EVS-GTR

Electrolyte leakage

Test items	Present Requirements
Vibration Thermal shock and cycling External short circuit protection Overcharge protection Over-discharge protection Over-temperature protection	-No evidence of electrolyte leakage -The evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the Tested-Device
Mechanical shock Mechanical integrity	-No evidence of electrolyte leakage -The evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the Tested-Device -An appropriate coating shall, if necessary, be applied to the physical protection (casing) in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. Unless the manufacturer provides a means to differentiate between the leakage of different liquids, all liquid leakage shall be considered as the electrolyte.
REESS requirements for whole vehicle post-crash	-For a period from the impact until **30 minutes** after the impact, there shall be no electrolyte leakage from the REESS **into the passenger compartment** -and no more than **7 per cent by volume** of the REESS electrolyte capacity spilled from the REESS **to the outside of the passenger compartment.**

Time

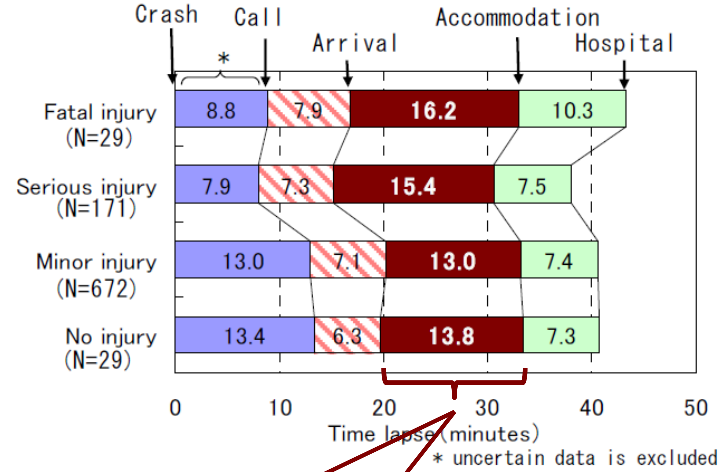
European Commission

Study from Japan Automotive Research Institute (JARI) and Japan Automotive Manufacturers Association (JAMA)*:

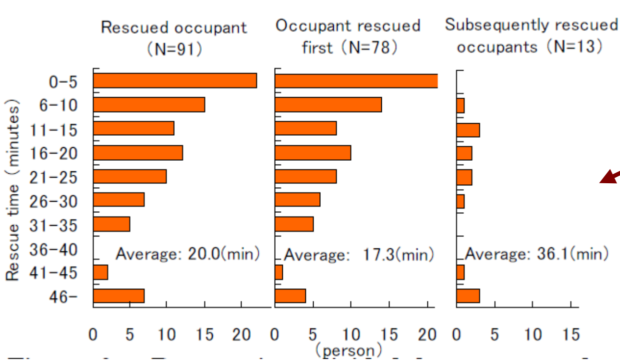
- Various crash scenarios are considered - among passenger cars as well as involving heavier vehicles (trucks)

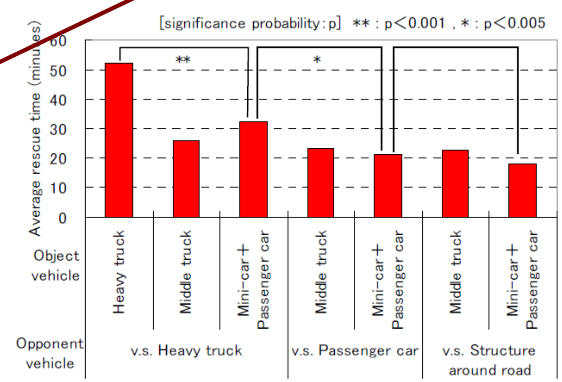
- Statistical analysis of the 1996-2006 field data in Japan shows that:

    - the *average* "Crash" – "Accommodation" time often significantly exceeds 30 minutes
    - especially when more than 1 occupant is to be rescued
    - and/or when a truck is involved



Average time lapse by injury severity *





* Y.Sukegawa, M.Sekino, "Analysis of rescue operations of injured vehicle occupants by fire fighters", paper#11-0101, presented at the 22nd Enhanced Safety of Vehicles Conference (ESV-22), Washington DC, June 2011. www.nrd.nhtsa.dot.gov/departments/esv/22nd/

Time

European Commission

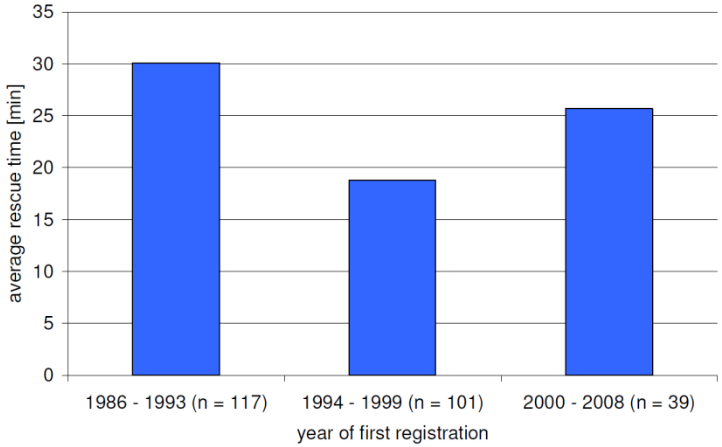
To our knowledge little data is available for Europe.

Rescue approach varies **:

- "Scoop and run" – transport a victim ASAP to a hospital – US
- "Stay and play" – stabilise the patient at the scene - Germany

Results of the German study** show that:

- the average rescue time ("Arrival" to "Accommodation") often exceeds 25 min;
- rescue time does not solely depend on technical issues as a medical treatment to stabilise the patient often occurs in parallel;
- rescue time may depend on the model, i.e. increase for newer cars.



* * H. Johannsen, G. Muller, C. Pastor, R-D. Erbe, H-G. Schlosser, "Influence of new car body design on emergency rescue", paper presented at the 4th International Conference on ESAR "Expert Symposium on Accident Research", Hannover, September 2010; http://bast.opus.hbz-nrw.de/volltexte/2012/556/

Time

USA data analysis***:

- The available sources of quantified information are limited
- Disaggregation of urban and rural data for response time analysis is consistently identified
- Average "Crash" to "Call" time varies between 4 and 7 to 8 min
- Average "Call" to "Arrival" time varies between 4 and 11 min
- No data available in this study on "Arrival" to "Accommodation" time

Table 2 Summary of Published Response Time Values

Interval	Time (Minutes)	Average or Percentage of Calls Included	Data Description	Source
Crash to Notification	3.87	Average	Urban, 1996 Fatal, EMS	Champion, 3-4/1999
	7.36		Rural, 1996 Fatal, EMS	
	4	Average	Urban, 1997 Fatal, EMS	Champion, 5/1999[1]
	7		Rural, 1997 Fatal, EMS	
	8.4 minutes	Average	Urban	Mayor's Committee for Urban Renewal, 1970
	3.9 minutes		Urban, Adjusted	
Notification to Arrival	4:19	Average, US cities	First Unit	Phoenix Survey, 2000[2]
	4:30	80%, US cities		
	0-10	81.7%	Rural Fatal, EMS	Traffic Safety Facts, 2001[3]
	0-20	94.3%	Rural Fatal, EMS	
	0-10	93.8%	Urban Fatal, EMS	
	0-20	97.7%	Urban Fatal, EMS	
	6	Average	Urban, 1997, Fatal, EMS	Champion, 5/1999[1]
	11		Rural, 1997 Fatal, EMS	
	0-10	88.3%	Urban, 1975-1993 Fatal, EMS	Tessmer, 1996[4]
	0-10	57.7%	Rural, 1975-1993 Fatal, EMS	
	0-20	97.8%	Urban, 1975-1993 Fatal, EMS	
	0-20	89%	Rural, 1975-1993 Fatal, EMS	
	5.1	Average	2000, Fire Service	CA NFIRS[5]
	5.3		2001, Fire Service	
	5.4		2002, Fire Service	
	5.3		2003, Fire Service	
	0-7	80%	2000, Fire Service	
		77%	2001, Fire Service	
		75%	2002, Fire Service	
		77%	2003, Fire Service	

**** L.E. Shields, "Emergency Response Time in Motor Vehicle Crashes: Literature and Resource Search", report prepared for Motor Vehicle Fire Research Institute, January 2004. http://www.mvfri.org/Contracts/Final%20Reports/Shields_Report-01.pdf*

Time

Summary:

1) "Crash" to "Accommodation" time needs to be considered. This includes: "Crash" to "Call", "Call" to "Arrival" and "Arrival" to "Accommodation" time slots.

2) "Crash" to "Accommodation" time depends on many parameters such as:
- a) density of population, rural/urban area
- b) type of an accident, including car model, number of occupants, involvement of heavier vehicles
- c) availability of the rescue workers (fire fighters, ambulance)
- d) …

and may, therefore, vary from country to country;

3) Rescue equipment and approach are different in different countries, making statistical data not directly relevant to other areas

Time

We propose:
- To increase the "no leak" time slot to at least 60 minutes.

Area/ average time, min	Crash-Call	Call-Arrival	Arrival-Accommodation	Total
Japan*	13	8	up to 36	up to 57
China				
South Korea				
USA***, Canada	4 to 8	4 to 11		> 8 to 19
Europe		*8 (NL)*	25** (DE)	> 33

More data for various regions needs to be collected to better define the "no leak" time slot for the present EVS-GTR

** Y.Sukegawa, M.Sekino, "Analysis of rescue operations of injured vehicle occupants by fire fighters", paper#11-0101, presented at the 22nd Enhanced Safety of Vehicles Conference (ESV-22), Washington DC, June 2011. www.nrd.nhtsa.dot.gov/departments/esv/22nd/*

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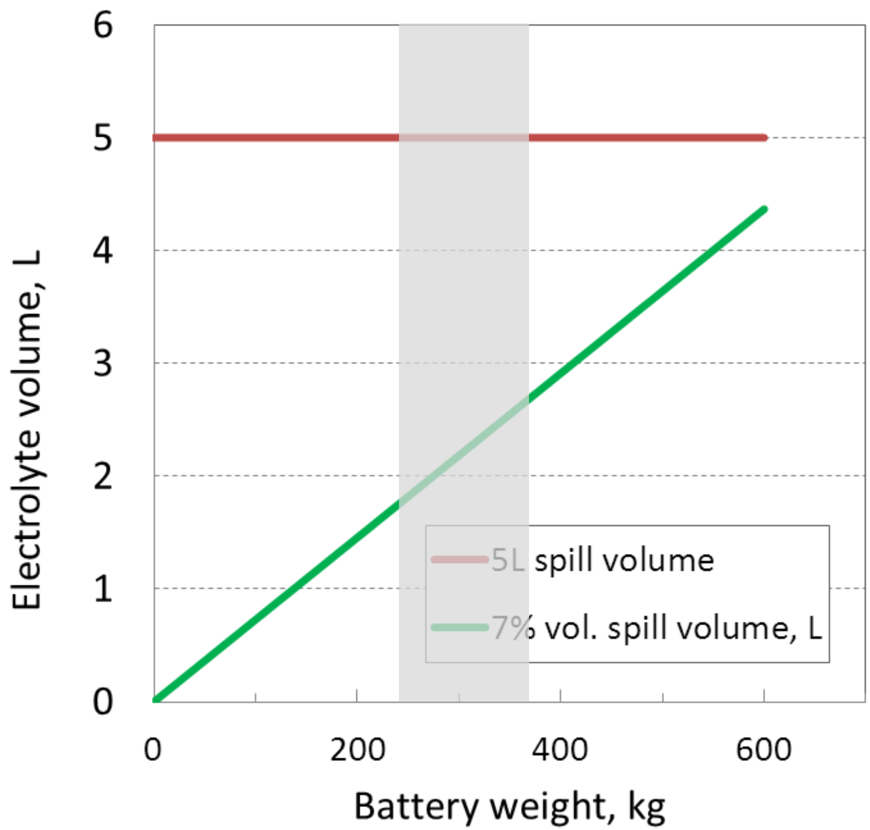
Amount



Assuming 13 wt% electrolyte content in a battery

- 7 vol% is a more stringent requirement than 5 L spill for most of the Li-ion battery sizes

Spilling ca. 1 L of dimethyl carbonate results in a PAC-3 concentration level in a volume of vehicle +3 m-thick layer around it

PAC stands for Protective Action Criteria

PAC-1: Mild, transient health effect
PAC-2: Irreversible or other serious health effects that could impair the ability to take protective action
PAC-3: Life-threatening health effects

European Commission

We considered the following conventional electrolyte solvents:

1) Ethyl acetate (EA), CAS # 141-78-6;
2) Dimethyl carbonate (DMC), CAS # 616-38-6
3) Ethyl methyl carbonate (EMC), CAS # 623-53-0
4) Diethyl carbonate (DEC), CAS # 105-58-8
5) Propylene carbonate (PC), CAS # 108-32-7
6) Ethylene carbonate (EC), CAS # 96-49-1
7) Tetrahydrofuran (THF), CAS # 109-99-9
8) Acetonitrile (AN), CAS # 75-05-8 (also used in supercapacitors)
9) γ-Butyrolactone (γ-BL), CAS # 96-48-0
10) 1,2-Dimethoxyethane (DME), CAS # 110-71-4
11) 1,3-Dioxolane, CAS # 646-06-0

Amount

Li-ion solvents

Solvent	Volume of evaporated solvent*, cm^3	
	PAC-2 level	PAC-3 level
γ-Butyrolactone (γ-BL), CAS # 96-48-0	0.22	17
Dimethyl carbonate (DMC), CAS # 616-38-6	25	149
Tetrahydrofuran (THF), CAS # 109-99-9	104	1038

** Volume, solvent evaporates into, is defined as vehicle + 1-m-thick layer around it; 61.5 m^3 in this study*

Small spills – 0.2 to 150 cm^3 - lead to dangerous situations

Small amount needs to be measured – impact on the method choice

Amount

Li-ion salts

Lithium Hexafluorophosphate	$LiPF_6$
Lithium Tetrafluoroborate	$LiBF_4$
Lithium Hexafluoroarsenate	$LiAsF_6$
Lithium Iodide	LiI
Lithium Perchlorate	$LiClO_4$
Lithium Trifluoromethane Sulfonate	$LiCF_3SO_3$
Lithium Bis (Trifluromethanesulfonyl) Imide	$LiN(CF_3SO_2)_2$
Lithium Bis(Perfluoroethylsulfonyl) Imide	$LiN(CF_3CF_2SO_2)_2$
Lithium Bis(Oxalato)Borate	$LiB(C_2O_4)_2$
Tetraethyl-Ammonium Tetrafluoroborate	$(C_2H_5)_4NBF_4$
Triethyl-Methyl-Ammonium Tetrafluoroborate	$(C_2H_5)_3CH_3NBF_4$

Some decomposition products of the salts, e.g. HF, may further limit the maximum allowed electrolyte leakage…

work in progress

Outside vs. Inside

How relevant is the distinction between "outside" the passenger compartment from "inside" the compartment after a crash and/or during the rescue operation?

One of the phases in the rescue operation is removal of the windows.

Proposal

European Commission

We propose:

- Differentiation of the maximum allowed electrolyte leakage per REESS type (e.g. aqueous vs. non-aqueous electrolyte based) may be a good approach;
- Change text for Li-ion based REESS as follows:

REESS requirements for whole vehicle post-crash	**-For a period from the impact until 30 minutes after the impact, there shall be no electrolyte leakage from the REESS into the passenger compartment -and no more than 7 per cent by volume of the REESS electrolyte capacity spilled from the REESS to the outside of the passenger compartment.**

↓

REESS requirements for whole vehicle post-crash	**For a period from the impact until 60 minutes after the impact, there shall be no more than X ml electrolyte leakage from the REESS**

Can the amounts acceptable from the toxicology point be reliably measured in a full vehicle crash test?

How to measure?

European
Commission

Weight loss measurement is unlikely to be reliable:
0.5 to 300 cm^3, i.e. grams on the scale of a full vehicle / REESS

Is it possible to measure such a small weight loss?
Also considering that components will be volatile.

Visual inspection may be difficult due to toxic and volatile electrolyte components in case of Li-ion based REESS

Is gas analysis (quantification) required?
Should requirement be based on the gas concentration and not volume/mass leaked?
Is this possible with range of potential electrolyte components?

Analytical techniques such as gas chromatography (GC), infrared spectroscopy (FTIR), mass spectrometry (MS) etc. may be required to:

a) Quantify the electrolyte leakage,
b) Differentiate between electrolyte leakage and combustion.