



Danish EV Committee
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Investigation of breakdown of the SAFT STM5-100 battery

by

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Abstract:

Electric vehicles have since many years been attractive for private and public organizations as well as individuals in the Nordic region.

When the first products from a large car manufacturer - Citroen - came to market, in the beginning of the nineties, it created a lot of expectation regarding performance, comfort and reliability.

In the beginning these expectations were fulfilled, but unfortunately time has shown a rather disappointing reliability of the cars and the main reason for the problems can be connected to the battery. The reason for the problems is not because the type of battery technology is wrong, as the flooded NiCd battery is the only type, which until further has sufficient robustness and performance for this application.

The main reason for the frequent battery breakdowns is caused by a material problem in the separator used in the battery cells. The separator breaks down after relative short mileage and especially if the vehicle is not used frequently.

The problem arises on nearly all Citroen and Peugeot cars equipped with the STM5-100 flooded NiCd battery produced from mid nineties until 2000.

Sometimes in the beginning of year 2000 the problem was corrected and batteries produced later do not have this dramatic breakdown rate.



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1. Background

One of the most detailed evaluation reports about performance in real life application of electric vehicles, is the final report from the Swedish projects: **Elbilar i Malmö** starting in may 1995 and **Elbilar i Skåne** starting September 1998. The summary report was finalized August 2000 by Per Brännström from KFB (Communication Research Organization) in Sweden.

The project **Elbilar i Skåne** had three main objectives:

- Supervision and support of vehicles in mostly public service
- Evaluation of information about coming vehicles
- Keeping close contact EV manufacturers and suppliers

The total amount of vehicles in this project was approx. 34 and consisted of Citroen, Peugeot and Renault all using SAFT NiCd STM5-100 battery blocks.

Half of the vehicles have been used in local community and power company.

The other half in private companies and delivery activities.

The driving patterns have mostly consisted of short distance trips. Probably not a good pattern for keeping the NiCd batteries in the best shape, but it should not be destructive. The so-called "memory" effect will decrease the apparent capacity, but it will be possible to regenerate the batteries to normal capacity by a few deep discharge cycles.

The users of the electric vehicles are generally very positive and experiences no major limitation in usage of the electric cars, when they have no defects, but a serious complaint has been extremely long duration of service and maintenance visits.

Even simple spareparts took several weeks to bring forward.

A very serious reason for worry are the experienced short lifetimes of the batteries - both in calendar lifetime and accumulated driving distance.

The average accumulated driving distance between battery changes has been less than 17.000 km. and it all happened in less than 4 years. A few cars even had to have the batteries replaced more than once during the relative short timeframe.

A battery renting agreement can level out the battery costs, but it does not prevent that the final cost of ownership will be far too high. It is also extremely disappointing that the claimed lifetime of the batteries of more than 100.000 km is very far from being reached.

More or less the same problems have been experienced with the vehicles in service in the Danish area. The type of cars taken into service are almost only Citroen types in version AX, SAXO and Berlingo. They are all equipped with SAFT STM5-100 battery blocks. Most of the vehicles started service during the 1995 to 1999 timeframe.

The main intension with this report is to try to clarify a little what is behind this dramatic failure rate. For some reason nobody has given a reasonable explanation and several contacts to the battery manufacturer has not revealed any interest in making further investigation to be able to come up with some preventive actions.

This has unfortunately led to a complete stop for further projects on introducing the electric vehicles in both private and public service in Denmark. There even seems to be an intension to try to get the still running cars out of service to prevent further warranty costs to come up.

2. Error description.

The problems the Danish owners of electric vehicles have experienced are similar to the pattern seen in the Swedish projects. From good performance for some tenth of thousand kilometers the



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max range drops fairly fast to an unacceptable low level over a few weeks. This indicates that the failure mechanism is not a normal wear out process, but must be another mechanism with dramatic deterioration of the performance of the individual battery blocks. In many cases nothing else has been noticed, but in some cases leakage of electrolyte from the batteries has been observed. It mostly happens during the last part of a charging sequence. In some rare cases also explosions have been heard during driving. This can perhaps have been caused by insufficient refill of water.

When the cars with severely reduced driving range have been taken to service it has been revealed that several of the battery blocks have reduced nominal voltage. The failure mechanism nearly always causes a condition of short circuit in the cells, which are damaged. This explains why the cars often still can operate, but with very reduced performance, after the failure happens. In some cases the service shops have tried to replace only the defective 6V blocks, but it has mostly given a very temporary performance improvement, as most cars relatively short time after being taken into service again were hit by new battery failures in the remaining old battery blocks. That happened especially if the time for repair has been long i.e. more than a few weeks.

3. Cell examination

Some of the defective battery blocks have been further examined. From outside it can sometimes be seen that they are defective.

One example can be seen on the pictures here below.

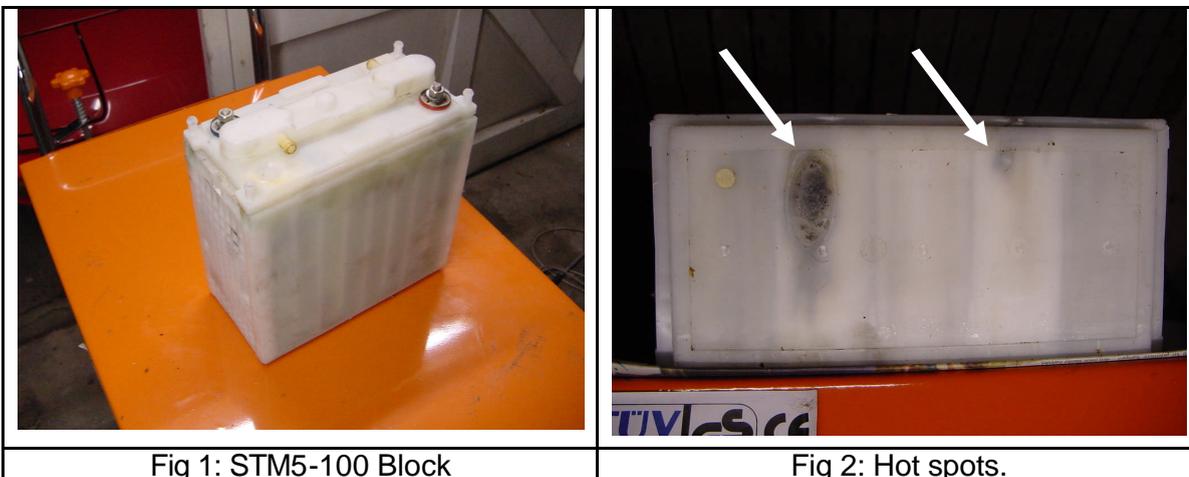


Fig 1: STM5-100 Block

Fig 2: Hot spots.

In this case it can be seen on the bottom plate of the block on Fig2 that two cells - #2 and #4 - in the five cell block have developed a lot of heat, which nearly has melted holes in the bottom plate. This amount of heat can only be developed by a rather solid short circuit between the anode and the cathode plates.

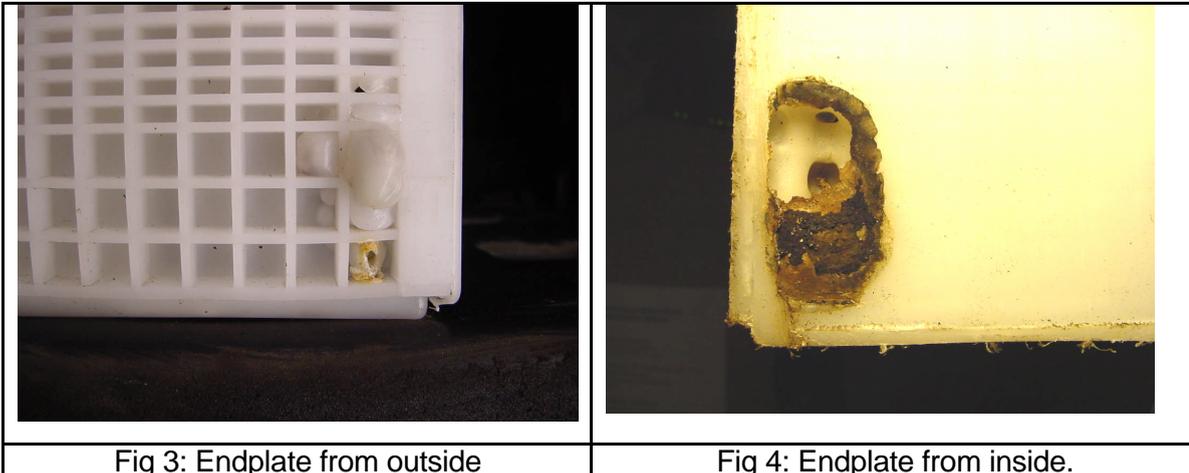
The most likely reason for such a condition is a breakdown of the separator in the battery. To further confirm this hypothesis one of the defective blocks was disassembled. The endplate was cut loose around the edge and the battery plates were investigated further.



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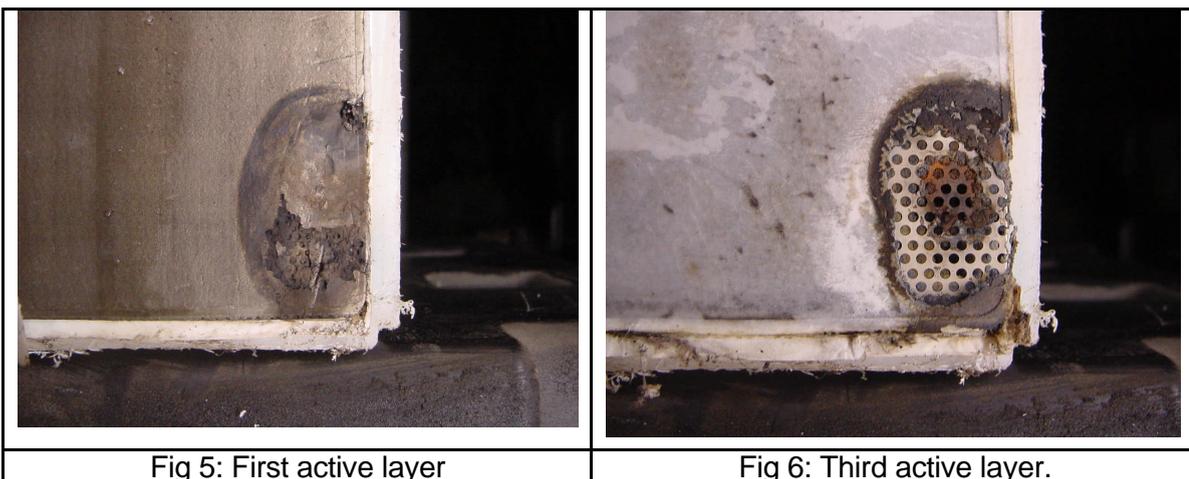
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The endplate of the block can be seen here under Fig. 3 from outside and Fig.4 from inside.



In this case it can be clearly seen that the heat development has been so strong that the strengthened endplate was melted through and hot electrolyte has leaked out in the battery case. If this only happens for a single cell it is possible to continue using the battery, but the problem will be revealed at the next water refill as the water will leak from the hole and remaining cells on the refill string will not be filled.

This can then result in that some cells will run out of electrolyte if usage of the battery is continued. Looking at the active cell plates following can be seen:



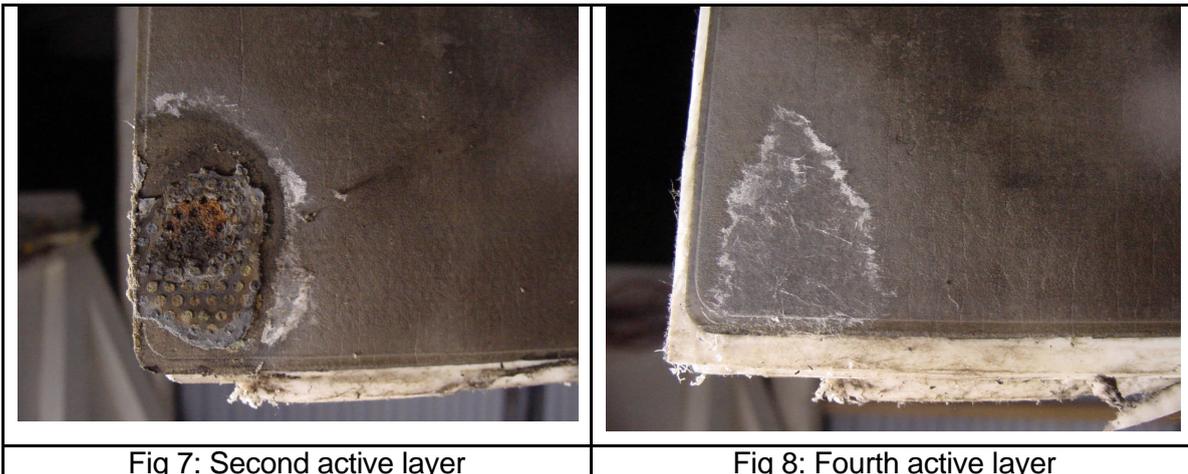
It is clear from the above pictures that the center of heat development was concentrated in the third layer as only the steel mesh, which has carried the active material is still remaining.



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Below are pictures of the 2nd and the 4th active plate. As can be seen the heat influence reduces quite fast on the next layers so the short circuit has probably been between the 2nd and 3rd active plate.



Other battery blocks, which have been investigated shows similar defects and it can be expected that the type of defects are the same on all blocks with defects.
The most likely reason for the short circuit is a weak separator.

4. Conclusion

From the reported errors and an investigation of several sets of batteries it can be concluded that the reason for breakdown of the vehicles from the period at least from 1994 until 2000 is primarily caused by defective batteries. Most of the damaged batteries have had a performance extremely below the expected and specified.

In the Swedish reports average performance figures less than 20.000 km are reported and the claimed performance figures are at least 100.000 km and 10 years calendar life.

The effect has been that all the Danish and Swedish programmes on promoting electric vehicles have been given up several years ago. They were initiated in the period when the batteries were produced with the weak separator and have been hit by the full effect of the weakness. Some cars are still in service, but the warranty costs have been extremely high and the electric car dealers want to get them out of service by replacing them with petrol driven versions for very generous offers. This is a very disappointing outcome as the cars else provides a very high driving comfort and could have been a real alternative to the standard petrol driven versions.

PS: Buyers of used electric vehicles having the SAFT STM5-100 battery should make sure that the batteries are not from the period 1994 to 2000.