Demonstration projects for end of Life (EOL) ODS Management/Destruction approved by the Multilateral Fund of the Montreal Protocol – the Colombian case

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Bogota, Colombia
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Man-West Environmental Group Ltd (Canada)
Presentation Scope

- Background and Context.
- Practical nature of the EOL ODS issue and status today.
- EOL ODS environmentally sound management (ESM) steps.
- EOL ODS destruction standards and technology options.
  - MLF EOL ODS mgt. demonstration project experience.
  - Colombian Experience.
  - Summary observations/Moving forward
• The global ODS bank is what is still in productive use (or otherwise secured) that has potential for atmospheric release ("consumption not yet emitted").

• EOL ODS is no longer in productive use and without the prospect thereof (ODS that is now subject to atmospheric release).

• EOL ODS is a “waste” whose default management option results in global environmental damage.

• Essentially a “hazardous waste” requiring environmentally sound management (ESM) but generally without a local environmental/health risk.
ODS BANKS/EOL ODS ISSUE BACKGROUND

• Serious interest in the issue within the MP dates from about 2000

• ESM of the global ODS bank/EOL ODS identified as one of the remaining ozone layer threats to be addressed by the MP.

• Recognition of significant GHG release reduction benefits particularly for CFCs

• Extensive analysis published (TEAP/IPPC -2005/06, TEAP 2009/10, GIZ – 2015-present)

• Capture/destruction of recoverable EOL ODS could accelerate ozone layer recovery and mitigate GHG release.
• Window of opportunity to have major GEB impact at a realistic level of cost effectiveness (CE) is closing
• Large scale capture of EOL ODS is inherently difficult for the largest sources and declining in GEB cost effectiveness
• Investment requirements very high - > US$ 500 million annually.
• Very modest international financial assistance has materialized – MLF (<US$12 million), GEF (<US$400,000)
• MP decisions limited to guidance on destruction technology and performance standards. No direct control measures yet agreed under the MP.
• Originally anticipated carbon finance mechanisms did not materialized – Perhaps viable if integrated into future HFC phase out?
TYPES AND SOURCES OF EOL ODS

• Retained refrigerants
  ➢ CFC-12, HCFC-22, HCFC blends
  ➢ Retiring/discarded domestic & commercial appliances, large refrigeration & A/C equipment

• Blowing agent retained in Foam
  ➢ CFC-11, HCFC-141b, HCFC-22, HCFC-142b
  ➢ Domestic/commercial appliances, building materials, packaging, automotive etc.

• Halons retained in fire protection systems
  ➢ Halon 1211,1301,2402
  ➢ Decommission systems/equipment

• Redundant/obsolete stocks, confiscations
Generally EOL ODS ESM involves a sequential three stage process:
- Capture
- Environmentally sound destruction/transformation
- Validation of its ESM and elimination as an emission

Priority source targets for most countries are:
- Refrigeration/fire protection ODS extracted from equipment
- ODS retained in foam
- Confiscated or expired stocks of ODS chemicals

Different potential mgt. processes between foam and other captured pure ODS chemicals
• Operational Steps
  ➢ Removal of actual ODS from equipment or securing stockpiles (obsolete or confiscations). Decision on future productive use (is it a waste?)
  ➢ Consolidation/analysis/secure storage
  ➢ Transportation
  ➢ Ownership/care and custody/regulatory arrangements
  ➢ Tracking documentation

• Base on existing service infrastructure upgraded for secure storage arrangements and regulatory system
Capture of refrigerants/halons is relatively simple/potentially cost effective in terms of GEB measures (ODP or CO2 Equiv.)

Basic required regulation, expertise, and infrastructure in most countries

Barriers/challenges are:
- Obtaining access to meaningful EOL ODS quantities
- Mandatory emission bans required
- Maintaining secure interim storage
  - Access to cost effective destruction
  - Sustainable financing of the management process

Overall this is where the most value can be obtained
Capture/Processing

• More complicated “dilute” EOL ODS waste stream:
  ➢ Widely distributed/large volume/low weight/mixed ODS
  ➢ Requires separation from equipment
  ➢ Mixed with general waste streams
  ➢ High emission losses during processing

• Low net actual ODS recovery volume for waste volume handled
• Requires significant incremental infrastructure
• Overall high cost/low CE relative to ODP or CO2 Equiv.
• Generally a lower priority EOL ODS except in developed countries where is integrated with other industrial scale resource recovery/waste mgt. systems
EOL ODS MANAGEMENT PROCESS – FOAM

Capture/Processing

• Process Option 1: Removal from equipment/application
  ➢ Bulk foam extraction from equipment/waste diversion (Manual process)
  ➢ Size reduce (significant ODS release)
  ➢ Package for transport/destruction
  ➢ Consolidation/secure interim storage

• Process Option 2: Processing in-situ
  ➢ Integrated material separation systems that involve blowing agent extraction and potential integration with destruction (refrigerator de-manufacturing plants)
  ➢ Direct destruction with metal white goods

• Ownership/care and custody arrangements/tracking/documentation of origin/analysis
EOL ODS Management Process – Destruction

• MP definition: “Permanent transformation or decomposition of all or a significant portion of the controlled substance”.

• MP adopted TEAP requirements applied:
  - Technical/environmental performance standards
  - Code of practice
  - Approved technologies

• Requirements generally track destruction requirements applicable to halogenated HW but in the detail are less stringent and more flexible.
For ODS


http://ozone.unep.org/Assessment_Panels/TEAP/Reports/Other_Task_Force/TEAP02V3b.pdf


2011 TEAP Report (Task Force Report - Pages 65-81)


Decision XXIII-12 on approved ODS destruction technologies


For POPs

Basel Convention POPs Disposal G/L

t.aspx

GEF STAP POPs disposal technology selection G/L (2011)

<table>
<thead>
<tr>
<th>Performance Parameter</th>
<th>TEAP Task Force Report Decision XV/9</th>
<th>Basel Convention G/L (POPs)</th>
<th>GEF STAP G/L for POPs</th>
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</thead>
<tbody>
<tr>
<td>Particulates (mg/Nm³)</td>
<td>50</td>
<td>NR</td>
<td>NR</td>
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<tr>
<td>HCl (mg/Nm³)</td>
<td>100</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>HF (mg/Nm³)</td>
<td>5</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>HBr/Br₂ (mg/Nm³)</td>
<td>5</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>CO (mg/Nm³)</td>
<td>100</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Dioxin/Furan (ng-ITEQ/Nm³)</td>
<td>0.2 (Conc.) 0.5 (Dilute)</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>DE (%)</td>
<td>n/a</td>
<td>99.9999</td>
<td>99.9999</td>
</tr>
<tr>
<td>DRE (%)</td>
<td>99.99 (Conc.) 95.0 (Dilute)</td>
<td>99.9999</td>
<td>99.9999</td>
</tr>
</tbody>
</table>

NR: National Regulation
## Decision XXIII-12 Approved Destruction Processes

<table>
<thead>
<tr>
<th>Technology</th>
<th>Concentrated Sources</th>
<th>Dilute Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1</td>
<td>Group 2</td>
</tr>
<tr>
<td>Argon Plasma Arc</td>
<td>Approved</td>
<td>Approved</td>
</tr>
<tr>
<td>Cement Kilns</td>
<td>Approved</td>
<td>Not Approved</td>
</tr>
<tr>
<td>Chemical Reaction with H₂ and CO₂</td>
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<td>Approved</td>
</tr>
<tr>
<td>Gas Phase Catalytic De-halogenation</td>
<td>Approved</td>
<td>Not Determined</td>
</tr>
<tr>
<td>Gaseous/Fume Oxidation</td>
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</tr>
<tr>
<td>Inductively coupled radio frequency plasma</td>
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<td>Approved</td>
</tr>
<tr>
<td>Liquid Injection Incineration</td>
<td>Approved</td>
<td>Not Determined</td>
</tr>
<tr>
<td>Microwave Plasma</td>
<td>Approved</td>
<td>Not Determined</td>
</tr>
<tr>
<td>Municipal Solid Waste Incineration</td>
<td>Approved</td>
<td>Not Determined</td>
</tr>
<tr>
<td>Nitrogen Plasma Arc</td>
<td>Approved</td>
<td>Not Determined</td>
</tr>
<tr>
<td>Porous Thermal Reactor</td>
<td>Approved</td>
<td>Not Determined</td>
</tr>
<tr>
<td>Portable Plasma Arc</td>
<td>Approved</td>
<td>Not Determined</td>
</tr>
<tr>
<td>Reactor Cracking</td>
<td>Approved</td>
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</tr>
<tr>
<td>Rotary Kiln Incineration</td>
<td>Approved</td>
<td>Approved</td>
</tr>
<tr>
<td>Superheated steam reactor</td>
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<td>Not Determined</td>
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<tr>
<td>Thermal Reaction with Methane</td>
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<td>Approved</td>
</tr>
</tbody>
</table>
Commercial High Temperature Incineration (HTI)

- High DE/DRE >99.99 DE/99.9999 DRE
- Readily available prequalified service providers in developed countries – Caution: Performance variation across facilities.
- Generally well monitored/regulated in developed countries
- Good tracking and validation
- Unit Cost Range US$1.5 – 15.0/kg depending on volumes
- Predominant technology of choice
- Export/import barriers in some regions/countries
- Public acceptance/ENGO opposition issues
Commercial High Temperature Incineration (HTI)
Cement Kilns

• High DE/DRE in theory but difficult to verify
• Limited direct systematic qualification data available
• Qualified operator interest due to small volumes/revenue and product quality issues
• Incremental investment, qualification and associated operating costs
• Option is limited to relatively new/current process facilities achieving BAT/BEP air quality standards which also have a broader halogenated waste market and prequalification
• Costs for an established/qualified facility should be similar to HTI but often higher – US$7/kg quoted in Mexico for CFC-12
• Potentially a good option in absence of HTI access and for foam if sufficient quantities can be regularly supplied
Cement Kilns
Commercial Scale Plasma Arc

- Designed for specialty HW destruction including EOL ODS and POPs
- Modular/transportable (single shipping container)
- Commercial facilities in Australia (4), Mexico (1), Japan (4) and US (1) with proposal in Russia
- High DE >>99.99 (varies with waste and feed rate)
- Low emissions (>0.006 ng/m3 TEQ for PCDD/F)
- Capacities range from 40-80 kg/hr. (250-500 MT/year) for gas and liquid ODS
- Capital Costs - approximately US$2.5-3.0 million w/o infrastructure
- Unit costs quoted in the range of US$5-20/kg. depending on overall plant throughput/market – US$9/kg quoted in Mexico
- Relatively high operating cost/power consumption
- Typically needs another stable waste market to be viable
Commercial Scale Plasma Arc
Small Portable Scale Plasma Arc

- Designed/marketed by ASADA as a small footprint transportable unit but status uncertain, variant reported developed in China
- Reported installations in China and Argentina/Ecuador (neither operational), considered in Uzbekistan/Belarus
- DE >99.99 and emission compliance reported
- Capacities range from 1-2 kg/hr. (3.6-7.2 MT/year)
- Capital Costs - approximately US$150,000 w/o infrastructure cost which are high (electrical, pad etc.)
- High operating costs (US$30-50,000/year) for labor, utilities, service/maintenance and imported consumables
- Unit costs estimated to be > US$25/kg. dependent on refrigerant and throughput
- Overall questionable utility/sustainability
Small Portable Scale Plasma Arc
A few MLF projects prior to 2009 included EOL ODS Mgt.

MLF approved a targeted funding window in 2009 (EXCOM 58/19) and set project eligibility guidelines:

- No funding for collection (existing stockpiles)
- Capped CE of US$13.2/kg ODS (non LVCs)
- Limitations on halons and CTC demonstrations
- Required to address co-financing, sustainability and ODS tracking/destruction validation
- Synergies with other priority chemical disposal (POPs)
- GEF eligibility for CEIT’s accepted in GEF-5 but only pursued in Russia, Belarus, Uzbekistan without success.
MLF Demonstration Program Experience

- 12 national and 2 regional demonstration projects approved – US$11.3 million
- 4 projects completed (Georgia, Ghana, Cuba, Nepal) – Approx. 50 t ODS destroyed
- 10 projects remain under implementation, some well advanced, others progressing slowly, paused or re-starting
- Ecuador, Costa Rica, Trinidad doing projects outside this program
- 8 projects - export to commercial HTI facilities, 3 projects qualifying national commercial HTI or plasma arc facilities, 6 qualifying cement kilns
- General issue of ability to collect sufficient of originally targeted EOL ODS for projects
## Survey of MLF National EOL Demonstration Projects (1)

<table>
<thead>
<tr>
<th>Country</th>
<th>Approval</th>
<th>Grant</th>
<th>IA</th>
<th>Destruction Option</th>
<th>Implementation Status/Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>2014/2014</td>
<td>250,000</td>
<td>UNIDO</td>
<td>Cement kiln</td>
<td>Starting implementation</td>
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<tr>
<td>Brazil</td>
<td>2012/2014</td>
<td>1,490,600</td>
<td>UNDP</td>
<td>National HW facilities – HTI, Plasma Arc Initial parallel development of two de-manufacturing plants</td>
<td>Project restructured to focus on competitive selection of HW disposal facility Implementation restarted</td>
</tr>
<tr>
<td>China</td>
<td>2012/2014</td>
<td>1,227,885</td>
<td>UNIDO</td>
<td>National HW HTI facility for CFCs/HCFC chemical and foam EAF steel furnace/cement kilns for foams Integrated with existing refrigeration servicing system and HW service providers. EPR funding and energy efficiency incentives being phased in to sustain system</td>
<td>Under implementation HTI test burns completed to qualify domestic HTI facility 2016 Trials on refrigerator components containing foam in EAF completed in 2017 Integrated with expanding EPR financed RAC equipment collection - 4 cities Planned Processing of 300,000 refrigerator units involving destruction of 100 t of CFCs</td>
</tr>
<tr>
<td>Cuba</td>
<td>2010/2014</td>
<td>525,500</td>
<td>UNDP</td>
<td>CFC-12 in cement kilns</td>
<td>Complete. Final result unknown</td>
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<tr>
<td>Georgia</td>
<td>2013/2014</td>
<td>55,264</td>
<td>UNDP</td>
<td>Export to EU HTI facilities</td>
<td>Complete - 2.13 t CFC-12 destroyed Export combined with GEF POPs project disposal</td>
</tr>
<tr>
<td>Ghana</td>
<td>2011/2014</td>
<td>198,000</td>
<td>UNDP</td>
<td>Initial intent to purchase ISADA unit (dropped). Export to EU HTI facility</td>
<td>Complete – 2.2 t CFC, 5.2 t MB destroyed Export combined with GEF POPs project disposal</td>
</tr>
<tr>
<td>Country</td>
<td>Approval</td>
<td>MLF Grant</td>
<td>IA</td>
<td>Destruction Option</td>
<td>Implementation Status/Remarks</td>
</tr>
<tr>
<td>---------</td>
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<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Lebanon</td>
<td>2014</td>
<td>123,475</td>
<td>UNIDO</td>
<td>Export to EU HTI facility</td>
<td>Unknown Potential opportunity to combine with POPs project not acted upon</td>
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<tr>
<td>Mexico</td>
<td>2011</td>
<td>927,915</td>
<td>UNIDO</td>
<td>Domestic plasma arc facility and cement kiln</td>
<td>Completing Originally intended for carbon finance based on export</td>
</tr>
<tr>
<td>Mexico</td>
<td>2011</td>
<td>500,000</td>
<td>France</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nepal</td>
<td>2009</td>
<td>157,200</td>
<td>UNEP</td>
<td>Export to HTI facility</td>
<td>Completed – 10 CFC-12 destroyed Qualified under carbon finance mechanism for revenue generation back to country</td>
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<tr>
<td>Nigeria</td>
<td>2012</td>
<td>811,724</td>
<td>UNIDO</td>
<td>Export to HTI facility</td>
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<tr>
<td>Turkey</td>
<td>2012</td>
<td>1,076,250</td>
<td>UNIDO</td>
<td>Initial intent to export to commercial plasma arc facility (potentially qualify national HTI unit in future)</td>
<td>Currently being restructured due to EOL ODS availability and export barriers Potential linkage to GEF POPs project</td>
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<tr>
<td>E. Europe</td>
<td>2013</td>
<td>274,480</td>
<td>UNIDO</td>
<td>Export to HTI facility</td>
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<tr>
<td>E. Europe</td>
<td>2013</td>
<td>75,000</td>
<td>UNEP</td>
<td>Export to HTI facility</td>
<td>No information</td>
</tr>
</tbody>
</table>

**Other MLF Projects Outside the Formal Program**

| Ecuador | 2008     | 500,000   | UNIDO | Initial purchase of ASADA unit but not utilized Now implementing cement kiln option | Continuing implementation                                                                     |
| Trinidad Tobago | 2015 | Unknown | UNDP | ASADA unit initially planned Now pursuing a cement kiln option | Under development                                                                             |
| Costa Rica | 2015 | Unknown | Unknown | Cement kiln                                           | Under development                                                                             |
Colombia MLF Demonstration – Project Design

• Approved in 2012 (MLF -US$1,195,000, C/F – US$1,555,000)
• Approach that integrated EOL ODS Mgt. within the developing overall national special waste management strategy and program (i.e. e-waste, tires, other resource recovery opportunities)
• Availability/qualification of cost effective destruction capability a perquisite for sustainable EOL ODS elimination program
• Pre-selection of destruction technology option involved a technical/commercial feasibility evaluation of export for HTI, possible domestic plasma arc facilities, domestic cement kilns, and domestic commercial HTI facilities)
• Developed private sector partnership network: ANDI, RED VERDE, HW service providers (TECNIAMSA, LITO, OCADE), steel maker (DIACO)
Colombia MLF Demonstration – Project Scope

- Assemble/consolidate EOL ODS for demonstration in partnership with the RAC service sector/special waste managers
- ODS destruction demonstration for CFC-11, CFC-12, CFC-11 foam, HCFC-141b foam in selected domestic HTI rotary kiln HW facility (TECNIAMSA) using confirmed existing EOL ODS stocks
  - Incremental development of EPR program for domestic RAC sector within the national special waste mgt. program for WEEE.
  - Parallel demonstration of using intact cabinets and doors directly fed to EAF steel making furnace (added as separately financed component)
- ODS destruction from developing EPR program on early retirement of initial 300,000 domestic/commercial units
  - Technical assistance/public awareness
Colombia MLF Demonstration – Components

- Assembled: 8 t CFC-11, 2 t CFC-12, 6 t CFC-11 foam, 6 t HCFC-141b foam.
- TECNIAMSA facility infrastructure upgrading investment.
- Test burns undertaken at TECNIAMSA Mosquera Plant in 3 stages - 2014 program, 2015 short program (optimize feed rates/calibrate emission monitoring systems) and 2016 program under optimized conditions.
- 2017 trials on using intact refrigerator cabinets/doors with foam directly fed to EAF steel making furnace (added as separately financed component).
- 2014-Present development of ANDI/Red Verde EPR program for domestic RAC sector.
- 2018-19 processing of up to 300,000 domestic/commercial units from ANDI/Red Verde program – Up to 100 t ODP destroyed.
- Planned transition to universal EPR nationally financed system – potentially supported under NAMA and potentially other international initiatives.
## Colombia HTI Trial Burn Program – Scope/Cost (US$)

<table>
<thead>
<tr>
<th>Cost Component</th>
<th>MLF Funds</th>
<th>Co-financing*</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly/consolidation of EOL ODS</td>
<td>200,000</td>
<td>50,000</td>
<td>150,000</td>
</tr>
<tr>
<td>Trail burn project management/technical support/Audit</td>
<td>75,000</td>
<td>20,000</td>
<td>80,000</td>
</tr>
<tr>
<td>Facility modifications</td>
<td>30,000</td>
<td>60,000</td>
<td>90,000</td>
</tr>
<tr>
<td>Sampling/Analytical Costs</td>
<td>280,000</td>
<td>-</td>
<td>280,000</td>
</tr>
<tr>
<td>Total</td>
<td>585,000</td>
<td>130,000</td>
<td>700,000</td>
</tr>
</tbody>
</table>

* Estimated/Excluding lost opportunity costs due to interruption in commercial operation
TECNIAAMSA HTI ODS Test Burn Program Design

- Determine technical/environmental performance for destruction of CFC-11, CFC-12, CFC-11 foam, HCFC-141b foam co-disposed commercial HW referenced against MP/TEAP & national regulations.
- Selected baseline (B/L) - hydrocarbon sludge.
- Detailed analytical characterization of B/L and each ODS waste.
- Dedicated liquid (CFC-11) and gas (CFC-12) feed systems with automated flow control and instrumentation, weighted foam fed in bulk bins along with B/L.
- Test sequence: B/L → B/L+Foam → B/L+CFC-11 → B/L+CFC-12
- 72 hr. minimum per test run with three 10-12 hr. sampling periods per test run.
- ODS feed based on total fixing chlorine/fluorine %
- Direct periodic analysis feed, stack emissions, and solid residuals all per international standard test burn/sampling/analysis protocols plus continuous digital record of feed rates, operating conditions, stack emissions.
Colombia HTI Trial Burn Program – EOL ODS Feed system
Colombia HTI Trial Burn Program – EOL ODS Feed System/HTI Unit
Colombia HTI Trial Burn Program – Emission/Release Sampling
### HTI EOL ODS Test Burn Program - Results 2014

<table>
<thead>
<tr>
<th>Test Run Material</th>
<th>Feed Rate (kg/Hr)</th>
<th>Chlorine (%)</th>
<th>Fluorine (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B/L</td>
<td>ODS</td>
<td></td>
</tr>
<tr>
<td>Base Line HC Sludge</td>
<td>800</td>
<td>-</td>
<td>0.02</td>
</tr>
<tr>
<td>HCFC-141b Foam</td>
<td>720</td>
<td>80</td>
<td>0.62</td>
</tr>
<tr>
<td>CFC-11</td>
<td>787 (18 l/hr)</td>
<td>26</td>
<td>2.62</td>
</tr>
<tr>
<td>CFC-12</td>
<td>774 (3.3 m3/hr)</td>
<td>16.8</td>
<td>1.22</td>
</tr>
</tbody>
</table>
2014 Test Burn Program - Conclusions/Lessons

• At relatively high feed rates and Cl/Fl content meets MP/TEAP for ODS destruction (DRE) and PCDD/F emissions.
• Exceeds MP/TEAP requirements for particulate, HCl, HF.
• Exceeds National Regulations for particulate, mercury, HCl, HF and marginal in some cases for PCDD/F and DRE.
• Particulate unrelated to ODS and linked to an unexpected equipment failure.
• Mercury associated with prior commercial waste stream residual effects.
• Optimization required for CEMS monitoring calibration and APC systems particularly for particulate/PCDD/F capture.
• General conclusion that ODS destruction feasible but will require reduced feed rates to address HCl and HF emission compliance.
2015 Short Test Burn Program

- Intended to optimize feed rates and test operational/equipment modifications.
- CFC-11 was used in a series of five 2 hour test runs where feed rates were increased incrementally based on calculated Cl content levels of 0.25%, 0.50%, 0.75%, 1.00% and 1.25%
- HCl and HF measured using the newly calibrated CEMS.
- Results indicated HCl and HF compliance with both MP/TEAP and Resolution 909 achieved to 0.75% Cl after which emissions increased rapidly.
- It was concluded that 0.75% Cl is a limiting feed parameter for EOL ODS.
<table>
<thead>
<tr>
<th>Test Run Material</th>
<th>Feed Rate (kg/Hr)</th>
<th>Chlorine (%)</th>
<th>Fluorine (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Line HC Sludge</td>
<td>720</td>
<td>0.02</td>
<td>-</td>
</tr>
<tr>
<td>CFC-11 Foam</td>
<td>720 75</td>
<td>0.17</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>CFC-11</td>
<td>787 4.9 (3.3 l/hr)</td>
<td>0.54</td>
<td>0.10</td>
</tr>
<tr>
<td>CFC-12</td>
<td>774 3.2 (0.63 m3/hr)</td>
<td>0.18</td>
<td>0.10</td>
</tr>
</tbody>
</table>
2016 Test Burn Program - Conclusions/Lessons

• At modest feed rates and Cl/Fl content meets MP/TEAP.
• Possibility of exceeding National Regulations in some cases likely related to B/L rather than ODS.
• TECNIAMSA facility is qualified for ODS destruction with a limit on feed rates.
• Improved B/L waste QA/QC and consideration of further APC upgrades for PCDD/F reduction recommended (both being implemented).
• Main issue may be low productivity for ODS destruction associated with long term destruction program of large quantities.
• Estimated capacity in the range of 25 – 50 t/year of EOL ODS chemical in a single unit (up to three units could be available).
Significance of HTI Qualification to EOL ODS

- MP compliant, technically qualified capability available to developing national EPR system for EOL ODS Mgt.
- Utilization remains subject to any pending national approvals (national legislation and environmental licenses modifications).
- Productivity limitations can be addressed by qualification of multiple units and technology upgrades to increase Cl and Fl content limitations.
- Indicative commercial costs competitive within alternatives for ODS chemicals (range of US$6-6.5/kg) with future application to HFC Mgt.
- Economic/GEB cost effectiveness for dilute ODS waste (foam) may require further analysis.
- Qualification process may be most rigorous undertaken globally at least for this technology and potentially has replication value.
General Concluding Remarks on EOL ODS Mgt.

- Importance of mainstreaming EOL ODS Mgt. into implementation of overall integrated/life cycle waste management approach.
- Only sustainable if robust financial mechanisms developed and implemented – mandatory EPR and/or carbon finance schemes.
- Capacity will develop incrementally as a real waste stream to be managed appears.
- Need to include future legacy chemicals (i.e. HFC) in planning.
- Approach to destruction/elimination needs to be pragmatic in terms of performance standards applied – particular for dilute waste streams – Waiting for perfection has negative GEB impacts.
Final Observation

Colombia, the Ministry and particularly UTO deserve our appreciation and thanks for their vision, persistence and commitment for what may be the most comprehensive and significant project in the MLF program.