Demonstration of reduced-HFO formulations for spray polyurethane foam applications

Objectives

The project's objectives were to strengthen the capacity of two local systems houses to formulate, test, and produce pre-blended polyols using HFOs for SMEs in the polyurethane (PU) spray foam sector; to validate and optimize the use of HFOs co-blown with CO_2 for spray foam applications to achieve a similar thermal performance to that of HCFC-141b with minimum incremental operating costs; to prepare a cost analysis of the different HFO-reduced formulations versus the HCFC-141b-based formulations; and to disseminate the results of the assessment to systems houses in Thailand and other countries.

Description

The project was implemented with the assistance of Bangkok Integrated Trading Co., Ltd and South City Polychem Co., Ltd., which supply polyols (mostly using HCFC-141b). Both systems houses had basic equipment to implement the demonstration project. Bangkok Integrated Trading formulated high density spray foam (50 kg/m^3) and South City Polychem formulated normal density spray foam (35 kg/m^3). Each systems house prepared and tested a minimum of 110 formulations based on HFO-1233zd(E) and HFO-1336mzz(Z); five HFOs; CO_2 ratios (i.e., 100:0, 75:25, 50:50, 25:75, and 0:100); and five cycles based on different ratios of polyether, polyester, and amine polyols. The resulting formulations were applied using a new spray foam machine (Graco) with a maximum pressure of 3,500 psi and adjustable polyol-to-isocyanate ratio. The results of the initial phase were analyzed to identify the best combinations of polyols. The optimal 30 foam formulations were tested (three samples from each formulation), and the critical foam properties (i.e., dimensional stability, adhesion to different substrates, thermal conductivity, and processability) were compared to those of a typical HCFC-141b formulation. A field test with selected formulations was carried out. A technical workshop was organized to disseminate the results. Access to experts and technology suppliers was given to systems houses and polyol suppliers to transfer knowledge and strengthen their technical capacity in formulation development.

Project title: Demonstration project at foam systems houses in Thailand to formulate pre-blended polyols for spray polyurethane foam applications using a low-GWP blowing agent

Country	Thailand
Agency	World Bank
Sector	Foam
Sub-sector/ Application	Rigid PU foam: spray foam
Enterprise/ systems house	Bangkok Integrated Trading Co., Ltd and South City Polychem Co., Ltd.
Baseline Technology	HCFC-141b
Alternative Technology	HFO-1233zd(E), HFO-1336mzz(Z), HFO/ CO_2
Global Warming Potential (GWP) of the baseline and alternative technology	HCFC-141b: 725 HFO: negligible
Potential safety issues	HFO-1233zd(E) and HFO-1336mzz(Z): non-flammable
Ozone Depleting Substances (ODS) phase-out in mt	35.30
ODS phase-out in Ozone Depleting Potential (ODP) tonnes	3.88

Results

▶The spray foam formulations with HFO blowing agents of about 10% of the polyol weight and proper adjustments in the choice of polyol and the catalyst package could yield foam properties acceptable to the Thai spray foam market.

▶The reactivity time of the new reduced-HFO formulation was found to be similar to the HCFC-141b formulation. The density of spray foam made from the reduced-HFO formulations was slightly higher than the baseline HCFC-141b formulation. A slight increase in compressive strength was also observed. Similarly, the initial K-factors of the reduced-HFO formulations were up to 22 per cent higher than the HCFC-141b formulation. All properties of HFO-blown foams were quite stable over time. HFO formulations passed the fire performance tests.

"The results obtained at the two systems houses were presented at the 13th Regional ODS Workshop in Bangkok held in February 2019, which reached over 80 participants from the national ozone offices and foam industries from China, Indonesia, Jordan, Malaysia, the Philippines, Thailand and Viet Nam."

Cost analysis

▶To ensure fast-track adoption, the cost of new HFO formulations must be competitive in comparison with the current HCFC-141b formulations. The cost comparison between the HCFC-141b and HFO formulations showed that the incremental operating cost of using HFO-1233zd(E)-based formulation is between US $4.72/kg and US $8.10/kg of HCFC-141b replaced, while the IOC of using HFO-1336mzz(Z) is above US $8.00/kg of HCFC-141b replaced. The HFO-based blowing agent percentage in the systems was 4.7 per cent compared to 10 per cent for HCFC-141b.

▶Equipment costs were higher than estimated at the outset. The cost of new spray foam machines procured at Bangkok Integrated Trading and South City Petroleum was about US $1,692 and US $3,675 higher than the originally approved funding level of US $40,000, and the cost of the thermal conductivity tester was US $29,821 and US $22,253 at the two enterprises compared to approved funding of US $5,000. Equipment prices were affected by initial underestimation of the cost and can vary based on negotiations and commercial factors.

Conclusions

While the HFO1233zd(E) formulation demonstrated instability, the issue could be solved by introducing a new catalyst package. Spray foams blown with HFOs exhibited adhesion performance that was acceptable to the market.

Reduction of the blowing agents required an additional amount of water to generate CO_2 from the water-isocyanate reaction. Consequently, an additional amount of isocyanate, which made the polyol-to-isocyanate ratio by volume deviate from 1:1, was required.

Spray foam enterprises may need to either retrofit or replace their existing spray machines to be able to apply these new formulations with a polyol-to-isocyanate ratio other than 1:1.■

Additional details on this project are available in the link below:
http://www.multilateralfund.org/83/English/1/8311.pdf
(paragraphs 247 to 259 and Annex V)

Multilateral Fund for the Implementation of the Montreal Protocol