Panasonic

VRLA

WHITE PAPER INDUSTRIAL BATTERIES FOR PROFESSIONALS

LEAD ACID BATTERY CONTAINERS MADE OF ABS

Author: Jens Kischkel
Company: Panasonic Automotive & Industrial Systems Europe GmbH
Title: Lead acid battery containers made of ABS
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FIXATION CONCERNS

Background

For many years it has been common experience for Panasonic as a VRLA battery manufacturer for the physical integrity of its products to be negatively influenced in some cases by external factors. One major enemy of the ABS hull is chemical interaction with incompatible substances. With a delay of months or years, the final consequence is a weakened container structure, which finally gives way for the electrolyte to break out. In almost all cases the result is an external short circuit which leads to heat development, melted battery block(s), fire or explosion. Although the battery manufacturer indicates in its specifications and technical handbook that users should exercise caution regarding the possible external negative influences on the battery container, few have observed these precautions and incidents of this nature have continued.

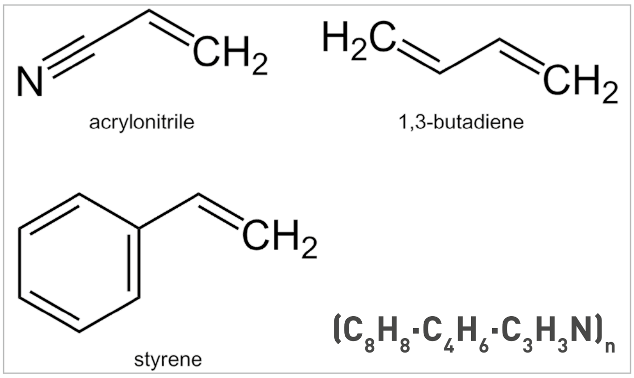
Scope

This paper aims to raise awareness amongst users of our VRLA products in order to minimize the number and gravity of incidents. It also advises on the parameters useful for fixation of the product. It is not meant to be a scientific study, and corrections about the chemical and physical assumptions made herein are welcomed by the author.

ABS (CAS Number 9003-56-9)

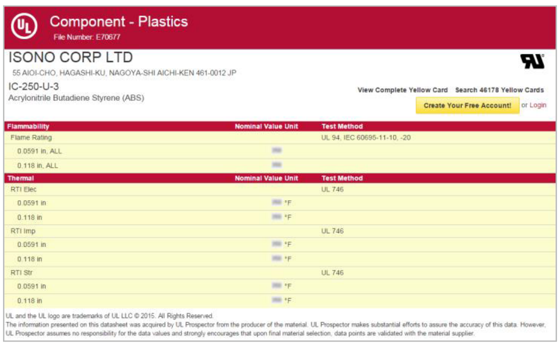
Acrylonitrile Butadiene Styrene is a terpolymer made by polymerizing styrene and acrylonitrile in the presence of polybutadiene. The proportions can vary from 15 to 35% acrylonitrile, 5 to 30% butadiene and 40 to 60% styrene.

Physical appearance of grains*[1]



Molecule structure*[2] Chemical formula

The physical and chemical properties of ABS are depending on the proportions, methods of manufacturing and the manufacturer itself.



Component - Plastics
File Number: E70677

ISONO CORP LTD
55 AIOI-CHO, HAGASHI-KU, NAGOYA-SHI AICHI-KEN 461-0012 JP

IC-250-U-3
Acrylonitrile Butadiene Styrene (ABS)

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Flammability	Nominal Value Unit	Test Method
Flame Rating		UL 94, IEC 60695-11-10, -20
0.0591 in, ALL	[illegible]	
0.118 in, ALL	[illegible]	
Thermal	**Nominal Value Unit**	**Test Method**
RTI Elec		UL 746
0.0591 in	[illegible] °F	
0.118 in	[illegible] °F	
RTI Imp		UL 746
0.0591 in	[illegible] °F	
0.118 in	[illegible] °F	
RTI Str		UL 746
0.0591 in	[illegible] °F	
0.118 in	[illegible] °F	

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Example of a UL-yellow-card specifying the physical properties of the product by manufacturer Isono Corp. Ltd.

*[1] https://en.wikipedia.org/wiki/Acrylonitrile_butadiene_styrene#/media/File:Gr%C3%A3os_de_pl%C3%A1stico_ABS_(ABS_plastic_grains).jpg
*[2] https://upload.wikimedia.org/wikipedia/commons/8/82/ABS_resin_formula.PNG

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,

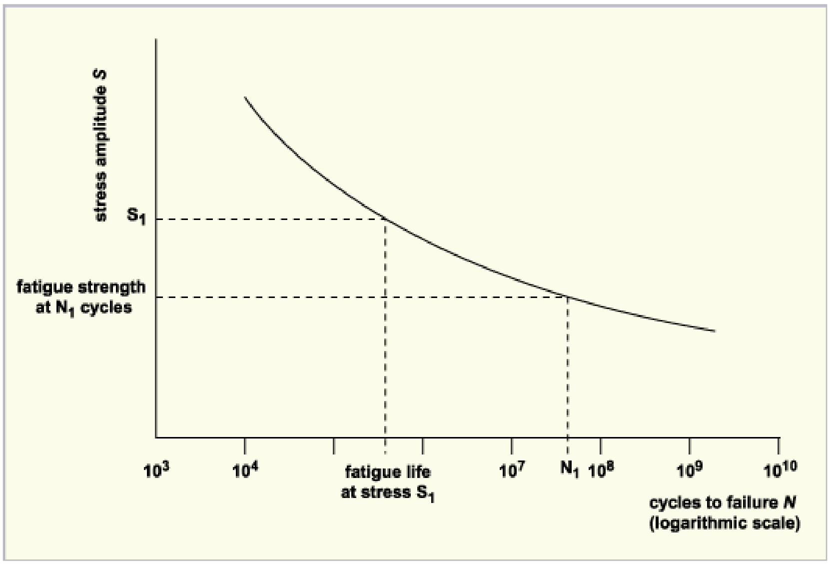
*[1] http://echa.europa.eu/regulations/reach

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 $10 N/cm^2$. The nominal bending strength of ABS is $5{,}000 N/cm^2$. At 1mm wall thickness the resulting bending strength is $500 N/cm^2$.
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

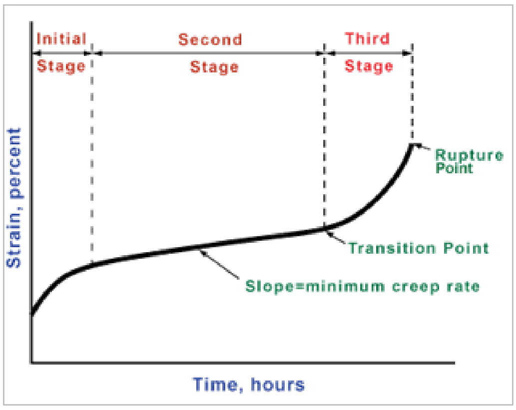
Especially when ABS is encapsulated in a V2A steel frame, the difference in the thermal expansion coefficients will contribute to material fatigue (when applied) by the magnitude of 20:

$\alpha_{steel} = 16 * 10^{-6} * 1/K$
$\alpha_{ABS} = 8 * 10^{-5} * 1/K$

[*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.

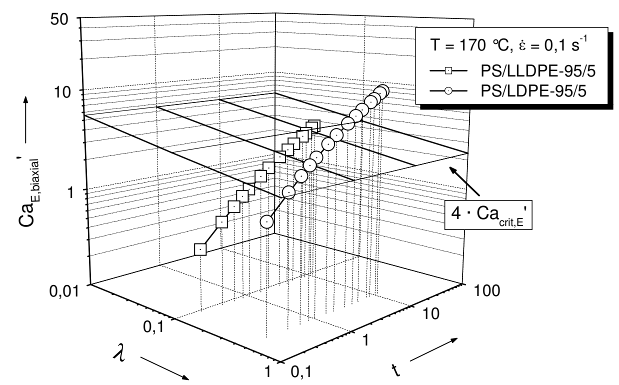


Bild 7.5 Verläufe von $Ca_{E,biaxial}$' für PS/PE-Blends bei äquibiaxialer Dehnbeanspruchung

*3

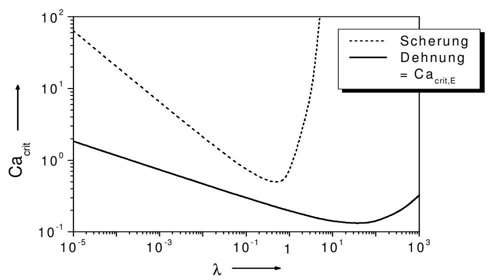


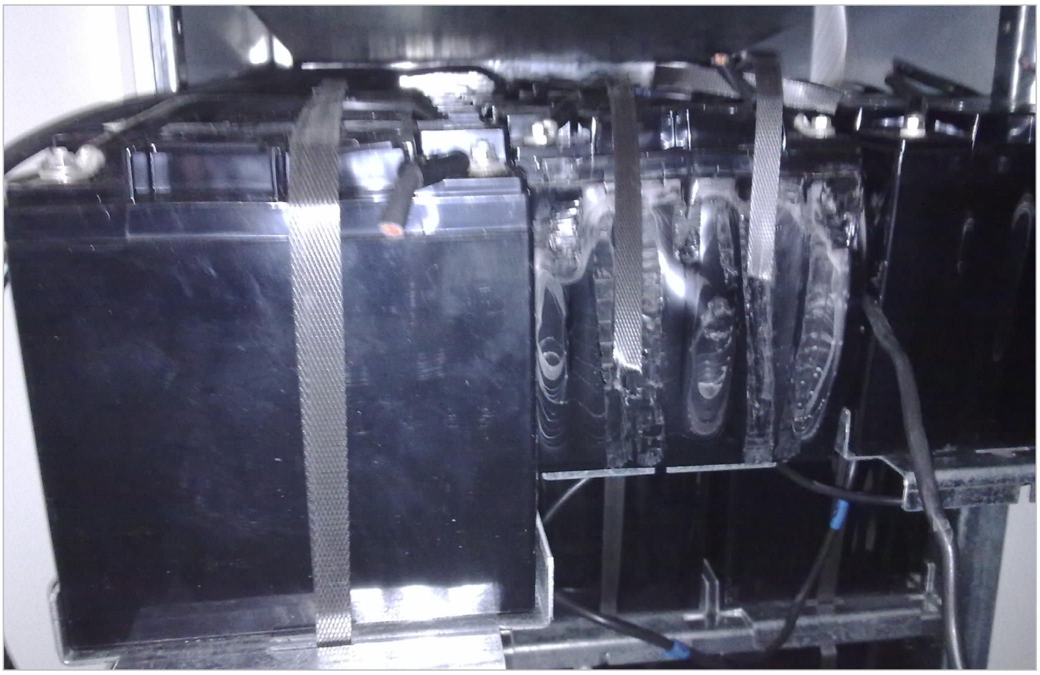
Bild 3.6 Verläufe der kritischen Kapillarzahlen in Abhängigkeit des Viskositätsverhältnisses in Scher- und Dehnströmung (nach *Grace 1982*)

*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

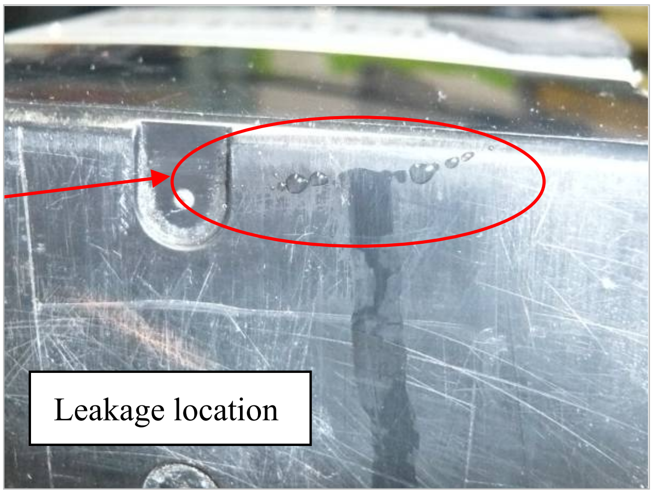
Examples of market incidents

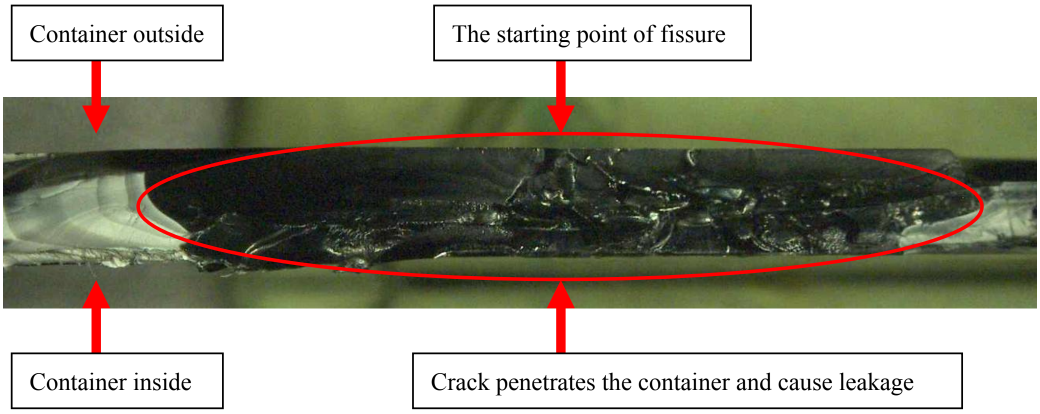
1) LC-X1228AP cabinet installation in an UPS (tensioning straps are used for fixation)



3 shelves of 6 batteries next to eacht 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)

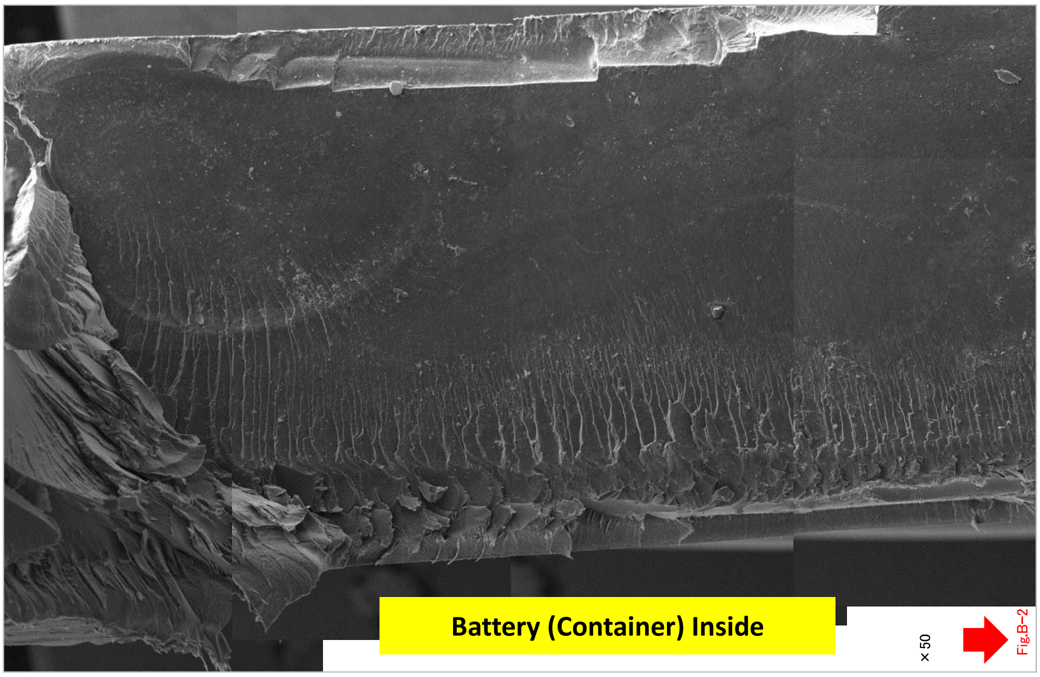




Excerpt from an analysis report where two batteries have been connected in series and installed in a box. Within less than two years of operation a crack developed and acid spilled out.

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.

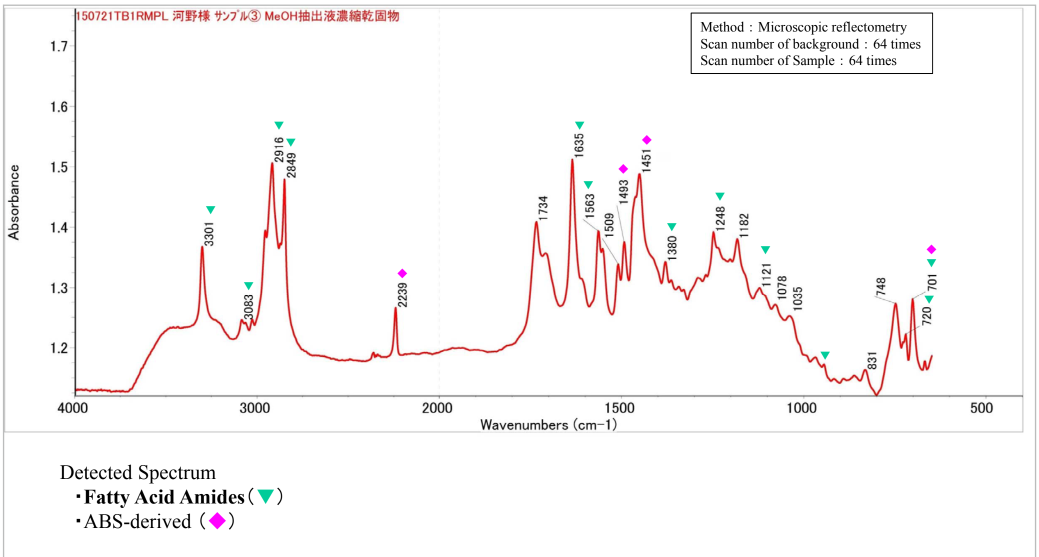


Fig. 3 Sample No.③ FT-IR Spectrum Analysis for MeOH extract of cracked container

MRM spectrum analysis of the leakage area

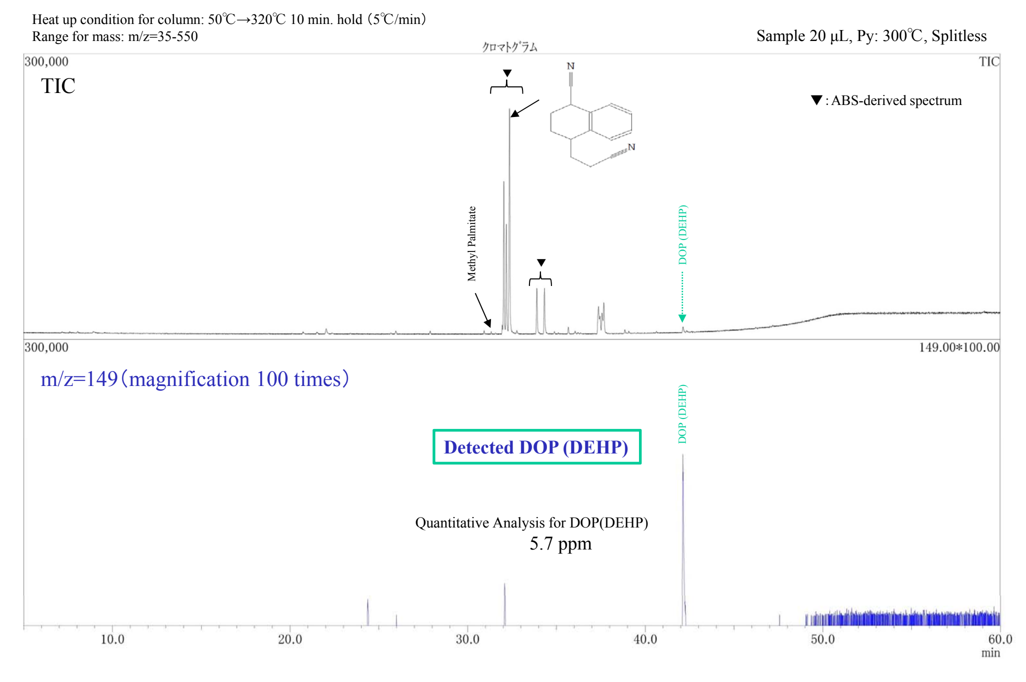


Fig. 4 Sample No.③ GC/MS Analysis for MeOH extract of cracked container

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

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

App Stores for Panasonic Battery Finder
The Panasonic Battery Finder is available for Android and iOS (iPhone) devices and can be downloaded free of charge in app stores. Scan QR code to go to app store and download app.

E-mail and website for all countries
battery-solutions@eu.panasonic.com
http://eu.industrial.panasonic.com/

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Panasonic®

United Kingdom/Ireland
Panasonic Automotive & Industrial Systems Europe GmbH (PAISEU)
Willoughby Road
Bracknell Berkshire
RG12 8FP, England
Phone: +44 1344 - 85 32 60
Fax: +44 1344 - 85 33 13

Panasonic Italia
Branch Office of
Panasonic Marketing Europe GmbH
Viale dell'Innovazione 3
20126 Milano, Italy
Phone: +39 02 - 6788 - 232
Fax: +39 02 - 6788 - 207

Spain/Portugal
Panasonic Automotive & Industrial Systems Europe GmbH (PAISEU)
Sucursal en España
Parque Empresarial @ Sant Cugat,
Via Augusta 15-25
Edificio B2 Planta 4 Oficina 17
08174 Sant Cugat del Valles
Barcelona, Spain
Phone: +34 93 - 504 30 10
Fax: +34 93 - 675 58 92

France
Panasonic Automotive & Industrial Systems Europe GmbH (PAISEU)
10, rue des petits ruisseaux
91370 Verrières-le-Buisson, France
Phone: +33 1 - 60 13 57 62
Fax: +33 1 - 60 13 57 72

Germany
(all other European countries)
Panasonic Automotive & Industrial Systems Europe GmbH (PAISEU)
Winsbergring 15
22525 Hamburg, Germany
Phone: +49 40 - 85 386 - 373
Fax: +49 40 - 85 386 - 238