

ARCEL® Resin

Storage and Handling Safety Guide



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INTRODUCTION

NOVA Chemicals manufactures ARCEL resins at its North American facility located in Beaver Valley (Monaca), Pennsylvania and also in Ningbo, China, near Shanghai, which is operated under a long-term manufacturing agreement with Loyal Chemical Industrial Corporation. The Beaver Valley and Ningbo sites are certified under the International Organization for Standardization (ISO) 9001 quality standard. The Beaver Valley site is also certified under the ISO 14001 environmental standard. Supporting the manufacturing and sales of our products is our technology center at Beaver Valley, which also hosts a pilot demonstration plant. NOVA Chemicals has sales offices located throughout the world.

NOVA Chemicals' ARCEL resin consists of small spherical beads (primarily polystyrene and ethylene vinyl acetate copolymer) typically 0.03 - 0.08 inches (0.8 - 2.0 mm) in unexpanded diameter. ARCEL resin contains 5% - 12% by weight of isopentane; a volatile, flammable blowing agent. The isopentane concentration may vary for developmental products, new products, and off-spec materials.

As a Responsible Care® company, NOVA Chemicals works to ensure the safest possible management of chemical products throughout their life cycle from the planning of new products through their manufacture, distribution, use and ultimate disposal. In support of our Responsible Care® commitment, NOVA Chemicals has compiled this document as a general guide to help our customers safely handle, store and process our ARCEL resin. The information provided in this Guide is believed to be accurate as of the publication date of this Guide.

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This Guide is intended for use in conjunction with NOVA Chemicals' Material Safety Data Sheet (MSDS) for ARCEL resin. Essential information relating to the safe handling, transporting, storing and use of ARCEL resin is detailed in the MSDS. It is important to note that government legislation/regulations and industry standards/codes for building, fire protection/prevention, environment, health and safety, processing, use and transporting of products such as ARCEL resin must always be observed. Certain information prescribed by government regulations is summarized on the MSDS. For an up-to-date MSDS, please contact NOVA Chemicals at 1-412-490-4063 or via e-mail at msdsemail@novachem.com. This document is intended as a general guide to processing ARCEL resins.

APPLICATIONS

NOVA Chemicals' ARCEL resin gives our customers the ability to develop innovative end-use products, providing versatility, durability, strength, performance and economy. Customers mold our ARCEL resin into a wide variety of everyday items.

Protective Packaging:

- High-end consumer electronics
 - Computers
 - Monitors
 - Printers
 - Televisions
 - Furniture and cabinetry

Protective Material Handling:

- Automotive dunnage
- Tote bins
- Bulk packaging trays

Recreation:

- Flotation devices
- Marine dock bumpers
- Water sports equipment
 - Boogie Boards

Safety:

- Helmets
- Infant car seats

Approval by NOVA Chemicals of any application for ARCEL resin is neither intended nor implied by the contents of this Guide.

PHYSICAL & CHEMICAL PROPERTIES

The information below will detail the properties of ARCEL resin and the blowing agent, Isopentane.

ARCEL Resin:

Property		Property	
Physical State and Appearance	Solid, bead	Color	White, blue, or gray-green
Odor	Fruity, slight aromatic	Vapor Density @ 0°C (Air=1)	2.5
Specific Gravity (Water=1)	0.99	Solubility (H ₂ O)	Non-soluble. Partially soluble in various organic solvents.
Melting Point	>180°C (357.8°F)	Softening Point	Approx. 100°C (212°F)
Flash Point	17.2 - 25.6°C (63 - 78°F)	Flash Point Method	ASTM D-3278

Blowing Agent: Isopentane, liquid hydrocarbon

Isopentane (C₅H₁₂) 5% to 12% by weight

Property	
Synonyms	i-pentane
Molecular Formula	C ₅ H ₁₂
Flash Point (Closed Cup)	-70°F (-57°C)
Auto ignition temperature	788°F (420°C)
Density (g/cc) – Liquid	0.62
Vapor density (Air = 1.0)	2.5
Flammable Limits:	
Lower (LFL)	1.4% by volume
Upper (UFL)	7.6% by volume
Heat of Combustion	~21,000 BTU/pound (48,800 KJ/Kg)

HAZARDS

As with many commercially available chemicals, products and services, there are hazards associated with ARCEL resins and molded foam articles. If appropriate measures are taken, however, the risks arising from these hazards may be minimized. The following sections highlight, but are not intended to exhaustively identify or describe the most common hazards associated with ARCEL resins and molded foam articles: Please refer to the MSDS for additional information.

Fire Hazards

The principal safety hazard associated with transporting, storing, handling and processing ARCEL resin is fire; ARCEL resin is flammable. ARCEL resin beads release a gas that is highly flammable in the presence of open flames, lit cigarettes, sparks, static electricity discharges or heat. The blowing agent, isopentane, evaporates from the beads at an accelerated rate when storage temperatures are above 40°F (4°C). Since ARCEL resin contains more isopentane than EPS it releases greater quantities of isopentane. Conversely, molded ARCEL resin foam parts release less isopentane compared to EPS. The United Nations Subcommittee on the Transport of Dangerous Goods and the U.S. Department of Transportation (DOT) have classified ARCEL resin as a hazard class 9 (miscellaneous hazard) and have assigned a material identification number of 2211 (polymeric beads, expandable, evolving flammable vapor).

Isopentane vapors are colorless and weigh approximately 2½ times more than air. They are flammable in vapor-in-air mixtures of 1.4% to 7.6% by volume; mixtures within this range can be ignited with low intensity ignition sources. If ignition occurs while the mixture is confined, explosion is possible. Therefore, when handling ARCEL resin, two

principal efforts should be made: eliminating ignition sources (including static sparks) and preventing isopentane vapor accumulation.

Eliminating Sources of Ignition

1. Prohibit smoking and the carrying of matches and lighters in all operating areas (receiving, processing, fabricating, storage, warehouse and shipping).
2. Separate equipment that may have open flames or generate sparks (boilers, water heaters, stoves) from operating areas described above. Fire doors should be either self-closing or kept closed.
3. Maintain equipment in good working order to avoid generation of electrical, frictional, or electrostatic sparks which can constitute an ignition source. Good electric bonding and grounding of all handling/processing equipment including transfer lines, storage bins, valves, and grinders are essential.
4. When hazardous work, such as welding, must be done in operating areas, remove combustibles from the area and perform the work under close supervision with a dry chemical, CO₂ or water fire extinguishers immediately available.
5. Other equipment and devices such as cellular phones and other communication equipment, circuit breakers or computers may generate electric sparks. Electronic equipment such as telephones and radios may be used as long as they are non-sparking.
6. ARCEL resin beads, pre-expanded beads or molded foam articles should be handled with caution as static electric discharge from any part of the body including skin and clothing could result in a fire. Proper grounding procedures - such as discharging static from the body before entering a potentially explosive atmosphere and wearing a wristlet connected to a ground source - are important safety controls that may reduce spark potential.

Preventing Isopentane Vapor Accumulation

1. Isopentane vapors, because they are heavier than air, may accumulate in depressions, enclosed areas [trailers, containers, low spots (e.g., trenches, sumps, stairwells) or confined spaces (e.g., bulk raw material storage bins)] that are not continuously ventilated. Provide positive ventilation in these and similar areas. Refrigerated storage is required because it minimizes isopentane loss from the unexpanded beads; however, storage areas and low spots should be equipped with an alarm system to warn of a power failure that may adversely impact storage temperatures or ventilation systems.
2. Molded foam articles may exhibit an isopentane halo immediately after molding or cutting. The halo may gradually diminish thereafter. ARCEL resin molded parts require little aging to dissipate remaining isopentane. The fire hazard from isopentane vapors diminishes as the isopentane concentration in molded foam declines during normal post molding inspection, storage, shipment and application. Molded foam articles should be stored in well-ventilated areas and away from all potential sources of ignition.

Health Hazards

ARCEL resin beads and properly aged articles fabricated or processed exclusively from ARCEL resin beads (e.g., in the absence of mold release, lubricant, colorant, paint or any other additive) are not considered toxic solids, primary skin irritants or strong skin sensitizers. Extended exposure to foamed ARCEL resin and blowing agent vapors in laboratories and processing plants has not resulted in significant health problems.

Although NOVA Chemicals' ARCEL resin is considered to be non-toxic, appropriate safety precautions during the manufacturing, processing, cutting, fabrication, finishing and recycling operations, with particular emphasis on housekeeping, is recommended.

ARCEL resin may be irritating to the eyes. ARCEL resin may cause irritation to the skin from repetitive handling. Skin contact with molten or heated ARCEL resin may cause severe thermal burns. Eyewash stations and safety showers should be near the work location.

ARCEL resin and foamed articles should not be eaten. Ingestion of foamed ARCEL resin is similar to the hazards of ingestion of other inert solids of similar size and weight. Mechanical irritation and blockage of the digestive tract are possible.

ARCEL resin may cause irritation to the respiratory system. The blowing agent used is isopentane. Components of the blowing agent can irritate eyes, skin and respiratory system. Inhalation of the blowing agent can cause nausea, headaches, shortness of breath and cough. The American Conference of Government Industrial Hygienists (ACGIH) and/or the US Occupational Safety and Health Administration (OSHA) have set exposure limits for ethylene-vinyl acetate copolymer and isopentane, which are components of ARCEL resin:

Ethylene-Vinyl acetate copolymer (24937-78-8)

ACGIH:	10 mg/m ³ TWA (inhalable particles)
	3 mg/m ³ TWA (respirable particles)
(OSHA (Vacated)*):	15 mg/m ³ TWA (total dust)
	5 mg/m ³ TWA (respirable fraction)
OSHA (Final):	15 mg/m ³ TWA (total dust)
	5 mg/m ³ TWA (respirable fraction)

Isopentane (CAS 78-78-4)

ACGIH: 600 ppm TWA

*Note: The Vacated OSHA Permissible Exposure Limits (PELs) are those provided in the 1989 update to OSHA's Air Contaminants Standard 29 CFR 1910.1000. These limits were vacated by the U.S. Court of Appeals, Eleventh Circuit but may be enforceable in some states.

Ensure adequate ventilation and use local exhaust, where possible, in confined or enclosed spaces. If user operations generate dusts, mists or fumes, use appropriate local exhaust ventilation to keep exposures below the recommended exposure limits. If ventilation is not sufficient to effectively prevent buildup of vapor/mist/fume/dust, appropriate NIOSH respiratory protection or self-contained breathing apparatus (SCBA) appropriate for exposure potential should be used.

Wearing personal protective equipment (such as chemical goggles, impervious gloves, protective coveralls and long sleeves, and respirators) will reduce the likelihood of exposure.

Please refer to the most recent ARCEL resin MSDS for additional details on health precautions.

Hazards from Decomposition Gases

Thermal decomposition products (fumes and/or vapors) can be generated during manufacturing, cutting (hot wire), fabricating (grinding and sawing) and finishing operations. Thermal decomposition gases may be irritating to the nose and eyes.

Complete thermal decomposition of NOVA Chemicals' ARCEL resin under flaming conditions with an adequate oxygen supply will result primarily in carbon monoxide, carbon dioxide, water and particulate matter (soot). Prior to and after the flaming mode of combustion, and, depending on the oxygen supply, a variety of other chemical species have been identified in the vapor phase. These species (e.g., aromatics, oxygenated organics, saturated and unsaturated aromatics) have also been identified in the vapor phase during the combustion of a variety of polymer materials, such as polystyrene, polypropylene, polymethylmethacrylate and wood. These findings are detailed in many references including "Chemical Fingerprint and Studies of Fire Atmospheres" by P J. Fardell, et. al., which concludes that while some of the oxygenated organic compounds pose an irritancy threat to the eyes and respiratory tract, carbon monoxide is, in all cases, the dominant toxic product.

Hot wire cutting of foam fabricated from ARCEL resin may generate thermal decomposition products. The type and concentration of these decomposition products may be dependent on several factors, including, but not necessarily limited to, wire temperature, cutting rate, block size and foam density. Cutting operations should be located in a well-ventilated area; additional controls (e.g. exhaust fans) may assist in minimizing personnel exposure.

Dust Hazards

Airborne particulate matter (dust) can be generated during transporting, transferring, manufacturing, finishing (cutting, stamping, grinding and sawing) and recycling (grinding and compacting) operations. Dust may be irritating to the nose and eyes. NOVA Chemicals recommends engineering controls, including the use of adequate ventilation and local exhausts. A filter mask is recommended where continuous exposure is involved.

The particle size and concentration of dust that may be generated by ARCEL resin processing operations is influenced by a range of factors including equipment type, operating conditions, such as cutting or grinding rate, and foam density. Fine dust particles may suspend in the air, form dust clouds and/or cause a dust explosion.

Good housekeeping should be employed throughout the work area to limit the build up of dust. Where practical, the following should be enforced:

- Dust from cutting and grinding operations should be collected and removed.
- All ignition sources must be strictly eliminated in areas where dust clouds might form.

Slipping Hazards

Any amount of ARCEL resin beads on a walking or working surface will pose a slipping hazard. Good housekeeping is essential to avoid accumulations of spilled ARCEL resin material. Personnel should be prevented from walking on spilled ARCEL resin beads and foamed articles. Precautions for storing and handling any foam product that was spilled should be as rigorous as for storing and handling ARCEL resin beads.

Static Hazards

ARCEL resin beads, pre-puff/pre-foam, and un-aged molded foam articles should be handled with caution as electrostatic discharges from any part of the body (including skin and clothing) or handling equipment (including transfer pipes, conveyors, pallet jacks and fork trucks) could result in a flash fire. Use of non-static accumulating and fire-resistant protective coveralls and long sleeves is recommended. Commercial synthetic clothing, unless specifically treated, carries a risk in a fire situation and can generate dangerous static electricity if donned or doffed in a flammable atmosphere.

Since ARCEL resin is an electrical insulator, electrical charges can accumulate on its surfaces. As such, significant charge accumulation could result in a potentially dangerous condition since uncontrolled discharge (in the form of an electrostatic spark) could ignite the flammable isopentane-blowing agent. Prevention of the uncontrolled discharge significantly reduces the chances of a flash fire.

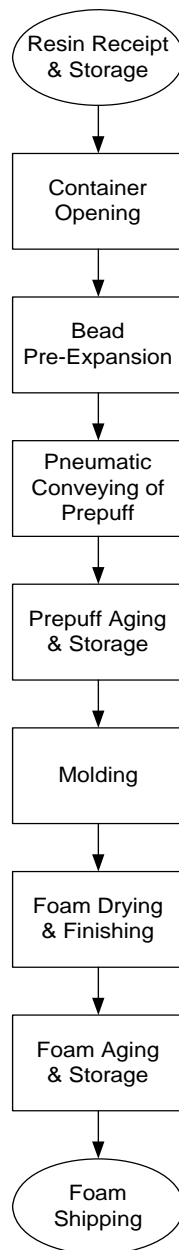
Appropriate electrical bonding and grounding of processing and handling equipment may help in safely dissipating accumulated electrical charges. Bonding equipment together with suitably conductive materials can help to minimize the difference in electrical charge between the bonded items. Grounding equipment with suitably conductive materials may help in providing a safe pathway for accumulated charge to travel and dissipate into the earth. Consult a qualified electrical expert for specific information on bonding and grounding system installations. Only qualified electricians should be permitted to install, maintain, and regularly monitor electrical bonding and grounding systems. Regular periodic testing of all bonding and grounding systems by a qualified electrician is necessary to support the safe dissipation of electrical charges.

Also, since moisture typically acts as an electrical conductor, the accumulation of charge on ARCEL resin is most likely to occur when the beads, pre-puff/pre-foam, or molded foam articles are dry. Due to this factor, there are many steps in the ARCEL resin converting process (see Figure 1 on the following page) where appropriate measures can

be taken to minimize the opportunities for uncontrolled static discharges. Humidified air (>40% relative humidity) may assist in minimizing static electricity build-up.

PLANT HAZARD ANALYSIS

The operations shown in the figure below are common to many ARCEL resin converting facilities. While the figure is not intended to depict every ARCEL resin converting facility, it is nonetheless important to understand the potential hazards associated with operations that can commonly be found in many manufacturing processes. These potential hazards are discussed in the following sections.



Please note that all structures and buildings should be constructed, occupied and protected in accordance with applicable jurisdictional building and fire codes.

Raw Bead Receipt and Storage

Transportation and Unloading

NOVA Chemicals' unexpanded ARCEL resin is shipped in 1000-pound (454 kg) capacity corrugated boxes. To minimize the loss of the isopentane blowing agent, ARCEL resin is sealed in a plastic EVA/Nylon liner within each box.

Each 1000 pound corrugated box is strapped on a wooden pallet. The 1000-pound boxes can be shipped globally in 20-foot or 40-foot refrigerated ocean containers and domestically in refrigerated trailers. 20-foot refrigerated ocean containers are loaded with up to twenty 1000-pound boxes and 40-foot refrigerated ocean containers are loaded with about forty boxes. Up to forty-two 1000-pound boxes are typically shipped in domestic refrigerated trailers. Boxes are typically double stacked in the containers and trailers. In North America, the gross weight of a loaded transportation vehicle must not exceed 80,000 pounds, unless exemptions are permitted. Transporters must ship ARCEL resin boxes at temperatures well below 40°F (4°C) to preserve and retain product quality during transport. ARCEL resin should be shipped at or below 20°F (-7°C) in case refrigeration is lost and to ensure the material does not exceed 40°F (4°C).



As long as the original box and sealed liner are intact and unopened and refrigeration is maintained, there is little chance that concentrations of isopentane vapor sufficient to create a flammable mixture with air will develop within the refrigerated ocean container or trailer. When the refrigerated truck trailer/ocean container is ready to be opened, ensure that all ignition sources are removed from the area. Transporters, carriers and receiving personnel should be advised to carefully open doors and leave open for at least 15 minutes in order to disperse any isopentane vapors prior to unloading in the unlikely event of a damaged box or loss of refrigeration. Smoking should be prohibited prior to and during opening or unloading the refrigerated ocean container or trailer. As the isopentane is diluted with air, the isopentane-in-air concentration may pass through the flammable range (between the LFL and the UFL). The vapor-air mixture should be below the LFL and safe to handle before unloading.

A hydrocarbon analyzer (also known as an explosimeter) should be used to monitor the isopentane level to determine if the isopentane levels pose a fire hazard. Strategic location of these meters throughout the receiving/handling/storage/shipment areas is highly recommended.

Warehouse Storage

ARCEL resin boxes must be stored in warehouses at temperatures well below 40°F (4°C) to preserve and retain product quality. At warehouses, ARCEL resin should be stored much lower than 20°F (-7°C) in case refrigeration is lost and to ensure the material does not exceed 40°F (4°C).

Stacking

All unopened ARCEL resin corrugated boxes should be stacked in accordance with all applicable safety, fire and building regulations and codes. The overall stack heights should be stable and the boxes' integrity should not be compromised as a result of over-stacking. The condition/stability of the stacked boxes should be assessed through periodic monitoring. Ceiling sprinkler systems/heads should be clear.

Storage of ARCEL resin in tightly sealed spaces may result in accumulation of flammable isopentane vapors. However, as long as the original boxes/bags are intact, quantities of vapor sufficient to create a flammable mixture with air are not expected to be present.

Handling of ARCEL Resin Shipping Corrugated Boxes

ARCEL resin corrugated boxes are shipped on wooden pallets and are most easily transported using a forklift truck or pallet jack. Forks should not extend beyond the back of the pallet when handling boxes to avoid accidental punctures. Use caution when maneuvering forklift trucks to prevent accidental "spearing" of boxes, which may result in a spill and slipping hazard. Ensure that all handling equipment is properly rated for the load it will experience when transporting boxes.

Customer Receipt and Handling

To maintain a safe storage environment and preserve product integrity, customers should store ARCEL resin in unopened boxes at temperatures below 40°F (4°C), ideally 33°F (1°C) to 40°F (4°C) in rooms free from any sources of ignition. Customers storing ARCEL resin at temperatures less than 33°F (1°C) may experience processing issues, such as increased energy for pre-expansion and ice crystals/condensation in pre-expander feed systems. A number of refrigerated storage options exist, including a leased reefer, an onsite refrigeration unit and an offsite rental. Whatever the choice, primary consideration should be given to safety and security. Boxes should be stacked, handled and assessed in accordance with the paragraphs above entitled "Stacking" and "Handling of ARCEL Resin Shipping Corrugated Boxes." The room should be equipped with an alarm to warn of a power failure or loss of refrigeration.

Initial Opening

Upon opening, a container of unexpanded ARCEL resin will generally have an isopentane rich atmosphere above the upper flammability limit (7.6%) in the free space over the raw material. After opening the container of unexpanded ARCEL resin, allow 15 minutes for the accumulated isopentane to dissipate. The isopentane-in-air concentration will pass through the flammability range to below the lower flammability limit of 1.4%. At this point the material is safe to handle.

To avoid static sparks, unexpanded ARCEL resin should never be handled by using an ungrounded metal bucket, a plastic bucket, or a bucket with a metal handle or parts. Partially opened containers pose a greater potential hazard because the isopentane vapor has a larger space to occupy. With containers to be resealed, be sure that the inner liner is tied at the material level to minimize headspace. When opening a partially-filled container, avoid jerking the liner (since this action may cause a spark) and ventilate the container thoroughly before handling.

Remove the box lid and exercise extreme caution when opening the liner and exposing the top surface of the beads. Gently fold the edge of the liner over the lip of the box and allow the box to ventilate for a minimum of 15 minutes.

Bulk Emptying

Some processes employ manual tools to transfer beads from the box to the hopper of the pre-expander, while others use automatic transfer devices. Manual tools such as scoops, buckets, and shovels should be either (1) non-sparking (for example, made entirely of wood) or, (2) constructed entirely of metal. Manual tools constructed of mixed component materials (for example, plastic buckets with metallic handles) should never be used to transfer or carry ARCEL resin beads or pre-puff/pre-foam. All metallic scoops, buckets, and shovels should always be properly grounded to earth by means of a conductive cable rigidly fixed to the tool. Consult a qualified electrical expert for specific information on grounding system installations. Only qualified electricians should be permitted to install, maintain, and regularly monitor electrical bonding and grounding systems.

When automatic electrical transfer devices (e.g., augers, vacuum tubes) are used, proper bonding and grounding are necessary to avoid static build-ups and electrostatic discharges. All components in an auger system should be made entirely of metal, be properly grounded, and be inspected frequently to prevent unwanted metal-to-metal contact. Vacuum tubes should also be made entirely of metal.

Vacuum hoses should have an internal grounding cable in direct contact with the pick-up tube at one end, and must be properly grounded to earth at the opposite end.

NOVA Chemicals does not recommend the practice of tipping/dumping of containers to remove ARCEL resin beads from corrugated boxes. If this practice is employed, however, appropriate systems should be in place to ensure that the lip of the box liner is pulled completely over the edge of the box and is placed so that the dumping mechanism holds the liner to prevent it from falling into the bead hopper. If the liner falls into the hopper and must be retrieved, extreme care should be taken to do so very slowly to avoid causing a static spark. Personnel performing this task should position themselves in a manner that would minimize the potential for injury due to flash fire. As with many other pieces of equipment that can be found in an ARCEL resin molding facility, ensure that the carton tipper is adequately grounded to earth. Avoid situations that may generate unwanted metal-to-metal contact to reduce the chances of a spark occurring.

Partially Emptied Boxes

At times, it may be necessary to re-seal a container (corrugated box) that has been only partially emptied of ARCEL resin. When this happens, the liner should be securely sealed in a manner that minimizes the free space between the beads and the liner (minimizes the space for vapor accumulation). Avoid liner movement within the box. Corrugated boxes from which liners have been removed should not be used for storage of ARCEL resin. Do not stack anything on top of a partially emptied corrugated box to avoid the risk of collapse.

When ready to remove the remaining ARCEL resin from a partially emptied box/bag, treat the box/bag as if it were full and refer to the "Initial Opening" section of this guide.

Complete Emptying

Use manual tools or automatic transfer systems to empty the liner of the remaining beads, avoiding movement of the liner to minimize the creation of an electrostatic discharge.

Use caution when leaning over or reaching into an open ARCEL resin box to:

- Minimize the potential for injury in the event of a flash fire, and
- Avoid falling into the open box

Liner Removal, Disposal and Recycling of Packaging

Use caution when removing the plastic liner from corrugated boxes and bulk bags as a static charge may have accumulated on the surface of the liner. Excess movement of the liner may result in an electrostatic discharge.

Packaging materials such as plastic liners, corrugated boxes, and wooden pallets are combustible. Where possible, these materials should be removed from the ARCEL resin bead and foam storage areas and away from sources of ignition. Disposal and recycling of these materials should be performed in accordance with applicable regulations.

Pre-Expansion

Pre-expansion of ARCEL resin involves the liberation of isopentane from the beads. Adequate ventilation is necessary in the pre-expansion area because of the amount of isopentane released. Ignition sources must be eliminated in the pre-expansion area.

Fresh pre-puff/pre-foam has lower isopentane content than unexpanded resin and may have high moisture content as a result of steam condensation from the pre-expansion process. Regardless, all pre-expansion equipment including pre-expanders, hoppers, transfer devices and piping should be properly bonded and grounded to earth.

Pre-expansion of ARCEL resin upon delivery is an alternative to refrigerated storage provided ample pre-puff storage is available. Unlike expandable polystyrene, ~50 – 60% of the isopentane in ARCEL resin beads is liberated during pre-expansion, and the amount of isopentane remaining is not critical to the molding process. As a result, the shelf life of expanded ARCEL resin is indefinite for practical purposes. It is worthwhile noting, however, that the amount of residual isopentane in 8 to 24 hour old pre-puff can be an asset to molding, particularly with challenging applications.

ARCEL resin can be pre-expanded using all traditional methods, e.g., as employed with EPS. Freshly expanded ARCEL resin pre-puff is more sensitive to thermal and mechanical shock than expandable polystyrene. In order to maintain minimum expanded densities several caveats are in order. Do not over expand. Do not transport fresh pre-puff long distances through air conveying systems. Avoid cold, drafty expansion areas. Avoid impellers. Properly designed and operated fluidized bed dryers can provide a benefit during first pass pre-expansion by removing excess moisture which helps stabilize the material. However, fluidized bed dryers are not recommended for second pass pre-expansion because they tend to cause excessive buildup of static electricity. In practice, minimum densities have been preserved through the use of short air conveying system runs and by expanding into open Gaylords or large portable mesh containers. Double pass expansion significantly reduces the thermal and mechanical shock of air conveying systems since density reduction is carried out in two steps. A technique using heated air to convey fresh pre-puff material has also proven effective. Additional details on expansion/conveyance methods are found in NOVA Chemicals' ARCEL Resin *Expansion and Molding Guide*.

Pneumatic Conveying of Pre-puff/Pre-foam

Pneumatic conveying is essentially the transfer of pre-puff/pre-foam between two points using air as the motive force or carrier. This process typically involves high volumes of air (by means of a fan or blower) relative to the available isopentane in the conveying system. The expansion and pre-puff conveyance operations usually involve the use of large amounts of steam for expansion and air for conveyance. As a result the potential for the hazardous accumulation of isopentane vapor is minimal. It is very important, however, to insure that the raw bead conveyor, expander and all air conveying equipment and lines are properly grounded to prevent static sparking and that other equipment, including fans, blowers and piping, are constructed of a conductive material and are properly bonded and grounded. Avoid flexible rubber or plastic transfer piping, as these materials are difficult to bond and/or ground.

Pre-puff/Pre-foam Aging and Storage

Pre-puff/pre-foam aging and storage accomplishes three primary tasks:

- Permits surface isopentane to disperse from freshly expanded ARCEL resin beads, thereby making the pre-puff/pre-foam less heat-sensitive during molding.
- Allows moisture to evaporate, producing a dry pre-puff/pre-foam.
- Provides time for air to penetrate into the pre-puff/pre-foam cells to displace the vacuum that was created during pre-expansion.

Since additional isopentane is released during aging and storage, it is essential to have adequate ventilation in these areas. As with all other ARCEL resin processing areas, all sources of ignition must be removed and kept out of and away from the aging and storage areas.

There are two primary types of pre-puff/pre-foam aging and storage vessels: woven cloth or mesh bags and metal silos. Regardless of the type of vessel, appropriate ventilation and electric charge dissipation are critical.

Woven Cloth or Mesh Bags

Some converting operations employ woven cloth or mesh bags that are either suspended from above or are supported by a structure built around the bag. Typically, the fibers used to create the woven cloth or mesh is nonconductive. As such, a means to dissipate accumulated static charge must be employed. Conductive wires sewn into the seams during fabrication, or sewn onto the fabric before use, provide a pathway for charge to dissipate as long as they are bonded and

grounded appropriately. Ensure that a valid, physical connection is made between the conductive cables and the inlet and outlet piping on the bag.

Metal Silos

Another type of aging and storage vessel is a conductive metal silo. As with all other metallic devices in an ARCEL resin converting facility, proper bonding and grounding of the silo are essential. Ensure that bonding connections span insulating gaskets at flanges and other piping connections. Dilution or make-up air can be an effective means of ventilating accumulated isopentane vapors and reducing the risk of fire.

Molding Areas

Due to the large amounts of steam liberated from molding presses, adequate ventilation in molding areas is important. While the typical high humidity found in molding areas may reduce the chances for uncontrolled electrostatic discharges, proper grounding of the molding presses is still important to reduce the opportunity for electric shock. Good housekeeping is essential to avoid accumulations of spilled pre-puff/pre-foam or scrap beneath and around the molding machines.

In addition, the high humidity, air movement and aged pre-puff make the molding area an unlikely area for the hazardous accumulation of isopentane vapor. Nevertheless, expanded ARCEL resin beads can be ignited and will burn so care should be taken to insure proper equipment grounding, housekeeping and close supervision of any welding or other operation that might generate heat, sparks or open flame.

Molded Foam Drying and Finishing Operations

Drying

During the drying of molded parts, isopentane continues to be released. Heating devices or systems should be configured to prevent the introduction of flames and/or sparks into drying rooms. Proper ventilation with adequate make-up air is necessary and may assist in preventing the accumulation of flammable isopentane-in-air mixtures.

Drying rooms must be designed to exchange air to prevent the hazardous accumulation of isopentane vapor. Molded parts fabricated from ARCEL resin require very little aging to dissipate any remaining isopentane. Ensure that molded part storage areas are well ventilated and all potential sources of ignition are removed.

Finishing Operations

Finishing operations may include hot wire cutting, hot stamping, laminating, printing and coating. ARCEL resin finishing equipment should be properly grounded, and the finishing area adequately ventilated.

Airborne particulate matter (dust) can be generated during finishing (grinding and compacting) operations and in other areas.

There are three main risks associated with hot wire cutting – electrocution, thermal burns and fires. Please refer to your equipment manufacturers' safety, health and maintenance guide for additional information. Hot wire cutting can be dangerous if wires break and arc upon grounding with the frame of the cutter. The resulting spark can ignite the isopentane vapor liberated from the ARCEL resin block by the cutting operation. Ventilation in this area should be supplemented with additional, properly bonded and grounded, fans and fume hoods to dissipate the isopentane vapors along with the other vapors from cutting. Fire fighting equipment should be readily available in this area. Controls for the cutter should be remote from the cutter itself, so that they may be shut off in case of fire.

Foam fabricated from ARCEL resin that will be hot-wire cut should be adequately conditioned (aged) to minimize the likelihood of fire. Consideration must be given to block size, foam density, conditioning time and conditioning temperature to ensure isopentane concentrations at the hot wire cutter do not create dangerous conditions.

Aging and Storage

After molding ARCEL resin, finished goods should be properly aged until the parts are adequately conditioned and the amount of residual blowing agent has diminished. Until the parts are properly conditioned, the residual isopentane may form a "halo" around them. If ignited, this halo could burn with a blue flame and may generate sufficient heat to promote the complete destruction of the foam article and the spread of fire to surrounding materials.

During processing, typical isopentane losses of 50 –60% occur during pre-expansion. The remaining isopentane will continue to diffuse slowly over prolonged periods.

The aging of the parts, therefore, presents a potential hazard in the plant, and must take place in a well-ventilated area. All ignition sources are to be avoided. Warehousing and molded part storage must be in accordance with local building and fire codes which may reference requirements such as: National Fire Protection Association (NFPA) codes, Factory Mutual (FM) standards and Industrial Risk Insurers.

Shipping

Prohibit smoking and open flames in the vicinity of all ARCEL resin.

Proper aging of foam articles, fabricated from ARCEL resin, before shipping will reduce the risk of an undesirable isopentane-in-air concentration in shipping containers. Transporters, carriers and receiving personnel should be advised to carefully open refrigerated truck trailer/ocean container doors and leave open at least 15 minutes prior to unloading. ARCEL resin foam articles should not be shipped in vapor tight containers. ARCEL resin should be shipped in accordance with applicable jurisdictional regulations.

SPILL CLEAN-UP

Spilled ARCEL resin beads may create a dangerous slipping hazard and should be cleaned up immediately. Good housekeeping is essential to avoid accumulations of spilled ARCEL resin material.

Eliminate all sources of ignition (such as cigarettes, sparks, etc.) from areas surrounding spills. Flammable vapors can be released from ARCEL resin spills. Consider evacuating the spill or leak areas immediately until ambient air sampling results indicate that the isopentane vapor concentration is below the flammable range.

Combustion engines and catalytic converters, such as those that can be found on motor vehicles and heavy equipment, may generate sparks or temperatures high enough to act as ignition sources. Extreme caution should be used when operating these and other types of engine-powered equipment (including chain saws, electrical generators, welders, etc.) in the vicinity of ARCEL resin beads (whether spilled or in boxes). Regardless of the quantity of ARCEL resin spilled, extreme care should be taken to eliminate ignition sources and prevent unwanted metal-to-metal contact or spark generation.

Appropriate protective equipment and clothing (chemical goggles, impervious gloves, protective coveralls and long sleeves) should be worn during clean up of spilled material. Persons not wearing appropriate protective equipment should be excluded from the area of spill until clean up has been completed.

Small spills of ARCEL resin can be cleaned up by using appropriate non-sparking tools. Spilled material can be placed in an appropriate waste disposal container. Adequate ventilation should be provided in waste areas.

A water spray curtain can be used to divert flammable vapor drift. Prevent entry into sewers, basements, or confined areas; dike if needed. Large spills of ARCEL resin can be cleaned up with bulldozers, backhoe, and other power vehicles provided appropriate precautions are taken to avoid such equipment generating sparks or temperatures high enough to act as ignition sources. The use of vacuum trucks is not recommended for clean up of large ARCEL resin spills.

Ensure statutory and regulatory reporting requirements in the applicable jurisdiction are met.

RECYCLING and DISPOSAL

Preferred methods of waste management in order of preference include the following:

- Clean and reuse, if possible
- Contact resin broker
- Contact plastics recycler
- Incinerate with waste heat recovery
- Landfill

Do not dispose of scrap or waste ARCEL resin by uncontrolled ignition (burning).

Scrap or waste ARCEL resin should be kept in well-ventilated areas before reuse, recycling or disposal.

Grinding and/or compacting equipment for managing/recycling scrap and waste ARCEL resin should be properly bonded and grounded. Adequate ventilation should be provided in the grinding/compacting areas. Dust should be collected and removed. All ignition sources should be eliminated in areas where dust clouds may form.

All reuse, recycling, storing/staging, treating, transporting and disposal must be in accordance with applicable federal, state/provincial and local legislation/regulations.

INTERNET RESOURCES/LINKS

The following Internet resources and links are provided for your convenience in obtaining additional information that may or may not be referenced in this Guide. **NOVA Chemicals assumes no liability for the content or accuracy of information obtained from such sources. Access to and use of such resources and links is at the sole risk of the user.**

NOVA Chemicals

www.novachemicals.com

Trade Associations:

Alliance of Foam Packaging Recyclers

www.epspackaging.org

American Chemistry Council

www.americanchemistry.com

EPS Molders Association

www.epsmolders.org

The Styrene Information and Research Center

www.styrene.org

Canadian Plastics Industry Association

www.cpia.ca

U.S. Government/Regulatory Agencies:

Department of Transportation

www.dot.gov

Environmental Protection Agency

www.epa.gov

Occupational Safety and Health Administration

www.osha.gov

Industry Standards:

American Conference of Governmental Industrial Hygienists

www.acgih.org

American Society for Testing and Materials

www.astm.org

American National Standards Institute

www.ansi.org

Factory Mutual

www.fmglobal.com

International Organization for Standardization (ISO)

www.iso.org

National Fire Protection Association

www.nfpa.org

National Institute for Occupational Safety and Health (NIOSH)

www.cdc.gov/niosh

GLOSSARY

Flash Point – The minimum temperature at which a flammable or combustible material will give off sufficient vapors to form an ignitable mixture with air near the surface or in the container, but will not sustain combustion.

Lower Flammability Limit (LFL) – The minimum concentration of a substance that, when mixed with air, will burn in the presence of an ignition source

Melting Point – The melting point or freezing point of a pure substance is the temperature at which its solid and liquid phases are in equilibrium at atmospheric pressure. The terms melting point and freezing point are often used interchangeably, depending on whether the substance is being heated or cooled.

Solubility – A numerical expression describing the degree to which one material will dissolve in another.

Specific Gravity – The weight of a material compared to the weight of an equal volume of water at specified temperatures.

Upper Flammability Limit (UFL) – The maximum concentration of a substance that, when mixed with air, will burn in the presence of an ignition source

Vapor Density – Weight of a volume of gas compared to the weight of an equal volume of dry air at the same temperature and pressure:

- If less than 1.0, the gas is lighter than air and will rise
- If greater than 1.0, the gas is heavier than air and will sink

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11/07 REV. 3.2 AC035-1107