ANNEXE 20 – Sommaire du HAZOP de Pyrogenesis

RES Phase 2 – 50 kg/hr ODS Destruction Pilot Plant
IPN No.: 2872S-18
TM-2012-337, Rev. 00

Technical Memo
Summary of RES HAZOP Studies 1,2 and 3 Results

Distribution List

Name	Organisation	Coordinates
Alain Communal	Recyclage ÉcoSolutions Inc.	3700 Francis—Hughes Laval (Québec), H7L 5A9
Arnold Ross	Recyclage ÉcoSolutions Inc.	3700 Francis—Hughes Laval (Québec), H7L 5A9

Approvals

	Name	Signature	Date (YYYY/MM/DD)
Prepared by:	Julie-Ann Barna	J.-A. Barna	2012/05/09
Checked by:	Pierre Carabin		2012/05/09
Approved by:	Rao L		2012/05/09

Revision List

Revision No.	Date	By	Description
00	2012-05-08	Julie-Ann Barna	Initial Release

PyroGenesis Canada Inc., 1744 William Street, Suite 200, Montréal (Québec), H3J 1R4, Canada,
Phone: +1-514-937-0002, Fax: +1-514-937-5757, Email: plasma@pyrogenesis.com

1.0 Summary

Pyrogenesis Canada Inc. (PCI) has successfully conducted internal Hazard and Operability Studies 1, 2 and 3 (HAZOP) for the "Recyclage ÉcoSolutions Inc. (RES) Phase 2 – 50 kghr ODS Destruction Pilot Plant." This document provides a brief summary of this study as they apply to the installation of the system at RES' facility in Laval, QC.

The main hazards identified in HAZOP Study 1, 2 and 3 were those associated with the safe handling of the toxic chemicals generated from the thermal destruction of ozone depleting substances (ODS). PCI has incorporated in its design, safety interlocks and safe shutdown procedures, which ensure the system to remain under negative pressure during operation, thus making the entire system inherently safe. To ensure that the personnel working with the system are not exposed to hazardous levels of toxic chemicals, the following site related design requirements were identified for this installation: proper ventilation, remote operation and gas leak detection for the main process skid. Following detection of any potential gas leaks, necessary alarms will be communicated to the control system so that it can take action and it must also be linked to emergency ventilation for the main process skid room. The RES emergency plan should be updated to include respective alarms and required actions including those responsible. A number of site security items were listed in regard to protecting the integrity of the new installations at the RES facility and the need for RES to ensure there are entry and re-entry controls for the main process skid room during operation, maintenance and in particular following a detected toxic gas leak.

2.0 Scope of the HAZOP Studies

The scope of the HAZOP is the PCI designed, "Recyclage ÉcoSolutions Inc. (RES) Phase 2 – 50 kghr ODS Destruction Pilot Plant", installed at the RES site in Laval, Quebec. This pilot plant process consists of a plasma torch installed in a reactor as well as a gas treatment system and includes the following utilities: a DI water cooling system, steam generator, compressed air, cooling liquid system fitted with an external radiator, MCC and power supply. These systems are installed on a number of skids and assembled on site with interconnecting piping.

The HAZOP also considered that the process is automated i.e., in case of any deviation from normal operation, the system is automated to shut down safely or go into a safe standby mode. To resume operation, an operator intervention is needed. The main process skid room is considered an unmanned room during operation i.e., while ODS is being fed to the system. The pilot plant will be equipped with local E-Stops onsite, however remotely the system can only be stopped with a normal shutdown procedure.

3.0 HAZOP Study Process Description

HAZOP study 1, 2, and 3 were conducted on the system. ***HAZOP study 1*** serves to identify the chemicals (inputs, outputs and intermediates) their associated hazards and processes to be used in the project at the planned site. ***HAZOP study 2*** serves to identify potential hazardous events such as internal and external fires, acute and chronic personal exposure, noise and environmental considerations. Major skids were studied based on their physical installation at the designated site. ***HAZOP study 3*** identifies potential hazards or mishaps using a series of guidewords for deviations that can occur with the said system during start up, operation and shutdown such as: no or none (Ex. no flow), more of (Ex. higher temperature, level or pressure), less of, and potential system failures. Each equipment and process line was studied in detail.

Keeping in mind the control logic, alarms and safety interlocks engineered into the system design by PCI, each potential deviation was examined in the above studies to determine whether any additional preventative/corrective measures (actions) were required to mitigate potential hazards identified in this process. Several actions were generated as a result of these HAZOP studies. These actions were classified into two categories namely, 1) actions to be addressed by PCI and 2) actions to be addressed by RES. Table 1 lists all the actions that were assigned to RES.

4.0 Summary of RES HAZOP Study Results

As a byproduct of the thermal destruction of ODS, two very corrosive gases namely hydrogen chloride (HCl) and hydrogen fluoride (HF) are produced in the reactor. These acid gases are neutralized into innocuous salts and water by the gas treatment section of the system. The pilot plant is designed to operate under negative pressure and hence eliminates the risk of any leak of the gases generated from the system. The entire main process skid which holds the reactor and the gas treatment system is placed in an unmanned area, bounded by fire proof walls and is equipped with proper ventilation.

Overall, the study team agreed that the greatest risk associated with the system is exposure of the personnel to either HCl or HF gases. Both HCl and HF are very toxic and corrosive in nature and have a very low threshold limit values (TLVs) for personal exposure i.e., 5 ppm and 3 ppm respectively. The study team found that safety interlocks engineered into the system mitigated most of the potential hazards. Additional design considerations such as audio and visual alarms were incorporated into the PCI design to further reduce the potential and/or consequence of a given identified hazard throughout the HAZOP. Example: An HCl gas detector, which has a detection limit of 1 ppm, was added to the main process skid to detect a system gas leak. In case of a leak, this detector was programmed to generate an audio visual alarm from the system and the signal is a) “hard wired” to close the CFC feed to the system, which is necessary for the production of these gases, and b) to start emergency ventilation of the process skid room which will exhaust any leaked gases from the process room.

The list of the actions generated during the HAZOP studies that require attention by RES are detailed in Table 1 below:

Table 1 : List of actions to be addressed by RES

No.	Action
1	Provide room ventilation for the main process skid room at all times with adequate air changes.
2	Provide a signal for the control room PLC to confirm main process room ventilation meets minimum flow requirement.
3	Install local gas detection for an oxygen (O_2) concentration in the main process room to ensure oxygen levels are within normal acceptable levels (>19.5%).
4	Provide a signal to the PLC in the control room to start the emergency fan to the exterior of the building and a local visual alarm outside the main process room should the oxygen concentration detection device reach its safety detection limit.
5	Provide personnel with HF exposure treatment cream (2.5% calcium gluconate gel). This HF cream should be available on site during commissioning and operation for personnel entering the main process skid area.
6	Provide containment for the caustic soda line from the caustic tank that will feed the main process skid caustic feed pump so that a line (hose) failure will not spill or splash onto nearby personnel.
7	Ensure spill kits are available on site for any potential spills or leaks of caustic soda, scrubbing solution, before any commissioning of the system begins.
8	Update RES site emergency plan for toxic gas leaks of HCl and HF in addition to potential Argon and CO gas leaks from the system and as well as caustic soda spills.
9	Provide operating personnel with the necessary personnel protective equipment as will be outlined in the safety section of the Operating Manual for the RES Phase 2-50 kg/hr ODS Destruction Pilot Plant.
10	Establish a procedure such as a lockout/tag-out procedure for the main process skid room entry. No entry permitted while CFCs are being processed or detected gas leak or during a power failure. Similarly, process cannot be started while someone is in main process room.
11	Install a sign that indicates there is “No Entry while CFCs are being processed, detected gas leak or power failure” on door of main process skid room
12	During operation i.e., while ODS are being destroyed, no personnel should be allowed to enter the unmanned process skid room. In case of an emergency, such as a small fire or gas leak, the ODS feed should be stopped and only **trained emergency response personnel wearing appropriate personnel protective equipment** such as full face mask, self contained breathing apparatus, appropriate acid resistant coverall, boots and gloves, should enter the process room. Ref. TM-2012-346 Protective equipment in case of HCl/HF gas leak.
13	Provide communication to control room for operation, to communicate emergencies elsewhere in facility and update emergency plan accordingly.
14	Install fire extinguishers in the area outside the main process skid room if they are not already present
16	Given that there is a lot of lift truck traffic near the MCC, install collision protection for MCC cabinets that will be installed for RES Phase 2-50 kg/hr ODS Destruction Pilot Plant
17	Ensure Boiler relief piping interconnection to exterior of building and boiler stack have the recommended protection from snow and rain accumulation as per the required code and protection from damage and nesting of animals and birds at their exits.

18	Provide emergency lighting for the area where manual valves HV-1513 on the DI cooling water skid and HV-1542 on the main fresh water manifold are located since they must be manipulated during a power failure.
19	Implement a procedure to confirm and verify that the type of CFC being fed to the ODS destruction pilot plant matches the CFC destruction program selected by operating personnel.
20	Determine during commissioning phase whether to direct the condensate from the boiler to the RES water treatment or directly to the drain following its analysis.
21	Provide protection from lightning if stacks of the RES Phase 2-50 kg ODS Destruction pilot plant such as boiler blowdown tank vent, relief lines or gas exhaust) are the highest metal (electrically conductive) stacks at the facility.

5.0 Conclusion

Many actions have resulted from HAZOP Study 1, 2 and 3 of the RES Phase 2, 50 kg/hr ODS Destruction Pilot plant, to reduce the potential exposure of personnel working in and around the pilot plant to toxic and corrosive gases generated by the system. The level 3 study, where process lines and system conditions were examined in detail, confirmed that there are sufficient safety devices to maintain the system within its safe operating regime. In general, the engineered controls coupled with the PCI recommended operating procedures, checklists and regular maintenance and inspection of the equipment, will reduce the likelihood of hazardous event. Each event studied either had means or protective measures to prevent them from occurring or reducing their consequences and additional safeties were assigned. HAZOP Study 3 also confirmed that the system will shut down safely even if abandoned during emergency situations. PCI strongly recommends RES to implement all the actions listed Table 1 above.