State of California
AIR RESOURCES BOARD

EXECUTIVE ORDER Q-16-005

Small Off-Road Engine Evaporative Emissions System Components

DSM Engineering Plastics
Akulon Fuel Lock FL40-HPX1
Innovative Products

WHEREAS, pursuant to California Health and Safety Code, sections 39600, 39601, and 43013, the California Air Resources Board (ARB) has established a certification process for evaporative emissions system components designed to control gasoline emissions from small off-road engines (SORE), as described in California Code of Regulations, title 13, section 2767.1;

WHEREAS, pursuant to California Health and Safety Code, section 43013, ARB has established criteria and test procedures for determining the compliance of evaporative emission system components with the design requirements in Cal. Code Regs., title 13, section 2754;

WHEREAS, pursuant to Cal. Code Regs., title 13, section 2767.1, ARB Executive Officer may issue an executive order (EO) if he or she determines that the SORE evaporative emission system component or innovative product conforms to the applicable performance requirements set forth in Cal. Code Regs., title 13, section 2754 and 2755;

WHEREAS, pursuant to California Health and Safety Code, sections 39515 and 39516, ARB Executive Officer issued EO G-05-008 delegating the Chief of ARB Monitoring and Laboratory Division (MLD) authority to certify SORE evaporative system components and innovative products; and

WHEREAS, DSM Engineering Plastic submitted an application for certification as an innovative product under in Cal. Code Regs., title 13, section 2767(c) for the model Akulon Fuel Lock FL40-HPX1 process and materials for blow molded fuel tanks.

NOW, THEREFORE, I, Michael T. Benjamin, Chief of MLD, find that fuel tanks produced using DSM Engineering Plastics Akulon Fuel Lock FL40-HPX1 process and materials specifications set out in Attachment A, constitute innovative fuel tanks pursuant to Cal. Code Regs., title 13, section 2767(c). Fuel tanks produced following the DSM Engineering Plastics process and materials specifications are hereby deemed equivalent to those tanks listed in Cal. Code Regs., title 13, section 2752(a)(5). This finding is based on a DSM Engineering Plastics demonstration that such fuel tanks have a permeation rate substantially less than the 1.5 grams per square meter per day set

forth in Cal. Code Regs., title 13, section 2754, when tested at a constant temperature of 40 °C using test fuel CE10 in accordance with approved Alternate Test Procedure ATP-10-001 and ATP-901.

IT IS ORDERED AND RESOLVED that no tank permeation data is required to be submitted in the certification process for equipment using the DSM Engineering Plastics model Akulon Fuel Lock FL40-HPX1 process and materials for blow molded fuel tanks.

IT IS ORDERED AND RESOLVED that all fuel tanks made from DSM Engineering Plastics Akulon Fuel Lock FL40-HPX1 with a minimum and an average wall thickness equal to or greater than the values listed in Table 1, incorporated herein, will yield the test emission rate as determined using ATP-901. Fuel tanks made using DSM Engineering Plastics Akulon Fuel Lock FL40-HPX1 innovative product are certified for use in SORE equipment.

Table 1

Specifications for DSM Engineering Plastics Akulon Fuel Lock FL40-HPX1 Blow Molded Fuel Tanks		
Minimum Barrier Wall Thickness (millimeters)	Average Overall Tank Wall Thickness (millimeters)	Test Emission Rate (grams/meter^2/day)
1.2	1.5 or greater	0.2

IT IS FURTHER ORDERED that equipment manufacturers utilizing DSM Engineering Plastics Akulon Fuel Lock FL40-HPX1 for fuel tanks shall provide warranty to purchasers of the fuel tanks. The warranty must conform to the requirements of Cal. Code Regs., title 13, section 2760.

IT IS FURTHER ORDERED that the certified Akulon Fuel Lock FL40-HPX1 blow molded fuel tanks shall be installed in accordance with the manufacturer's installation and use instructions for the tanks. A copy of this EO and installation and use instructions for the fuel tanks shall be provided to manufacturers purchasing DSM Engineering Plastics Akulon Fuel Lock FL40-HPX1 blow molded fuel tanks for installation on small off-road engines and equipment introduced into commerce in California.

IT IS FURTHER ORDERED that DSM Engineering Plastics Akulon Fuel Lock FL40-HPX1 blow molded fuel tanks introduced into commerce in California shall be clearly identified by a permanent identification showing the manufacturer's name, model number, and EO number.

IT IS FURTHER ORDERED that any modification of the DSM Engineering Plastics approved process or material specifications for producing Akulon Fuel Lock FL40-HPX1 blow molded fuel tanks is prohibited. Any alteration or modification of the process or material specifications set out in Attachment A of this EO will require the manufacturer to apply for a new EO.

IT IS FURTHER ORDERED that the DSM Engineering Plastics Akulon Fuel Lock FL40-HPX1 blow molded fuel tanks shall be compatible with fuels in common use in California at the time of certification and any modifications to comply with future California fuel requirements shall be approved in writing by the Executive Officer or the Executive Officer's delegate.

IT IS FURTHER ORDERED that the innovative product certification of the DSM Engineering Plastics Akulon Fuel Lock FL40-HPX1 blow molded fuel tanks can be referenced in certification applications for small off-road engines and equipment that use SORE unless the Executive Officer finds that the DSM Engineering Plastics Akulon Fuel Lock FL40-HPX1 blow molded fuel tanks no longer meet the performance requirements set forth in Cal. Code Regs., title 13, section 2754, when tested pursuant to Cal. Code Regs., title 13, section 2765.

Executed at Sacramento, California, this 27th day of May 2016.

Dr. Michael T. Benjamin, Chief
Monitoring and Laboratory Division

Akulon®

Akulon® Fuel Lock Recommendations for Blow Moulding

A practical guide for processing Akulon® Fuel Lock

Akulon® Fuel Lock is a generation of polyamides (nylon polymers), which exhibit very effective barrier properties. Akulon® Fuel Lock is used in applications that require low permeation and extreme impact requirements at low temperature, like SORE (small off road engine) fuel tanks or liners in Type IV light weight composite tanks for CNG (Compressed Natural Gas).

Blow moulding requires specific knowledge regarding balancing the process window, product properties and the equipment capabilities. This practical guide aims at explaining how to successfully use Fuel Lock in the blow moulding process and how this differentiates from processing HDPE.

Akulon® Fuel Lock is mostly used in continuous extrusion blow moulding processes or intermittent processes like reciprocating or accumulator extrusion blow moulding. Reciprocating screw, intermittent extrusion blow moulding technology, is the preferred choice for high-volume production of lightweight containers at the lowest cost per container. This process provides fast parison delivery and control that are typical requirements of dairy, juice and water industry. Accumulator head technology is the best choice for the production of large and heavy parts in mono layer. It covers the widest range of applications: from industrial packaging to fuel tanks, from toys to household and gardening items.

Material handling

Pre-drying conditions

While processing polymers that absorb moisture, such as nylons, care must be taken to assure that the moisture content of Fuel Lock resin, as well its regrind, is maintained at a maximum level of 0.10% or lower. Processing at moisture level higher than the recommended level may lead to a decrease in mechanical and physical properties. A modern, closed loop, desiccant bed dryer sized for proper throughput should be utilized. It is also advisable to regularly check the moisture content of the molding resin plus regrind using a commercially available moisture analyzer.

Drying conditions:

Drying time [hr]	**Temperature** [°C]	**Remarks**
4-8	80°C (175°F)	Maximum moisture content will be 0.10%

Akulon can be used straight out of the bag, only if there is no dryer available. The bags should not be pre-opened before usage. Time between opening the bag and usage should be limited. The volume of the hopper should be such that the material, when in direct contact to air, is used within 0.5 hr.

Regrind

Since the blow molding process generates scrap at up to a 50% by weight level, the reuse of this material is required due to process economics. Evaluations of the use of Fuel Lock regrind has shown that levels up to 100% have been successful in maintaining the physical and mechanical properties of the virgin material. The successful use of Fuel Lock regrind in the blow molding process requires good initial care of the molded material, like proper initial drying.

Processing

Melt temperature

The melt temperature mainly affects processing behavior via the viscosity and the color. A too high processing temperature results in a decreased melt strength and can result in discoloration (yellowness of natural material). Recycle of material that was processed at a too high temperature is not recommended.

Mould temperature

No/limited impact of the mould temperature can be expected on the pinch line or the part surface when processing Akulon® Fuel Lock. The mould temperature can be optimized to tune the result in surface quality and/or should be taken into account considering the design. It is recommended to use a mould temperature within the upper range of the recommended mould temperature regime for high article complexity.

	Extrusion Zones			Resin	Mold
	Feed	Compression	Metering	Melt	Temperature
°C	220 - 235	240 - 260	260	250 - 260	30 - 50
°F	430 - 455	465 - 500	500	480 - 500	85 - 125

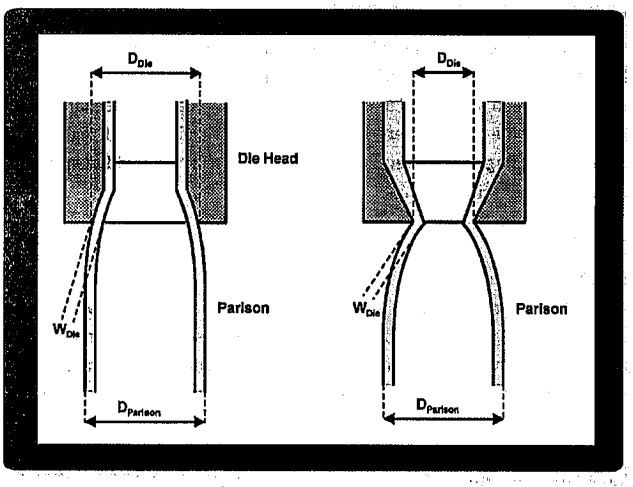
The intake of material can be restricted by limitations of the equipment, like the power of the motor, which can be overcome by increasing the feed zone temperature or use an inverse temperature profile. The preferred melt temperature at the die head is around 250 °C. The die head temperature can be increased if surface roughness (sharkskin) is experienced.

Screw design
It is recommended to use a gradual compression screw with a L/D (length/diameter) ratio of ~25 and a compression ratio of ~3.0 (depth feed zone/depth metering zone). A shorter screw may result in inhomogeneous mixing, while an improper compression ration may result in air entrapment or overheating of the melt.

Residence time
Downtime of the equipment or production stops may result in a relatively long residence time of the material at high temperature. Expect a reduction of the melt strength during extrusion when restarting. The impact on melt strength is higher for polyamides compared to HDPE. Akulon® Fuel Lock is designed to withstand process interruptions of ~1 hour without concessions to the quality of the performance. First 3-5 articles should be scrapped to ensure highest quality.

Machinery

Swell and blow-up rate
Die swell can be defined as the ratio between the outer parison diameter and the outer diameter of the die. The die swell of Fuel Lock is less than for HDPE. Typically a die is used for Fuel Lock that is about 1.5-2x the size than when processing HDPE. Besides the material, flow rate, viscosity, melt strength and die width, the die swell depends on the design of the die.



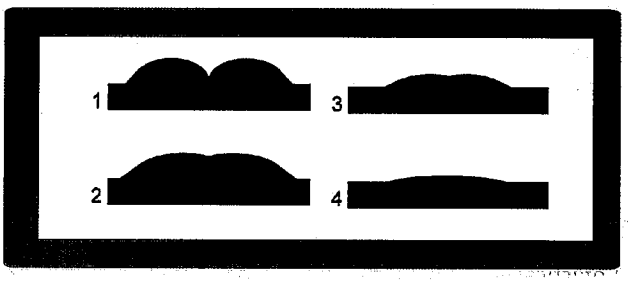
Diverging and converging die heads result in different die swell

A die swell of around 10 to 50% can be expected with Akulon® Fuel Lock. In general, Fuel Lock has a lower die swell than HDPE. Blow-up ratios of 1:3 to 1:5 can be achieved, depending on the part complexity.

The blow-up pressure and speed have impact on the polymer distribution in the shape (wall thickness, etc.) and the final color (in case oxygen is used as blow-up medium). Preferably, the blow-up speed is optimized with a profile.

Closing speed
The closing speed of the mould has an impact on the pinch line (depending on the design of the mould). The closing speed has an optimum, which means in practice that closure of the final few mm should be done at reduced pace to allow material to flow into the pinch.

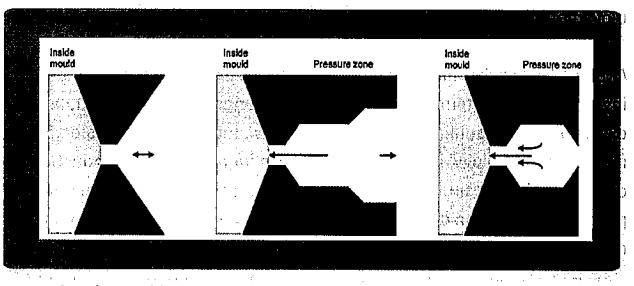
Mould design
The mould design should be considered to improve the pinch of the application. Below an overview of pinch profiles that could be encountered:



Pinch lines

Typically category 1 pinches (crack sensitive) should be avoided by using the correct mould design in combination with a proper processing window (temperature, pre-drying, recycle, heat stabilization, air/nitrogen, closing speed, etc.) and closing speed profile.

A pressure zone is recommended in the mould design to process Fuel Lock. Below three examples of how a mould designs could look like:



Regular mould, type 1 | *Pressure zone mould, type 2* | *Pressure zone mould, type 3*

Safety

For the safety properties of the material, we refer to our MSDS, which can be ordered at our sales offices. During practical operation we advise to wear personal safety protections for hand/eye/body.

Cleaning

Production has to be started and stopped with a clean machine. Cleaning can be done with high viscous PA6, applicable cleaning agents or HDPE. It is recommended to start-up with natural Akulon® Fuel Lock to visually check on contaminations.

Conclusion

Akulon® Fuel Lock is a polyamide, which can be processed via blowmoulding in a broad operating window with similar equipment as used for HDPE. Akulon® Fuel Lock is an intrinsic robust solution for reduced permeation of hydrocarbons through tank walls.

Troubleshooting guide

Parison strength	Q: Parison strength too little. Sagging observed.
	A: The melt temperature is too high, due to a too high barrel temperature. Reduce the barrel temperature or reduce the extrusion speed.
	A: The melt temperature is too high due to friction of the screw or in the die head. Increase the barrel temperature or increase the die temperature.
	A: The residence time is too long, resulting in degradation.
	A: Too much moisture in virgin material or regrind.
	A: Use high-flow material
Inner surface	Q: The inner surface is rough / sharkskin.
	A: Reduce the extrusion speed (though balance the speed to avoid sagging).
	Q: The inner surface (natural tank) shows discoloration (yellowish/brownish).
	A: The wall thickness is too high, resulting in storage of intrinsic heat (low cooling speed) and therefore oxidative degradation. Optimize die position or optimize extrusion volume profile.
	A: Viscous dissipation at the extrusion die, resulting in too high surface temperature of the parison. Reduce extrusion speed or reduce melt viscosity (barrel temperature increase).
Power	Q: The power of the machine reaches the maximum power.
	A: Increase overall barrel temperature or shift from an increasing barrel temperature profile to a decreasing temperature profile (when having a grooved intake zone) by increasing the temperature at the intake/feed zone(s) ⟶ inverse temperature profile.
Pinchline	Q: The pinchline strength is too little.
	A: Contamination with HDPE could form an inner layer of HDPE that heavily affects the pinchline strength.
	A: The parison is too cold, resulting in limited flowability of the melt and therefore a reduced contact area and too little melt mixing.
	A: Mold design is not tailor made for polyamides, resulting in too little backflow of material into the pinch.
	A: Oxidation of the inner layer
	Q: Black lines or spots are observed on the surface.
Contamination	A: Possibly HDPE contamination, which will negatively influence the pinchline and the impact performance. More cleaning required. Mostly, contamination originates from the accumulator (low self-cleaning capability).
Defects	Q: The wall has a 'popcorn' like structure.
	A: Too much moisture in the material.
	Q: Loud noise/bang from the die.
	A: Too much moisture in the material.

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