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December 15, 2009

FROM: Jeff Cohen  
 VP, Science & Policy

TO: Tim Kidman  
 Climate Action Reserve

Dear Tim:

EOS Climate submitted its Methodology for Destruction of Ozone Depleting Substances (ODS) to the Climate Action Reserve (CAR) and to the Voluntary Carbon Standard in December 2008. We developed that methodology to jumpstart the voluntary and ultimately the compliance carbon markets to address the ongoing threat that ODS banks pose to the climate system and to the stratospheric ozone layer. Our methodology was peer reviewed and determined to be in adherence to ISO 14064-2; our decision to submit it to CAR as a starting point was based on the belief that CAR would provide the most transparent and extensive process for development of a technically sound protocol. We are hopeful that this public review will yield the most credible standard possible that insures GHG credits of the highest quality.

We are developing projects that are both creating incentives for collection and destruction of ODS refrigerants and foam blowing agents. Our primary concern is that a number of the provisions in the current draft for domestic projects related to foam destruction, or separation and destruction of ODS blowing agents from foam, are not technically justified and impractical. Foam represents the largest portion of US and global ODS banks. A fair incentive is needed to collect foam from the many, scattered, and relatively small individual sources, and then to extract and destroy the ODS. Under the draft provisions, projects that would otherwise promote the most environmentally responsible practices for disposal of appliances would become cost prohibitive. The protocol as drafted would have the unintended outcome of promoting business as usual practices in the U.S. -- shredding and landfilling appliance foam, or separation of blowing agent from foam and sale back into secondary refrigerant markets. This would represent a significant missed opportunity to address the largest remaining "bank" of ODSs.

Our specific comments on both foam and refrigerant methodologies in the Version 1.0 public draft Project Protocols for Destruction of Domestic and for Imported Ozone-Depleting Substances are provided below.

### **Draft Domestic Protocol**

#### Section 2.2, page 5, 3<sup>rd</sup> paragraph

The third sentence should be revised to include the underlined:

“Non-RCRA permitted facilities cannot receive and destroy ODS materials that are classified as hazardous waste, and must demonstrate compliance the Title VI

requirements of the CAA for destruction of ODS, as well as demonstrate destruction and removal efficiency of 99.99% and emission levels consistent with the guidelines set forth in the aforementioned TEAP report.”

Section 2.3.1, page 6, 2<sup>nd</sup> paragraph

We disagree with the proposed decision that “ODS extracted from a foam source for use in refrigeration equipment is not considered part of (the refrigerant) source category.”

In the U.S., there are facilities that separate ODS blowing agent, specifically CFC-11, from insulation foam. Those facilities are able to sell the CFC-11 to refrigerant reclaimers for its re-use in older refrigeration and air conditioning equipment.

Because of the significant reductions the draft Protocol would impose on foam destruction projects, the proposed decision noted above would have two outcomes:

- 1) Facilities will continue to separate CFC-11 from insulation foam but rather than pay for its destruction, they would sell the CFC-11 to meet demand to service older refrigeration and air conditioning equipment.
- 2) Facilities that are planning to deploy systems to separate ODS blowing agents from foam will abandon that technology, and simply continue the normal practice of shredding and landfilling foam.

Both of these outcomes will increase GHG emissions that could otherwise be prevented, discourage implementation of innovative technologies, and would represent an unfortunate, perverse consequence of the CAR Protocol. We strongly believe this decision should be carefully considered before final submission to your Board.

Section 2.3.2, page 6

HCFC-22 and HCFC-142b should be added to the eligible blowing agents. Use of HCFC-142b for foam applications was banned in the U.S. as of 2008; production of HCFC-142b for any other use will end in the U.S. on January 1, 2010. Similarly, production of HCFC-22 for any application, other than for servicing existing equipment (i.e., refrigeration and air conditioning, not foam manufacture) will end in the U.S. on January 1, 2010.

1<sup>st</sup> bullet: The requirement to extract ODS blowing agent from foam to a “liquid form” prior to destruction would certainly apply to CFC-11. However, CFC-12 in extruded polystyrene foam would be extracted in gaseous state. We recommend either not specifying what form the blowing agent needs to be extracted in, or require that the blowing agent be extracted in a “concentrated form”.

Section 3.4.1, page 9, 2<sup>nd</sup> Paragraph

We suggest further clarification around the statement that “Any project which seeks HFC allowances under this program (should the [American Clean Energy and Security Act] legislation become law), or under any other current or future regulations or regulatory programs, will be ineligible according to this protocol.”

We understand that CRTs could not be issued for a project where ODS destruction is being used to generate HFC allowances. However, it is possible that future climate legislation or regulatory programs would recognize ODS destruction as an eligible GHG offset. In that event, we would hope that the relevant regulatory agency(ies) would have the discretion to adopt the CAR protocol(s) as appropriate.

Section 5.1.1, page 19, 1<sup>st</sup> paragraph

The protocol defines the baseline scenario for ODS refrigerants as “recovery and resale of ODS into the secondary market to recharge existing equipment.”

This certainly applies to equipment at the end-of-life (or at least should be under federal requirements). However, the baseline scenario for projects where ODS is recovered from operating equipment is continued use of that ODS in that equipment. There are tens of thousands of functional refrigeration and air conditioning systems in the U.S. that continue to leak and continue to be “topped off”. Under the protocol’s baseline scenario, a project that provides an incentive for the early retirement of such systems are likely not realizing the full GHG reduction credit. This will not only discourage worthwhile projects but it creates two inconsistencies within the protocol relative to foam projects.

CAR’s presumed rationale for preferring “default” values for refrigerant projects – to allow for “homogenous”, standardized system and project reviews – contrasts with the approach proposed for foam projects where project developers would be required to analyze hundreds or even thousands of individual foam samples. The degree of variability in blowing agent content of foam is far less than the degree of variability in refrigerant leak rates. We believe that the protocol should provide discretion to project developers and the owners/operators of operating refrigeration and air conditioning equipment, that can clearly demonstrate they are retiring the equipment as part of a project, the ability to present leak rate data specific to that equipment.

In addition, the assumption that all refrigerant destroyed would be first reclaimed and sold into the secondary market – as opposed to being continuously used in operating equipment - is inconsistent with the baseline assumed for projects where ODS blowing agent is extracted from insulation foam. Ironically, for those projects where the extracted ODS can be sold into the secondary market to recharge existing equipment, the protocol instead assumes that the ODS blowing agent will be disposed of, still entrained in the foam, even though the actual baseline would unfortunately be, separation and re-sale.

Table 5.2, page 20

The “percent of remaining foam blowing agent released during anaerobic conditions” (Column C) and the “percent of released foam blowing agent degraded in anaerobic landfill conditions” in Column D, appear to have typographical errors.

The corresponding values from Scheutz et al. (2007) would be:

	Release Rate (Column C)	Degradation Rate (Column D)
CFC-12	52%	60%
HCFC-141b	41%	48%

These parameters are derived from models and well-conducted laboratory studies that were designed to evaluate the potential for, and simulate, landfill degradation of blowing agents. The authors of these studies explicitly stated that their calculations do not represent actual field conditions in real-world landfills. We believe that reliance on these data to quantify GHG emission reductions is not appropriate, and ignores a large degree of uncertainty in the underlying studies.

### Column C

The release rates (Column C) were calculated using a modified version of a spreadsheet model (Model for Organic Chemicals in Landfills, or MOCLA), developed by Kjeldsen and Christiansen (2001) and a diffusion coefficient for CFC-11 calculated in the same paper. The model assumes:

- The blowing agent will be in equilibrium with the landfill waste components
- Continuous release of blowing agent into the pore air space of landfilled waste
- Fully mixed conditions exist
- Concentrations of the blowing agent in aqueous (leachate), gaseous (pore space), and sorbed (solid waste) are uniform

The diffusion coefficient, a measure that represents the movement of blowing agent out of the foam, was calculated by Kjeldsen and Christiansen (2001) based on short-term laboratory experiments of shredded foam, and on model simulations of long-term releases. The laboratory experiments involved:

- Compression of foam cubes (2 cm<sup>3</sup>) by a 30 ton press to measure the “distribution factor” which is used in the MOCLA model to calculate release rates
- Foam sample cubes placed in glass jars to measure the amount of CFC-11 that is off-gassed; as the authors noted, the available CFC fraction in the open pores of the sample cubes was unknown and had to be “fitted” using a “spreadsheet solution”, which is another model. The authors noted that the equation in that model is only valid for experiments using a single foam cube.
- An “infinite bath” experiment in which the CFC content in foam cubes was measured over 50 days.

The fitted diffusion rate coefficients that were obtained from the short-term experiments were between 100 and 10,000 times higher than values obtained in other experiments of intact polyurethane foam without open pores. A lower diffusion rate from intact foam is to be expected, but what is striking is the degree of variability across these data, which indicates significant uncertainty in applying these laboratory-derived values to quantify the baseline scenario for this protocol.

The authors stated that the variability in the results “clearly shows that there is a need for systematic research determining diffusion coefficient (sic) for different foam products and different measuring techniques in order to evaluate if the observed differences in diffusion coefficients truly reflect differences in foam properties or merely are due to experimental artifacts using different measuring techniques” (Kjeldsen and Jensen, 2001).

The release rates in Table 5.2 of the protocol are based on the diffusion coefficients calculated using the Kjeldsen and Jensen (2001) modeling, as cited in Scheutz et al. (2007). Scheutz et al. presented 10-fold larger diffusion coefficients in their Table 3 as part of a sensitivity analysis. However, given the uncertainty cited by the authors in their earlier paper, we believe it would

have been more appropriate to more fully bound the diffusion coefficients (D), e.g., using  $1/10D$  in addition to D and  $10D$ .

### Column D

The degradation factors in Column D of Table 5.2 also fail to reflect significant uncertainty in the underlying database. Scheutz et al. (2007) exposed ODS blowing agent – both in pure form and in pieces of foam – to different types of organic waste in glass bottles kept under anaerobic conditions. The organic wastes were inoculated with anaerobic digester sludge. The model calculations of the degradation coefficients assume constant levels of organic content, and fully mixed, continuously maintained anaerobic conditions.

The authors recognize those ideal assumptions do not simulate conditions in actual landfills, with different degrees of compaction, moisture, and nutrients:

“The evaluation by using the model MOCLA-FOAM clearly indicates that the emission of BAs disposed of at landfills in foam insulation waste may be attenuated by microbial degradation reactions. However, to which extent the BAs are being attenuated depends especially on how fast a degradation can be obtained under real landfill conditions and also on the release rate of BA from the foam waste. For the current disposal of foam waste in landfills it is difficult to predict the fate of the released BA.”

The same researchers previously stated that:

Due to the very volatile nature of CFC-11, a substantial fraction of released CFC will be found in the air pore space of the landfilled waste and will be emitted with the biogas produced in the landfill (Kjeldsen, P.; Christensen, T. H. In *Sardinia '97 Sixth International Landfill Symposium*; Christensen, T. H., Cossu, R., Stegmann, R., Eds.; CISA Environmental Sanitary Engineering Centre: Cagliari, Italy, 1997; Vol. I, pp 195-206).

Kjeldsen and Jensen (2001) also noted that:

“Numerous measurements of the CFC-11 concentrations in landfill gas have shown concentrations in the range of 20-220 mg m<sup>-3</sup>” (Rettenberger, G.; Stegmann, R. In *Landfilling of Waste: Biogas*; Christensen, T. H., Cossu, R., Stegmann, R., Eds.; E & FNSpon: London, GB, 1996; pp 51-58).

Given the limited data, and the multiple uncertainties in terms of accessibility and conditions needed for soil microbes to digest blowing agent in partially shredded foam, the EPA has previously assumed conservatively that 50% of remaining blowing agent in shredded foam is degraded by landfill microbes.

EPA’s analysis was based on a 2006 ICF report:

"In cases where appliances are shredded and landfilled, this analysis assumes that in the landfill, under anaerobic conditions, some of the CFC-11 blowing agent dechlorinates to HCFC-21 and HCFC-31 (Kjeldsen 2006). Specifically, this analysis assumes that 22 percent of the remaining (post-production) charge at end-of-life is broken down in the landfill as a result of anaerobic degradation (Ashford 2006). The ODS and GHG impacts of the breakdown products are not analyzed in this report. The remaining 78 percent of the charge at end-of-life is assumed to be released during the shredding process and over time from the landfill where the shredded foam is disposed."

The experiments by Scheutz et al. confirm the ability of specific soil microbes under ideal laboratory conditions to digest ODS blowing agents. However, the results are limited to the specific conditions in the lab and should not be extrapolated to quantify actual degradation rates in the real world. We believe that given the limited data and the uncertainties, the most conservative approach would be to assume that 50% of the blowing agent in landfilled foam is degraded, and the remainder released to the atmosphere.

Section 5.2.1, page 22, Last Paragraph

The protocol states “The use of site specific substitute parameters (refrigerant, GWP, and leak rate) are not permitted”.

This position is presumably based on the belief that CAR could not review this information on a case-by-case basis and that there is no reliable way to demonstrate what the substitute emissions would be for a given project.

The EOS methodology does allow for project-specific data to be collected as a way to incentivize adoption of advanced technologies that have lower refrigerant charges, lower GWPs, and/or lower leak rates compared to “default” values. We would encourage CAR to allow for this flexibility, while putting the burden on project developers to fully document the basis for the improvements that would allow verifiers and CAR to routinely review the projects in a standardized format. Without this flexibility, the protocol is failing to provide incentives for additional and verifiable GHG reductions.

Equation 5.7, page 23

The protocol specifies that foam separation must be done in a manner that achieves at least a 90% recovery and destruction efficiency, but the equation assumes as a default that all projects will not exceed greater than 90% recovery and destruction efficiency. We believe that there are technologies and practices that can achieve significantly more than 90% recovery, and therefore the protocol should allow projects to demonstrate and document their recovery rates with empirical data.

The comments at the December 7 public meeting that manual disassembly releases excessive blowing agent is apparently based on an unpublished study involving 9 refrigerators, with questionable sampling and weighing procedures. As discussed during workgroup review, based on studies by the Japanese Technical Committee on Construction Materials (JTCCM, 2004) and the Kjeldsen et al studies, the 2005 TEAP Foam End-of-Life Report concluded that "less than 5%" of the blowing agent is released upon manual separation of foam from appliances and recommended manual disassembly for appliances to minimize emissions.

Section 6.2, page 27

We support the proposed requirements to identify point of origin – inability to identify the origin of ODS, especially large quantities, would create excessive uncertainty for project developers, verifiers, and increase the risk of duplicative projects, or those that involve illegally obtained materials, or ODS that was required to be destroyed.

Section 6.4, page 29, 1<sup>st</sup> bullet

Bullet 1a: As noted above, CFC-12 in extruded polystyrene foam would be extracted in gaseous state. We recommend either not specifying what form the blowing agent needs to be extracted in, or require that the blowing agent be extracted in a “concentrated form”.

Bullet 1d: We recommend adding the requirement that destruction of the foam or the ODS separated from the foam must be certified by a facility that meets the criteria established by the 2002 TEAP Task Force on Destruction Technologies.

Section 6.4, Page 29

Bullet 2c: We recommend that the percentage of foam pieces that must be larger than 100 cubic inches be lowered from 90% to 70% to account for older appliances where it is difficult to remove large foam pieces. Many old appliances contain wiring and coils that run through the foam, which prevents the removal of foam in such large pieces. As discussed during workgroup review, having a minimum requirement that 90% of foam pieces be greater than 50 cubic inches would be appropriate.

Bullet 2d: Because the ODS content in foam is relatively constant in older appliances, requiring that foam be separated according to year of manufacture will provide an unnecessary burden on the appliance foam recovery process. Separation according to ODS species would be sufficient.

Bullet 2e: Rather than requiring containers to be “hermetically” sealed, it would be equally effective to require that the containers be sealed so as to be air and water tight.

Section 6.5.1, page 30, bullet #1

Footnote #30 specifies where the project developer is the destruction facility itself, a 3rd party should take samples. We recommend that similarly, if the project developer is, or operates an ARI-certified laboratory, that a different ARI-certified lab not affiliated with the project developer must be employed to take and analyze the samples.

Section 6.5.1, page 30, last two paragraphs

The definition of a “non-mixed” ODS as greater than 99% composition of a single ODS species will require virtually any large, “non-packaged” container of recovered refrigerants to be sampled according to the requirements for mixed ODS. This will add significant costs and delays to the majority of projects, and ultimately will make a number of projects economically unviable. We understand the need to ensure precision, especially for mixtures of multiple refrigerants. However, defining mixtures as anything less than 99% is overly restrictive. We recommend using a lower threshold of 90%.

We also recommend adding a size limit such that only containers greater than 0.5 tons capacity, for example, would be subject to mixed refrigerant analysis. Smaller containers will typically be fully mixed in the course of transport and as long as the sampling is documented to be done within a few hours of delivery, there should be sufficient assurance.

Similarly, we recommend that larger containers that can be demonstrated not to have baffles or other internal obstructions that would impede mixing also not be subject to the mixed ODS

analytical requirements. Our understanding is that a large proportion of iso-tanks that hold liquid refrigerants do not contain baffles. We do not see any data or other technical rationale to require pumping out the contents of such tanks into separate holding tanks for recirculation, if their contents are mixed freely in the course of transportation.

### Section 6.6.3, page 31

The requirement for each project involving destruction of foam to analyze the blowing agent content of the foam may be appropriate for building foam, which will involve large volumes of materials that can be aggregated. However, the burden of analysing potentially thousands of samples would make foam projects involving manual separation and destruction of intact foam economically unviable. This would result in unnecessary and preventable emissions.

The 2005 TEAP Foam End-of-Life Report addressed this issue. Based on studies by the Japanese Technical Committee on Construction Materials (JTCCM, 2004) and the Kjeldsen et al studies noted previously, the TEAP Task Force concluded that "less than 5%" of the blowing agent is released upon manual separation of foam from appliances and recommended manual disassembly for appliances to minimize emissions.

The proposed requirement is presumably based on the belief that there is significant variability across appliances in terms of the blowing agent content of foam. However, there are a relatively small number of actual manufacturers with relatively little variability in terms of design and dimensions of the units. More importantly, the CFC-11 based foam that was used was manufactured using similar chemistries and processes according to standardized safety, performance and environmental requirements.

This consistency is apparent in the data.

Scheutz et al (2007) collected and analysed blowing agents in foam panels from 8 refrigerator units, and found total blowing agent contents of 13-15.7% w/w (average of 14.9%). The investigators attributed this higher range compared to other studies to the fact that they, unlike other studies, measured blowing agent that was lost when cutting out the foam sample for analysis. This is consistent with prior studies by the same investigators (Kjeldsen and Scheutz, 2003) who found the total initial foam content of CFC-11 extracted from refrigerators manufactured prior to 1993 was 13.3% w/w. Kjeldsen and Jensen (2001), discussed previously, analyzed foam in four refrigerators and found a CFC-11 content between 11.4 and 14.5%.

According to Quality Assurance and Test Specifications issued by the RAL Institute, the German government/industry standard certification organization, and the RAL "Quality Assurance Association for the Demanufacture of Refrigeration Equipment Containing CFCs", there are 85 grams of CFC-11 contained in every kilogram of appliance insulation foam. This is consistent with the lower bound estimate from The UNEP TEAP May 2005 Report of the Task Force on End of Life Issues estimates there are approximately between 400 and 600 grams (0.88 and 1.32 pounds) of CFC-11 contained in a typical refrigerator (with an average of 10 pounds of foam per unit), i.e., a ratio of 0.088 to 0.132.

An AD Little study of rigid urethane foam in different applications found the CFC-11 content of household refrigerators was 8.7%. (Little A. D.: Inc, 1980, U.S. emissions of CFC-11 from rigid plastic foams. Final report on contract FC-79-275. CMA).

Between August 14<sup>th</sup> 2008 and May 6, 2009, refrigerators and refrigerator/freezers were collected and demanufactured by Ecosolutions Recycling and JACO Environmental Services as part of Quebec’s utility energy efficiency program (JACO, 2009, attached). In that time, 40,362 residential refrigerators were collected and demanufactured using SEG stage 2 technology where the refrigerator carcass is shredded in a chamber that separates all metals, plastics, and insulation foam. The insulation foam was milled and the CFC-11 content recovered in a negative-pressure chamber and collected in cylinders. Foam from all of these units was weighed; an analysis of CFC-11 content was done on foam from 40,044 of the units. The units manufactured before 1996 with polyurethane foam insulation contained an average of 12.66 lbs foam, with 0.083 lbs of CFC-11 per pound of foam.

The available data provide a relatively consistent range for CFC-11 content in appliance foam. We recommend that CAR include, as is being done throughout the protocol, a conservative default value for the mass ratio of ODS blowing agent in appliance foam. The low end of the range of available data is 0.083-0.085 lbs of CFC-11 per pound of foam. Provided that the project developer demonstrates that the foam is properly removed, stored, and transported to a certified destruction, use of this default value will ensure a technically sound and conservative quantification of GHG reductions.

We also recommend that the protocol retain flexibility for a project developer to collect, document, and use data on ODS blowing agent content from the appliances in their specific project. The analytical requirements in the draft protocol however, should be revised so as to allow greater aggregation of the foam that is sampled and eliminate the need to take duplicate samples from every container of foam.

Tables D-4 and D-6, pages 68-69

The HFC blends R-404a and R-410a are substitutes for R-22 but not for CFCs, and should therefore not be included in the calculation of replacement leak rates.

Section 8.5 Table 8.2 pg. 41

Within an individual project, appliance foam extraction and separation may take place across 15 or more sites nationwide. The requirement that all foam extraction / separation sites be visited on a per-project basis will be cost and time prohibitive. We strongly recommend allowing the verifiers to determine the number of site visits where there are multiple facilities controlled by the same company, using the same technology, the same training procedures, etc.

### **Draft Imports Protocol**

Section 2.2, 1<sup>st</sup> paragraph, page 4.

A project is defined as destruction of “eligible imported ODS at a single destruction facility over a 12-month period”. We suggest that CAR provide flexibility for combining individual destruction activities that include both imported and “domestic” ODS under a single project. There may be cases where a project developer will have both imported and “domestic” ODS destroyed at a given facility over a 12-month period, and the imported quantities may be significantly smaller than the domestic (or vice versa). The separate materials would not be physically aggregated, and the monitoring and verification would be kept separate. However,

allowing flexibility to combine separate import and domestic projects would eliminate potentially significant delays and transactional costs that would otherwise jeopardize the viability of projects.

Table 5.1, Page 14

Clarification needed that the applicable emission rates are annual rates that would be used to calculate 10-year cumulative emissions for the baseline scenarios (as in Equation 5.3).

Section 5.2.1, last paragraph, page 15

The conservative assumption that destroyed ODS refrigerants are replaced by HFC-134a appears to have been chosen because of a lack of data on market share of alternatives across different end-uses. While this is a reasonable assumption for motor vehicle air conditioning, for other applications such as commercial refrigeration and commercial and residential air conditioning, other alternatives with lower GWPs including HCFC-22, HCFC-123, hydrocarbons, and carbon dioxide are in wide use as documented in the 2006 Report of the Refrigeration, Air Conditioning, and Heat Pumps Technical Options Committee.

Equation 5.5, page 16

The assumption that HFC-134a leaks at the same rate as CFC refrigerants is not consistent with the data for U.S. equipment and with the available technical literature for developing countries. For example, Table 5-1 of the 2006 RTOC Report estimates that for Article 5 countries, refrigerant leak rates for industrial refrigeration were 24.2% for CFCs and 13.7% for HFCs.

Section 6.4.1, page 23

As noted for the domestic protocol, the definition of a “mixed” ODS as any material containing less than 99% of a single ODS will impose significant logistical and cost constraints on projects, with little if any benefit in terms of accuracy. We recommend that mixed ODS be defined as less than 90% composition of a single ODS, and that only containers with internal obstructions be required to pump out and recirculate the ODS before sampling.