

The image features a detailed technical drawing of a battery container, overlaid with the Panasonic logo. The drawing includes various views and dimensions for manufacturing and assembly. Key dimensions include: 151^{+1.5}/_{-0.5}, 130.3, 34^{+1.5}/_{-0.5}, 9, 6.35, 4.75, 3.2, 6, 197±2, 165±2, 155, 111, 181±2, 112.7, 175±2, 179.5, 163.4, 76±2, 74.5, 151^{+1.5}/_{-0.5}, 130.3, 94^{+1.5}/_{-0.5}, 6.35, 9, and 61. Other features include M5 screws, a 11.8mm hole, and a 22mm slot. The drawing is rendered in a light gray color on a white background.

Panasonic

VRLA

WHITE PAPER INDUSTRIAL BATTERIES FOR PROFESSIONALS

LEAD ACID BATTERY CONTAINERS MADE OF ABS

Properties / Influencing substances

ABS' physical properties (wide range universal spec):

Maximum useful temperature range:	+85 - 100°C
Softening temperature:	+90 - 120°C
Melting point:	+220 - 250°C
Cold temperature breaking point:	-40°C
Percentage elongation at break:	15 - 30%
Density:	1.04 to 1.12g · cm ⁻³
Specific thermal capacity:	1.3kJ · kg ⁻¹ · K ⁻¹
Specific thermal conductance:	0.18W · m ⁻¹ · K ⁻¹
Dielectric strength:	up to 120kV · mm ⁻¹

Substances which react with ABS alter the molecule structure or affect the polymer chains, thereby irreversibly compromising the physical properties. Premature stress cracks are the result:

- Alcohols
- Adhesives
- Detergents
- Lubricants
- Oils
- Plasticizers
- Solvents

The problem for the end user with these 7 (selected) substance categories is that the list in detail tends to be very long and also that comprehensive identification is not easy as the various trade products are not subject to a full substance listing.

Examples:

- A) Alcohols used as sterilizers for hand sanitation; the user may come in contact with the battery
Ex: Hartmann Sterillium® med, Eff. substance : Ethanol
- B) Adhesives used as bonding material, threadlocker and/or gasket between metal-to-metal constructions
Ex: Loctite® 243 or other anaerobic adhesives, Eff. substance: DEP
- C) Detergents for disinfection of medical devices; may come into contact with battery containers
Ex: Densys Onda®, Eff. substance : Chlorene
- D) Lubricants used for machine operation/insertion purposes may contain additives which are incompatible with ABS
Ex: Bechem Berulub® PAL 3, Eff. substance: higher fatty acid amides
- E) Steel sheets for fabrication of battery support trays are coated with forming oil for easy cutting and forming as well as corrosion protection. Some synthetic oils and/or their additives may be incompatible with ABS
Ex: Fuchs Renoform® MZAN, Eff. Substance : Chlorene
- F) Plasticizers are widely used in rubbers, spacers, locking ties, adhesive tapes and tensioning straps, which are themselves widely used as fixing devices for battery containers
Ex: tesa® 51903 double-sided adhesive tape, Eff. Substance: DOA
- G) Solvents used for cleaning purposes may also contain substances which can harm ABS
Ex: Eastman Eastapure®, Eff. Substance: ethyl acetate

Great care has to be taken when selecting the mating materials to the ABS housing of the battery. Thanks to REACH*1 and other legislation, the composition of the chosen materials may change unnoticed at any time, so users must be constantly alert about their final product.

A full and comprehensive list of all substances with negative impact on ABS would be a dream come true. Currently end users have to find their own way through scarce and scattered documentation on the web. Sometimes the limited information to be found is questionable, e.g. <http://www.mdtmag.com/blog/2013/09/study-focuses-how-plasticizers-pvc-affect-non-pvc-plastics> lists DEHP and DINP plasticizers as OK for ABS,

*1 <http://echa.europa.eu/regulations/reach>

whereas our own studies from field incidents show a clear negative effect.

Furthermore, as pointed out before, the specifications of fixation products do not list all the constituent substances of the product. So, in general, there is a shortage of information from either side.

Fixation force

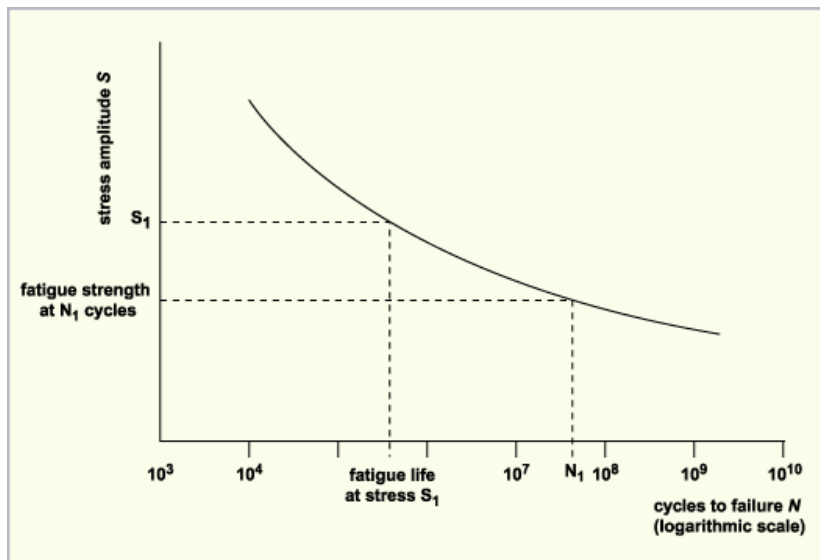
Panasonic recommends a fixation force of no more than 10N/cm². The nominal bending strength of ABS is 5,000N/cm². At 1mm wall thickness the resulting bending strength is 500N/cm².

The safety factor therefore is 50.

Why is it so high?

Material fatigue

*“Fatigue is a form of failure that occurs in materials subjected to fluctuating stresses[...]. Under these circumstances, it is possible for failure to occur at a stress level considerably lower than the tensile or yield strength for a static load.”*1*



*1

Fluctuating stresses on ABS containers could be described as:

- Temperature cycles
- Vibrations (mechanical)
- Or a combination of both

Especially when ABS is encapsulated in a V2A steel frame, the difference in the thermal expansion coefficients will contribute to material fatigue (when applied) by the magnitude of 20:

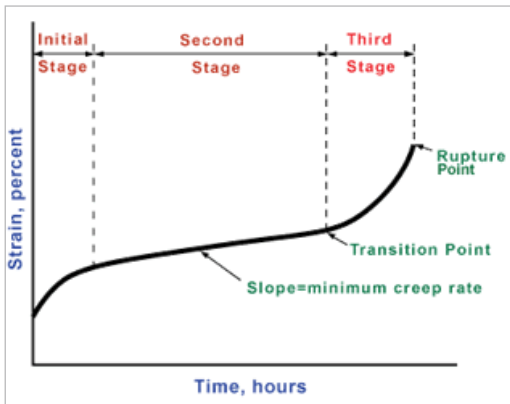
$$\alpha_{\text{steel}} = 16 \cdot 10^{-6} \cdot 1/\text{K}$$

$$\alpha_{\text{ABS}} = 8 \cdot 10^{-5} \cdot 1/\text{K}$$

*1 Martin Tarr in http://www.mtarr.co.uk/courses/topics/0124_seom/index.html

Creep

“Creep is a time-dependent deformation of a material while under an applied load that is below its yield strength.” *1



*1

“Since neither fatigue nor creep while acting on their own is fully understood, the mechanisms involved when they act together are even less well understood. However: There is evidence of a synergistic relationship i.e. the sum of their joint effects is greater than their individual contributions.” *2

If we also take into account different thermal expansion coefficients of the fixation material(s) and the ABS container, the influence of temperature variations on both fatigue and creep forces cannot be underestimated.

ABS as a terpolymer is mechanically characterized by its viscosity. Since it is essentially liquid, the calculation of loads becomes extremely complex. Here is an example of a different polymer blend based on polystyrene (PS), where the viscosity λ is different for each blend, but at the same time the critical deformation point depends also on time (t), plus it cannot be simply extrapolated.

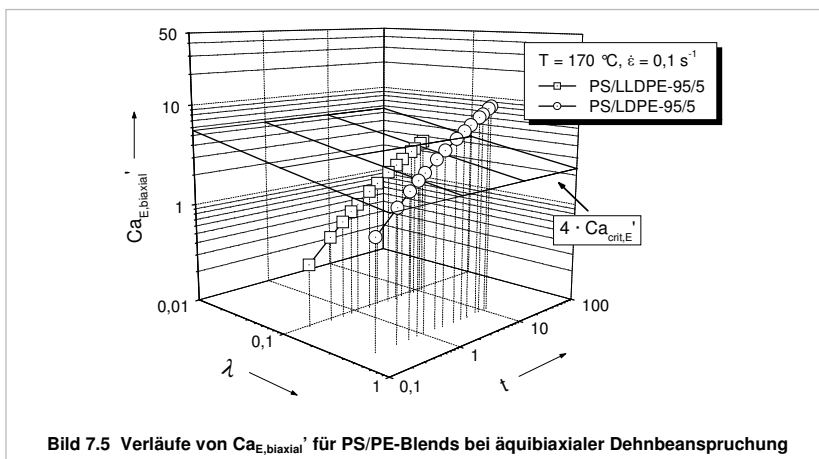


Bild 7.5 Verläufe von $Ca_{E,biaxial}$ für PS/PE-Blends bei äquibiaxialer Dehnbeanspruchung

*3

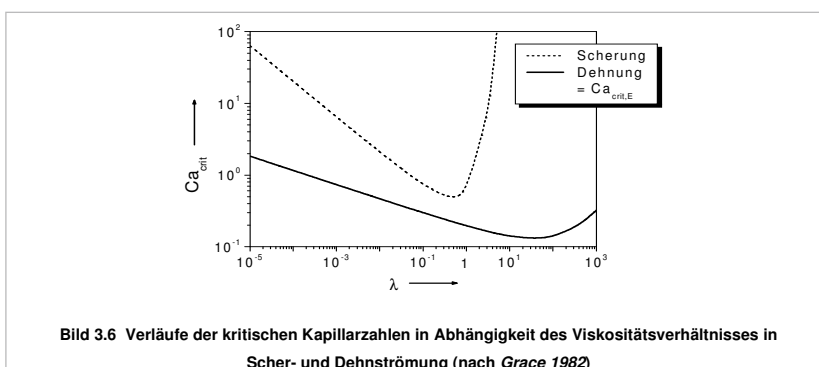


Bild 3.6 Verläufe der kritischen Kapillarnzahlen in Abhängigkeit des Viskositätsverhältnisses in Scher- und Dehnströmung (nach Grace 1982)

*3

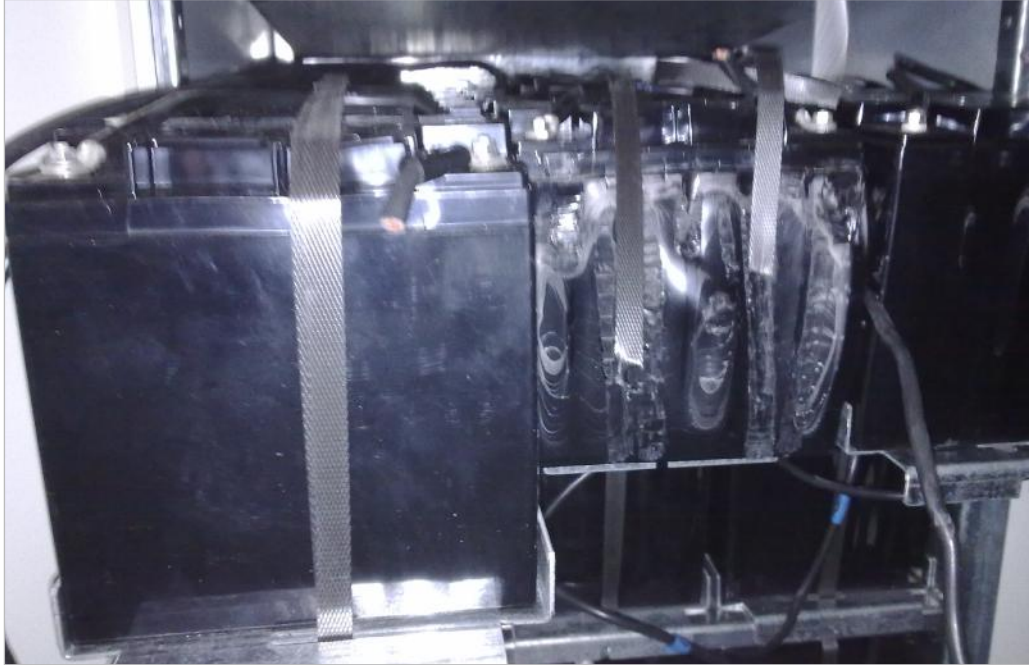
*1 <https://www.nde-ed.org/EducationResources/CommunityCollege/Materials/Mechanical/Creep.htm>

*2 Martin Tarr in http://www.mtarr.co.uk/courses/topics/0124_seom/index.html

*3 https://opus4.kobv.de/opus4-fau/files/109/Dissertation_MarcusHeindl-2005.pdf

Examples of market incidents

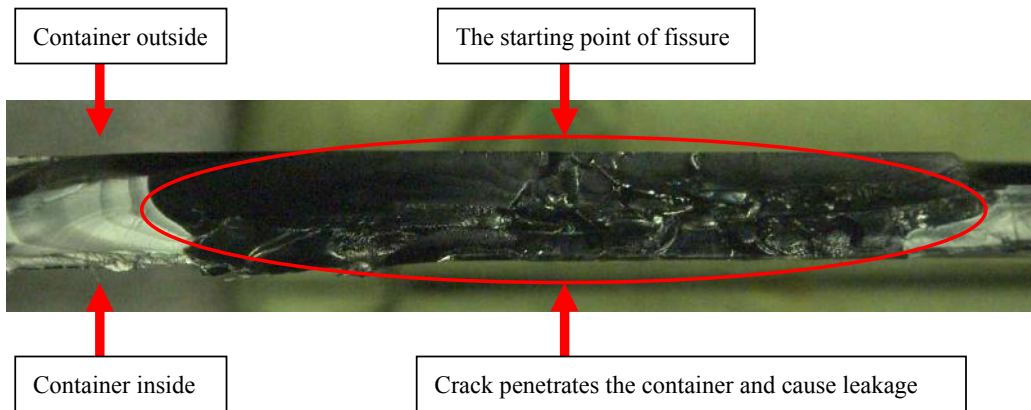
- 1) LC-X1228AP cabinet installation in an UPS (tensioning straps are used for fixation)



3 shelves of 6 batteries next to each other in this tight battery cabinet. Every shelf holds its 6 batteries by a tightening strap. After 7 years in service a middle shelf battery lost some of its acid due to a cracked container. In the process, a short-circuit developed and the resulting heat caused the container ABS to melt.

- 2) LC-XC1222P V2A box carrying case (oily residues on steel surface)



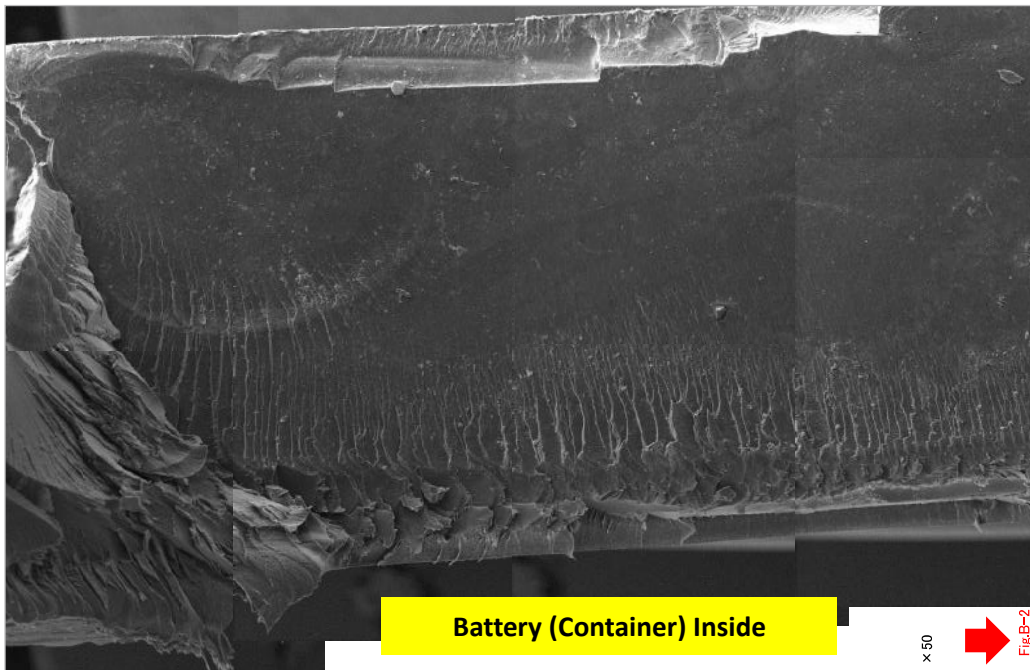


Excerpt from an analysis report where two batteries have been connected in series and installed in a box. Within less than two years of operation a crack developed and acid spilled out.

3) LC-R127R2PG1 in V2A steel case (plasticizers and fatty acid amides remnants from assembly process)



Excerpt from an analysis report where 32 batteries have been connected in series. After 3 years in operation one battery started to leak. Location was near the sidewall of the installation bracket.



Cut-view picture of the container wall near the leakage area. The “Inside” area shows a broken pattern, the texture of which is like the intact ABS compound. The “Surface” or outside area of the container sidewall looks smooth, like glass. This pattern is typical for ABS which has been chemically altered.

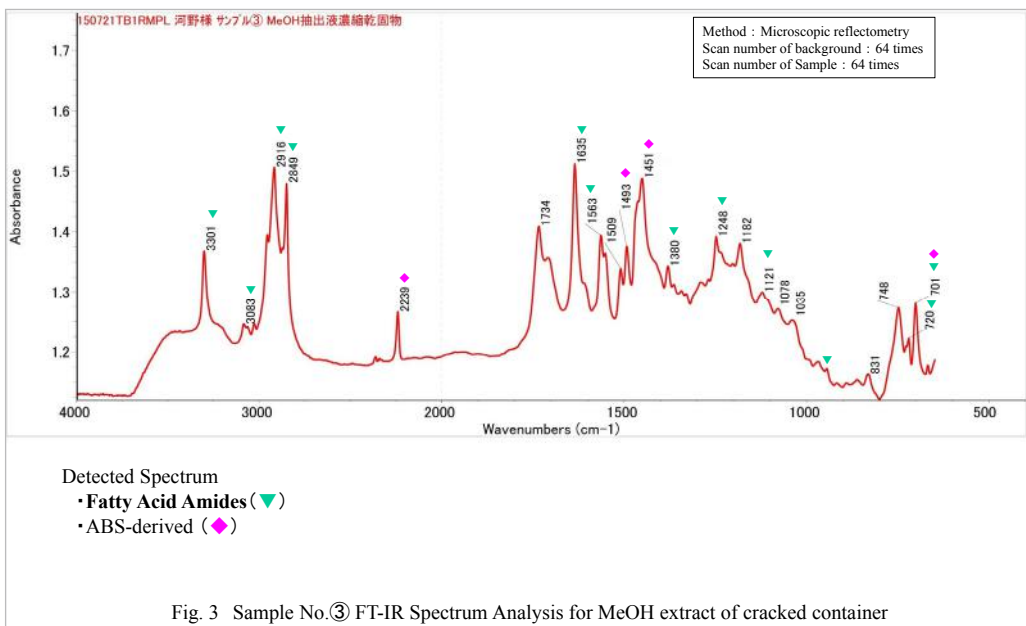
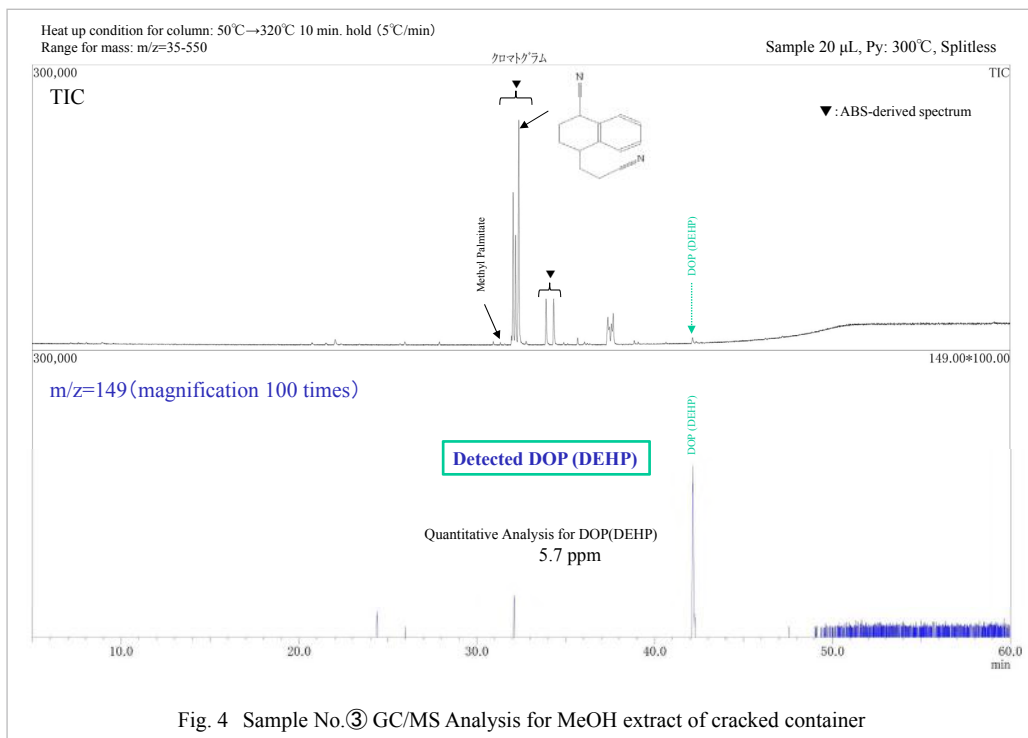


Fig. 3 Sample No.③ FT-IR Spectrum Analysis for MeOH extract of cracked container

MRM spectrum analysis of the leakage area



GC/MS plot of the leakage area

Conclusions

In all three portrayed cases of container leakages, it is quite likely that the combination of material fatigue and creep, plus the negative influence of ABS-sensitive substances, has caused the integrity of the container to locally collapse.

In some cases, this has occurred within less than two years of operation.

The safety factor of 50 regarding the fixing pressure of VRLA containers is well chosen, but it cannot prevent fractures if the ABS is made brittle by harmful substances.

FIND THE RIGHT CONTACT



Website for Panasonic Battery Finder

Get more information on Panasonic Battery Finder website.
<http://eu.industrial.panasonic.com/battery-finder>
<http://eu.industrial.panasonic.com/battery-finder-html-app>



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