Commonwealth of Kentucky House of Representatives
State Representative Mr. Don Pasley
Frankfort, KY
Page 5 of 21

TECHNOLOGY CONCEPT EVALUATION

TOXIPLEX Process for Destruction of Chemical Agents

1. Technology Overview

The TOXIPLEX Process, developed by Dynecology of Harrison, NY, is proposed for destruction of chemical agents [1]. The process is not designed for high salt aqueous feeds and therefore would not be appropriate for the destruction of hydrolysate or neutralents [11]. The process employs a slagging, fixed bed gasifier (British Gas/Lurgi) to destroy organic compounds at 3000°F (1650°C) and requires a treatment system to clean the product gas containing particulate aerosols and gaseous contaminants. The off-gas cleanup system generates a waste that will require disposal. The cleaned product gas consists primarily of hydrogen and carbon monoxide and can be used as a fuel for commercial boilers or for advanced gas turbines. The residual solid waste leaving the bottom of the gasifier is a slag that is converted into a vitreous frit.

The gasifier used in the TOXIPLEX process may be considered a "boiler"; however, from a regulatory perspective it may also be considered an "industrial furnace". It is not considered an "Incinerator" based on the definition of "Incinerator" in 40CFR260.1. This technology was originally developed for producing fuel gas.

The information available for this review was evaluated relative to the application of the TOXIPLEX concept to the destruction of chemical agents. Site specific information required to assess implementation, such as requirements for systems interface, construction, permitting, schedule, demonstration and testing, etc., was not available in the information reviewed. This evaluation incorporates the comments on this process in the letter from J. Bacon (PMCD) to H. Schulz (Dynecology), dated December 22, 1997 [8].

2. Process Description

As shown in Figure 1 [1], the Lurgi gasifier is a cylindrical vessel in which carbonaceous material (coke) and limestone (as a fluxing agent) are fed through the top of the gasifier. A slag is removed from the bottom as a vitrified frit by quenching the slag with water. The organic feed (e.g., chemical agent) is introduced into a partial oxidation zone near the bottom of the gasifier through the oxygen and steam inlet tuyere. (The liquid form of the agent fits well with the feed requirements of the gasifier and no further preparation is considered necessary.) The product gas, which is partially oxidized, consists predominately of CO, H_2, CH_4, CO_2 and compounds such as H_2S, HCl, and others, depending on the elemental composition of the feed.

The organic feed is in contact with the partial oxidation zone for 50-100 milliseconds in the lower region of the gasifier. The temperature of the partial oxidation zone is controlled at 3000°F by regulating the oxygen to steam ratio to balance the exothermic partial oxidation of carbon with the endothermic water gas reaction. Upon leaving the partial oxidation zone, the reaction

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Comment No. 8 (cont.) **Issue Code: 07**

concerning drinking water quality. Therefore, no impacts to drinking water are expected.

Comment No. 9 **Issue Code: 16**

Comment noted. The purpose of this project is to demonstrate a technology with the potential to generate clean and safe energy from high-sulfur coal.

Comment No. 10 **Issue Code: 16**

DOE selected the Kentucky Pioneer IGCC Demonstration Project for further consideration under DOE's fifth solicitation (CCT-V) of the CCT Program and concludes that the project falls under the CCT Program requirements due to the use of the modified version of the BGL technology. The purpose of the CCT Program is to demonstrate technologies with the potential to provide cleaner and more efficient energy from coal resources. All coal and RDF pellets will be transported in covered containers. The concrete-floored storage building for the RDF pellets and coal will be located within the 4.8-hectare (12-acre) project site and would be capable of housing a 10-day supply of coal and RDF pellets. The 4.8-hectare (12-acre) project site is located within the larger 1,263-hectare (3,120-acre) J.K. Smith Site and is approximately 1.6 kilometers (1.0 mile) from the closest residence.

Comment No. 11 **Issue Code: 07**

As stated in Section 5.8, Water Resources and Water Quality, the Proposed Action would withdraw a total of 15.1 million liters per day (MLD) (4 million gallons per day [MGD]) of water from the Kentucky River. This is equivalent to 0.1 percent of average flow conditions and 4.0 percent of low-flow conditions. Should drought conditions warrant or the state mandate it, KPE would cease withdrawals from the river and shut down the plant temporarily.

Commonwealth of Kentucky House of Representatives
State Representative Mr. Don Pasley
Frankfort, KY
Page 6 of 21

Technology No. 17 July 17, 2000

products then come in contact with an incandescent bed of coke (for one or more seconds) in the upper region of the gasifier (a highly reducing environment) where complete pyrolysis is achieved.

The product gas exiting the top of the gasifier is scrubbed free of contaminants such as H_2S, NH_3, and HCl. The product gas is a medium BTU fuel gas (300 BTU/ft^3), which can be substituted for natural gas in commercial boilers or as fuel for the advanced gas turbines of an integrated gasification, combined cycle power plant. All feed material that is not gasified is continuously withdrawn from the base of the gasifier as a molten slag. The slag is then fritted by quenching in water.

Figure 2 [1] provides a process flow schematic of the gasifier and gaseous effluent cleaning system. A mass balance is shown in Figure 3 [1] (based on a chemical agent feed of 11 tons per day). The mass balance of solid waste exiting from the gasifier is primarily dependent on the ash characteristics of the carbonaceous fuel used rather than the agent or toxic material destroyed. Dynecology has stated that in order to substantially reduce the solid waste exiting the gasifier and virtually eliminate any concerns related to heavy metals in the mass balance, refractory oxide packing may be used instead of coke to provide surface area for reaction. In this case, supplemental fuel will be required to ensure the desired reaction conditions are attained. The process produces a medium BTU product gas that provides a readily available source for this supplemental fuel [11].

3. Process Efficacy

3.1 Maturity of Technology

Gasification has been in commercial operation for many years. Lurgi has over 170 Gasification plants in operation including various downstream processes for gas clean-up, sulfur recovery and waste water treatment. These gasification reactors are of dry bottom design, meaning that the slag is removed in dry form in contrast to the slagging gasifier where melted slag is quenched with water to make a non-leachable frit for disposal purposes. British Gas and Lurgi developed a slagging gasifier design that was built and operated in Westfield, Scotland to produce synthesis gas [9]. British Gas discontinued its gasification efforts after natural gas was found in the North Sea.

The basic gasifier and auxiliary equipment are readily available, although they would have to be designed for site specific CWM application and integration with the plant site.

3.2 Process Monitoring and Control

The controlling parameter in operating the slagging gasifier to destroy chemical agents is the ratio of agent to oxygen/steam mixture. In general, adjusting the quantities of oxygen and steam flow entering the reaction zone can control the bed temperature and product gas composition.

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Stone & Webster Engineering Corporation 2/12

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Comment No. 11 (cont.) **Issue Code: 07**

In order to minimize potential conflicts over water availability during low-flow conditions, the State of Kentucky limits permitted users to no more than 10 percent of the lower average monthly flow.

Comment No. 12 **Issue Code: 02**

Comment noted. The Draft EIS is designed to present all of the possible environmental impacts of the various alternatives relating to the proposed federal action, both beneficial and detrimental. The economic benefits associated with the project are not intended as justification for the environmental costs of the project; however, they are presented as one of many resource areas impacted by the project. All 120 jobs associated with the operation of the Proposed Action would be created onsite in Clark County and all 270 of the jobs indirectly created would be within Clark, Fayette, and Madison Counties.

Comment No. 13 **Issue Code: 21**

The Kentucky Pioneer IGCC Demonstration Project is a federal action. The EIS is used as a tool to decide whether or not the DOE should provide funding to the project. If the project is approved, KPE would be required to abide by all local, state, and federal regulations.

Comment No. 14 **Issue Code: 22**

The facility would not be used as a nerve gas incinerator at any point during its operation.

Comment No. 15 **Issue Code: 21**

Comment noted. The proposed project would demonstrate power generation technology to produce clean energy from high-sulfur coal and RDF pellet co-feed.

Commonwealth of Kentucky House of Representatives
State Representative Mr. Don Pasley
Frankfort, KY
Page 7 of 21

The oxygen/steam ratio balances the exothermic partial combustion reaction, $C + 1/2\ O_2 \rightarrow CO$, with the endothermic water gas reaction, $C + H_2O \rightarrow H_2 + CO$. Variations in the ratio of hydrogen/carbon monoxide and the carbon monoxide/carbon dioxide in the gas indicate departures from steady-state conditions.

Use of the gasification process for destruction of chemical agents would not appear to significantly alter the number of process controls required, as the mass of agent added compared to the mass of coke or coal utilized for oxidation is small.

If refractory oxide packing were used instead of carbon pellets, to provide surface area for reaction, supplemental fuel would be required to ensure the desired reaction reduction conditions would be present.

3.3 Process Robustness

Given the large thermal mass contained within the reactor system, periodic process feed perturbations will not significantly affect the high reaction temperature, and hence reaction kinetics.

Variation in agent feed flow rate would require small adjustment in oxygen, steam and supplemental fuel flow to maintain bed temperature. The thermal inertia of the gasifier (due to the large mass of bed material) should allow small variations in feed without compromising destruction efficiency. Upon shutdown of agent feed, Dynecology reports that the gasifier can be turned down to 10 percent of its feed rate for coke, oxygen, and steam to put the unit on standby and remain in stable operation [1].

Specific data on operational reliability was not available in the information reviewed but the TOXIPLEX process would most likely achieve high operability and reliability given the maturity of the technology and the long operating history of commercially sized plants.

3.4 Destruction Efficiency

Dynecology reports destruction efficiencies of 6 and 7 nines when treating hexachlorobenzene and PCB's [6]. Dioxins and furans measured in the PCB tests were below 0.03 ng/m^3, which is below the 1 ng/m^3 EPA limit. Destruction efficiencies for chemical agents were not available and, while required as a condition for further process development, would not be expected to be significantly different. Dynecology reports that the time required for the destructive processes to occur is less than 500 milliseconds and most likely in the range of 50 to 100 milliseconds [1].

4. Process Safety

Due to the rapid destructive rate (low contact time required), the inventory of toxic materials available for release from the gasifier during an abnormal or accidental release condition is low.

14/22
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Commonwealth of Kentucky House of Representatives
State Representative Mr. Don Pasley
Frankfort, KY
Page 8 of 21

The low inventory minimizes both the on-site and off-site consequences for reaction vessel failure or leakage.

The high temperatures involved, the use of pure oxygen in the process, and the presence of hydrogen and carbon monoxide gas would require the use of normal industrial process safety measures. Experience with commercial operating facilities indicates that there have been no known accidents due to the release of hydrogen or carbon monoxide [2].

Dynecology recommends operation of the gasifier under a relatively low pressure (compared to commercial gasifiers) of 100 psig. A jacketed design with an inert gas is used for leakage detection and control. An even lower operating pressure could be used with a corresponding increase in vessel and equipment size and cost, if justified by a HAZOP analysis for reducing risk of failure.

For organic feed streams containing oxidizing agents such as dissolved munitions or explosives, the usual industrial safety design and operating requirements for this type of feed would need to be implemented.

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5. Environmental Impact

The overall mass balance provided in Figure 3 identifies the quantity of waste generated. Assuming 10,000 pounds per day of VX as the agent treated, 27,293 pounds per day of solid waste would be sent to disposal. This includes 16,363 pounds per day of slag from the gasifier bottoms and 10,900 pounds per day of calcium sulfate from the gas clean-up units. The mass of slag generated is directly related to the ash content of the carbon/coal used in the gasifier. The total solid waste would be expected to be higher for treatment of the chemical agent hydrolysates, due to higher salt and water content, than for the treatment of chemical agents.

The solid waste volume from slag can be substantially reduced by substituting a refractory metal oxide (such as zirconia) to serve as the incandescent contact surface or by using a coke product with a low ash content [10]. The use of refractory packings as a bed may not be appropriate for feeds containing phosphorus due to the production of phosgene gas. A moving bed reactor design may be required an/or an external off-gas treatment process may be needed for the phosgene formed in the highly reducing environment of the reactor.

The glassy frit produced by quenching the molten slag is non-leachable and may be sold as an aggregate for road building or landfill. The practicality of utilizing solid waste products from an agent destruction plant is unlikely. Waste disposal alternatives to using the molten slag as an aggregate must be planned.