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CONTENTS

TABLES

1. INTRODUCTION

Battery rooms are normally used for the housing of lead acid batteries, whereas nickel cadmium batteries are housed within battery cabinets inside the control room. Vented batteries with a liquid electrolyte release hydrogen and oxygen due to the electrolysis of water. These batteries allow the generated hydrogen and oxygen to escape freely through the cell vent cap. This process is more significant in vented lead acid batteries and, the rate of hydrogen and oxygen released is therefore higher than for nickel cadmium batteries.

A mixture of hydrogen and air, in hydrogen concentrations of between 4% (LEL – lower explosive limit) and 74% (UEL – upper explosive limit), is explosive. Burning is enhanced by oxygen enrichment. The volume of gasses (H2 and O2) produced is considerably greater under boost charge, particularly as the battery nears a fully charged state.

SANS 60079-10: 2006, Electrical Apparatus for Explosive Gas Atmospheres – Part 10: Classification of Hazardous Areas requires that the following steps should be taken in areas where an explosive gas atmosphere may occur:

a. Eliminate the likelihood of an explosive gas atmosphere occurring around the source of ignition, or

b. Eliminate the source of ignition.

Requirement a. may be achieved by ensuring that the ventilation inside the area is sufficient to ensure that the hydrogen concentration never enters the explosive range. Requirement b., on the other hand, may be achieved by ensuring that the correct equipment is used inside battery rooms and that working procedures are put in place that prevents the usage of equipment that generates sparks, arcs and excessively hot surfaces that can ignite the gas and cause an explosion.

1.2 KEYWORDS

Hydrogen, battery room, classification, hazardous, zone

2. SUPPORTING CLAUSES

2.1 SCOPE

The purpose of this document is to set out the procedure for the classification of battery rooms.

2.1.1 Purpose

See Scope

2.1.2 Applicability

This document shall apply to the Distribution Division of Eskom Holdings Limited.

2.2 NORMATIVE/INFORMATIVE REFERENCES

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

South African National document(s):

[1] SANS 10108: 2005, The Classification of Hazardous Locations and the Selection Of Apparatus for Use in Such Locations.

[2] SANS 60079-0: 2005, Electrical Apparatus for Explosive Gas Atmospheres – Part 0: General Requirements.

[3] SANS 60079-10: 2006, Electrical Apparatus for Explosive Gas Atmospheres – Part 10: Classification of Hazardous Areas.

[4] Occupational Health And Safety Act, 85/1993

Eskom Divisional Documents

[5] DSP_34-479, Rev 1, Specification for Battery Rooms

2.2.2 Informative

None

2.3 DEFINITIONS

Definition	Description
Non-hazardous area	Locations in which an explosive gas atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of apparatus.
Zone 0	Locations in which flammable gases or vapours are continuously, or for long periods, present in concentrations within the lower and upper limits of flammability.
Zone 1	Locations in which hazardous concentrations of flammable gasses or vapours occur intermittently or periodically under normal operating conditions OR, frequently because of repair or maintenance operations OR, because of leakage OR, due to the breakdown or faulty operation of equipment or processes.
Zone 2	Locations where the operation concerned with flammable or explosive gases or vapours are so well controlled that an explosive or ignitable concentration is only likely to occur under abnormal conditions. A further requirement of a zone 2 area, which is applicable to battery rooms, is that the area should be so well ventilated that, if abnormal conditions arise, ignitable concentrations of the gas or vapour are rapidly dispersed and their possible contact with electrical equipment is of minimal duration.

2.3.1 Classification

a. **Controlled Disclosure:** Controlled Disclosure to External Parties (either enforced by law, or discretionary).

2.4 ABBREVIATIONS

Abbreviation	Description
Ah	Ampere hour
DC	Direct Current
ED	Electricity Delivery
FS	Field Services
TSC	Technical Services Centre
TSS	Technical Specialist Section

2.5 ROLES AND RESPONSIBILITIES

None

2.6 PROCESS FOR MONITORING

None

2.7 RELATED/SUPPORTING DOCUMENTS

None

3. STANDARD FOR THE CLASSIFICATION OF BATTERY ROOMS

3.1 REQUIREMENTS

3.1.1 General

Area classification is the process of analysing and classifying the area where explosive gas atmospheres may occur in order to facilitate the proper selection and installation of apparatus to be safely used in that area, taking into consideration the gas groups and temperature classes. By doing this, a firm basis is established on which the zoning of the area can be determined. This will ultimately determine what the legal requirements for that area are in terms of installed electrical equipment, inspections, certification and ventilation.

SANS 10108: 2005, The Classification of Hazardous Locations and the Selection of Apparatus for Use in Such Locations defines the four types of zones, i.e. zone 0, zone 1, zone 2 and a non-hazardous area. The zones are determined by the frequency and duration of release of the explosive gas and by the level of ventilation in the affected area.

According to SANS 60079-10: 2006, Electrical Apparatus for Explosive Gas Atmospheres – Part 10: Classification of Hazardous Areas, it is recommended that zone 0 or zone 1 areas should be minimized in number as far as possible. Therefore the objective of this exercise would be to classify battery rooms either as zone 2 or non–hazardous areas.

The following points shall be taken into consideration whenever area classification is performed:

a. The source of the release and grade of the release shall be established. In the case of battery rooms, the source of release are the cell vent plugs and the grade of release would be primary as per SABS IEC 79-10:1995 clause A1.2 c), "sample points which are expected to release flammable material into the atmosphere during normal operation".

b. Ventilation, i.e. movement of air and its replacement with fresh air due to the effects of wind, temperature gradients, or artificial means (e.g. fans or extractors). Suitable ventilation rates can also avoid persistence of an explosive gas atmosphere thus influencing the type of zone.

c. Relative density of the gas or vapour when it is released. If the gas or vapour is significantly lighter than air (relative density of below 0.8), it will tend to move upwards, but in the case of a significantly heavier (relative density of above 1.2) gas or vapour, it will tend to accumulate at ground level. Refer to table 1 below:

Table 1: Properties of Hydrogen

Gas Group	Ignition Temperature [°C]	Explosive limit in air % (by volume)		Flash point [°C]	Relative density (air = 1)
		Upper	Lower		
Sub group IIC	585	74,0	4,0	Gas	0,07

Note:

Lighter-than-air gases tend to collect at the highest point in well-ventilated areas, but are quickly dispersed in the open. Such gases can move upward even against a downward ventilation current. Their tendency to collect against roofs should be borne in mind, especially when lighting installations are being planned.

The area classification needs to be done on a "per site" basis and therefore, a blanket approach for identical battery rooms, in terms of physical dimensions and installed plant, is not acceptable. The area classification procedure also ensures that the original design of the battery room in terms of ventilation requirements is verified. It is important to note that once the area has been classified and all necessary records made, that no modification to equipment or operating procedures is made without prior discussion with those responsible for the area classification. Unauthorised action may invalidate the area classification.

All battery rooms where vented, flooded batteries are used shall be classified as zone 2 areas, given that sufficient extraction facilities are provided. However, battery rooms where valve regulated lead acid (VRLA) batteries are used which do not release hydrogen under normal operating conditions, may be classified as non-hazardous areas.

3.1.2 Battery room classification committee

The classification of battery rooms shall be carried out by a committee consisting of the following people:

a. The DC TSS head

b. EDNS DC Technology Engineer

The risk management coordinator for the area shall convene a meeting where the classification of existing battery rooms, including necessary upgrades (where applicable), and the classification of new battery rooms shall be discussed.

3.1.3 Classification of existing battery rooms

The following process shall be followed for the classification of existing battery rooms:

3.1.3.1 A list shall be compiled of all the battery rooms within the region.

3.1.3.2 The following information per battery room, where available, shall also be gathered:

3.1.3.2.1 A drawing, detailing the physical dimensions and layout of the battery room.

3.1.3.2.2 The volume of the battery room.

3.1.3.2.3 The installed electrical equipment i.e. the type of lighting, extraction facilities and switches.

3.1.3.2.4 The details of the installed battery banks i.e. rated Ah capacity, type, volume per cell, no. of cells and the stand type.

3.1.3.3 A schedule shall be drawn up to indicate when the identified battery rooms shall be inspected and how and when the necessary upgrades, where applicable, shall be affected. It may be necessary to establish a capital project for the initial upgrades to get the battery rooms in line with the legal requirements, but the resources required for future maintenance should be built into the regions' operating expenditure budget.

3.1.3.4 The following tasks shall be done during each site visit / inspection:

3.1.3.4.1 Measurement of the room dimensions and verification of the battery room layout drawing. It may be necessary to update the drawing or make a new layout drawing.

3.1.3.4.2 Recording and verification of the battery bank and installed electrical equipment information.

3.1.3.4.3 Measurement of the rate of airflow at the available inlet points.

3.1.3.4.4 Perform the calculations as shown in section 3.1.5

3.1.3.4.5 Evaluate the results and decide if the requirements of a zone 2 classification are met.

3.1.4 Classification of new battery rooms

In the case of new battery rooms, it shall be ensured that all designs meet the minimum requirements as set out in DSP_34-479, Rev 1, Specification for Battery Rooms. Once the site has been completed, the battery room shall be inspected as part of the commissioning process, to ensure that the necessary classification is done and documented. This step shall also be used to verify the effectiveness of the ventilation system.

3.1.5 Ventilation calculations

3.1.5.1 Calculation of hydrogen emission rate

The rate of hydrogen evolution per hour, under overcharge conditions, may be calculated as follows:

$$V_{H_2} = N \times I \times 0{,}00045\, m^3 \qquad ....1.$$

where

V is the volume (in cubic metres at standard atmospheric pressure) of hydrogen liberated / hr;

N is the number of cells in the battery;

I is the overcharge current, in amperes.

Note 1: In the case of vented, flooded lead acid cells, the current (I) should be that value declared by the manufacturer at the maximum boost voltage to be used across the battery.

Note 2: In the case of valve-regulated cells, the current (I) should be that value declared by the manufacturer as IE, which is determined from an overcharge gas emission test at 2,4 V/cell.

Note 3: If a valve-regulated cell has not been subjected to a gas emission test, the current (I) should be that value declared by the manufacturer at an overcharge voltage of 2,4 V/cell.

Note 4: Some batteries are made up of monoblocs, each containing a number of cells. It is essential that the number of cells is used in the calculations, and not the number of monoblocs.

Note 5: The calculation must be made per battery bank and then summed to get the total emission rate for all the battery banks combined.

3.1.5.2 Calculation of hydrogen concentration

The hydrogen concentration (by volume) can be calculated by doing the following:

a. Calculate the volume [m^3] of the room by using equation 2:

$$V_{\text{battery room}} = l \times w \times h \quad \text{....2.}$$

where

l is the length of the battery room;

w is the width of the battery room;

h s the height of the battery room.

b. Calculate the volume [m^3] of the battery by using equation 3:

$$\begin{aligned} V_{\text{battery}} &= V_{\text{cell}} \times N \\ &= l \times w \times h \times N \end{aligned} \quad \text{....3.}$$

where

L is the length of the cell;

W is the width of the cell;

H is the height (up to the top of the terminals) of the cell;

N is the number of cells.

c. Calculate the volume [m^3] of the battery stand by using equation 4, if the stand is a stand which is closed along the side e.g. a concrete stand, otherwise the stand volume may be neglected:

$$V_{\text{battery stand}} = l \times w \times h \quad \text{....4.}$$

where

l is the length of the battery stand;

w is the width of the battery stand;

h is the height of the battery stand.

d. Calculate the volume [m^3] of free air in the battery room by using equation 5:

$$V_{\text{free air}} = V_{\text{battery room}} - V_{\text{battery}} - V_{\text{battery stand}} \quad \text{....5.}$$

e. Calculate the hydrogen concentration after 1 hour of charging by using equation 6:

$$H_2(\%) = \frac{V_{H_2}}{V_{free\,air}} \times 100 \quad \text{....6.}$$

3.1.6 Calculation of required number of air changes

The number of minimum air changes required to keep the hydrogen concentration below the recommended maximum of 0,8% (by volume) can be calculated by recognising the fact that the hydrogen concentration is inversely proportional to the number of air changes, i.e. as the number of air changes increase, the hydrogen concentration is reduced. This can be calculated by using equation 7:

$$N_{\text{air changes}}(required) = \frac{H_2(\%)}{0{,}8} \quad \text{....7.}$$

Note 1: To allow for the inevitable variations and contingencies, a safety factor may be built in to the calculated number of air changes.

Note 2: The effectiveness of a ventilation system can only be assessed by sampling gas concentration under operational conditions.

3.1.7 Air flow measurements

An anemometer is used to measure the velocity at which air moves through the inlets of the battery room. The airflow is measured in meters per second [m/s] and the measurement is done at 3 to 4 points along the surface of the inlet (filter) to eventually be able to calculate an average air flow value for the inlet.

The average airflow [m/s] can be calculated by using equation 8:

$$\bar{v}_{air} = \frac{(v_1 + v_2 + \ldots v_n)}{n} \qquad \ldots.8.$$

The average volume of air [m^3] that is moved through the inlet per hour can be calculated by using equation 9:

$$\begin{aligned} Vol_{\text{air}} &= Inlet\, surface\, area \times \bar{v}_{air} \times 3600 \\ &= l \times w \times \bar{v}_{air} \times 3600 \end{aligned} \qquad \ldots.9.$$

The actual number of air changes per hour can be calculated by using equation 10:

$$N_{air\,changes}(actual) = \frac{Vol_{air}}{V_{battery\,room}} \qquad \ldots10.$$

3.1.8 Equipment selection and inspections

If the battery room is classified as a zone 2 area, then the electrical equipment used shall be of the type permissible for zone 1 locations, or shall be of the non-sparking (Ex n) electrical apparatus.

Ex n apparatus, also termed non-sparking electrical apparatus, are apparatus that in normal operation and in the absence of electrical or mechanical failure, cannot, because of its method of operation or because of its enclosure, ignite mixtures of air and prescribed flammable gases or vapours.

The equipment shall have been certified by an approved testing / certification body as suitable for use in the presence of the gases and vapours present in the hazardous location concerned. Luminaires shall not be installed directly above cells, but over the access areas to facilitate safe maintenance of the luminaire fitting.

SANS 10108: 2005, The Classification of Hazardous Locations and the Selection of Apparatus for Use in Such Locations requires that a certificate of compliance shall be issued by an MIE for any new and upgraded hazardous area installations up to 1000 V. The latter part is also a requirement of the Eskom Risk Audit System (RAS). The certificate of compliance is only issued once unless any modification to the electrical installation is made, in which case the affected circuit needs to be certified. The Occupational Health and Safety Act requires that the electrical installation of any hazardous area shall be inspected and maintained, where necessary, at least once every 2 years by a Master Installation Electrician (MIE) or an accredited person which has been trained and found competent.

A battery room that is classified as a non-hazardous area does not need to comply with the aforementioned requirements, but all the classification documentation need to be available.

The graphs in Appendix B and Appendix C can be used to respectively determine the maximum Ah capacity and what number of air changes per Ah, given the volume of free, are required to be within the recommended limit of 0.8% hydrogen (by volume).

As indicated by the red arrows in Appendix B, for a free air volume of 100m3 a maximum capacity battery of 340Ah (C10) consisting of 52 cells may be installed in the battery room to ensure that the hydrogen concentration remains below 0.8% for one air exchange every hour.

Appendix C indicates that for a free air volume of 100m3 the ratio between number of air changes and Ah capacity is 0.003 which means that for a 52 cell battery of 340 Ah, one air change per hour would be required to keep the hydrogen concentration below 0.8%.

3.1.9 Documentation

It is important that the area classification is done in such a way that the various steps which lead to the final area classification are properly documented. Documentation shall include the following:

a. A project plan;

b. Recommendations from relevant codes and standards;

c. Ventilation calculations – Forms are available from the DC Technology website at http://intranet.eskom.co.za/tescod/prt16DC/Checklists-SettingSheets-Forms.htm.

d. A study of the ventilation system at a site for evaluation of the ventilation effectiveness;

e. A list of all electrical apparatus for each site detailing the equipment information and equipment checklists.

f. Layout drawings, datasheets and tables. Drawings should also indicate the location and identification of the source of release and also indicate the position of openings in buildings (e.g. doors, windows and inlets and outlets for air ventilation).

3.1.10 Responsibilities

The ED department shall be responsible for the classification of the battery rooms and shall keep copies of all original documentation, including a copy of the original certificate of compliance, per battery room on file.

The FS department shall keep the original certificate of compliance which is required for RAS audits and the original battery room classification documentation on file. The FS department shall further ensure that the required inspections and maintenance is carried out.

4. AUTHORISATION

This document has been seen and accepted by:

Name	Designation
P Moyo	Corporate Manager Divisional Technology
PR Groenewald	Technology Development Manager

5. REVISIONS

Date	Rev.	Compiler	Remarks
July 2014	2	G Pretorius	--- Document copied to new template. It replaces document DPC 34-763.
February 2012	1	G Pretorius	--- Document copied to new template.
March 2008	0	G Pretorius	--- Ensure that contents of document are still current and address shortcomings. --- Document reformatted into new template. Reference number changed from DISPVAEU1 to DPC_34-763.

				Updated the reference numbers.
			4.2	Removed the following people from the classification committee: A Master Installation Electrician (MIE), the risk management coordinator for the area, FS representative (Technical Support Department) and a representative from the Field Services Technical Specialist Centre which is responsible for the battery room. Changed EDNS representative to EDNS DC Technology Engineer.
				Removed the requirement for two meetings per year.
			4.4	Added "This step shall also be used to verify the effectiveness of the ventilation system."
			4.8	Updated the inspection requirements.
			4.9 c)	"Gas dispersion characteristics and calculations" changed to "Ventilation calculations". Location of forms added.
			Annex B	Corrected the calculation.
January 2005	1	T Jacobs	---	Original issue - DISPVAEU1 authorised and published

6. DEVELOPMENT TEAM

The following people were involved in the development of this document:

Gert Pretorius

7. ACKNOWLEDGEMENTS

None

APPENDIX A: VENTILATION CALCULATION EXAMPLE

(informative)

Information: Stikland s/s

Room size: 7100x5780x3000mm

Louver size: 4x 500x500mm

Battery: 2x FCP25- 24 cells @ 384 Ah; size 248x203x349mm

2x 2EWA7- 52 cells (2 per block) = 26 blocks @ 168Ah; size 257x431x175mm

Airflow measured: (0.23; 0.41; 0.51; 0.31) = 0.365 m3/s (using eq. 8)

Calculations:

1. **Hydrogen emission rate V (using eq. 1):**

V = Nx I x 0.00045 cub/m where N = number of cells & I = 10% of Ah rating of battery

V(FCP25) = 2x N x I x 0.00045
= 2x24x38.4x0.00045
= 0.829 m^3 of hydrogen

V (EWA7) = 2x N x I x 0.00045
= 2x52x16.8x0.00045
= 0.786 m^3 of hydrogen

Total V = 0.829 + 0.786 = 1.615 m^3 hydrogen

Note: There are 2 battery banks of each type installed, therefore the 2 in each calculation.

2. **Hydrogen concentration (using equations 2, 3, 4, 5, 6 and 7):**

Total volume free air = volume room – volume FCP25 - volume 2EWA7
= (7100x5780x3000) - (2x24x248x203x349) – (2x26x257x431x175)
= 123- 0.843- 1.0079
= 121.15 m^3 free air

% hydrogen after 1 hour = hydrogen emission rate/ volume free air x 100%
= (1.615 / 121.15) x 100%
= 1.33% hydrogen

Required Air changes/ hour = (% hydrogen after 1 hr) / 0.8
= 1.33/0.8
= 1.66 changes per hour to keep the H2 concentration below 0.8%.

MUST BE BELOW 0.8% !!

3. **Air changes** (using equations 9 and 10):

Airflow Q = airflow measured x surface area of vents
= 0.365x(500x500mm)
= 0.091 m^3/sec

Airflow per hour = Qx3600
= 0.091x3600

= 328.5 m^3/h

Actual Air changes/ hour = Q/volume room

= 328.5/ 123

= 2.67 changes per hour.

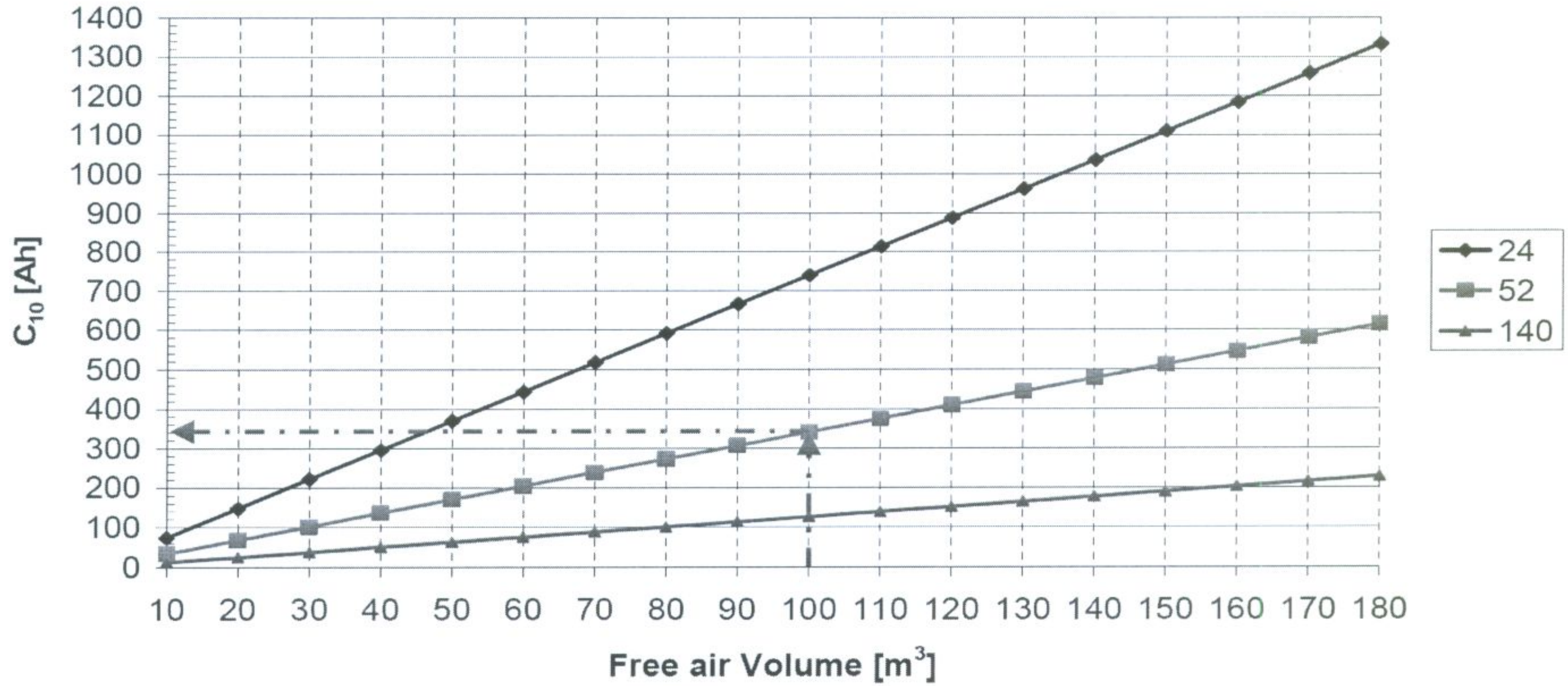
Recommendations:

This battery room must be classified as a minimum to a Zone 2 area as per SANS 10108 & SANS 60079-10. All equipment in this room must at least comply with Ex n (non-sparking) requirements.

APPENDIX B: CAPACITY VS. NO. OF VENTED LEAD ACID CELLS

(informative)

C10 vs. Volume (free air) for given no. of vented lead acid cells (0.8% H2 concentration / hr)



APPENDIX C: NO. OF AIR CHANGES/AH VS. FREE AIR VOLUME

(informative)

Number of air changes / Ah vs. Volume (free air) for given no. of lead acid cells (for a 0.8% H2 concentration / hr)