TECHNOLOGY ASSESSMENT

Shell 29 Limestone / 14-2-33-10 W5M

Shell Canada test in January 2000

- Tested at 2 rates - 2.5 and 4.8 MMscf/d
- Sour gas containing 11% H_2S
- Questor Q5000 incinerator - 40 ft high unit

Results:

- 99.99% combustion efficiency - at both rates
- Plume rise of 250 meters - SO_2 dispersion comparable to a 110 ft stack – 5% heat loss
- Naturally aspirated with up to 100% excess air
- No ground level violations of SO_2 or H_2S

Also independently tested and verified by Exxon/Mobil, Vaquero, Dominion Exploration and TransCanada Pipelines

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20 March, 2000

Regarding: Portable Incinerator Test
Shell 29 Limestone 14-2-33-10W5m
Jan 25, 2000/03/04

Attached are the findings of the Portable incinerator test conducted by Shell Canada Limited in conjunction with Norward Energy Services, the owner of the incinerator, and Questor Technologies, the manufacturer of the incinerator.

Yours truly,

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Drilling and Production Engineering Advisor

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Division Manager
Norward Energy Limited

Daniel Motyka
President / COO
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CAPP Well Test Flaring Committee members & CAPP Well Construction Committee Chairman

CAPP Environmental Committee Chairman

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Portable Well Test Incinerator Test Results

Shell 29 Limestone 14-2-33-10W5M

2-2-33-10W5 surface location

Conducted on Jan 25, 2000

Portable Well Test Incinerator Test Results

Conducted on Jan 25, 2000 at Shell 29 Limestone 14-2-33-10W5M 2-2-33-10W5 surface location

A. Program Objectives:

1. The objective is to collect technical information on portable incinerator performance. This information can then be used to better define the circumstances where it can replace portable flaring for well tests and what, if any, improvements are needed.
2. Test data desired at 2 different flow rates, one rate near the maximum design capacity of 140 E3m^3/d (5 mmcfpd) and one rate at about 70 E3m^3/d (2.5 mmcfpd):
   - i) Gas rate into the incinerator.
   - ii) Incinerator inlet gas composition.
   - iii) Incinerator stack exit composition.
   - iv) Incinerator stack exit temperature.
   - v) Incinerator flame temperature.
   - vi) Inlet air vacuum.
   - vii) Noise data.
   - viii) SO_2 ground level monitoring.
   - ix) Meteorological data.
   - x) Plume height using infrared photography.

B. Equipment Description:

3. Attachment 1 is a picture of the general lease layout showing the incinerator and the flare stack.
   1) The incinerator nominal specs were:
      - i) Height: 12.8 m (42 ft)
      - ii) OD: 3.66 m (12 ft)
      - iii) ID: 3.35 m (11 ft)
      - iv) Weight: 36364 kg (80000 lbs.)
      - v) Assembly: in sections using a crane.
      - vi) Design rate: 155 E3m^3/d (5.3 mmcf/d)
      - vii) Inside Temp: 1200 °C
      - viii) Exit Temp: 730 °C using heat guns

   2) The flare stack specs were:
      - i) Height: 33.4 m (110 ft)
      - ii) Exit ID: 1.22 m (48 inches)
      - iii) Assembly: in one section using a crane.
4. The incinerator test was done during the well test flow period of the Devonian Wabamun formation with downhole pressure recorders in the well. This period was after the well had cleaned up post acid frac and so the gas composition and gas rate was expected to be stable (the ideal working conditions for an incinerator). The equipment was arranged so that the gas from the well went to a heater, then the portable test separator where total gas rate was measured. Gas samples were taken from here. The gas stream was then split, with the majority going into the pipeline and the remainder being diverted to the flare stack/incinerator. There was a manifold upstream of the flare stack/incinerator so that the flow could be quickly diverted from one to the other. There was an additional orifice meter on the incinerator leg to

measure the gas rate going into the incinerator. For start-up, the gas was first diverted to the flare stack and then gradually switched to the incinerator.

C. Results:

General:

1. The overall results can be seen in the spreadsheet of Attachment 2.
2. The low rate averaged about 75 E3m^3/d. The high rate started at about 150 E3m3/d and was adjusted downward to an average of 130 E3m^3/d until there were no visible flames exiting the top of the incinerator. Hence, the maximum rate to avoid visible flame under the Limestone 29 conditions was 130 E3m^3/d, which is below the design rate of 155 E3m^3/d.

Combustion:

1. Combustion Efficiency was measured by comparing the inlet gas composition to the exhaust gas composition. Sample tubes were placed in the exit stream of the incinerator. No traverse across the diameter was done as would normally be done on a permanent incinerator stack in a gas plant due to equipment limitations and the safety aspect of having a man at the incinerator top. Three sample periods were taken at each rate. The executive summary report provided by Maxxam Analytics is included in Attachment 3.
   1) **H_2S to SO_2 conversion was measured at >99.9% efficiency for both gas inlet rates.** The average H2S concentration in the inlet stream was 11%. The average H_2S, COS, and CS_2 in the exhaust was <4ppm.
   2) Sample period 1 on the 75 E3m^3/d measured a carbon monoxide level of 580 ppm. This is probably due to the start-up conditions not being totally stable. Similarly, sample period 1 of the 130 E3m^3/d rate measured a carbon monoxide level of 2473 ppm. This is the period when the gas rate was being lowered from 150 E3m3/d downward to an average of 130 E3m^3/d to eliminate the visible flames exiting the top of the incinerator. Hence, the sample tube was not in the completely combusted part of the exhaust.
   3) Sample period 3 on the 130 E3m3/d rate showed some minor peaks in the 15-25 ppm range for methane, propane, and butane. The inlet gas composition and rate did not look abnormal and the incinerator appeared to be running in a stable condition at the time.
2. It was hoped to calculate air inflow to the incinerator from measurements of created air vacuum, but the pressure drop proved to be too small for the instrument to measure. Hence, air to fuel ratios were calculated using balances of five species in the mixture streams: SO_2, CO_2, H_2O, N_2 and O_2. See Attachment 3 for details.
   1) The Air:Fuel calculations vary from about 14:1 to 21:1.
      i) The calculations are very sensitive to the measured concentrations, especially when using N2.
      ii) The calculations for sample run 1 at the high rate should be ignored because the incinerator conditions were transient (see point 1 above).
      iii) A 17:1 ratio resulting in a stack exit O_2 of about 10% provides 100% excess air (100% more air than needed for combustion), which is about right for this type of incinerator.

Temperatures and Heat Loss:

1. Exhaust gas temperatures were measured using a thermocouple placed in the top of the incinerator. It was not moved across the diameter during the test for the same reason that the sample tubes were not moved. These measurements were compared to heat gun readings.
   1) The average **thermocouple temperature** once the air intake louvers were adjusted to provide stable conditions was **1100 °C**. This was pleasantly surprising because previous heat gun measurements were about 700 °C. Indeed, our on-site heat gun measurements