Multilateral Fund
for the Implementation of the Montreal Protocol

OBJECTIVE

To demonstrate the use of supercritical CO_2 for spray applications of rigid polyurethane foam (polyurethane (PUR) and polyisocyanurate (PIR)), and to disseminate the technology to interested systems houses in Colombia and other Latin American countries

DEMONSTRATION OF SUPER-CRITICAL CO_2 IN SPRAY POLYURETHANE FOAM

Project title	Demonstration project to validate the use of super-critical CO_2 in the manufacture of sprayed polyurethane rigid foam
Country	Colombia
Agency	Japan/UNDP
Sector	Foam
Subsector/application	Spray foam
Enterprise/ systems house	Espumlatex
Baseline technology	HCFC-141b
Alternative technology	Super-critical CO_2
GWP (alternative technology)	Negligible
Potential safety issues	Non-flammable
ODS phase-out (mt)	0
ODS phase-out (ODP tonnes)	0

DESCRIPTION

Super-critical CO_2 technology is a patented technology owned by Achilles Corporation and applied in Japan since 2004. The project evaluated the technology in an Article 5 country. The demonstration, foam application and testing activities took place at Espumlatex, the largest locally owned PU systems house in Colombia. The technical assessment included issues related to:

- Processability (e.g. ease of application, required modifications to the conventional equipment)
- Foam physical properties (reactivity, foam core density, thermal conductivity, compression strength, adhesion strength, water vapour permeability, water absorption, close cell content, dimensional stability, aging and fire performance).

Three qualitative factors were considered in the assessment: the technology, the foaming location and the foam density. Accordingly:

- Supercritical CO_2-based foams were produced and compared against local, commercialised HCFC-141b-based formulations differing in water content and density;
- Production and testing took place in two locations differing in altitude, temperature and relative humidity (Barranquilla and Bogota).

RESULTS

Health, safety, environment: Super-critical CO_2 technology is a non-flammable, zero-ODP and low-GWP technology. Compared to HCFC-141b-based technology it does not create any incremental industrial hygiene and safety hazard.

Processability: In tropical weather and at various levels of altitude over sea level, super-critical CO_2 showed a similar processability to the standard HCFC -141b-based system currently used. Polyol and isocyanate components of both technologies were stable during the six months of project duration.

Foam physical properties:

- On PUR foam, compared to HCFC-141b-based formulations super-critical CO_2 showed: higher thermal conductivity but better aging; similar aging behaviour in compressive strength; similar dimensional stability performance at -20 ºC and improved dimensional stability at 60 ºC and 96% RH; similar adhesion strength to galvanised steel.
- On PIR foam, compared to HCFC-141b-based formulations super-critical CO_2 showed the same performance pattern as PUR, except for dimensional stability at 60 ºC and 96% RH. While it was similar in absolute values, the behaviour was totally different: super-critical CO_2 experienced a negative change in volume while the HCFC -141b formulation had a positive one. Super-critical CO_2 also showed lower adhesion strength to galvanised steel.

According to fire performance test ASTM E84-12c, run on just one sample per formulation, the PIR and PUR foams based on super-critical CO_2 would be classified as A and B respectively (NFPA).

Results of the super-critical CO_2 foam assessment compared to HCFC-141b foam

Category assessed	Results of super-critical CO_2 foam compared to HCFC-141b foam	
Processability under different temperature, altitude and humidity conditions	- Similar. Polyol and isocyanate components of both technologies were stable during the six months of project duration - It does not create any incremental industrial hygiene and safety hazard	
Foam physical properties	Polyurethane (PUR)	Polyisocyanurate (PIR)
Thermal conductivity	Higher but better aging. The difference between the two technologies decreased over time	Higher but better aging. The difference between the two technologies decreased over time
Aging behaviour in compressive strength	Similar. Values remained stable during six months	Similar. Values remained stable during six months
Dimensional stability at -20 ºC	Similar	Similar
Dimensional stability at 60 ºC and 96 per cent relative humidity	Improved	Similar in absolute values. However, while super-critical CO_2 experienced a negative change in volume, the HCFC-141b formulation experienced a positive change
Adhesion strength to galvanised steel	Similar	Lower
Incremental costs	PUR	PIR
Retrofit of a typical spray machine to apply super-critical CO_2	From US $9,800 to US $13,700	From US $11,800 to US $15,700
FOB price in Japan of the super-critical CO_2 system (*)	US $7/kg	US $7/kg
Technology fees	Super-critical CO_2 technology is a patented technology owned by Achilles Corporation. The interested parties should come to an agreement with Achilles on technology fees.	

COST ANALYSIS

The cost of retrofitting a typical spray machine to operate with super-critical CO_2 would vary from US $9,800 to US $15,700. Most of the spray machines currently in the market can be retrofitted, but in cases where a machine cannot be retrofitted, the enterprise would need to add US $30,000 for a new dispenser that can be retrofitted. The FOB price in Japan for the PUR and PIR systems is US $7 per kg. As super-critical CO_2 technology is a patented technology owned by Achilles Corporation, the interested parties should come to an agreement with Achilles on technology fees.

CONCLUSION

The demonstration project showed that, from a technical point of view, this technology could be successfully applied in Article 5 countries. The main barrier to the adoption of super-critical CO_2 in Article 5 countries will be the incremental capital cost incurred in the modification of the spray machine and technology fees. The minimum requirements for systems houses to adopt the technology are technical capacity to design rigid foam formulations; human resources and simple laboratory facilities; and conventional blending facilities to prepare the formulated polyol side. A challenge for the systems houses will be the development of suitable water-based formulations that use locally available raw materials (polyols and isocyanate). A challenge for downstream users will be adequate training of the spray operators.

FINAL REPORT AND SECRETARIAT'S COMMENTS

Additional details on this project are available in the link below:

http://www.multilateralfund.org/71/English/1/7106a1.pdf
(paragraphs 108 to 121 and Annex IV in page 177)