EXECUTIVE SUMMARY

The Saskatchewan Research Council (SRC) was contracted to provide independent third-party emissions and performance testing of the Black Gold Rush Industries Ltd. (BGR) 36 LP Combustor. The material presented in this report could be used by operators requesting exemption to "distance to residence" regulatory requirements (SK Direction S10, AB Directive 056 and 060, and BC Drilling and Production Regulations, Section 47c, and 48) and/or associated guidance (such as the BC Flaring and Venting Reduction Guideline). The results of this testing may also be used to inform regulations related to combustor operation, pending regulator priorities. If so, exploration and production companies will have added flexibility when designing and operating facilities near occupied residences.

SRC has provided independent third-party field testing on the BGR 36 LP Combustor, dispersion modeling, a safety and regulatory review, and validation services on this project. The field testing took place at a Western Canadian oil producer site. Gas production at this site was around 95% methane, typical of heavy oil sites and natural gas production. An industry partner provided the site, and BGR provided a stack extension containing the appropriate sample ports. SRC personnel travelled to the site with one of SRC's Centre for the Demonstration of Emissions Reductions (CeDER) trailers during the week of May 27-31, 2019. Personnel from BGR were on-site to observe the data collection.

Nuisance testing determined no measurable light was emitted from the combustor, and the noise generated was less than that of the existing equipment on site. Methane destruction efficiency was calculated at >99.99% for the 100% load condition and between 45% and 54% on average for the 10% load condition. The methane destruction efficiency during the 10% load tests was lower than the 99% or greater required by Alberta's regulation D60 and BC's Flaring and Venting Guideline. The degree to which this is significant will be assessed by the individual provincial regulators, based on their priorities. It is uncommon to operate at such a high turn-down ratio, as most combustors will be sized for the flow anticipated at a site. Still, inconsistent flow is typical of production operations.

Incomplete combustion at 10% load still reduced the amount of methane and non-methane hydrocarbons emitted to the atmosphere when compared to venting. Some nitrogen oxides (NOx) were generated, though not as much as from combustion at the higher (100%) load. As one would expect, incomplete combustion resulted in greater formation of BTEX and carbon monoxide than complete combustion. It generated BTEX at 0.011 g/h and significantly more carbon monoxide than during complete combustion at 100% of the maximum inlet flowrate (0.5% vs 0.03%).

Despite the incomplete combustion during the 10% load tests, the results of the dispersion modelling indicate compliance with the standards listed in Appendix G. Dispersion modelling found VOC, CO, NO_X, and particulate measurements were well below the ambient air quality objectives and/or standards listed in Table G-6 of Appendix G for all test runs.

From the safety review completed by SRC, the BGR-36LP appears to meet the requirements of Saskatchewan, Alberta, and British Columbia. Best practices for operation and integrity management systems for critical components are recommended based on Alberta Boiler Safety Association's document AB-512 "Owner-User Pressure Equipment Integrity Management Requirements".

Alberta's D60, and BC's Flaring and Venting Guideline require combustion efficiency of 99% or greater. BGR combustors at or near capacity were able to achieve >99.99% destruction efficiency of methane during this testing. However, at 10% load destruction efficiency was measured to be 45% and 54%. These results suggest that enclosed combustors can meet or exceed regulations when properly sized to the application.

Additional test work is recommended, pending regulator and AUPRF approval, to explore the boundary operating conditions for enclosed combustors with high-methane content natural gas such as that observed at the test site, and identify at what turndown ratio they no longer meet emission regulations. In this case, SRC would propose to monitor methane, carbon monoxide, oxygen, fuel conversion efficiency, and temperature to conduct partial load testing to establish lower operating limits governed by destruction efficiency limits. This methodology is recommended to minimize costs and timelines in future projects. It is also recommended that the combustor outlet be tested at a site with H_2S and higher inlet concentrations of volatile organic compounds to confirm the reduction efficiency. It is not appropriate to assume destruction efficiencies are equivalent for all compounds. Additional options for future testing are discussed further in the Section 6.2.

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