RESISTANCE+ DURABILITY

Chemical Resistance Performance Testing for Healthcare Materials

CHEMISTRY THAT MATTERS™

INTRODUCTION

HARSH DISINFECTION AND STERILIZATION ENVIRONMENTS…

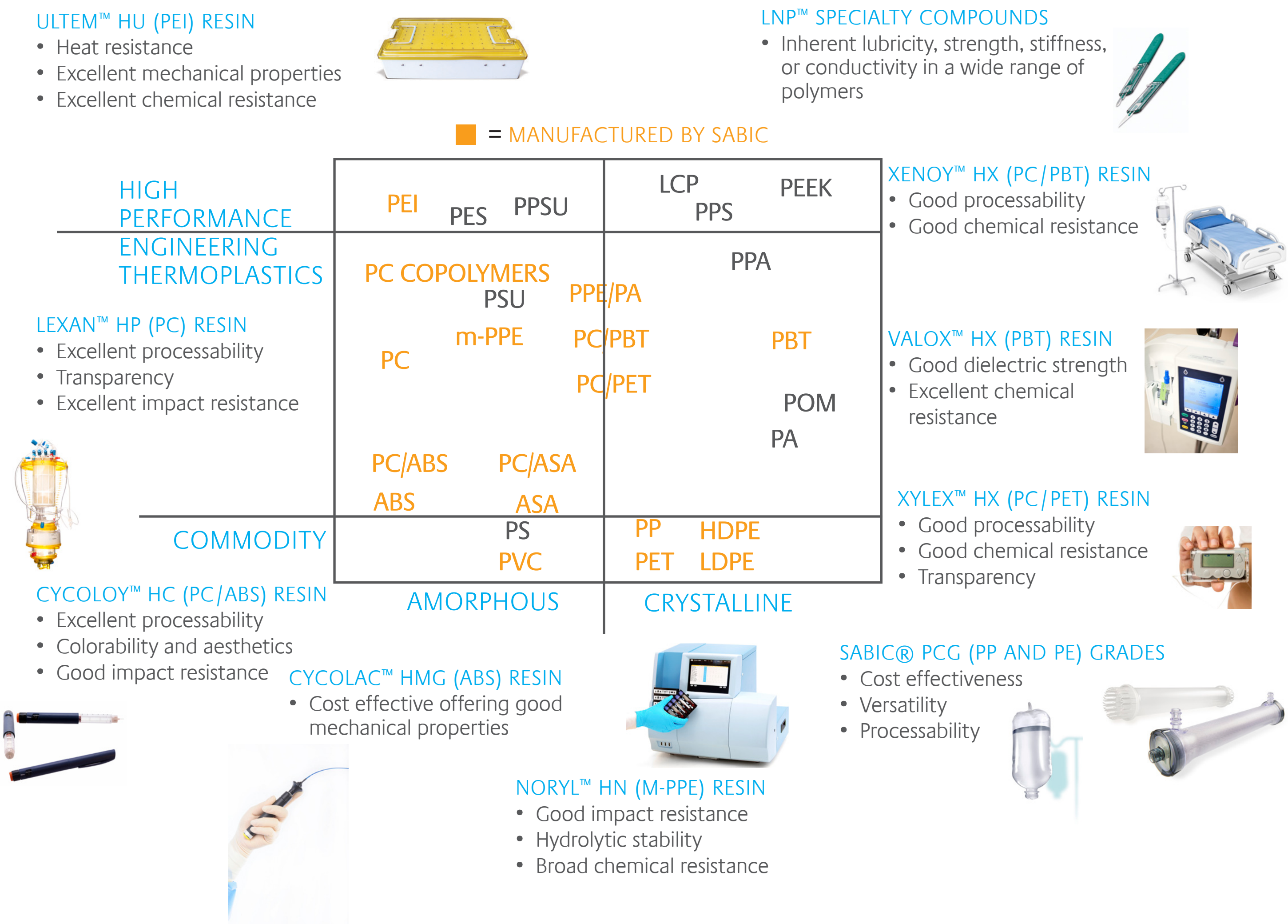
With patient safety at the forefront, the healthcare industry is mobilizing to address the concerns of increasing patient infections associated with medical care, known as HAIs (healthcare acquired infections). To help meet this challenge, medical equipment and high touch surfaces in patient care settings are repeatedly wiped down with increasingly aggressive chemical disinfectants.

…REQUIRE A HIGH PERFORMANCE SOLUTION

Materials used to manufacture medical device enclosures must withstand ever increasing in-service demands due to chemical resistance needs, complex designs and performance requirements. SABIC's portfolio of enclosure materials has been created to help the industry meet a broad range of potential device requirements (see Figure 1).

THE SABIC RESINS PORTFOLIO

FIGURE 1
THE SABIC RESINS PORTFOLIO



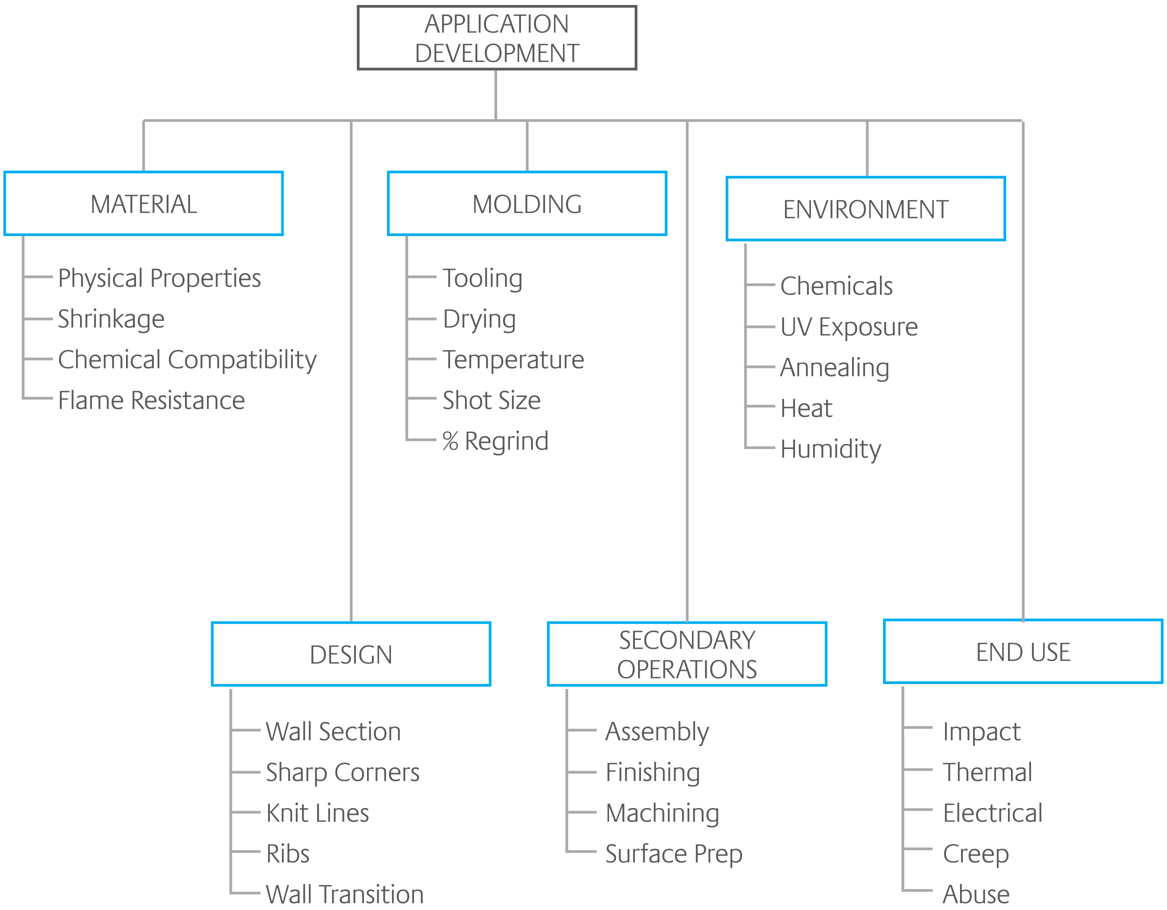
DESIGNING FOR ESCR

APPLICATION DEVELOPMENT

Each phase of the application development process (shown in Figure 2) can influence environmental stress cracking. Outlined below are key factors to consider when designing to prevent environmental stress cracking or chemical attack.

FIGURE 2

APPLICATION DEVELOPMENT PROCESS



UNDERSTANDING CHEMICAL COMPATIBILITY

Chemical resistance can be dependent upon exposure time, temperature, stress (molded in and any external stress), type of chemical and the chemical concentration. Chemical exposure may result in either physical degradation (stress cracking, crazing, swelling and discoloration) or chemical attack (reaction of chemical with polymer and loss of properties of the thermoplastic material).

The severity of the exposure and the reaction by the plastic is dependent upon several variables:

- Time: the exposure can be brief as when the part is wiped, or the contact can be longer term as when the part is continuously immersed in a fluid or is a container for the fluid.
- Temperature: elevated temperatures are more likely to affect the exposed parts as the chemical reaction could be accelerated.
- Stress: stresses may be induced from an applied load or may be trapped during the molding process. Highly stressed parts are more likely to experience failure.

When exposed to chemicals, plastic materials may generally react in either of two ways:

- Plasticization: which can result in material softening, increase in weight, decrease in tensile strength and possible occurrence of yielding.
- Crazing: which can result in localized fracturing and potentially a decrease in elongation to failure.

Selecting and testing appropriate materials for an application can be critical to its success. For medical device applications that are subject to frequent cleaning, it is important to consider the cleaning process, the types of disinfectants, and the anticipated frequency of cleaning. Part design and the related cleaning protocol can also be a critical application performance factor.

THE INFLUENCE OF STRESS

Stress is a common factor in most part failures. Even if all stresses are accurately evaluated, failure can still occur from unanticipated factors. Stresses are cumulative - a part may pass a compatibility test as molded, but with externally applied stresses induced by an assembly operation for example, the part may be more susceptible to attack. Often the best approach may be to test actual parts and then modify the design accordingly.

Achieving optimal performance in a component made from an engineering thermoplastic requires the use of good design practices. Two principles of design to consider are:

- Minimum stress: stress (load) should be minimized to prevent high localized stresses (stress concentration)
- Uniform stress: stress should be distributed uniformly

To achieve these design objectives, maintaining a uniform and consistent wall thickness and using gradual transitions when uniformity cannot be maintained will help. Also, to reduce stress concentrations, all sharp corners should have as large a radius as possible.

DESIGNING FOR ESCR

MATERIAL SELECTION & ENVIRONMENTAL STRESS CRACK RESISTANCE (ESCR) TESTING

It is important to fully define the application requirements and environment in order to properly select and evaluate material candidates. SABIC's broad portfolio of materials lends itself to a wide variety of applications. One important test that can help aid in the selection of materials is the environmental stress crack resistance (ESCR) test. This test is designed to evaluate the effect of chemical media on a plastic material that is under stress or load. In the ESCR test, tensile bars are bent to specific strain levels (typically 0, 0.5, 1.0, 1.5% strain) in special test fixtures and the chemical is then applied to the most highly strained area of the tensile bars. The bars are kept in constant exposure to the strain and chemical agent for a specific test period. At the end of the test period, the bars are removed from the test fixtures and analyzed for the amount of change in certain material properties. The magnitude of change in these material properties can provide a good indication of the subject chemical's severity as a stress cracking agent.

A simplified version of the ESCR test allows engineers, processors and designers to screen candidate materials for an application using the anticipated chemical environments. Although simplified, this version of the ESCR test has proven useful as an indicator of expected performance. Figure 3 shows a simple test fixture that can be constructed to provide three different levels of bending strain. If 8.50 inch long tensile bars are used for the test, the indicated lengths in the fixture will correspond to the following approximate strain levels:

- 0.5% strain – 8.42 inches
- 1.0% strain – 8.19 inches
- 1.5% strain – 7.83 inches

These lengths and corresponding strain levels were determined experimentally using a strain-gauged ASTM 8.50 inch tensile bar. The tensile bar will be bent into an arc when gently forced into the test fixture at the various lengths. In addition to the strained tensile bars, an unbent or unstrained set of bars should always be a part of the test to serve as the control set. Figure 4 shows a tensile bar bent into the 1.5% strain arc. The length of the test fixture for this strain level is 7.83 inches.

FIGURE 3

FIXTURE WITH OPPOSING SLATS

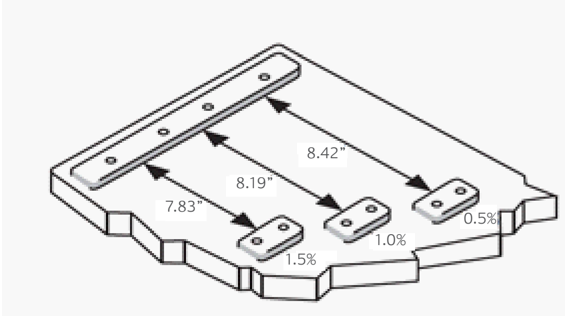


FIGURE 4

TENSILE BAR INSERTED AT 7.83" OR 1.5% STRAIN

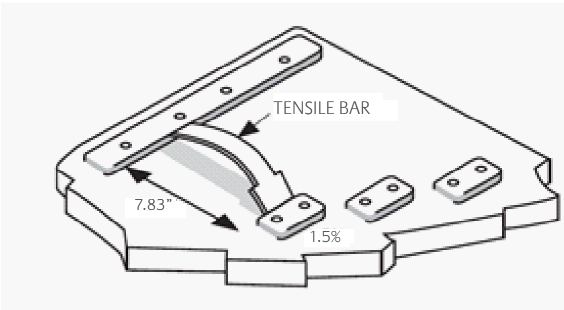
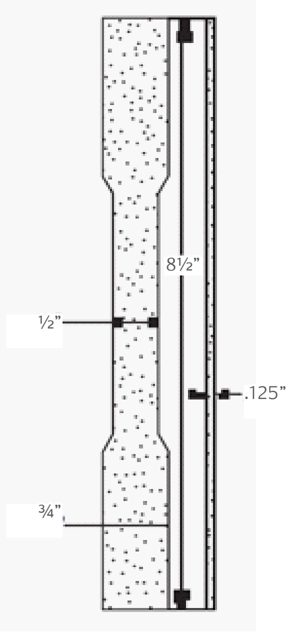


FIGURE 5

TENSILE BAR 8.5 X 0.75 X 0.125 INCHES NECK DOWN TO 0.5 INCH WIDE GAGE AREA



Once the tensile bar has been inserted into the test fixture, the chemical agent to be evaluated should be applied to the top center of the test bar arc and left exposed for a designated time period at room temperature. A common method of ensuring constant exposure to chemical agents is to wrap clean cheesecloth around the tensile bar and keep saturated while in contact with the strained area of the bar. Another common test method is to wipe the sample tensile bars with the chemical a number of times during the testing period to simulate the end use condition. Volatile agents may require a closed container such as a polyethylene bag to prevent evaporation, thereby maintaining wet exposure throughout the test period.

Test fixtures should, of course, be thoroughly cleaned after each test series. The tensile bars suggested for use in this test are injection molded and measure 8.50 inches x 0.75 inch x 0.125 inch, with a 0.5 inch wide necked down gage area, shown in Figure 5. ESCR testing can also be performed using tensile bars that are cut from sheet stock or finished parts (providing they are flat and approximately 0.125 inch thick) if the sides of the bars are very smoothly cut and finished. It is important to note that the tensile bars with different dimensions will result in strain levels that are different from 0.5%, 1.0% and 1.5%. Also the test results obtained from cut bars will be more erratic due to the effects of varying specimen orientation and the fact that the sides of the bars are mechanically cut and finished. However, since the purpose of the ESCR test is to provide a rough screening for chemical resistance effects, mechanically cut bars can be used to provide an indication of performance.

At the end of the predetermined exposure time period, the test specimens should be removed from the fixture, wiped clean, and examined for indications of crazing or embrittlement. If stress whitening, cracking, breakage, or other failure is evidenced for any of the tensile bars, the compatibility of the material with the chemical agent should be questioned. If no effects are visible, the simplified ESCR test method includes bending the bars with the chemically exposed area in tension (at the outermost point of the bend). If any of the tensile bars crack, the chemical agent being evaluated can be considered a mild stress cracking agent for this material. If no effects are visible and the bars do not break or seem embrittled, the agent can be considered fairly compatible.

Results should be tabulated for each strain level. The more complex and quantitative version of the ESCR test involves evaluating the retention of tensile stress at yield and retention of tensile elongation at break compared to the control. It should be noted that compatibility criteria may vary since there is currently no agreed upon industry standard. SABIC defines compatibility as ≥90% retention of tensile stress at yield and 80-139% retention of tensile elongation at break, and is the criteria that was used for the evaluation data in this report. There are many variables which can affect environmental stress cracking such as chemical exposure, concentration, temperature, exposure condition and level of stress or strain in a part. Therefore, it is suggested to use the defined compatibility criteria, shown in Figure 6, and consistent test procedures when evaluating and comparing ESCR performance of materials in order to provide a more accurate representation of material performance.

FIGURE 6

LAB BENCH COMPATIBILITY RATING:

Color rating	Retention tensile stress at yield, %	Retention tensile elongation at break, %
COMPATIBLE	≥ 90	80 -139
MARGINAL	80 - 89	65 - 79
NOT COMPATIBLE	≤ 79	≤ 64 OR > 140

DESIGNING FOR ESCR

This ESCR test protocol evaluates material performance over a short time period with limited chemical exposure and only approximates stresses and strains to be encountered in a final end use application. It should be noted that strain levels of 1.0% and 1.5% exceed the normal design limit for some materials, which is approximately 0.75% strain. The higher strain levels are used in the ESCR test to help accelerate the simulation of the effects of low strain, longer-term exposure. When comparing ESCR datasets, it is important to compare similar test conditions since there can be many variables such as exposure time, temperature, strain level, and chemical application method.

PROCESS OPTIMIZATION

Polymer degradation is a decrease in average polymer length, generally due to heat and shear in the conversion process from pellets to part. Excessive degradation can result in the loss of some or all physical properties. Proper molding practices should be employed to prevent excessive degradation.

The level of molded in stress is a function of the pressures and temperatures in the molding cycles, the tool temperature, the material viscosity and the part geometry. It can affect the dimensional stability, chemical resistance and physical properties of the part. Following proper molding practices with careful consideration of cumulative drying time, residence times, shear rates, temperatures and pressures will help to create a robust part.

FAILURE ANALYSIS

When attempting to determine the cause or causes of a part's failure, it is a good practice to look for secondary or tertiary factors which may also be significant contributors to the part's failure.

The failure of a part molded from a thermoplastic resin can be caused by a number of factors during its useful life. Errors in design, processing, secondary operations, assembly and the end use environment can lessen the expected performance. Often, two, three or more factors can contribute to less than satisfactory performance of the part. However, the three most common problems are polymer degradation during processing, chemical attack and unexpected stress concentrators or accumulations.

SUMMARY

There are many variables that should be considered when evaluating a material's compatibility with a given environment. It is critical to fully understand the application needs and the end use environment when selecting material candidates. Material candidates should be screened for ESCR with the chemicals and environmental conditions that the part will be exposed to during its application. Part design should be carefully considered to ensure that stress concentrations are minimized and applied loads are evenly distributed. Process optimization should also be investigated to ensure that polymer degradation is minimized.

It is important to remember that the customer is responsible for performing end use part testing to determine the suitability of a material in their application.

Application development and process development engineers at SABIC are available to aid you throughout the material selection, application development and molding processes. Additional data and resources may be available. To learn more please contact your SABIC representative or use the contact information listed on the last page of this document.

ESCR TESTING

SABIC has provided chemical resistance performance test results for a broad portfolio of both amorphous and semi-crystalline materials to aid medical equipment manufacturers in selecting materials for their device requirements (see Table 1). To supplement this test data, SABIC has performed an ESCR study of common flame retardant medical enclosure materials with newer chemical disinfectants (see Table 2 and Table 3). Additionally, SABIC has collaborated with a leading disinfectant supplier, PDI, to further assess compatibility between medical enclosure materials and chemical disinfectants (see Table 4).

CHEMICAL RESISTANCE PERFORMANCE TESTING

TABLE 1

CHEMICAL RESISTANCE PERFORMANCE TESTING - HEALTHCARE RESINS, STANDARD RESINS

PRODUCT FAMILY	GRADE/SERIES	Exposure time (days)	Bleach sodium hypochlorite solution, 50%	Cidex† glutaraldehyde based disinfectant	Methyl ethyl ketone (MEK)	Virex† organic ammonium chloride based disinfectant	Betadine† microbicide; povidone-iodine solution	Ethanol (ethyl alcohol)	Hydrogen peroxide 3%	Isopropanol (isopropyl alcohol; ipa) 70%	Saline 10%	Lipid hydrocarbon-containing organic compounds; fatty acid derivatives	DEHP diethylhexylphthalate
LEXAN PC RESINS													
Healthcare products													
	HP1R	3	⊕	⊕	■	●	⊕	●	⊕	⊕	⊕		
	HPS2R	3	⊕	⊕	■	●	⊕	⊕	⊕	⊕	⊕		
	HPS7	3	⊕	●	■	●	⊕	⊕	7 days ⊕	⊕	⊕	●	5 days ⊕
	HPX4	3	⊕	⊕	■	▲	⊕	⊕	⊕	⊕	⊕		
	HPH4404	3	⊕	⊕	■	⊕	⊕	⊕	⊕	⊕⊕	⊕		
	HPH4704	3	⊕	⊕	■	⊕	⊕	⊕	⊕⊕	⊕⊕	●		
Standard products													
	925	7	⊕	●	■	●	⊕	⊕	⊕	⊕	⊕		
	945	7	⊕	● ▲+	■	●	⊕	⊕	⊕	⊕	⊕⊕		
	925A	7	⊕	●	■	⊕	⊕	⊕	⊕	⊕	⊕		
	945AU	7	⊕	⊕	■	⊕	⊕	⊕	⊕⊕	⊕	⊕⊕		
Standard Products — Enhanced flow / ductility resins													
	EXL1414	7	⊕⊕	⊕⊕	■	●	⊕⊕	⊕⊕	⊕⊕	⊕⊕	⊕⊕		
	EXL9112	7	⊕⊕	⊕ ▲++	■	●	⊕⊕	⊕	⊕⊕	⊕⊕	⊕⊕		
	EXL9330	7	⊕⊕	⊕⊕	■	⊕	⊕⊕	⊕⊕	⊕⊕	⊕⊕	⊕⊕		
	EXL9335	7	⊕	⊕	■	⊕	⊕	⊕	⊕⊕	⊕⊕	⊕		
XYLEX™ PC/POLYESTER RESIN BLENDS													
Healthcare products													
	HX7409HP	3	⊕	⊕	■	●	⊕	⊕	⊕⊕	⊕	⊕⊕	●	
	HX8300HP	3	⊕	●	■	● ▲+	⊕⊕	■	⊕	⊕⊕	⊕⊕	■	
XENOY™ PC/POLYESTER RESIN BLENDS													
Healthcare products													
	HX5600HP	7	●	⊕	■	▲	⊕	⊕	⊕	●	⊕		●
	HX6600HP	7	⊕	⊕	⊕	⊕	⊕	▲+	⊕	⊕	⊕		⊕
CYCOLOY PC/ABS RESIN BLENDS													
Healthcare Products													
	HC1204HF	7	●	▲	■	▲	■	■	⊕⊕	⊕	●		
Standard products													
	C2950	7	●	■	■	■	■	▲	●	●	▲		
	C6600	7	●	■	■	■	⊕⊕	■	●	■	⊕⊕		
	CX2244ME	7	●	■	■	■	⊕⊕	■	⊕⊕	●	⊕⊕		
	CX2142ME	7	●	■	■	■	⊕⊕	■	⊕⊕	●	●		
CYCOLAC ABS RESINS													
Healthcare products													
	HMG47MD	7	⊕⊕	●	■	●	■	■	▲+	●	●		
	HMG94MD	7	⊕⊕	■	■	■	■	■	⊕	■	●		
Standard products													
	MG37EPN	7	⊕⊕	●	■	⊕ ▲++	●	■	⊕⊕	■	⊕⊕		
	XHMM1	7	⊕⊕	▲	■	●	■	■	⊕⊕	■	⊕⊕		
	GRM2600L	7	⊕⊕	●	■	⊕⊕	●	■	⊕⊕	●	⊕⊕		

LEGEND FOR SYMBOLS

- ⊕⊕ Compatible at 1.5% strain
- ⊕ Compatible at 1.0% strain
- ● Compatible at 0.5% strain
- ▲++ Marginal for one or both measures at 1.5% strain
- ▲+ Marginal for one or both measures at 1.0% strain
- ▲ Marginal for one or both measures at 0.5% strain
- ■ Not compatible

LAB BENCH COMPATIBILITY RATING:

Color rating	Retention tensile stress at yield, %	Retention tensile elongation at break, %
COMPATIBLE	≥ 90	80 -139
MARGINAL	80 - 89	65 - 79
NOT COMPATIBLE	≤ 79	≤ 64 OR > 140

PRODUCT FAMILY	GRADE/SERIES	Exposure time (days)	Bleach sodium hypochlorite solution, 50%	Cidex† glutaraldehyde based disinfectant	Methyl ethyl ketone (MEK)	Virex† organic ammonium chloride based disinfectant	Betadine† microbicide; povidone-iodine solution	Ethanol (ethyl alcohol)	Hydrogen peroxide 3%	Isopropanol (isopropyl alcohol; ipa) 70%	Saline 10%	Lipid hydrocarbon-containing organic compounds; fatty acid derivatives
ULTEM PEI RESINS												
Healthcare products												
	HU1010	7	(++)	(+) ▲++	■	(+)	(++)	(+) ▲++	(++)	(++)	(+)	
	HU2300	7	●	(++)	■	●	(++)	(+) ▲++	(++)	(++)	(++)	
NORYL MODIFIED PPE RESIN BLENDS												
Healthcare products												
	HN731E	7	(++)	(++)	■	●	(++)	(++)	(++)	(++)	(++)	
	HNA033	7	(+)	(+)	■	▲	▲+	(+)		▲+	●	■
	HNA055	7	(++)	(++)	■	(++)	(++)	(+)	(++)	(++)	(++)	(+)
Standard products												
	GFN2	3	(++)	(++)	(+)	(++)	(++)	(++)	(++)	(++)	(++)	
VALOX PBT AND/OR PET RESINS AND BLENDS												
Healthcare products												
	HX215HPR	3	(+)	(+)	(+)	(+)	(+)	■	(+)	(+)	(+)	(+) ▲++
	HX420HP	3	(+)	■	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)
Standard products												
	365	3	(+)	(+)	■	(+)	(+)	●	(+)	(+)	(+)	
	855	3	● ▲+	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	
LNP LUBRICOMP™ COMPOUNDS – Internally lubricated												
	AL003	7	(+)	▲	■	(+)	▲+	■	(+)	■	(+)	
	DFL36	3	(+)	● ▲+	(+)	● ▲+	(+)	(+)	(+)	(+)	(+)	
	EL003	7	(+)	(+)	■	▲+	(+)	(+)	(+)	(+)	(+)	
	RFL36	7	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	
	WFL36	7	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	
	ZFL36CCX	7	(+)	(+)	▲	(+)	(+)	(+)	(+)	(+)	(+)	
LNP THERMOCOMP™ COMPOUNDS – Internally reinforced												
	DF006ER	3	(+)	(+)	(+)	● ▲+	(+)	(+)	(+)	(+)	(+)	
	EF006	7	(+)	(+)	▲ ▲+	(+)	(+)	(+)	(+)	(+)	(+)	
	LF006	7	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	
	RF006	7	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	
	UF008	7	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	
	WF006	7	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	

CHEMICAL RESISTANCE TESTING ACCORDING TO ISO 22088-3:2006 (PLASTICS DETERMINATION OF RESISTANCE TO ENVIRONMENTAL STRESS CRACKING (ESC) PART 3: BENT STRIP METHOD) OR ASTM D543 (EVALUATING THE RESISTANCE OF PLASTICS TO CHEMICAL REAGENTS).
This information should be used as indicative only. This is essentially a ranking test and is not intended to provide data to be used for design or performance prediction. Accurate chemical compatibility can only be determined under final application conditions. Therefore, extensive testing of the finished part is strongly recommended. The performance and interpretation of end-use testing are the end producer's responsibility.

STRAIN LEVEL <0.5%
Generally represents molded-in stress of actual part, when designed and molded in line with recommended guidelines

STRAIN LEVELS >0.5%
A material is generally more susceptible to chemical attack at higher strain levels. [e.g. chemically induced cracking will more readily occur at strain level 1.5% than at strain level 0.5%]

TEST TEMPERATURE: 23 °C (73 °F)

ESCR TEST RESULTS

TABLE 2

CHEMICAL RESISTANCE PERFORMANCE TESTING – COMMON RESINS USED FOR ENCLOSURES IN THE HEALTHCARE INDUSTRY

Chemical Application Method: Wipe (5x/day) Total Wipes: 15

Exposure Time: 3 Days

CHEMICALS	**PDI Sani-Cloth† Plus** Alcohol, QAC based disinfectant		**PDI Super Sani-Cloth** Alcohol, QAC based disinfectant		**PDI Sani-Cloth AF III** Alcohol Free, QAC based disinfectant	
	Yield Strength	Nominal Strain at Break	Yield Strength	Nominal Strain at Break	Yield Strength	Nominal Strain at Break
PRODUCT FAMILY/ GRADE						
CYCOLOY C6600 resin	●	■	●	■	■	■
CYCOLOY CX2244ME resin	■	■	●	■	■	■
LEXAN EXL9330 resin	●	●	●	●	■	■
LEXAN 945 resin	●	▲	●	●	■	■
ULTEM ATX200 resin	●	●	●	●	●	■
VALOX 357U resin	●	●	●	●	●	●
VALOX 364 resin	●	●	●	●	●	■
VALOX V3900WX resin	●	●	●	●	■	■

LEGEND FOR SYMBOLS

- ● Marginal at 0.5% strain
- ▲ Marginal for one or both measures at 0.5% strain
- ■ Not compatible

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TABLE 3

CHEMICAL RESISTANCE PERFORMANCE TESTING – COMMON RESINS USED FOR ENCLOSURES IN THE HEALTHCARE INDUSTRY

Chemical Application Method: Saturation

Exposure Time: 3 Days

CHEMICALS	PDI Sani-Cloth Plus Alcohol, QAC based disinfectant		PDI Super Sani-Cloth Alcohol, QAC based disinfectant		PDI Sani-Cloth AF III Alcohol Free, QAC based disinfectant	
	Yield Strength	Nominal Strain at Break	Yield Strength	Nominal Strain at Break	Yield Strength	Nominal Strain at Break
PRODUCT FAMILY/ GRADE						
CYCOLOY C6600 resin	■	■	⊕	■	■	■
CYCOLOY CX2244ME resin	■	■	●	■	■	■
LEXAN EXL9330 resin	⊕	● ▲+	⊕	●	■	■
LEXAN 945 resin	●	●	⊕	●	■	■
ULTEM ATX200 resin	⊕	● ▲+	⊕	⊕	■	■
VALOX 357U resin	⊕	● ▲+	⊕	● ▲+	●	■
VALOX 364 resin	⊕	⊕	⊕	⊕	●	■
VALOX V3900WX resin	⊕	▲	● ▲+	●	■	■

LEGEND FOR SYMBOLS

- ⊕ Marginal at 1% strain
- ● Marginal at 0.5% strain
- ▲+ Marginal for one or both measures at 1% strain
- ▲ Marginal for one or both measures at 0.5% strain
- ■ Not compatible

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Color rating	Retention tensile stress at yield, %	Retention tensile elongation at break, %
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ESCR TEST METHODOLOGY

CHEMICAL RESISTANCE TESTING ACCORDING TO ISO 22088-3:2006 (PLASTICS DETERMINATION OF RESISTANCE TO ENVIRONMENTAL STRESS CRACKING (ESC) PART 3: BENT STRIP METHOD) OR ASTM D543 (EVALUATING THE RESISTANCE OF PLASTICS TO CHEMICAL REAGENTS).

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STRAIN LEVELS >0.5%

A material is generally more susceptible to chemical attack at higher strain levels (e.g. chemically induced cracking will more readily occur at strain level 1.5% than at strain level 0.5%)

TEST TEMPERATURE: 23 °C (73 °F)

ESCR TEST RESULTS

SABIC and PDI recently collaborated to conduct an ESCR study using SABIC's materials that are typically selected for medical enclosure applications and PDI's **Sani-Cloth**† wipes, a leading surface disinfectant widely used to help prevent healthcare-associated infections (HAIs). Results from the study (below in Table 4) can help medical device manufacturers better understand the interaction between SABIC materials and PDI disinfectants, enhancing their ability to evaluate and select materials to help them meet challenging chemical resistance requirements for their devices in the healthcare setting. In this study, SABIC and PDI evaluated a broad set of engineering thermoplastic resin families, including the additional factors of pigmentation and flame retardant additives to assess potential effects on compatibility with PDI **Sani-Cloth** Germicidal Disposable Wipes. Additionally, higher strain rates were studied as compared to earlier SABIC testing.

TABLE 4

CHEMICAL RESISTANCE PERFORMANCE TESTING – PDI and SABIC collaboration

Chemical Application Method: Saturation

Exposure Time: 2 Days

CHEMICAL	PDI **Super Sani-Cloth** Germicidal Disposable Wipes Alcohol, QAC based disinfectant	
	Yield Strength	Nominal Strain at Break
PRODUCT FAMILY/ GRADE/ COLOR DESCRIPTION		
CYCOLOY C6600-BK1005 resin (black)	●+ ●++	●+ ■
CYCOLOY C6600-111 resin (natural)	●+ ▲++	■ ■
CYCOLOY CX2244ME-BK1005 resin (black)	●+ ●++	●+ ■
CYCOLOY CX2244ME-111 resin (natural)	●+ ●++	●+ ▲++
LEXAN 945-7T3D124 resin (gray)	●+ ●++	●+ ▲++
LEXAN EXL9330-BK1A233 resin (black)	●+ ●++	▲+ ▲++
LEXAN EXL9330-BK1A068 resin (black)	●+ ●++	●+ ▲++
VALOX 325-BK1006 resin (black)	●+ ●++	●+ ●++
VALOX 364-GY8G001 resin (gray)	●+ ●++	●+ ●++
XENOY ENH2900-1001 resin (natural)	●+ ●++	●+ ■
XYLEX 2230-GY4E246 resin (gray)	●+ ●++	●+ ●++

ESCR TEST METHODOLOGY

CHEMICAL RESISTANCE TESTING ACCORDING TO ISO 22088-3:2006 (PLASTICS DETERMINATION OF RESISTANCE TO ENVIRONMENTAL STRESS CRACKING (ESC) PART 3: BENT STRIP METHOD) OR ASTM D543 (EVALUATING THE RESISTANCE OF PLASTICS TO CHEMICAL REAGENTS).

This information should be used as indicative only. This is essentially a ranking test and is not intended to provide data to be used for design or performance prediction. Accurate chemical compatibility can only be determined under final application conditions. Therefore, extensive testing of the finished part is strongly recommended. The performance and interpretation of end-use testing are the end producer's responsibility.

STRAIN LEVEL <0.5%

Generally represents molded in stress of an actual part, when designed and molded in line with recommended guidelines.

STRAIN LEVELS >0.5%

A material is generally more susceptible to chemical attack at higher strain levels (e.g. chemically induced cracking will more readily occur at strain level 1.5% than at strain level 0.5%)

TEST TEMPERATURE: 23 °C (73 °F)

LEGEND FOR SYMBOLS

- Compatible at 1.5% strain
- Compatible at 1.0% strain
- Marginal for one or both measures at 1.5% strain
- Marginal for one or both measures at 1.0% strain
- Not compatible

LAB BENCH COMPATIBILITY RATING:

Color rating	Retention tensile stress at yield, %	Retention tensile elongation at break, %
COMPATIBLE	≥ 90	80 -139
MARGINAL	80 - 89	65 - 79
NOT COMPATIBLE	≤ 79	≤ 64 OR > 140

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