, and notice of this hearing was published on March 8, 2006, both in the *Madisonville Meteor*, a newspaper of general circulation in Madison County.
4. The proposed injection well will dispose of hydrogen sulfide (sour gas, or H₂S) that is produced along with hydrocarbon gas from Crimson Exploration Inc.'s Johnston Lease Well No. 2 and subsequent wells.
5. The H₂S to be disposed of will be removed from the hydrocarbon gas, at a gas plant operated by MGP.
6. The Crimson Exploration, Inc. Rogers No. 2D will inject waste gas which has been compressed, at daily rates up to 4000 barrels of liquid (known as acid gas), containing 45% H₂S and 55% carbon dioxide.
7. The proposed H₂S disposal well, the Rogers No. 2D, will be drilled, cased and cemented to confine the injected fluid to the basal Wilcox Formation.
 - a. The applied-for injection interval is from 4720' to 5200' and actual perforations into the basal Wilcox Formation are expected to be between 5010' and 5090'.
 - b. The base of usable-quality water has been determined to be at 3450'.
 - c. Surface casing will be set to 3500', and the production casing will be cemented from total depth to the surface.
 - d. Injection will be through tubing set on a packer at 4700' and the fluid injected will be

- a mixture of CO₂ and H₂S.
- e. All of the equipment installed that might come in contact with H₂S will be stainless steel, and will meet all Commission safety standards.
 - f. The field name of Madisonville (Wilcox H₂S Disp) has been approved for the disposal interval to alert other operators in the area to the possibility of encountering sour gas in their wells.
 - g. If the injection fluid is not confined to the approved strata, then the disposal well permit will be suspended and disposal cease until the fluid migration from such strata is eliminated.
8. The disposal well is at least 500' inside Crimson Exploration's unit boundaries in all directions.
 9. The porous basal Wilcox has at least 35', and as much as 146', of net porous sandstone, all with good permeability.
 10. Maximum dispersal of the acid gas will be 1000'-1300' from the Rogers No. 2D.
 11. The maximum pressure increase, right around the disposal wellbore, will be 165 psi.
 12. Over the expected life span of the Madisonville (Rodessa) Field, the ultimate production will be as much as 100 BCF and 21.5 BCF acid gas will be injected into the Rogers No. 2D.
 13. The maximum daily injection rate will be 4000 barrels, at a maximum injection pressure of 2360 psi, which is less than the fracture pressure of the basal Wilcox.
 14. During a catastrophic failure of the injection line and/or the injection well, portions of public highway 1372 will be within the radius of exposure to gas that is at least 100 ppm H₂S.
 15. The injection well, compressor and flow lines transmitting sour gas, will be designed to contain the sour gas, and monitoring devices will immediately shut down the system if any leakage of sour gas is detected.
 16. A contingency plan has been devised to warn residents, county officials, and law enforcement immediately if there is any hazardous release of sour gas.
 17. The calculated exposure radius ("ROE") of 100 ppm H₂S due to a catastrophic release during workover operations is 5915' and of 500 ppm is 3175', assuming unfavorable weather conditions.
 18. There are 65 residences, businesses and other buildings within 5915' of the Rogers No. 2D.
 19. The two wells within 1/4 mile of the proposed location of the Rogers Well No. 2D will not be conduits for migration of injected fluid outside the disposal interval.
 - a. The Nucorp Energy Johnston No. 1 was plugged according to Commission standards

but does not have H₂S rated cement across the disposal interval.

- b. Crimson Exploration, Inc., will re-enter and replug the Nucorp Energy Johnston No. 1 using H₂S rated cement through the disposal interval.
- c. The Marshall Exploration Rogers No. 1 is an inactive well under the control of Crimson.
- d. Crimson Exploration, Inc., plans to recomplete the Marshall Exploration Rogers No. 1 and will cement through the disposal interval using H₂S rated cement before beginning injection operations.

CONCLUSIONS OF LAW

1. Proper notice was issued as applicable in all statutes and regulatory codes.
2. All things have occurred and been accomplished to give the Commission jurisdiction in this matter.
3. The application of Crimson Exploration, Inc. to inject hydrogen sulfide gas (acid gas) into the Rogers Lease, Well No. 2D, in the Madisonville (Wilcox H₂S Disp) Field, Madison County, complies with the applicable provisions of Statewide Rules 9 and 36, 16 T.A.C. §3.9 and §3.36.

EXAMINER'S RECOMMENDATION

Based on the above findings and conclusions, the examiner recommends that the application of Crimson Exploration, Inc. be **APPROVED**. Before injection operations begin, the applicant must cement across the disposal interval of the Marshall Exploration Rogers No. 1 using H₂S rated cement; and re-enter and replug the Nucorp Johnston No. 1 using H₂S rated cement across the disposal interval. A permanent marker should be placed on this wellhead after injection ceases. The depth of the Madisonville (Wilcox H₂S Disp) Field should be modified to 4700' to notify other operators to expect a formation containing hydrogen sulfide at 4700' rather than the current depth of 4950'.

Respectfully submitted,

Margaret Allen
Technical Hearings Examiner