

DuPont™ Formacel® Z-2

foam expansion agent

Safety and Handling of DuPont™ Formacel® Z-2: Thermoplastic* Foam Extrusion Applications

Flammability of Formacel® Z-2 and Other Alternative Expansion Agents

Flammability of chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) expansion agents has not been a concern of foam manufacturers. But, because of increased awareness and understanding of the environmental effects of the fully halogenated CFC and HCFC expansion agents, those familiar products are being phased out of production and out of use.

As a result, foam manufacturers working with alternative expansion agents—like DuPont™ Formacel® Z-2 (HFC-152a)—will need to take certain steps to ensure the safe handling of these flammable products.

Understanding Flammability

To understand the flammability of the alternative expansion agents a foam manufacturer may be working with, it's helpful to review some basic terms used to define a product's flammability.

Liquids vs. Gases

First, a distinction between liquids and gases must be made, because different codes and regulations apply to each group. The distinction between the two classes is best stated in terms of vapor pressure, although definitions do vary somewhat. The Department of Transportation (DOT), for example, defines a liquid as a material that has a vapor pressure less than 40 psi absolute at 21°C (70°F). National Fire Protection Association (NFPA) Code 30, on the other hand, defines liquids in terms of the same vapor pressure, but at 38°C (100°F). Formacel® Z-2 is a gas by either definition.

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*Thermoset manufacturing may require other modifications.

Concentration

Vapor concentration is one of the factors most crucial to the formation of flammable vapor/air mixtures. Each flammable vapor can form such mixtures only within a limited range of concentrations.

The Lower Explosive Limit (LEL or LFL, for Lower Flammability Limit) of a material marks the point below which the amount of vapor present in the mixture is insufficient to promote continued combustion. That is, even if one layer burns, it releases insufficient energy to ignite a neighboring layer. The Upper Explosive Limit (UEL or UFL, for Upper Flammability Limit) marks the point beyond which the vapor/air mixture contains too little oxygen to support combustion. Both LEL and UEL are usually expressed as volume percentages.

Plant Modifications Recommended to Handle Flammable Expansion Agents**

Our recommendations are based primarily on the NFPA Standards. These standards are nationally recognized as essential in maintaining safety in handling flammable materials. DuPont strongly endorses them.

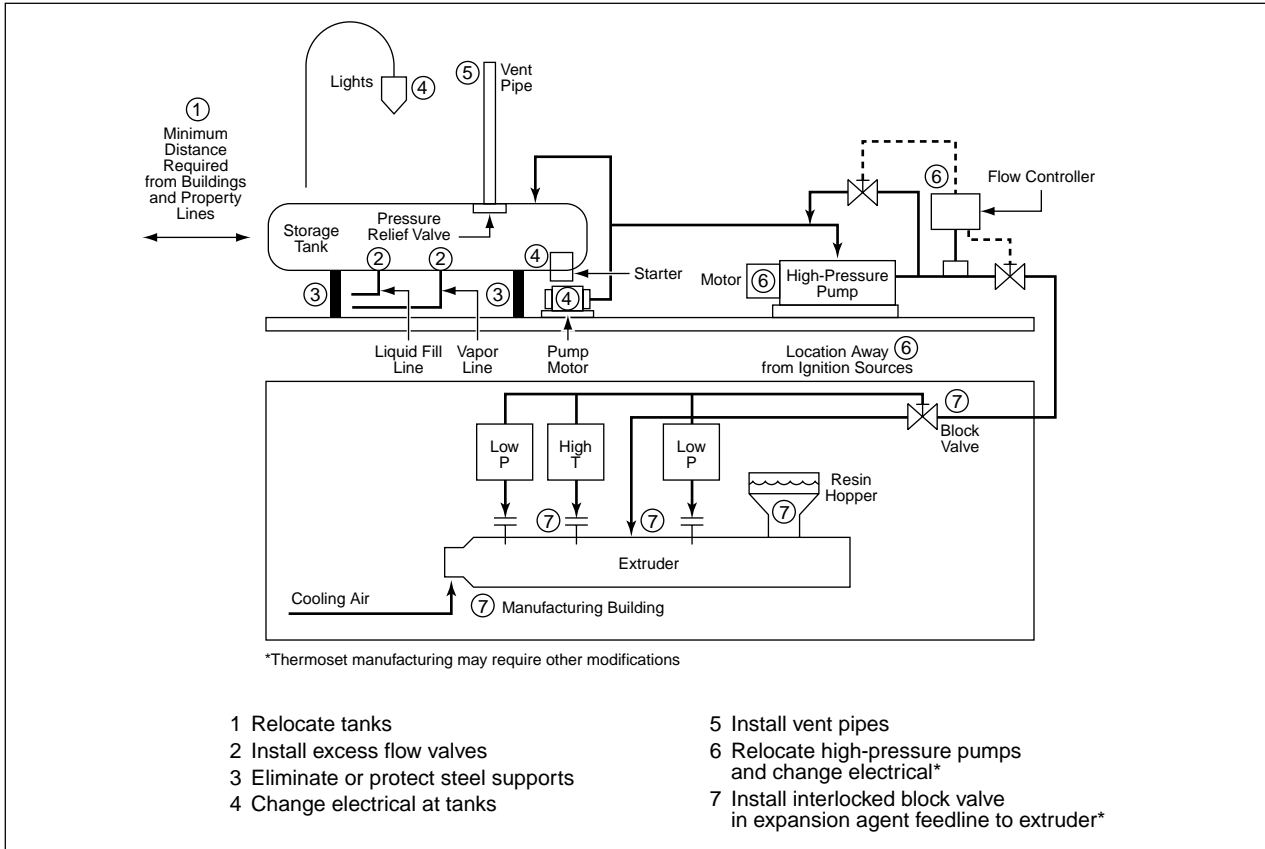
The flammability and physical properties of Formacel® Z-2 are such that we view part of the codes and regulations, especially NFPA 58, for liquefied petroleum gases (LPG), as applicable, particularly in the outside storage area.

**See Figure 1.



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Figure 1. Potential Plant Modifications



Storage Tank—General

NFPA 58 should apply to the storage tank. If the tank has been designed for R-12 or R-22, its pressure rating should be more than adequate for HFC-152a.

The tank should be located at least 15.24 m (50 ft) from buildings or line of adjoining property that may be built upon to comply with NFPA 58-1992, Table 3-2.2.2 for tanks of 7,573.78 to 113,550 L (2,001 to 30,000 gal) capacity. Our interpretation would be that this minimum applies to the distance from resin silos as well. The tank should be positioned with the heads facing away from buildings.

A distance of 1.52 m (5 ft) should be maintained from any other tank of similar size, also per Table 3-2.2.2. Valves and excess flow valves should be on the tank per Section 2-3.3. Any steel supports on the tank should be suitably protected, such as by insulation, against fire or be replaced with concrete (Section 3-2.4.2).

The tank should be located such that vehicular traffic is maintained at a distance of at least 4.57 m (15 ft) from the bulk unloading point, because para. 3-7.4.1 (a) states that internal combustion engines within that distance be shut down while transfer operations are in progress. Diking is not recommended around nonrefrigerated tanks per para. 3-2.2.7.

The storage tank and piping not otherwise protected from lightning should be grounded with a resistance of no more than 10 ohm to earth at any point in the system. All outdoor piping and ductwork should be grounded (10 ohm max.) just prior to entering the building. Any piping or ducts within a classified location inside a building adequately protected from lightning should not exceed 100 ohm in resistance to earth. Points that exceed the 100-ohm requirement can typically be remedied by installation of bonding jumpers. Refer to NFPA 77 “Static Electricity” and NFPA 78 “Lightning Protection Code” for further guidance.*

* A copy of the NFPA Standards can be obtained by calling the National Fire Protection Association at (800) 344-3555.

Storage Tank—Electrical

Formacel® Z-2 is a Class I, Group D material as defined in Article 500 of the National Electrical Code (NFPA 70). The space within the direct path of discharge of relief devices is Class I, Division 1, Group D. Within 1.52 m (5 ft) in all directions from the point of discharge is also Division 1. Beyond 1.52 m (5 ft), but within 4.57 m (15 ft) in all directions from point of discharge except within the direct path of discharge, is Division 2. These classifications are per NFPA 58-1992, Table 3-7.2.2.

It is recommended that:

- Any electrical equipment be approved for area classification in accordance with the above.
- The relief device(s) discharge be vertically upward and unobstructed to the open air at a point at least 2.13 m (7 ft) above the top of the tank per para. 3-2.5.3 (b).

The space within 4.57 m (15 ft) in all directions from the storage tank pumps should be considered Class I, Division 2, Group D. The space within 4.57 m (15 ft) in all directions from the tank connections also has the same classification. The space within 1.52 m (5 ft) in all directions from the connections regularly made or disconnected for product transfer (hose connections) is Class I, Division 1, Group D, and an additional 3.04 m (10 ft) in all directions is Division 2 (Table 3-7.2.2).

It is recommended that:

- The motors on the pumps be suitable for Division 2 service and wired accordingly. NFPA 70 (National Electrical Code), Article 501-8 (b) describes the types that can be used. Included in the information in this Article is the statement that the installation of open or nonexplosion-proof enclosed motors, such as squirrel-cage induction motors without brushes, switching mechanisms, or similar arc-producing devices shall be permitted. It also states that it is important to consider the temperatures of internal and external surfaces that may be exposed to the flammable atmosphere. These temperatures should not be allowed to exceed 80% of the autoignition temperature of HFC-152a. Any other electrical equipment should also be approved for the area classification.
- Lighting be located at least 4.57 m (15 ft) from the tank or otherwise be approved for Division 2 service.
- Conduit be sealed in accordance with National Electrical Code Article 501-5.

It is suggested that the transfer hose disconnect spot be located at least 4.57 m (15 ft) from any electrical equipment to avoid the potential requirement for approved electrical equipment.

Piping from Storage Tanks to High-Pressure Pumps

According to NFPA 497A, para. 2-6.1, it is not necessary to classify locations that are:

- Adequately ventilated where combustible materials are contained within suitable, well-maintained, closed piping systems.
- Not adequately ventilated but where piping systems are without valves, fittings, flanges, and similar accessories that may be prone to leaks.

If the high-pressure pumps are located inside the building, it is recommended that:

- The piping from the storage tank to the high-pressure pumps be free of valves, fittings, flanges, and similar accessories. This removes any element of doubt as to adequacy of ventilation.
- The piping inside the manufacturing building be as small in inside diameter as feasible, to minimize the inventory of expansion agent inside the building. As a guide to sizing the piping, we have estimated that a maximum of 3.2 kg (7 lb) of Formacel® Z-2 per 100,000 ft³ of room volume could be released without the necessity of providing explosion venting of the building. Block valves should be located at both ends of the pipeline to isolate the line in the event of a leak.
- The piping be adequately supported and protected from damage.
- A limited orifice be provided in each of the lines ahead of the high-pressure pumps to limit the flow in the event of a line break. The location of the orifices should be such that they are away from and upstream from areas where damage is likely to occur. The flow should be limited to as low a rate as possible without interfering with operation of the high-pressure pumps.

We do not recommend installing piping underground, primarily because it prevents inspection for leaks, which we recommend be conducted regularly and frequently. Furthermore, corrosion tends to be more severe with underground lines compared with overhead. Back-welded Schedule 80 piping is preferred to minimize leaks.

Pumps and Piping

NFPA 58 does not apply to the extrusion operation in our opinion because of the low inventory and flow rates of flammable gas generally found in foam-blowing processes compared with typical LPG container-filling operations. We do feel, however, that the high-pressure systems are potential leak sites. Therefore, we have applied our engineering experience and judgment to develop recommendations consistent with our conclusions as to the hazard levels present.

It is recommended that:

- The space within 3.04 m (10 ft) in all directions from the high-pressure pump systems be considered Division 2. This would include the pumps themselves and any fittings, valves, etc., on the high-pressure tubing that are potential sources of leaks.
- All electrical equipment within that space be appropriately approved.
- The high-pressure tubing beyond the Division 2 space, downstream of the pump systems and leading to the extruders, be free of any valves, fittings, etc., which are potential sources of leaks. To minimize the inventory of flammable material in the line, the smallest diameter for the required flow rate should be used.

Extruder Area

Based on our previous experience, our general conclusion is that the extruder area is not a classified area. This is based primarily on the operation of the extruders that inherently prohibits the leakage of expansion agent at concentrations approaching the flammable range. Our understanding is that operating procedures and interlocks are designed for a high degree of assurance that resin is always in the extruder in the molten state when an expansion agent is being fed, other than at start-up. Therefore,

the probability is extremely low that expansion agent alone would exit the extruder. We recommend as extra precautionary measures that the HFC-152a expansion agent feed be interlocked to shut down by means of an automatic block valve in the event of:

- Low pressure in the extruder immediately ahead of the expansion agent injection port. This is intended to ensure the presence of an adequate supply of molten resin on the extruder screw to prevent backflow of expansion agent out of the resin feed hopper. The interlock should be set in the range of 500–1,000 psig, depending on extruder design.
- Low pressure in the extruder immediately prior to the die. Again, pressure measurement will detect the presence of molten resin to prevent expansion agent from exiting the discharge end without polymer.
- High temperature immediately ahead of the secondary extruder exit. A temperature 5.5 or 11.1°C (10 or 20°F) above the normal operating temperature is suggested for this point. This is intended to prevent the formation of low-viscosity polymer with subsequent leakage of expansion agent.

Our experience shows that at start-up, high concentrations of expansion agent can exit the extruder before foam stability is established. Therefore, it is recommended that a nonflammable expansion agent such as HFC-134a or CO₂ be used at start-up with a changeover to Formacel[®] Z-2 once the extruder operating conditions have stabilized.

Any expansion agent sample or blow-down lines or pressure relief device discharges should be vented outside to avoid an otherwise Division 1 and 2 area.

Note: Adequate ventilation should be maintained in the extruder room to ensure that the expansion agent concentration under normal operation is well within 25% of the lower flammability limit of 3.9 vol%.

We have determined that Formacel® Z-2 can be ignited by discharge of static electricity and requires installation of static eliminators on the foam web. Experience has shown that in the event of interruption in standard extruder operation, hollow tubes of unexpanded foam may be formed with expansion agent trapped inside. The potential for ignition from static discharge exists in handling this type of material, particularly if it is continuously wound. To avoid a significant flammability hazard, it is essential that accumulation of this material be minimized. A mechanism should be installed to immediately detect any interruption in standard extruder operation, especially a web break, and activate an alarm signal.

The polymer grinders should be interlocked such that they cannot be operated without air flow. Thus, any expansion agent released in grinding should be diluted well below its lower flammability limit.

Summary

The recommendations included herein should be implemented prior to start-up with Formacel® Z-2. We will check the facilities before delivery of the product.

We consider our recommendations as outlined to be minimum. It is recognized that the “local authority having jurisdiction” as defined in the NFPA Standards may enforce more or less stringent requirements than those outlined herein.

It is our understanding that you will cover any questions as to increased hazards in your warehousing operation with your insurance carrier to ensure that your fire protection facilities are adequate.

Take the Next Step

Before starting plant modifications, it is important to be thoroughly familiar with all pertinent regulations and product specifications. NFPA Standards can be obtained by contacting the National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9904 or calling (800) 344-3555.

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