

# bestmag

No. 92 Spring 2026

The international quarterly for the battery technology industry

## Nodular corrosion: detecting the hidden problem



Reprinted with permission from Energy Storage Publishing Ltd

From lithium to lead – we've got you covered

# Nodular corrosion – detecting the hidden problem

With nodular corrosion ignorance is not bliss – it is just ignorance. Pete DeMar, founder of Battery Research and Testing, explains how to detect nodular corrosion in your lead-acid battery positive posts years before it puts your system at risk. This applies to all vented lead-acid (VLA) batteries, with particular application to high-inrush loads such as found in UPS and power plants.



In the Summer 2020 edition of *BESTmag* I first shared my experience of nodular corrosion in VLA batteries in the article titled *Avoid catastrophic failure events – Detecting internal post-seal failures due to nodular corrosion in VLA cells*. In that article we explained how to perform a visual Nodular Corrosion Detection Inspection. We recommended that when running a discharge test, if the site load requires higher inrush currents than the normal steady state loads, the user performs an IEEE 450™ 2010 modified performance test.

### **Visual detection**

At that time a visual observation of the results of nodular corrosion was the only way to learn that nodular corrosion was occurring. However, a visual observation will not inform you of the changes to the resistance of the positive post(s) that have already occurred from this condition.

The visual observations are

cracks in the plastic, usually beginning in the sides of the post seal well, or in the cover, or the post seal compression seal nuts, or that area. Depending upon the design of the post seal, the cracks, which are caused by the expansion of the positive post, exhibit varying changes. By the time cracks are observed the post(s) will have been under attack for many years and substantial irreversible damage will already have been done.

### **A hidden cause of failure**

To demonstrate that this is not some rare occurrence the anonymised case studies statements (below) are excerpts from various reports on specific issues for specific incidents. These reports are all from generation plant issues, but nodular corrosion does occur in all sizes of vented lead-acid cells, and all types of applications, from high-rate to low-rate site loads. These statements all occurred within a 12-month period.

The reader should understand, as the resistance in a circuit increases, the voltage drop through the circuit (post) increases, as does the heat generated at the respective current flow. Ohm's law at work.

This increase in resistance within the positive post(s) is the primary reason that an older battery – which easily passes a discharge test at a longer duration, lower discharge rate – will fail the test if it is run at a shorter duration higher rate. That same battery, when new, can pass testing at any of its published rates. The plates in the aged cells have the same capacity for either test, and they will provide whatever current is required, but the increase in post resistance degrades the cell(s) performance at the higher rates.

### **A new detection method**

Up until last year, visual observations were the only way to detect this problem. In 2025 there were two new processes

## Anonymised case study statements from events recorded over a 12-month period

1. Received reports of failures of individual battery cell positive posts on vented/flooded lead acid batteries, which are susceptible to this failure mode. The post failures have been attributed to nodular corrosion, which caused the posts to fracture in the post seal well, and in extreme cases resulted in arcing or a localised fire at the cell post during the initiation of a service test discharge. This failure mode has the potential to cause the station battery string voltage output to fluctuate or to drop to 0VDC, interrupting power to critical equipment. This condition could cause a critical failure depending on the specific installation arrangement at the plant.
2. Based on the analysis, the observed failure mode takes several years to advance to the point of failure. Operating experience shows this failure mode has not occurred in batteries less than 10 years old from the time of shipment. For in-service batteries, the following recommended inspections enable the user to identify suspect cells and allow for corrective action prior to reaching the point of individual cell failure such that the battery system will perform for the intended service life.
3. The post material, in the presence of electrolyte (sulphuric acid  $H_2SO_4$ ) and stress, allows nodules of lead sulphate ( $PbSO_4$ ) crystals to form in micro cracks in the post seal area. Once the nodules form, the corrosion can propagate over time and result in post fracture. The initial micro cracks form over several years due to creep of the lead material which can occur due to the stress placed on the post(s).
4. Indication of nodular corrosion is visible in advanced stages, if you know where to look. Jar cover cracks, post blackening, bulging or cracking of the post seal and cracking of the post seal well under the surface of the cover are indications of nodular corrosion. It is recommended users perform a visual inspection of their batteries for nodular corrosion. Use of a flashlight and borescope (for full internal inspection of the positive post seal well) is recommended while employing appropriate safety precautions. The inspection requirements and safety precautions will be provided in the revised Instruction and operation manual.
5. Battery terminal failure is often due to stress corrosion cracking (SCC). The terminal fracture surface morphology is primarily inter-granular. The metal grains are extremely coarse and oriented in a radial pattern, extending from the outer surface to the centre. When this alloy has coarse grains, corrosion along the grain boundaries can penetrate deep into the material, which can lead to catastrophic failure.
6. When black areas are observed on the surface of the positive posts, they are lead oxide corrosion, which is from exposure to sulphuric acid.
7. When the positive post(s) within the post seal well area are covered with corrosion/pits/nodules/cracks this is an indication that the surfaces were exposed to battery acid for an extended period of time.
8. Stress corrosion cracking (SCC) occurs when a susceptible material is exposed to critical threshold tensile stress intensity in a corrosive environment. Cracking initiates at the surface of the post in the seal well. The crack propagates over an extended period of time, until it reaches a critical length and then a fracture occurs.

developed<sup>[1&2]</sup> that allow anyone that knows how to perform an annual inspection following the guidelines in the IEEE 450<sup>TM</sup>450-2020<sup>[3]</sup> to be able to measure the internal resistance of the post(s)

current-carrying path. This allows for a direct comparison of the resistance of the post's current-carrying path at that moment in time to baseline values.

For those assuming that nodular corrosion is only a risk for larger cells, such as those that protect large power plants or large UPS equipment, that is an incorrect assumption as it can

# 4 bestinsight

be present in any size vented lead-acid cell. (See Fig 1)

## Baseline values

To know what is an acceptable, or unacceptable, resistance for the positive post current-carrying conduction path being tested, a baseline value must be known. Baseline values for the different model cells can be established by any of the following three means. (These are numbered in what we consider to be the best order of priority.)

1. Obtain the value from the manufacturer
2. Utilise the readings measured when the cells are first installed
3. Utilise the value from the negative post(s) value of the cell

## Understanding the issue

For those that are new to this issue, the following pictures and explanations should help bring you up to speed on this subject. We will not be including the multiple pictures that were included in the Summer 2020 article, but anyone can go online

and look at them. Below are some pictures that show the severity of the post attacks and the results of the damage when undiagnosed.

It is important to understand that every battery manufacturer worldwide is aware of this issue, and that they all do their best to design and build batteries that limit or control this issue. It also is important to understand that once nodular corrosion begins there is no repair or fix for it, and that eventually it will destroy the post as explained at Intelec 1988<sup>[4]</sup> and at Intelec 2001<sup>[5]</sup>.

What often is overlooked when thinking about aged batteries, and the difference in capacity they deliver at different rates, it must be realised that any increase in resistance in any of the current carrying paths in the cells – from the plate grids, to the plate collector bus, to the posts themselves – can cause a substantial reduction in the capacity test results when the test is run at the higher discharge rates.

The following example shows the different voltage drops in a 60-cell 930 AH string, whose internal resistance has increased by approximately 400%, at

Fig 1: A small VLA cell – under 100Ah

different rates of discharge. This type of result is not abnormal when nodular corrosion is present. From this, it is easy to understand how not being aware that nodular corrosion is present will skew your understanding of the discharge test results.

Duration	Rate	O/A voltage difference
8 H	116	1.16
5 H	158	1.39
3 H	213	1.976
2 H	279	2.458
1 H	413	3.639
15 M	649	5.718
1 M	752	6.625

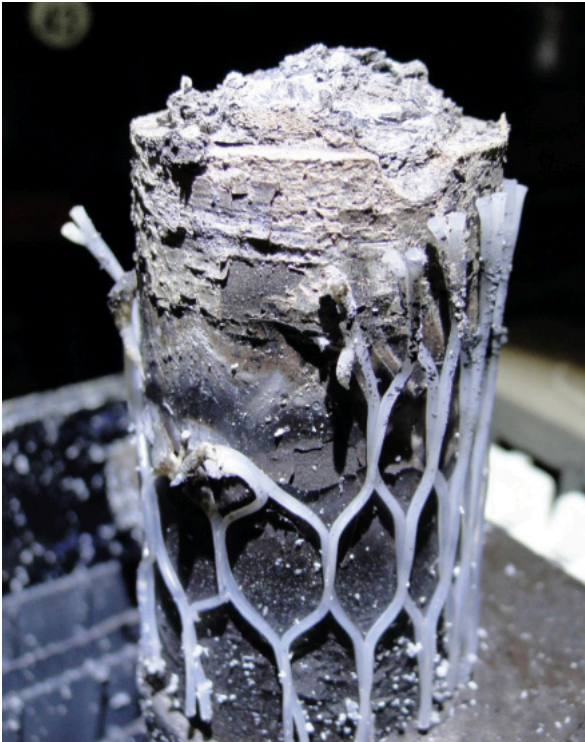
## The results of failure

Fig 1 shows a very small cell (under 100Ah), whose flag terminal melted apart under load. This post was previously identified as breaking due to physical pressure being placed on the flag terminal, but upon closer examination of the upper portion, it is now understood to having melted.

Whatever equipment that this battery was protecting no longer was protected. One instance of a small battery failing was at a switchyard, at a manufacturing plant. When it was called upon it resulted in the switchyard not being able to open a circuit to isolate a fault in the line. The lines got very hot, sagged, and contacted a parked car which ended up in flames.

Fig 2 shows the positive post that melted apart when the power plant tripped and the battery was called upon. This investigation was reported in the





2020 article. This picture was taken once we removed the cover so that we could closely study the post. The damage to the generator required months to be repaired and placed back into service. The losses were in the millions of dollars. This cell did not explode when it opened, it just melted apart. The gas mixture in the headspace was not the correct ratio to cause an explosion.

**Fig 3** shows a cell in a medium-size battery at a power plant – the battery was off-line for testing. As can be seen, the cell exploded when the right rear positive post opened during the test – which meant that the gas mixture supported ignition, and this was the result. If this unit had tripped when the battery had been in service, the result would have been the loss of millions of dollars to the power plant.

*Fig 2: Positive post that melted apart*

*Fig 3: Cell that exploded when right rear positive post opened*

**Fig 4** shows a cell from a large amp-hour battery at a power plant. This battery was offline being tested – to verify that it could support the site loads if called upon – and this shows what happened. One of the two positive posts melted apart during the inrush part of the test. It is possible that if the user had not been performing a service test, and just performed a standard performance test, that the battery, which had passed previous tests, might have passed its test again.

This is exactly why it is important to perform all discharge tests at rates that encompass the actual required loads. This plant's loss, if it had occurred when the battery was online, would have been in many millions of dollars.

#### **Early-detection methods**

The two processes now available that provide the means to

measure resistance in the post(s) current-carrying conduction path are different. One process requires the battery to be out of service with all connection hardware removed, and the other can be performed with the string in service. Both processes are patent pending<sup>[1&2]</sup>. Both processes utilise standard electronic equipment that all stationary battery users or companies (that perform service) are familiar with, own and use.

It is now possible for any qualified person that works on these batteries to determine if the battery has this condition or if it is free from it. If they do have it, the new NCDI<sup>SM</sup> Nodular Corrosion Detection Inspection processes allow the earliest possible identification and quantification of the severity of the degradation. By being able to measure the changes to the resistance within the posts it



# 6 bestinsight



allows time for proactive decisions and actions to be performed.

## Risk elimination

Never has anyone – whether user, plant manager, insurance carrier, etc – that has a vested interest in the battery performing its intended function, been able to eliminate the risk of battery failure due to this cause.

Failures related to this cause are usually written off as “something unusual” and the effort required to identify the cause ends up with it being an “unknown”. These electronic inspections provide a quantification as to the resistance in the post(s).

It would be remiss if I did not recommend that, when running any battery discharge test in any aged battery, you perform an infrared scan of the cover in the area where the post goes into the cover while the load is running. This should be done after some amount of time has

been allowed for any temperature changes – caused by an increase in resistance within the post – to occur. This could be as soon as 15 minutes, if a one-hour test is being run. If the temperature in the area around the positive post exceeds that of the negative post by a noticeable difference, then there most likely is nodular corrosion occurring in that positive post.

One does have to wonder if the damage caused by one of these failures is more damaging due to the costs incurred, or from the negative publicity the company receives.

We welcome questions from anyone that is interested in gaining a deeper understanding of this issue or wants to be able to conduct these inspections. Please contact us at [info@batteryresearch.com](mailto:info@batteryresearch.com). Only by sharing our individual knowledge and experiences can all of us benefit from each of those separate experiences. +

*Fig 4: positive post that melted apart during the inrush part of testing*

## References

1. A method for performing a nodular corrosion detection inspection on lead-acid battery cells utilising electronic instrumentation to identify and quantify degradation – patent pending # 63/882/027
2. A method for performing a nodular corrosion detection inspection on stationary battery lead-acid cells within a fully assembled battery string with the battery string being either in service and on charge or out of service and off charge, by measuring the current flowing through the post, measuring the voltage drop through the post, and using ohm’s law calculations to determine the resistance through the post, and using that measured value to identify and quantify degradation of the post – patent pending # 63/988/898
3. IEEE Std 450™-2020 IEEE *Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications*
4. *Vulcanised rubber post seal for lead-acid batteries a new generic type* – William B. Brecht and Sudan Misra
5. *On the development of a long-life post seal for stationary batteries* - S.S. Misra and T. M. Noveske