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Memorandum

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Re: Targets for Air Emissions "Best Available Control Technology"

This memo will catalogue the air pollution control technologies and emission levels that we recommend for inclusion in preliminary design of the proposed PADD II refinery and its integral IGCC facility. Most importantly, this memo will identify those recommendations that we feel are worthy of further discussion, particularly where our technology recommendation could potentially be identified by a project opponent as something less than the "greenest" alternative.

I. BACT Recommendations

The following are our recommendations for air pollution control technologies and design emission rates for preliminary design purposes.

Targets for Storage Tanks:

- Where feasible, storage of hydrocarbon liquids in pressurized tanks with sweep gas routed to compressors and into the refinery fuel gas system. For Arizona Clean Fuels, tanks permitted with this configuration include natural gasoline, isomerate, coker feed, light naphtha, and slop oil.
- All other hydrocarbon liquids, and sour water, stored in internal floating roof tanks.

Targets for Process Heaters:

- Fuel gas amine treating to achieve a total sulfur content not to exceed 35 ppmv, expressed as H_2S, daily average.
- Low-NO_X burners on all heaters designed to achieve a NO_X emission limit of 0.027 lb/MMBtu heat input, [1] based on a 3-hr average.

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[1] All heat input values expressed as higher heating value (HHV)

- On all heaters exceeding 150 MMBtu/hr heat input capacity, selective catalytic reduction (SCR) to achieve a NO_X emission limit of 0.006 lb/MMBtu heat input, with ammonia slip not to exceed 5.0 ppmvd, corrected to zero oxygen, both on a 3-hr average.
- Combustion controls to achieve a CO emission limit of 0.018 lb/MMBtu heat input, 1-hr average.

Targets for Sulfur Block:

- Sulfur recovery unit (SRU) with tail gas treating unit (TGTU) and thermal oxidizer to achieve an exhaust SO_2 concentration limit of 93 ppmv, maximum 3-hr average regardless of operating rate, and an SO_2 emission rate limit equal to 99.97 recovery efficiency, based on maximum capacity, on a 1-hr average.
- Thermal oxidizer with low-NO_X burners to achieve a NO_X emission limit of 0.06 lb/MMBtu.
- Thermal oxidizer H_2S emission rate limit equal to 0.00015 percent of inlet sulfur loading, based on maximum capacity, on a 3-hr average.
- Either 100% redundancy in the sulfur block, or the following measures to minimize the occurrence of excess emissions during sulfur block upsets:
    - Continuously available rich amine storage capacity, minimum of 24 hours normal refinery operation.
    - Continuously available sour water storage capacity, minimum of 24 hours normal refinery operation.
    - Continuously available lean amine solution, minimum of 24 hours normal refinery operation.
- Sulfur product degassed to 15 ppmw prior to loading.
- Sweep gases from sulfur tanks/pits routed to SRU inlet.

Targets for Product Loading:

- Gasoline loading controlled with carbon adsorption and vapor incinerator in series to achieve VOC emission limit of 1.25 lbs per million gallons loaded.
- Distillate products loading controlled to achieve minimum 99.9 percent VOC control efficiency.

Targets for Equipment Leaks:

- Inherently leakless technologies, such as magnetic drive or diaphragm pumps and bellows valves, should be specified where available and cost-effective.

Targets for Process Cooling:

- Cooling water systems equipped with continuous analyzers for detection of hydrocarbon leaks into cooling water.
- Mechanical-draft cooling towers equipped with high efficiency drift eliminators. For towers of sufficient size, drift eliminators can be obtained with vendor-guaranteed drift less than 0.0005% of circulating water flow rate.

Targets for Wastewater Treatment:

- Except for segregated stormwater, all sewers controlled using dual carbon canisters.
- All wastewater tanks/vessels vented to vapor incinerator to achieve minimum 99.9 percent VOC control efficiency.

Targets for Coke Handling:

- All coke handling performed with coke in a water slurry, using dewatering bins and slurry pumps rather than a coke pit and conveyor belts.

Targets for Refinery Flares:

- Refinery equipped with sufficient flare gas recovery capacity (i.e., compressors) and redundant electric infrastructure to ensure no flaring except in unavoidable, emergency conditions. No flaring allowed during routine startups, shutdowns, or coke drum switches.

Targets for IGCC Combustion Turbine(s):

- Diluent nitrogen and SCR to achieve NO_X concentration limit of 3 ppmvd, corrected to 15% O_2, 3-hr average, while burning syngas.
- Selexol® syngas cleanup to achieve a total sulfur content not to exceed 10 ppmv, expressed as H_2S, daily average.
- Combustion controls to achieve CO concentration limit of 15 ppmvd, corrected to 15% O_2, 3-hr average, while operating at or above 50% load.

II. BACT Discussion

The following are air pollution control techniques and technologies, not identified in the recommendations above, that we feel are worthy of further discussion. Some of the controls discussed here are less effective than what we have recommended, but would meet the minimum regulatory requirements, where we feel that proposing a less effective control would be inconsistent with the project's Green Charter. We have included this discussion to allow Hyperion the opportunity to consider the additional costs associated with these voluntary air pollution control enhancements.

The other control technologies discussed here are those where our technology recommendation could potentially be identified by a project opponent as something less than the "greenest" available alternative. The BACT requirement provides for consideration of costs and commercial demonstration status. In a few instances, there exist air pollution control technologies that have the potential to provide greater control effectiveness than the options we have recommended, but we have not recommended them because they would be unreasonably costly or risky.

NO_X Control for Small Process Heaters

For process heaters with heat input capacity of 150 MMBtu/hr or less, we have recommended the use of low-NO_X burners without SCR based on diminishing cost-effectiveness. (The incremental cost effectiveness threshold for NO_X BACT is generally perceived to be $10,000 to $15,000 per ton. For heaters of this size range, we expect that the incremental cost effectiveness of adding SCR will be more than $20,000 per ton.)

Syngas Cleanup

We have recommended the use of Selexol® to achieve a maximum total sulfur level of 10 ppmv for syngas burned in the IGCC combustion turbine(s). Although it would meet minimum, objective regulatory requirements and would likely suffice as BACT, we did not recommend conventional amine-based syngas cleanup (e.g., with methyl diethanol amine) to achieve 25 ppmv sulfur because (a) while not within the cost effectiveness range historically associated with BACT, Selexol® is reasonably cost effective; (b) several proposed IGCC-based power plants are proposing to use Selexol® for syngas cleanup; and (c) amine-based syngas cleanup does not provide for future CO_2 capture.

On the other hand, we did not recommend Rectisol® because its incremental cost effectiveness for SO_2 emission control is well outside the historically accepted range for BACT, and no other proposed IGCC project in the U.S. has announced plans to use Rectisol®. (The incremental cost effectiveness threshold for SO_2 BACT is generally perceived to be $10,000 to $20,000 per ton. For this project, we expect that the incremental cost effectiveness of Selexol® over amine-based syngas cleanup is probably more than $25,000 per ton, and the incremental cost effectiveness of Rectisol® over Selexol® is probably more than $50,000 per ton.) If a decision is made to employ Rectisol®, based on either future CO_2 capture considerations or Green Charter considerations, that would greatly exceed regulatory air permitting requirements.

Refinery Fuel Gas Cleanup

We have recommended the use of conventional amine-based cleanup of refinery fuel gas to achieve a maximum total sulfur level of 35 ppmv. We did not recommend potentially more effective technologies such as Selexol® or Rectisol® because we do not believe that those technologies are cost effective or commercially proven in this service. However, because amine-based cleanup is being proposed for the syngas produced at the same site, the permit application will include a detailed analysis to justify the use of amine-based cleanup, and this analysis is potentially a target for parties opposing the project.

VOC Control for Storage Tanks

For storage tanks where it is infeasible to route the sweep gas to the refinery fuel gas system, we have recommended the use of internal floating roofs. We have not recommended the configuration currently required by the air permit for the proposed Arizona Clean Fuels Yuma refinery, which involves venting the headspace of internal floating roof tanks to a vapor incinerator for control of VOC emissions. This alternative configuration is not cost effective and would require combustion of significant quantities of supplemental fuel in order to sustain combustion in the incinerator. (The incremental cost effectiveness threshold for VOC BACT is generally perceived to be $10,000 to $15,000 per ton. Taking into account the increased emissions of NO_X from burning supplemental fuel, we expect that the incremental cost effectiveness of the alternative configuration for all remaining tanks at the proposed PADD II refinery, as is required of the Arizona refinery, would be more than $25,000 per ton of emission reduction.)

Process Cooling

We have recommended the use of generally accepted monitoring and equipment design standards to minimize emissions of VOC and particulate matter from mechanical-draft cooling towers. Air-cooled heat exchangers and air-cooled condensers are alternative means of heat rejection to the atmosphere and would eliminate air pollutant emissions. We have not recommended those alternatives because of cost concerns generally and technical feasibility concerns for certain applications.

Equipment Leaks

We have recommended the use of inherently leakless pumps and piping components only where those components are available and cost effective. We have not recommended any firm requirements for leakless technologies, as is required of refineries in the Los Angeles basin, because of concerns with reliability. The permit will require a very stringent leak detection and repair program, likely including maximum allowable incidence of leaking components, thereby creating an incentive to employ leakless technologies wherever reliability and cost concerns are not overwhelming.

Coke Handling

We have recommended the use of a slurry-based coke handling system. To our knowledge, such a system is in use at only one refinery (Valero in Wilmington, California). Although it is commonly selected as BACT even in more populated areas and would almost certainly suffice as BACT in this instance, we have not recommended a conventional coke handling system with conveyor belts and water sprays due to possible nuisance dust issues.

CO and VOC Control for IGCC Combustion Turbine(s)

We have recommended the use of combustion controls to minimize emissions of CO and VOC from the combustion turbine(s). We have not recommended the use of oxidation catalyst, as is frequently required of natural gas-fired combustion turbines, due to a lack of commercial demonstration in this service. Further, even if this technology were commercially available with a meaningful performance guarantee, we would expect its cost effectiveness to be marginal. Depending on the level of syngas cleanup to be achieved, the technical infeasibility argument may be mooted, and failure to include oxidation catalyst is potentially a target for parties opposing the project.

IGCC Combustion Turbine Backup Fuel

It is our understanding that the combustion turbine(s) burning primarily syngas will be designed to burn liquid fuel (e.g., ultra low sulfur diesel) as backup fuel. If feasible, specifying natural gas as backup fuel would be a less-emitting alternative. This decision will have to be justified based on technical infeasibility due to limitations of current combustion turbine technology offerings.