Hastings Deering CAT

Equipment Safety Bulletin

Technical Support Department

Reference Number	Bulletin 03 – 2021
Affected Product	All stationary and mobile battery applications
Risks Identified	Potential risk of personal injury and/or property damage associated with lead acid batteries
Release Date	11 August 2021

NB. This bulletin replaces bulletin 004/2015. Changes have been made to all areas of this bulletin.

Potential Hazard Overview

- Lead acid type batteries used on all types of mobile equipment and stationary plant produce hydrogen gas. Hydrogen gas is highly flammable - under certain circumstances batteries can explode with the potential to cause serious injury and property damage.
- Lead acid batteries contain diluted sulphuric acid with the potential to cause burns and severe eye damage.
- Battery posts, terminals and some internal components contain lead or lead compounds. Lead absorbed by the body can lead to long term health issues.
- Manual handling injuries caused by poor lifting practices, in some cases compounded by difficult to access battery locations.
- Short circuits can cause severe burns, battery explosions and fires.

Background

Several types of lead acid battery are used in automotive and heavy equipment applications - Traditional lead acid batteries, Low Maintenance, and Maintenance Free ('MF') lead acid batteries are the most common. The terms 'flooded', or 'wet cell' batteries are often used to describe these three battery types.

Absorbed Glass Mat (AGM) and Gel batteries may also be used in some applications. AGM and Gel batteries also use lead and acid and operate on the same principles as 'wet cell' lead acid batteries, with some differing attributes, materials, and construction. AGM batteries have the electrolyte contained in 'glass mats'. Gel batteries use gel instead of liquid electrolyte.

The ideal operating temperature for batteries discussed in this bulletin, is in the range 20°C - 25°C. Most batteries will achieve reasonable life, charge, and operate without noticeable performance or maintenance changes in the range of 13°C to 30°C.

During normal operation, all types produce Hydrogen and Oxygen to varying degrees, and can even produce small amounts of gas when sitting idle due to self-discharge action. As battery temperatures increase above 25° C the tendency to self-discharge and produce more hydrogen progressively increases.

These gases can be highly explosive in the presence of an ignition source. Hastings Deering is aware of incidents where batteries have exploded when attempting to start an engine. Most relate to normally unattended engine applications, e.g., Generator sets.

This bulletin focuses on the potential hazards, precautions and maintenance requirements associated with 'flooded' or 'wet cell' lead acid batteries. Much of the information provided is

also relevant to AGM or Gel filled batteries. Maintainers should always refer to and follow both the Original Equipment Manufacturers' (OEM) and battery manufacturers advice when working around or maintaining all types of battery.

Maintenance Free Batteries

The term 'Maintenance Free' (MF) is widely used. It is used to describe the battery grid composition that is manufactured from lead-calcium alloys as opposed to the traditional lead-antimony construction. As previously discussed, these batteries are still classified as 'wet cell' batteries.

Batteries manufactured using lead-calcium alloys produce less gas when charging, resulting in less water consumption over the life of the battery. However, the term 'Maintenance Free' is misleading. These batteries can still lose water over an extended period, especially when subjected to high temperatures or overcharging.

Maintenance Free (MF) batteries can be either 'non-accessible' or 'accessible'. Accessible MF batteries have non-vented caps (separately vented in upper case) to allow checking and topping up with distilled water. Failure to replenish the water level so that the electrolyte level is above the battery plates can result in short battery life and an explosion. Some limitations apply regarding the use of 'non-accessible' MF batteries in certain applications – see below.

Unattended applications

Reports of explosions on stationary and unattended plant are more common than OEM designed mobile installations. Some examples of unattended applications include generator sets, compressors, pumps, and mobile crushing plants. These applications have the potential to encounter additional problems:

- Battery maintenance and regular inspections can be overlooked on unattended engines, e.g., stand-by generator sets.
- Batteries are often located within engine enclosures – this can result in poor ventilation and high battery temperatures. High ambient and operating temperatures will shorten battery life and accelerate the rate of electrolyte loss.
- Stand-by generator sets often have 'trickle' or 'float' chargers to keep batteries fully charged. Electrolyte loss and hydrogen production will still occur when the set is on 'stand-by', especially if charge rates are excessive.
- Engines operating continuously with engine driven alternators can lead to battery overheating if the charge rate is excessive. This will result in the accelerated loss of electrolyte and excess hydrogen production.
- At times 'non accessible' MF batteries are installed on unattended engines. Due to the high temperatures encountered in many of these applications, constant charging or 'trickle' charging, and the inability to check or top up electrolyte, the electrolyte can become depleted resulting in a high risk of a battery explosion.

The use of 'non accessible' MF batteries is not recommended in unattended applications – especially when high ambient [(1)] temperatures are encountered.

[(1)] The use of the phrase 'High ambient temperatures' in this bulletin refers to the immediate operating environment of the battery. High temperatures can be due to the design of the enclosure, poor ventilation or radiated engine heat.

Risk Overview

Risk: Explosion – The hydrogen gas in batteries can explode if exposed to an external or internal ignition source. Battery explosions may be caused by one, or a combination of the following issues:

- An ignition source near battery, e.g., loose terminal, spark.
- Loss of electrolyte due to high ambient temperatures, overheating, overcharging or poor maintenance.
- A loose connection or a direct short circuit either within the battery or externally, or sustained high current draw, e.g., sticking starter motor solenoid.
- Maintenance Free (MF) batteries operated beyond recommended lifespan in unattended applications and high ambient temperatures (depleted electrolyte).

Risk: Sulphuric acid – 'Flooded' or 'Wet cell' batteries use Sulphuric acid diluted with distilled water as the electrolyte. Wet cell batteries must always be shipped, stored, and installed in the upright position. Sulphuric acid will damage clothing and surrounding surfaces as well as causing skin burns. The most serious risk from diluted sulphuric acid is eye damage.

Risk: Lead Absorption – Excessive levels of lead absorbed by the body, usually over a prolonged period, can have serious health effects. Batteries, battery posts, and terminals contain lead or lead compounds. The most common entry points are via the nose, mouth, and eyes, if they are touched with the hands after handling lead.

Some studies have shown that lead can be absorbed through the skin – including lead lodged under fingernails. Airborne lead as fine dust, can be absorbed by the lungs. e.g., mining and refining of lead. These risks can be easily managed with awareness and basic handling precautions.

Risk: Manual handling – Most batteries are heavy in relation to their size due to the high lead content and heavy-duty case construction. Installing and removing batteries in difficult to access areas can result in sprains and hand injuries.

Risk: Short circuits and sparks – Any conductive object connecting negative and positive battery posts, leads or electrical terminals, or positive terminals or leads to earth, can cause severe burns, and create a fire or explosion risk, e.g., spanners, metal watch bands, incorrect use of jumper leads. Disconnecting and connecting batteries with even minor electrical loads present can result in sparks.

Recommended Management Actions – all applications

- Only suitably trained personnel should carry out maintenance activities on batteries and the electrical systems of stationary and mobile plant.
- Refer to the manufacturer's specific service and repair procedures and safety warnings, before attempting to jump start an engine or working on any part of an engine vehicle electrical system including the battery.
- Wear suitable protective equipment during all maintenance and testing activities related to batteries and battery cables, including 'jump starting'. Protective equipment **must** include eye and face protection, hand protection and approved industrial clothing.

- Before inspecting or servicing batteries or the related engine/machine, the engine should be stopped, and the battery isolation switch turned off.[2] If there is no isolation switch, remove battery negative [3] (earth) lead – preferably at earthing point on engine away from battery.
- Do not touch face including nose, mouth, and eyes during and after handling batteries.
- Remove metallic jewellery, watches, rings, and wristbands prior to working near batteries, battery cables, starter motors and alternators.
- Keep all ignition sources away from batteries including flames or cigarettes. Sparks can be caused by a loose terminal, when removing or installing a terminal when there is an electrical load on battery, or by careless handling of metal tools. A damp cloth placed over cap vents and top of battery will reduce the risk of explosions.
- Do not use a mobile phone, tablet, or similar electronic device near a battery.
- Never lean over a battery when inspecting, testing, charging, or 'jump starting'.
- Maintain batteries in accordance with the equipment or battery manufacturer's instructions. Maintain electrolyte levels in accessible batteries at approximately 13 mm above plates or to the indicators provided by the battery manufacturer. Always top up with de-ionized or demineralised water. As only water is lost during due to the evaporative process, do not add acid to batteries as this will change the chemical composition of the electrolyte.
- Always disconnect the earthed negative [3] (black) cable first, before removing positive (red) cable. When reconnecting battery leads, always connect the positive (red) cable before connecting the earth (black) cable. Disconnecting ground cable at 'frame' or engine end will reduce the danger of sparks at battery.
- Keep battery tops clean and dry to avoid slow discharge from conductive moisture/debris, using approved methods, e.g., use a solution of 100 grams of baking soda added to 1 litre of clean water, followed by a clean water rinse.
- Never clean batteries with compressed air. In the presence of dust, static electricity may be generated with the potential to cause a battery explosion.
- Keep battery enclosures free of debris that impedes air circulation around batteries
- Keep battery terminals and cable connections clean and tight. Use a specifically designed terminal brush to clean corrosion from terminals, e.g., Cat part # 1U9921. After securing terminals, coat with grease or other terminal protectant to prevent corrosion.
- Inspect cables at all service intervals for insulation damage, clamp, and cable security. Loose clamps or plastic-coated P-clamps can cause chaffing damage. Inspect under clamps - refer illustrations on page 7.

*[2] **Warning.** Solid-state equipment like electronic governors and speed sensors may be damaged by transient currents and voltage spikes. Seek advice from suitably qualified people, to select the best charging options, and before modifying starting and charging systems in any way, including the installation of battery-isolation switches.*

[3] Although very rare, some older vehicles in the automotive field may have 'positive earth' systems. Always verify that the system is 'negative earth' before proceeding with battery disconnection or connection. Procedures must be reversed for positive earth systems.

- Terminal 'boots' or covers are recommended to protect terminals from debris and to reduce the possibility of short circuits. Refer Caterpillar publication "One Safe Source".
- Replacement batteries should have the same dimensions as those specified by the OEM. This will ensure batteries have adequate clearance and are properly restrained by OEM's clamps. Increased height batteries may contact covers and cause short circuits.
- Ensure replacement batteries meet OEM quality recommendations. Batteries designed for construction equipment have more resistance to vibration, heavier case construction and better resistance to plate buckling and retention – reducing the risk of internal short circuits or poor (heat creating) connections.
- Ensure battery hold down clamps are in good condition and tightened securely – makeshift hold down clamps can allow battery movement and short circuits.
- Starting systems with two or more interconnected batteries require batteries of the same type and rating. All batteries should be replaced at the same time. Failure to observe these points can lead to overcharging and overheating of one of the batteries.
- Do not connect a 12V appliance to one battery in a 24V system as this can lead to overcharging and overheating of one battery and damage to the appliance. Use a voltage convertor designed for the task.
- Refer to the relevant manufacturer's instructions and safety warnings when 'jump starting' engines. Incorrect procedures can cause a battery explosion and damage electronic components. NB. Always connect the negative (black) lead to the negative terminal of battery last, before jump starting, and disconnect the negative lead first when disconnecting jump start leads. A damp cloth can be placed over the cap vents of both batteries when jump starting to reduce the risk of hydrogen ignition.
- Read the manufacturer's instruction before connecting a battery charger. Do not turn on charger until leads are connected.
- Investigate rapid depletion of electrolyte levels. Excessive charge rates and high ambient or battery operating temperatures are possible causes.
- Keep battery enclosures clean and free of debris to allow air circulation around batteries.
- If using 'Maintenance Free' batteries, 'accessible type' batteries are recommended in applications where high temperatures may be encountered. Accessible batteries allow electrolyte to be checked and topped up.
- Batteries are heavy relative to their size and access can be difficult in some applications. Sprains and finger/hand crush injuries can occur. Risk assess all aspects of manual battery handling and develop safe solutions to manage identified risks.
- Batteries contain products harmful to health and the environment if disposed of incorrectly. Dispose of batteries in accordance with local laws and regulations.

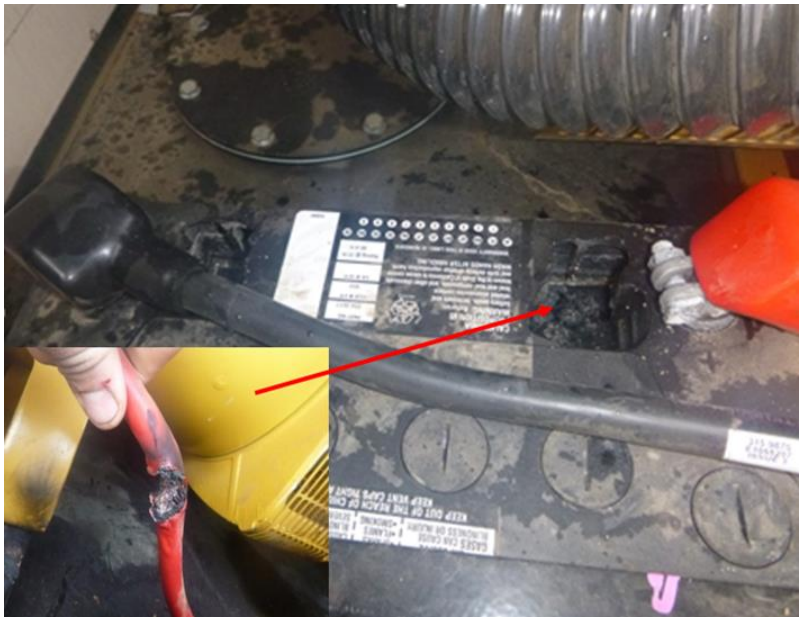
Additional battery maintenance recommendations for unattended engines

- Exercise additional caution when commencing checks or service work on unattended engines. The same precautions as listed previously apply, including hand, eye, and face protection - do not lean over batteries.

- Before entering enclosures, ensure engine and battery enclosures are well ventilated. Hydrogen is lighter than air. Pay special attention to 'ceiling' area of enclosures to ensure they are well ventilated to prevent hydrogen gas accumulating. Even small concentrations of hydrogen can explode.
- Isolate electrical system and turn of battery charger if installed. Disconnect negative battery lead at the engine end if possible (away from battery).
- Disconnect battery charger cables, removing negative terminal first.
- Do not attempt to start engine before isolating electrical system and conducting a careful visual inspection of batteries. Check for:
  - Cracked or damaged case or cover
  - Swollen or distorted case
  - Corroded or loose cable connections
  - Leaking case to cover seal, leaks around posts
  - Corrosion and debris on battery top
  - Damaged battery posts or terminals
  - Identify battery type. Non accessible MF batteries should be replaced after 2.5 years when operating in environments above 25°C, after 3 years if the operating environments do not exceed 25°C. <u>These batteries are not recommended for unattended engine use</u>.

Replace batteries showing any case defects or leakage. Corrosion should be cleaned using recommended procedures:

- The primary recommendation in unattended applications is to replace 'non-accessible' MF batteries with 'accessible' MF or conventional lead acid batteries, regardless of age.
- At minimum replace existing non accessible type MF batteries within 2.5 years of installation in warmer geographical regions (above 25° Celsius), and no later than 3 years in other regions. If MF batteries outside these age guidelines are identified on unattended applications, recommend to owner to replace batteries immediately. Do not attempt to start engine.
- Voltage regulators should be checked for correct charge rate at 6 monthly intervals or immediately if the battery has an abnormal loss of electrolyte, is hot, 'bubbling', pushing electrolyte from vents or has a bulged case.
- Check battery electrolyte levels at specified intervals. Accessible MF batteries are a good option for applications where engine cannot be shutdown regularly. Check accessible MF batteries at 500-hour intervals if the battery is subject to temperatures above 25°C. Conventional lead acid batteries require more frequent checking at 250-hour intervals or less, based on site/application experience.

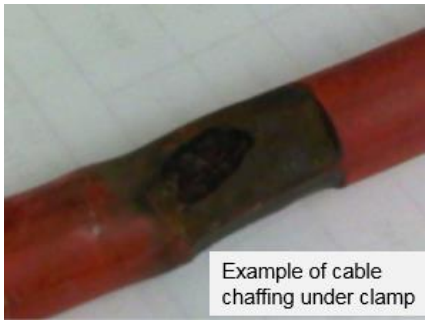


Battery explosion damage caused by poorly secured cable (inset).

8S-0948 clip & 2V-1771 Grommet (12mm ID)

4S-1962 Clip & 7V-6571 Grommet (16mm ID)

Recommended clip type (do not use plastic coated P-clips).



Example of cable chaffing under clamp

Reference documents and useful Caterpillar Publications

- Battery Service Manual - produced by Battery Council International – available online or in hard copy form as Caterpillar form number SEBD0625.
- PEWP4050 Cat Battery Care & Maintenance Guide wall chart (electronic only).
- PEGP7801 Cat Batteries Application Guide.
- PECP9067 “One Safe Source” lists battery accessories including terminal covers.
- LEBW4980 Starting and Charging Systems – Application and Installation Guide. (Current edition 13 December 2020).
- PEWJ0214 Maintenance Free versus Accessible Maintenance Free batteries.

If you have any questions about the contents of this bulletin please contact your Hastings Deering Mining or Product Support representative.

This bulletin is to inform you of the recommendations of the supplier in respect of issues dealt with in the bulletin and should not be used as specific advice in respect of any events. Advice from a qualified repairer should be sought in respect of any events and Hastings Deering (Australia) Limited accepts no responsibility for any loss or damage occasioned by a party using this general bulletin.