These guidelines are provided for DuPont™ Formacel® S (HCFC-22) and Formacel® Z-4 (HFC-134a). The discussion assumes some level of expertise in handling liquefied gases and operating polyurethane foam plants. Please seek help from experienced personnel, if necessary.

Introduction
This guide provides general instructions for foam producers who wish to convert from liquid HCFC-141B to a blowing agent gas. This guide is designed for use with other previously issued bulletins and applies to Formacel® S and Formacel® Z-4. Each foam plant is different, so caution is advised when using these general guidelines. The specific arrangement and processing procedures at each plant must be considered as changes are made.

These guidelines are part of the changes that would be required for Formacel® Z-2 (HFC-152a). However, because Formacel® Z-2 is flammable, additional safety modifications would be necessary, but are NOT discussed in this guide.

Plant Trials Versus Commercial Production
Using a gaseous blowing agent usually requires some testing before commercial conversion. Typically, temporary equipment modifications are necessary to handle pressures generated by these alternative blowing agents. With some forethought, these temporary changes could become part of the final changes in a permanent conversion. Thus, the sections below will discuss procedures for gaseous blowing agent trials, followed by discussion of considerations for a final conversion.

Blowing Agent Storage and Feed
The first consideration for switching from HCFC-141B to a gas is the storage facility. The storage tank, lines, and pumps must be designed for handling pressure. Minimum recommended pressure rating for facilities to handle Formacel® S is 250 psig (18.2 bars), and 185 psig (13.6 bars) for Formacel® Z-4 or Formacel® Z-2.

Temporary Storage for Plant Trials
For plant trials with gases, blowing agent storage can simply be the cylinder itself. Pressure is used to transfer material from the cylinder to a pump or blending vessel.

Small cylinders will require a pressure flow valve (see Figure 1). This valve has a port for pressurizing the cylinder’s vapor space with nitrogen to force blowing agent out of the cylinder. The outlet on the valve is connected to a standpipe that extends to the bottom of the cylinder. The cylinder is used in the vertical position; the blowing agent comes out as a liquid under pressure. Figure 2 shows a typical setup for feeding blowing agent from a cylinder to the process.
Ton containers have two valves with short tubes that extend to the shell of the container (see Figure 3). The ton container is used in the horizontal position. The valves on the side MUST be aligned vertically so that the upper tube extends into the vapor space and the lower tube is below the liquid level. Figures 4A and 4B show two possible feed arrangements for the ton containers used in a trial: pressure feed using nitrogen or pump feed. In either case, the cylinder’s vapor space is pressurized with nitrogen through the top valve, and liquid is removed from the bottom valve.

For foam trials with the gases, the cylinders are usually pressurized to 200–250 psig (15–18 bars). Cylinder pressure should be at least 30 psig (2 bars) above process pressure to ensure flow into the process only.

**Caution:** The small cylinders have pressure relief devices on the valves. The relief valve setting is stamped on it. The ton containers do not have pressure relief valves; they have fusible plugs that melt when heated.

DO NOT OVERPRESSURIZE THE CYLINDERS.

Use only nitrogen to pressurize the blowing agent cylinders; DO NOT USE AIR.

**Permanent Blowing Agent Storage**

Bulletin H-53024 shows details of a permanent storage and pumping facility for nonflammable gaseous blowing agents. The minimum recommended pressure rating for this type facility is 250 psig (18.2 bars) for Formacel® S (HCFC-22), and 185 psig (13.6 bars) for Formacel® Z-4 (HFC-134a) and Formacel® Z-2 (HFC-152a); additional modifications beyond those shown are required for Formacel® Z-2 because it is flammable.

**Mixing the Blowing Agent into the Polyol**

Mixing the low-boiling blowing agent into the B-side can be accomplished in two ways:

- **Batch Addition**—Adding the blowing agent to the B-side batch and mixing completely. The B-side is then processed normally, except that the equipment must be rated for the appropriate pressures. Pressure ratings of 50–100 psig (5–8 bars) are typically sufficient for B-side storage tanks.
Continuous Addition—Injecting the blowing agent into a B-side stream as it is fed to the foam process. This approach usually eliminates the need for pressure-rated batch mixing equipment, but requires more control instrumentation. The amount of pressure developed in the mixing process will depend on the mixing equipment and the formulations. Potentially, with poor mixing, pressures could be as high as the vapor pressure of the blowing agent at the operating temperatures.

If mixing is good, the pressure of the B-side will equilibrate quickly to the vapor pressure characteristic of the chosen formulation. These formulation vapor pressures depend on the polyol that is used. DuPont bulletins ABA-6 and ABA-13 provide general vapor pressure data for formulations using different type polyols. Prior to a trial or conversion, laboratory data on vapor pressure and solubility for the specific formulation should be developed.
**Temporary Arrangement for Plant Trials**

For a given equipment configuration and recipe, pressure can be controlled by adjusting the blowing agent addition rate, stopping if necessary to allow the blowing agent to mix. The pressure limit is determined by the equipment rating. As an example, Figures 5A and 5B show pressure versus addition rate for a Formacel® S trial with a polyester polyol recipe. Final vapor pressure of the B-side will depend on the polyol compatibility and mixing efficiency.

The mixing process can also add heat to the B-side. If a cooler is used, temperature can be controlled to help control pressure rise. If no cooler is used, additional pressure increase may occur as the mixture temperature rises.

In cases where the foam plant mix tanks are not rated for required pressures, DuPont can provide a small pressure tank for conducting trials. The tank is rated for 250 psig (18.2 bars) and is temporarily installed in the foam plant. It is used as the mix tank for preparing a B-side recipe using a gas. It can be installed with its own recirculating pump (if one is available), or use the foam plant’s pumping and cooling equipment.
Typically, the temporary tank is piped into the process in parallel to the existing mix tank or B-side feed tank. Figure 6 shows this arrangement. (An engineering drawing of the test tanks is available, as needed.)

DuPont can also provide a small injection pump for trials. This diaphragm metering pump can be used to continuously add the blowing agent to the B-side stream at the desired rate. A static mixer is typically used to ensure good blowing agent/B-side mixing. Feed rates are controlled manually because trial runs are typically short.

**Permanent Blowing Agent Addition System**

Process design changes will be required for permanent installation using low-boiling blowing agents. These changes are usually minor, but will depend on each foam plant and the type of equipment already in place. Generally, design changes need to address:

- Pressure ratings of mixing, storage, and process equipment
- Mixing efficiency
- Control instrumentation, safety devices, and safety interlocks
- Materials of construction

Commercial equipment for efficiently mixing blowing agent gases into polyols and systems for a high pressure blowing agent process are currently available from various suppliers. Some vendors have provided a brief description of their equipment in Formacel® Frontiers Newsletter issues of Fall 1992 and Spring/Summer 1993.

**Materials of Construction Compatibility**

**Metals**

Most of the commonly used construction metals, such as steel, cast iron, brass, copper, tin, lead aluminum, can be used satisfactorily with the Formacel® blowing agents under normal conditions of use. Though they have not been tested with Formacel® compounds as yet, zinc and magnesium alloys are not recommended based on experience with CFCs where they show some reactivity.
Elastomers and Plastics
Most elastomers and plastics used for HCFC-141B will be adequate for the Formacel® blowing agents. Generally, Formacel® Z-4 and Formacel® Z-2 will not affect the more commonly used elastomers and plastics to any significant degree. Formacel® S is more aggressive than the HFCs, and a greater affect on elastomers and plastics may be observed. DuPont bulletins ABA-12 and ABA-13 provide elastomer and plastic compatibility data for all three Formacel® blowing agents. These bulletins provide data from screening tests, which can be used to help identify parts that may need to be monitored or changed.

Plant Trials
Typically, for plant trials, none of the parts used in the foam equipment are changed; the exposure time for a trial is relatively short, and the amount of exposed material are minimal (as in the case of a gasket or an O-ring). However, if there is a critical process point where failure should not occur, it would be appropriate to survey and change any parts of concern.

Permanent Conversions
Changes for permanent conversions should be done on a specific schedule. Usually, even elastomer or plastic parts that are affected by the new blowing agents will have some useful life. The life of the part may be shorter than expected or required, which may warrant a change in materials. After identifying parts of concern, the choices are to make a change with blowing agent conversion or to carefully monitor the existing part’s performance. In either case, when beginning to run the new blowing agents, a schedule should be developed to inspect all elastomer and plastic parts soon after start-up to confirm initial conclusions.

Safety Equipment and Interlocks
The predominant safety consideration for using nonflammable low-boiling blowing agents is handling the pressure. All equipment and piping should be properly protected against high pressure with relief devices and interlocks. The process should be reviewed for failures that could cause high pressures, and appropriate equipment and procedures should be used to prevent such failures. Once installed, safety protection equipment and instrumentation should be checked on a regular basis.
Formulations
Experimentation will be required to evaluate the need for formulation changes. The magnitude of any changes will vary widely from application to application and will have to be developed for each case. The type of work is usually done in conjunction with the foam chemical suppliers.

Processing Changes for Gaseous Blowing Agents
Once the equipment and formulation changes are made to store, feed, and mix low-boiling blowing agents into B-side, our experience, so far, has been that no other changes are required on the foam processing equipment. Typically, all of the foam processing equipment is capable of handling the pressures of the new B-sides. However, because each foam plant is different, a careful process review is recommended for each trial. The most significant difference with the gases may be that the foam pour is no longer a liquid, but rather a frothed mixture. This depends on the amount of blowing agent used and the type of polyol. To date, processes using low-boiling blowing agents have either minimized the frothing or have not required any changes for the amount of frothing developed.

Related DuPont Reference Bulletins

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