Workshop C

# O F F - G A S  T R E A T M E N T

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# OFF-GAS TREATMENT CONSIDERATIONS FOR INEL RADIOACTIVE SLAGGING PYROLYSIS INCINERATOR

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A slagging pyrolysis incinerator (SPI) has been selected to process 42,000 kg/day of transuranic-contaminated wastes stored at the Idaho National Engineering Laboratory (INEL) which contain up to 60 wt % soil. A significant design consideration for radioactive application is the treatment of the off gases. The off gas from the secondary combustion chamber (SCC) will flow at 10,600 standard $m^3/h$ at an exit temperature of 1400°C and will contain approximately 6.4 g entrained particulates per standard cubic meter. A particulate decontamination factor of $10^7$ will meet requirements for radionuclide removal. Control of $SO_x$ and HCl will not be required to meet applicable regulations, but is desirable to minimize corrosion. Nitrate salts in the waste will result in an average process off-gas concentration of 2700 $ppm_v$ $NO_x$ and a maximum concentration of 9400 $ppm_v$; the gases will be diluted by a factor of approximately 6 in the stack. Catalytic reduction by $NH_3$ is planned for $NO_x$ control.

The conclusions and recommendations of a Task Force which reviewed off-gas treatment system (OGTS) designs for application to the INEL SPI are summarized. A final system design has not been selected.

All but one of the systems considered include a waste heat boiler for cooling the gases from the SCC and generating electricity. Because of corrosive gases and condensible, corrosive vapors, this may be a high maintenance item. $NO_x$ control would occur downstream of process HEPA filters in any of the systems.

Three systems were considered: a wet system with Venturi scrubber, a dry system with spray dryer (for additional cooling after the waste heat boiler) and sintered-metal filters (SMFs), and a dry SMF system with a fluidized-bed boiler in place of the

waste heat boiler and spray dryer.

Selection criteria were developed. The most important, in addition to the normal safety considerations, was to provide a system that would function reliably under upset and emergency shutdown conditions, as well as to provide the nominal required cleanup performance during normal operations. In addition to handling large quantities of particulates, the OGTS may be exposed to significant amounts of condensible vapors of metals, oxides, and salts, which may be present in the gases from the incineration of the TRU-containing waste materials, and which could lead to corrosion and/or plugging problems. Emphasis was placed on specifying conditions to control the plateout and removal of the vapors.

A dry OGTS utilizing SMFs was chosen over a wet system with Venturi scrubber because:

1. The dry off-gas system has a higher particulate removal efficiency than the wet system in the expected particle size range, thus resulting in a less-frequent HEPA filter changeout rate. The wet system would require an average changeout interval of approximately 9 days; the HEPA filters in the dry system with SMFs should last over a year.

2. In the wet system, evaporation of large quantities of liquid secondary waste is required. This is known to be a source of operational problems and significant evolution of airborne radioactivity.

3. The SMFs provide greater overpressure protection of the HEPA filters than the Venturi scrubber.

The recommended OGTS consists, in order, of a waste heat boiler to cool the gases from 1400 to 350°C, a spray dryer to cool the gases to 200°C, while neutralizing the HCl and $SO_2$ with $Na_2CO_3$ in the spray water, emergency reheater, SMFs, air dilution to 81°C, roughing filters, and two sets of HEPA filters in series. Emergency bypasses are included around the spray dryer and the SMFs. The exit temperature of the boiler is set as high as possible to minimize plateout of metal-containing vapors; however, above 400°C, high-temperature corrosion by HCl could become significant. An exit temperature from the spray dryer of 200°C should result in precipitation of the condensible vapors for removal by the SMFs while assuring that collected hygroscopic salts do not absorb moisture. Air dilution is required ahead of the HEPA filters,

which are limited to 81°C for continuous operation. If commercially available high-temperature (260°C) HEPA filters can be shown to operate properly, their use is recommended without air dilution.

Because the proposed boiler system is a potential source of significant operating and maintenance problems, a fluidized-bed boiler should be developed for SPI conditions (high inlet temperature, high particulate loading, and corrosive gases). If the technology is demonstrated, a fluidized-bed boiler would be recommended in place of the conventional boiler and spray dryer for cooling the gases to 200°C. It could function as a backup afterburner, would remove condensible vapors, and could neutralize the acid gases in the bed.

Particulates collected by the SMFs would be recycled to the SPI, probably bound in concrete and pelletized, or bound with the soil if it must be pretreated.

The recommended OGTS would have the following design features for emergency upset situations. The spray dryer would have nozzles for flooding and scrubbing the gases to remove tars and pyrolysis gases in the event the SCC fails; the emergency reheater would reheat the gases about the dew point. The spray dryer and dilution air units would have extra capacities to cool the gases from 1400°C if the boiler fails; standby additional HEPA filters would be placed in use for the added gas flow. The backup air dilution would also cover failure of the spray dryer.

If the SMFs suddenly plug, they can be bypassed, or, if the cause is corrected, a spare set placed in service. In the bypassed mode, activation of the flooding mode of the spray dryer with emergency reheat would permit operation until the incinerator could be shut down enough to stop off gas flow (2 to 3 h).

Because of the uniqueness of the OGTS and the materials to be treated, and uncertainties in how it will function during long-term operation or during upset conditions, testing is recommended at a pilot-scale OGTS connected to a small SPI burning simulated INEL waste. Questions regarding quantities, types, and behavior of condensible vapors and corrosion control could be addressed. Unanticipated operational or design problems should be identified and resolved before final design is completed.