Material compatibility and environmental stress cracking: the overlooked risk in infection prevention and control

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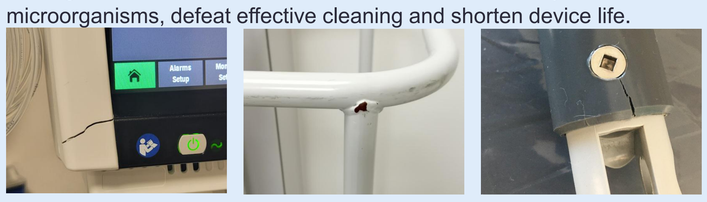
Background

Infection prevention and control depends on frequent cleaning and disinfection of high-touch surfaces and shared patient care equipment. Every clean is also a chemical exposure.

Healthcare surfaces are not one material. A single infusion pump may combine a dozen thermoplastics, each with its own compatibility profile.

Repeated exposure can cause environmental stress cracking (ESC): premature cracking of a plastic caused by strain plus contact with chemical ESC agents.

Damage is often invisible at first. Once cracks appear they harbour microorganisms, defeat effective cleaning and shorten device life.



Damage observed on in-service healthcare equipment: cracking of plastic housings, frames and fittings following routine cleaning and disinfection.

Aim

To give IPC teams a practical overview of ESC in healthcare: why it happens, how it is tested, what testing of commercial products shows, and what to do in practice.

Why it matters in IPC

- Devices and high-touch surfaces are predominantly plastic.
- Moulding, screws and joints lock strain into those plastics.
- They are cleaned and disinfected many times a day.
- Detergent and disinfectant formulations can contain ESC agents.
- An efficacious product that damages the surface is not a safe product.

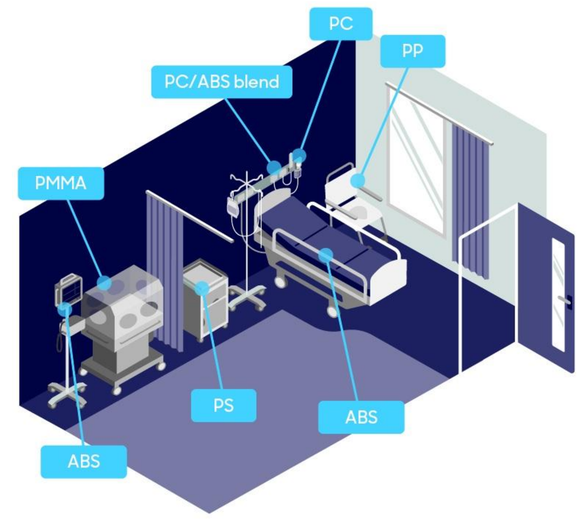


Figure 1. Thermoplastics commonly present in a single patient bay. PC polycarbonate; PMMA poly(methyl methacrylate); ABS acrylonitrile butadiene styrene; PS polystyrene; PP polypropylene.

What is ESC?

ESC is the premature cracking of a plastic caused by two things acting together: strain (molecular deformation from moulding, screws and handling) and ESC agents (molecules that enter the polymer and weaken the bonds between chains).

Types of strain:

1. Dimensionless deformation caused by a change in length or angle of a material or a stress.
2. External stresses such as operator usage, other parts,, screws etc
3. Internal strain resulting from manufacture.

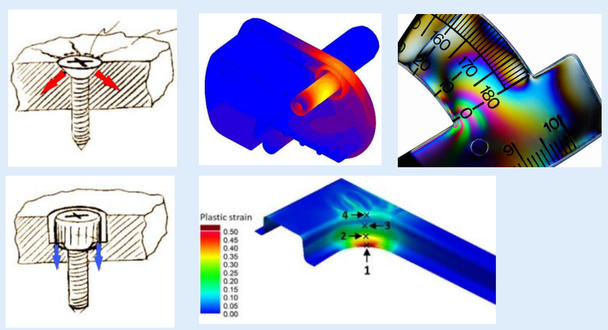


Figure 2: Examples of strain materials

How ESC develops

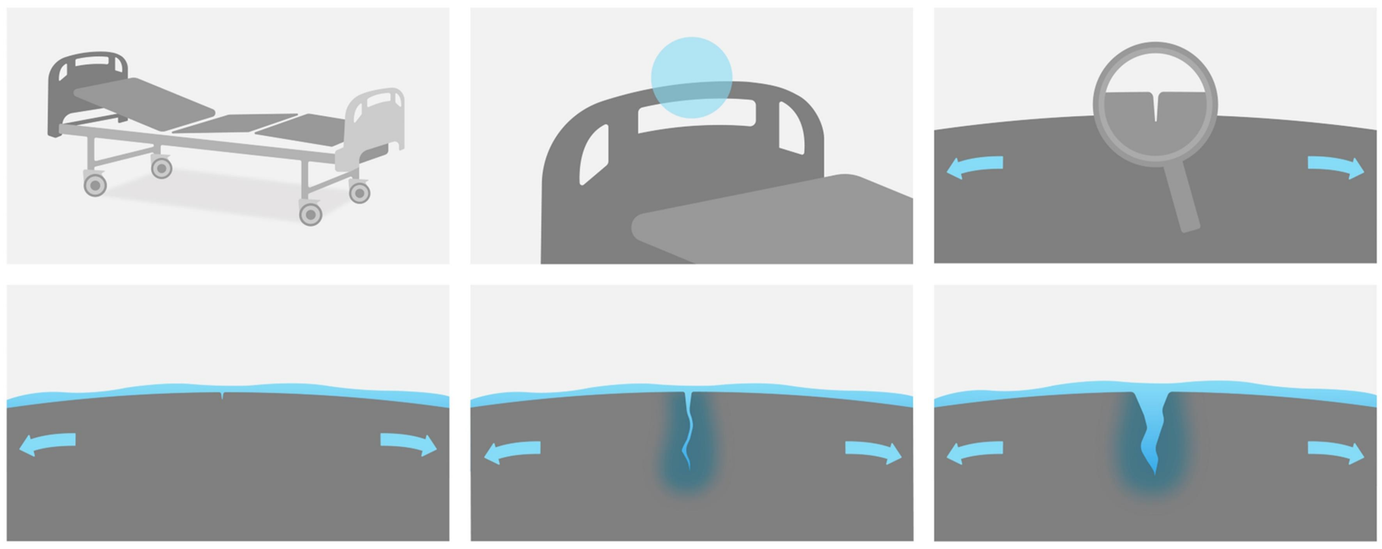


Figure 3. Strain is locked into moulded components during manufacture. Fluid containing ESC agents enters microscopic surface flaws and, over repeated exposures, drives them into visible cracks.

Methods — How material compatibility is tested

Standards — ISO 22088-3:2006 (bent-strip method) and ASTM D543 Practice B.

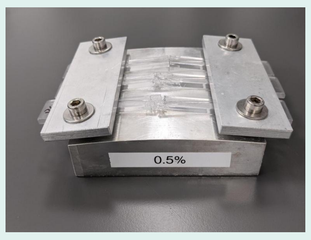
Strain — specimens held on a jig at 0.5 % strain.

Exposure — wet-patch method — cotton wool re-saturated with the test formulation for 7 days at 23 °C and 50 % RH.

Assessment — visual inspection for crazing and cracking, then tensile testing to detect invisible damage. Pass = no cracking AND no tensile weakening.

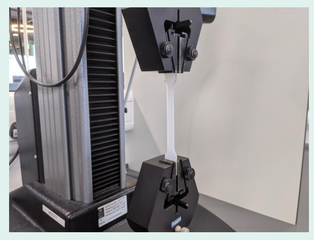
Materials — polycarbonate (medium viscosity, high viscosity, 10 % glass-filled), ABS, PC/ABS blend, PMMA and polypropylene.

Products — six disinfectants and three detergents in current UK and Australian hospital use, tested in-house and reported anonymously.



Specimens held at 0.5 % strain

Crazing and cracking after exposure



Tensile testing on a tensometer

Results

Table 1. Disinfectant products (n = 6) — 0.5 % strain, 7 days

Polymer	Product 1	Product 2	Product 3	Product 4	Product 5	Product 6
Primary biocide(s)	QUATs (BZK, DDAC)	QUATs (ADBAC, DDAC)	QUATs (ADBAC, BZK) + isopropanol	QUAT (DDAC)	QUAT (DDAC)	QUAT (DDAC)
pH	5.2	6.1	5.6	10.8	10.5	8.8
Polycarbonate (medium viscosity)	PASS	PASS	PASS	FAIL 36 h	FAIL 12 h	FAIL 36 h
Polycarbonate (high viscosity)	PASS	PASS	PASS	FAIL 36 h	FAIL 36 h	FAIL 36 h
Polycarbonate (10 % glass fibre)	PASS	PASS	PASS	FAIL 120 h	FAIL 120 h	FAIL 80 h
ABS	PASS	PASS	PASS	PASS	PASS	FAIL invisible
Polycarbonate / ABS blend	PASS	PASS	PASS	PASS	FAIL 48 h	FAIL 48 h
PMMA (Perspex)	FAIL invisible	FAIL invisible	FAIL immediate	PASS	FAIL 120 h	FAIL 24 h
Polypropylene	PASS	PASS	PASS	PASS	PASS	PASS

Table 2. Detergent products (n = 3) — same conditions

Polymer	Detergent A	Detergent B	Detergent C
Primary biocide(s)	None — detergent formulations with preservative systems only		
pH	Near-neutral		
Polycarbonate (medium viscosity)	PASS	FAIL 48 h	FAIL 120 h
Polycarbonate (high viscosity)	PASS	PASS	PASS
Polycarbonate (10 % glass fibre)	FAIL	FAIL	FAIL
ABS	FAIL 96 h	FAIL 24 h	PASS
Polycarbonate / ABS blend	FAIL 60 h	FAIL 12 h	FAIL
PMMA (Perspex)	FAIL 24 h	FAIL 24 h	FAIL
Polypropylene	PASS	PASS	PASS

PASS no crazing or cracking and no loss of tensile properties

FAIL n h visible cracking first observed at that exposure time

FAIL invisible no visible defect, but significant tensile weakening

Discussion

Compatibility is driven by the whole formulation, not the biocide class. Products 1–3 (QUAT, pH 5.2–6.1) passed almost every test; Products 4–6 (also QUAT, pH 8.8–10.8) failed widely.

Adding isopropanol to Product 3 cracked PMMA immediately — relevant to incubators and isolettes.

Detergents performed worse than disinfectants. PP passed every test; PMMA and PC failed most often.

Conclusions

Material compatibility is an under-recognised part of IPC practice.

Damage is invisible long before it is visible; once cracked, a surface is harder to clean.

Efficacy alone is not enough — a product must also be compatible with the surfaces it is used on.

Compatibility cannot be predicted from the biocide. It has to be tested.

Recommendations

- Ask suppliers for ASTM/ISO compatibility data, not efficacy data alone.
- Assess the full formulation and pH, not just the biocide.
- Follow device manufacturers' cleaning instructions.
- Train staff: correct technique, avoid over-saturating, allow to dry.
- Build compatibility into procurement criteria.

References 1. ISO 22088-3:2006 Plastics — determination of resistance to environmental stress cracking — Part 3: bent strip method. 2. ASTM D543 Practice B. 3. Ward AL et al. Polymer 1991;32:2172–8. 4. Hulme A, Cooper J. Life prediction of polymers for industry, 2014. 5. Otter JA, Galletly T. Nursing Times 2018;114(9):25–8.

Data source Compatibility testing performed in-house by GAMA Healthcare (unpublished). Commercial products are reported anonymously.

Declaration of interest All authors are employees of GAMA Healthcare, a manufacturer of cleaning and disinfection products.

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