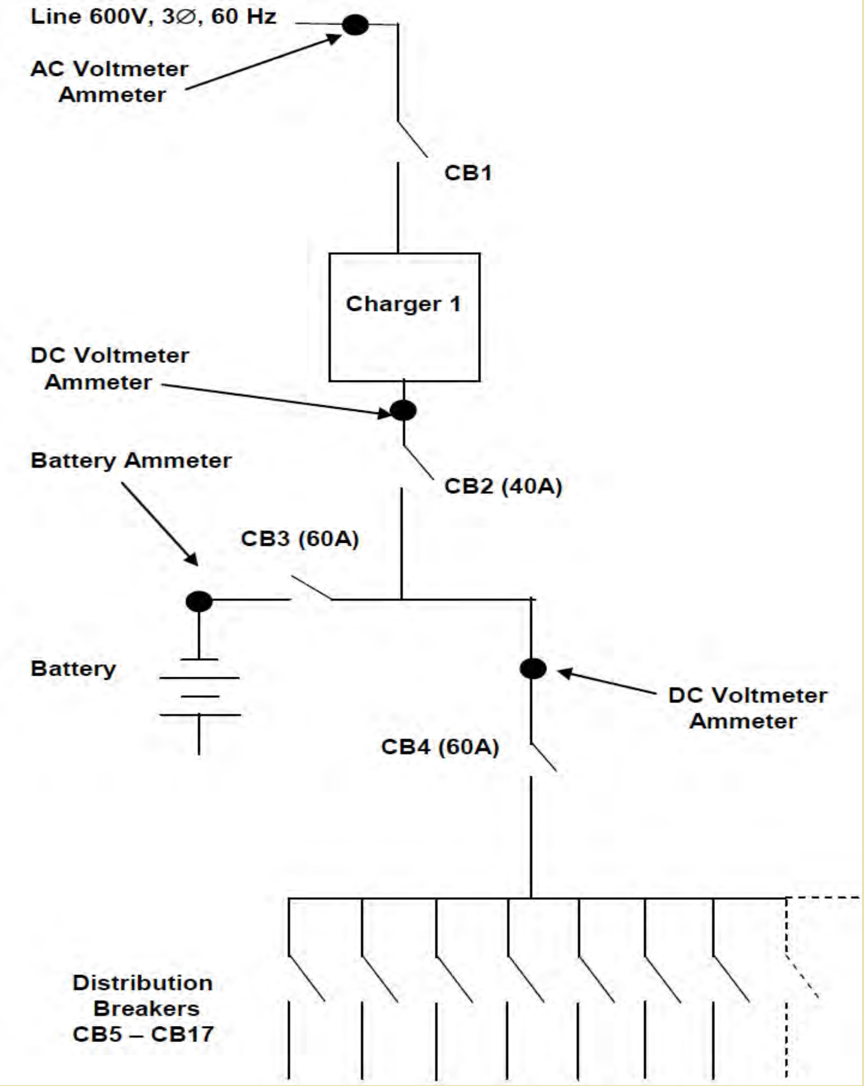
Strategic Decisions in Battery & Charger Selection for the Electrical substation

1. Introduction

- What is the role of a DC system?
- What are the various possible components of a DC system?

What is the role of the DC System



- <u>Loads</u>
  - Constant
    - Meters
    - Relays
    - Lights
    - Inverter
  - Temporary
    - Tripping coils
    - Charging motors
    - Lube pumps

What are the various possible components of a DC system?

Possible Components:

- Charger Breakers & Fuses (AC and DC)
- Charger (Rectifier)
- Battery
  - Battery disconnect
  - Battery maintenance bypass
  - Battery rack
  - Battery breaker
- DC Distribution panel
- Cable
- DC Transfer switch

2. The system's environment

- What is the **Temperature** range that my system will be subjected to?
- What are the optimum **Space and Layout** requirements of my system?
- Ventilation?

What is the **Temperature** range that my system will be subjected to?

- The ambient temperature that your batteries will be exposed to will affect their performance, longevity and reliability
- In North America the reference temperature is 25 ˚C (77 ˚F), Batteries built according to IEC Standards are rated at 20 ˚C (68 ˚F),
- If the operating temperatures in your battery room vary from the norm by +/- 3 ˚C adding temperature compensation to your charger is a prerequisite
- Batteries exposed to lower temperature will have lower performance and their sizing needs to be compensated during sizing
  - The worst case scenario temperature has to be supplied to the battery manufacturer for proper sizing.
  - If batteries run the risk of being completely discharged at temperatures below freezing point, Nickel Cadmium need to be considered.
- Batteries exposed to higher temperatures will have a higher performance but a shorter life due to accelerated corrosion.
- The rule of thumb for decrease in life at higher temperatures is:
  - Lead-Acid 50% of life removed for every 10 ˚C
  - Nickel-Cadmium 20% of life removed for every 10 ˚C

Temperature related decisions

- Do we climate control the room?
- Do we add temperature compensation to our charger?
- What battery chemistry should we use.

What are the optimum **Space and Layout** requirements of my system?

- Battery Blocks vs. individual cells
  - Blocks have a smaller footprint but due to a smaller ratio of electrolyte to lead surface and temperature variations between cells, their life is generally 10 to 20% shorter.
  - Individual cell monitoring may not always be possible
  - If a cell is defective you have to replace the whole block
  - Allows you to size your batteries with a lower number of cells
- Number of tiers and steps in your battery rack
  - Racks that are narrow and high will expose batteries to temperature variations. These variation will cause some batteries to be undercharged wile others will be overcharged. Over time the imbalance is going to worsen and your system's reliability and battery life will be jeopardized. If you have no choice, install a fan above the batteries.
  - Local Seismic requirements

Layout related decisions

- Are we going to use single cells or blocks?
- Will we sacrifice battery reliability and life to the almighty footprint ?

Ventilation

- Vented vs. VRLA
  - If we use vented batteries we will need to determine the quantity of hydrogen generated by the battery versus the number of air changes in the battery room
    - Hydrogen Concentration has to be less than 2% in the battery room
    - Room has to be free of areas where Hydrogen could collect
    - Maximum hydrogen generation is 0.127 mL/s per charging ampere per cell at 25 °C and standard pressure.
    - Worst-case scenario: Charger current limit rating.
  - It is generally accepted knowledge that VRLA batteries, ***under normal circumstances*** do not require ventilation when installed in a regular room...
    - Should the rectifier loose regulation and fail in high Voltage, the VRLA battery can generate as much hydrogen as a vented one
    - If your charger was not specified with a ***Hi-Volt Shutdown*** we recommend that the room's air changes be verified against the possible Hydrogen generation
  - In all cases a good quality Hydrogen sensor is always recommended
    - It is a good practice to connect it to a shunt trip on the charger's AC breaker

Ventilation related decisions

- Are we going to ventilate?
- How do I ventilate?
  - All the time?
  - Charger activates a fan when the battery reaches gasing voltage
  - Do I install a hydrogen detection device with a contactor to activate the fan
- I am installing VRLAs..... do I need to ventilate?
- High volt shutdown... Can my charger spec really be without one ?
- Hydrogen sensor?

3. The duty cycle (Load profile)

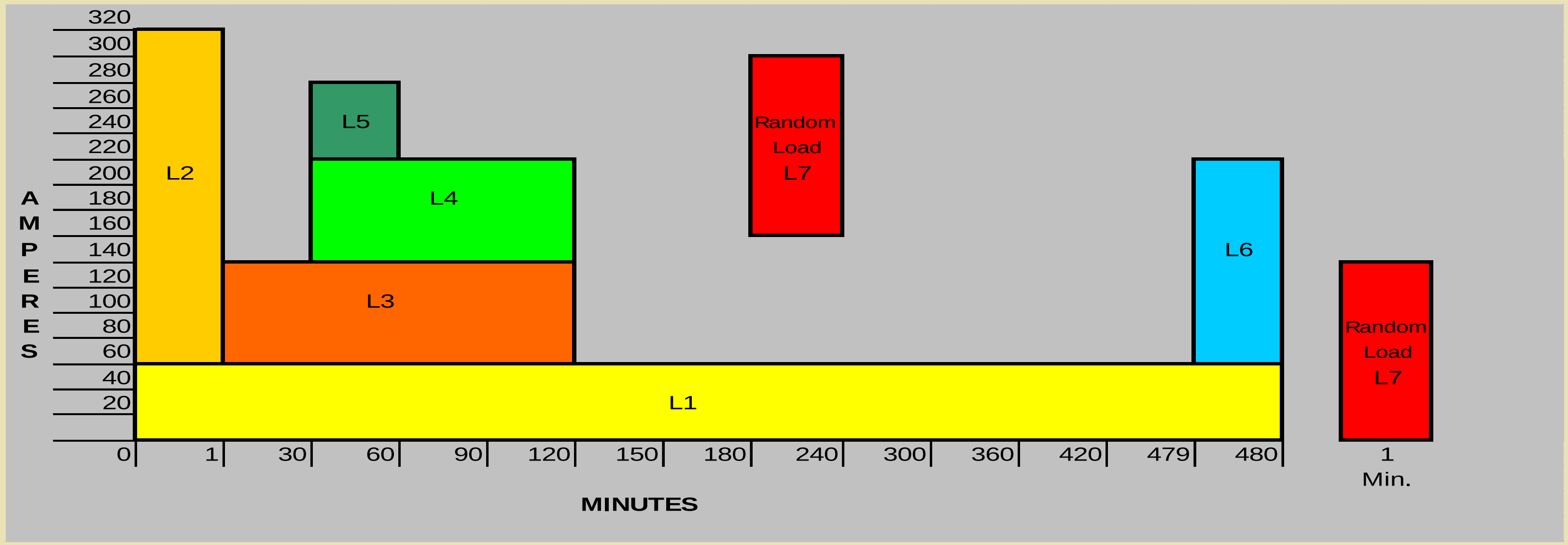
- What is a duty cycle
- What is the Nature of the loads?
- What will be the voltage of the DC system
- How will I Structure the load profile?

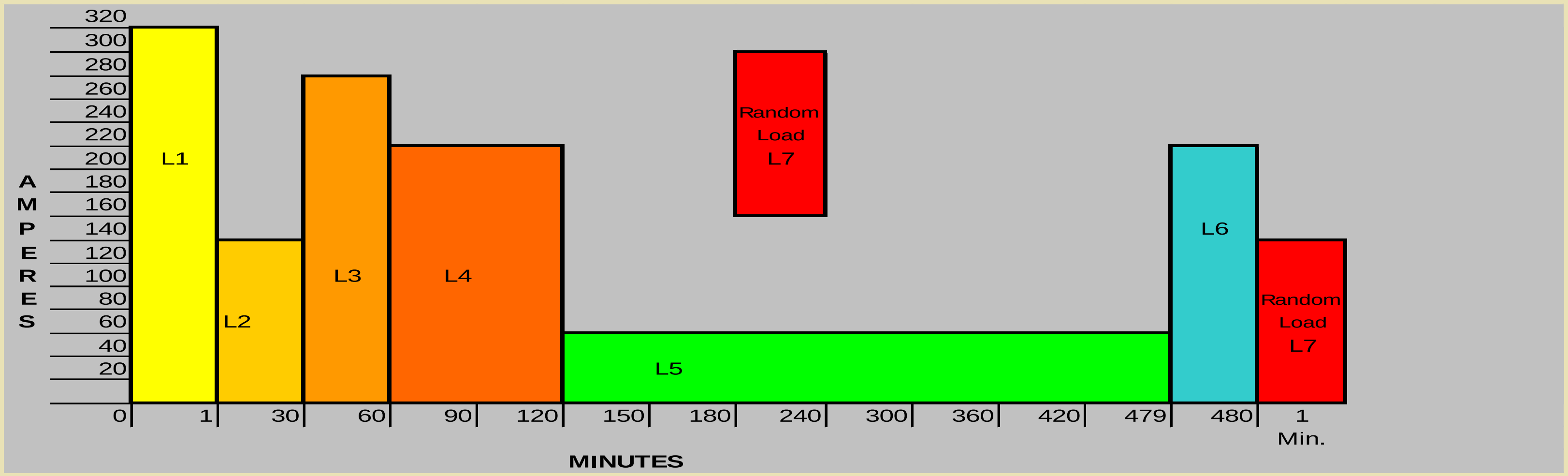
What is a duty cycle

- The duty cycle is basically a wish list of all the tasks that we want the battery to perform should the rectifier stop supplying DC
  - The ability to run protection relays, meters, pilot lights, DCS/SCADA, inverter, for a predetermined period of time *(generally 8 hours)*
  - The ability to trip all breakers at once sometimes more than once and to operate charging motors
  - The ability to run certain equipment like lube pumps, process motors, etc...

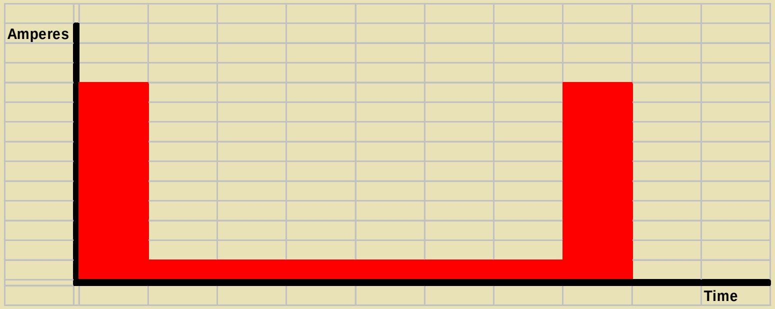
What is a duty cycle

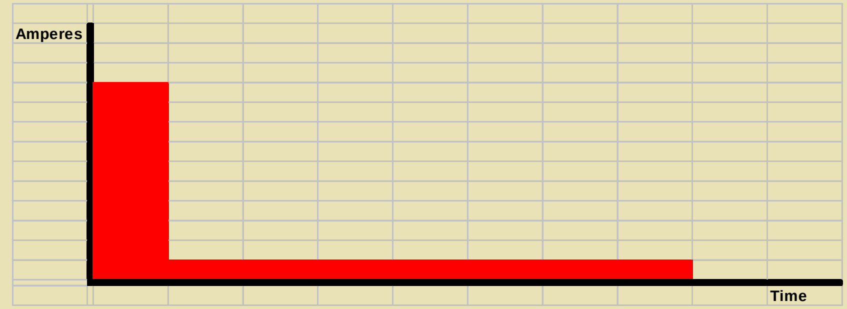
Loads have to be structured in a coherent manner so that the battery can be sized

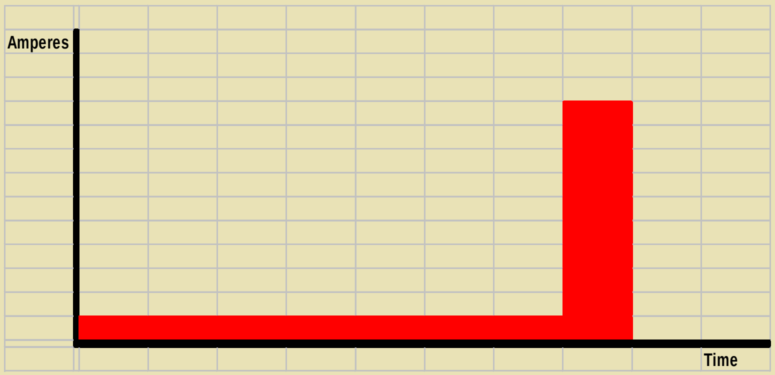


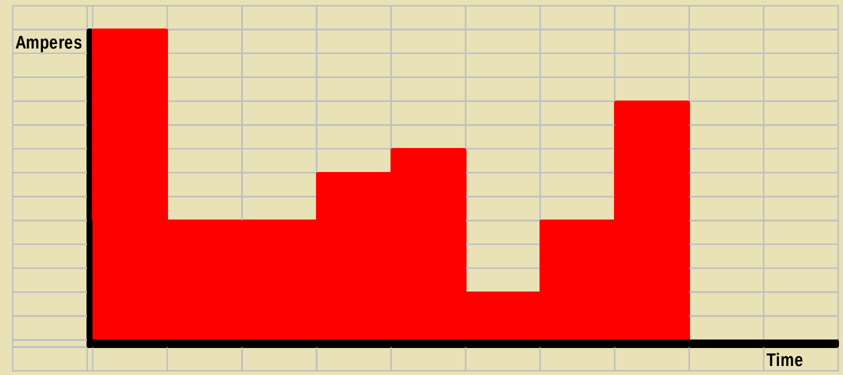


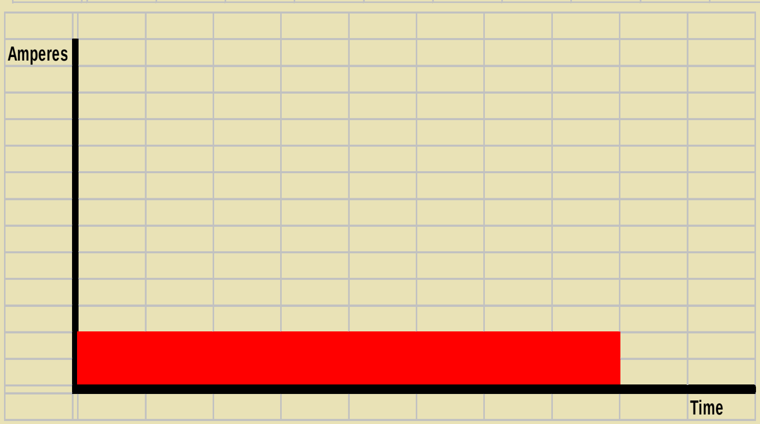
Different load profiles? / Different batteries

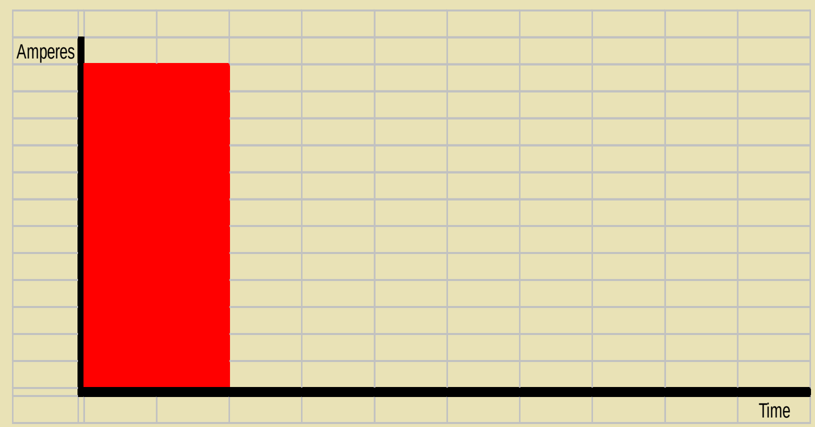












What is the nature of the loads?

- What is the operating voltage window of each equipment the system will be supplying
  - Minimum and maximum voltage of each equipment
  - The voltage window of each equipment will determine the highest voltage that my can be charged at:
    - V(max) (130 Vdc) / Equalize voltage per cell (1.47 Vdc) = maximum number of cells (88 Cells)
    - V(max) (140 Vdc) / Equalize voltage per cell (2.40 Vdc) = maximum number of cells (58 Cells)
    - V(max) (140 Vdc) / Equalize voltage per cell (2.33 Vdc) = maximum number of cells (60 Cells)
- How much current will each equipment draw *(don't forget inrush)*
- Design margin
  - Is there a chance that additional equipment may be added in the future.

System Voltage?

- The majority of substations operate in 125 Vdc but other Voltages might be considered.
  - 48 Vdc
    - You could look into this if the required 125 Vdc battery size is below regular stationary batteries: (30 to 50 Ah)
    - If the required 125Vdc charger is below 5 Adc
  - 250 Vdc
    - If you have very distant loads which will generate to much voltage drop you should seriously consider a 250Vdc system
    - If the required charger is above 1000 Adc

Backup time ?

- Is there an application required minimum?
  - The time required to stop a $$$ uninterruptable process
    - Aluminum smelter... Mine... Any high revenue generating process
- How long would a rectifier failure last?
    - Should rectifier repair be to long what is the best solution? Acquiring a larger battery or specifying redundant chargers?
- What is the longest blackout that I need to prepare for?
    - Are alternate AC power sources available?
    - Are there any regulatory factors that I need to consider?

Voltage window

- The voltage window of each equipment will determine the highest voltage that my can be charged at:
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Duty cycle related decisions

- What equipment will be fed by the system?
- What is my voltage window?
- What will be the structure of my load profile?
  - Duration
  - Shape
- What should the design margin be?

4. Maintenance, monitoring, testing and replacement

- If no maintenance, monitoring or testing is performed on any stationary battery:
  - You are not protecting your investment
  - How will you ascertain the battery’s ability to perform?
    - There are many battery failure modes that will not show while the battery is float.
    - A discharge test is the only way to ascertain a battery’s capacity... Everything else is just an indicator that you should perform a capacity test.

Maintenance, monitoring and testing

Vented

- Visual Inspection
  - Signs of corrosion or sulphation
  - Post growth or seal leaks
  - Cracked covers or jars
- Water replenishment
- Specific gravity readings
- Cell or block Voltage readings
- Cell or block Ohmic measurement
- Battery continuity test
- Verify torque measurements
- Connector & Post resistance
- Temperature measurement *(Battery or Ambient)*
- Battery capacity / Service test

VRLA

- Visual Inspection
  - Post growth or seal leaks
  - Cracked covers or jars
  - Bloated covers or jars
- Cell or block Voltage readings
- Cell or block Ohmic measurement
- Battery continuity test
- Verify torque measurements
- Connector & Post resistance
- Temperature measurement *(Battery or Ambient)*
- Battery capacity / Service test

Maintenance, monitoring and testing

- Maintenance and Monitoring
  - Over 100 years of experience has shown that **BATTERIES CAN AND WILL FAIL** sometimes less than 3 months after installation.
  - Different batteries have different monitoring & maintenance needs
  - Read the Manual. Ask the battery manufacturer. Read IEEE Recommended practice
  - If qualified personnel is difficult to hire you will need to train your current personnel . If hiring or training is not feasible, you will need to automate or even partial y automate coupled with contracting out the balance of the tasks.
  - If a battery monitoring system is chosen who will analyse the data, who will respond to the alarms? Who will be responsible?
  - Some companies will monitor your monitor over the internet or cellular links and send you an email when something is wrong.
  - If you do not maintain or monitor you will need to specify a charger with the proper test and alarm features.

Battery replacement

- Stationary batteries need to be replaced when they reach 80% of their capacity
- They also need to be replaced when they can no longer perform as designed
- Individual cells or blocks will need to be replaced when they fail
- There is a cost associated to battery or cell replacement
  - Loss of investment on the original battery
  - Actual cost of the new Cell, block or Battery
  - Labour
  - Down time or rental of temporary battery

Battery maintenance related decisions

- How will the batteries be taken care of ?
  - Manually
  - Manually and Automated
  - Automated
  - Who will be responsible?
- What is the cost of battery replacement
- Your choice of battery technology should be influenced by the decision you just took above... The reverse is also true !

5. Battery Selection

- Criticality of the application
- Is budget in line with criticality?
- The environment my batteries will be in
- Load profile
- Available on site Maintenance
- Initial budget versus life-cycle cost

Choosing the right battery for my application

- Initial budget vs. Lifecycle cost
  - $Automotive, Marine deep cycle. (Emergency patch for a week or two)
  - $$$ 5 year design life AGM (1.5 to 2.5)
  - $$$$ 10 year design life AGM (2 to 4)
  - $$$$$ 20 year design life AGM (5 to 9)
  - $$$$$ Flat plate Gel OGiV (Thin Plate) (10 to 15)
  - $$$$ Tubular plate Gel OPzV (15 to 20)
  - $$$$$$ Vented Flat plate Calcium (Thick plate) (12 to 20)
  - $$$$$$ Vented Tubular plate Calcium (15 to 20)
  - $$$$$$ Vented Flat plate Selenium Ogi (Thin plate) 12 to 20
  - $$$$$ Vented Tubular plate Selenium OPzS (15 to 25)
  - $$$$$$$$$$ Low maintenance Nickel cadmium (20+)
  - $$$$$$$$$$ Vented Nickel cadmium (20+)

Choosing the right battery for my application

- Type of plates
  - Flat plates come in a variety of thicknesses to accommodate various applications.
  - Active material density will also vary with design and application
    - More economical to build
    - Require more lead for the same energy as the plates thicken for longer backup times.
    - A design with thinner and correspondingly more grids has a reduced inner resistance and a better active mass utilisation * they are then more suitable for very short backup times. <u>(20 to 30 minutes or less)</u>

Choosing the right battery for my application

- Type of plates
  - Tubular plates
    - More expensive to build
    - Require less lead for the same energy. Except when compared to thin flat plates
    - No horizontal spines means a marked reduction in positive plate growth thus less chances of cover leaks.
    - Plate grid casted under pressure *(Generally around 110 bar)* ensures less cracks and voids than the mold casted flat plates
    - Woven polyester tubes keep the active material under pressure against the horizontal spines thus reducing corrosion.
    - Tube flexibility allows for better utilisation of active mass with less risk of shedding.
    - Dry fill process ensures uniformity in density again helping to reduce corrosion

Choosing the right battery for my application

- Lead Acid
  - Alloy
    - Lead-Acid Calcium
      - Proven reliability 12 to 20 years
      - Best stability of the float current throughout battery life
      - Poor cycling (capacity likely to exhibit a marked reduction after 50 cycles)
      - Positive grid growth especially with flat plates (Positive post seal problems)
      - Subject to Passivation (Sudden Death). Requires regular testing
      - Latest studies have shown that Electrolyte Specific Gravity has very little correlation to battery health and state of charge.

Choosing the right battery for my application

- Lead Acid
  - Alloy
    - Lead-Acid Selenium
      - Proven reliability up to 12 to 20 years in float application
      - Good stability of the float current throughout battery life
      - Good cycling (800 to 1000 cycles typical)
      - Requires slightly more watering than Lead calcium batteries
      - Slow loss of capacity
      - Specific gravity excellent indicator of state of charge and good indicator of battery health
      - Float current monitoring gives ample warning as to when to start planning for replacement.

Choosing the right battery for my application

- Nickel-Cadmium
  - Pocket plate *(Active material encased in perforated steel pockets)*
    - Rugged construction
    - Proven reliability up to 20 and 25 years
    - Available in short, medium and long duration versions
    - Completely impervious to ripple
    - Less sensitive to high current charging and discharging
    - Less sensitive to temperature variations
    - Generates slightly more Hydrogen than Lead-Acid
    - Maintenance differences with Lead-Acid

Choosing the right battery for my application

- Valve Regulated (VRLA)
  - Absorbed or Starved Electrolyte or Absorbed Glass Mat (AGM)
    - Available in 5, 10 or 20 year design life, In a substation application you can expect 2-3, 4-5 and 8-10 years of relatively stable performance. In a UPS application expect an additional reduction of 10 to 30% mainly due to the additional ac ripple imposed on the battery by the inverter
    - Highest Energy Density in the Lead-Acid realm, excellent for limited footprint applications.
    - Excellent availability and low cost per Ah
    - Flat plate only , no Tubular plates
    - Extremely sensitive to AC ripple (micro-cycling increases temperature and corrosion)
    - All inside cell connections exposed to Oxygen (Negative bus corrosion)
    - Open Cell failure more frequent than with any other Lead-Acid
    - Mostly made with recycled “Non 100% pure lead”. Leeds to Negative plate Self Discharge (Requires the use of Catalyst)
    - Very sensitive to heat and dry out due to limited quantity or electrolyte.
    - Highest susceptibility to thermal run away
    - Unpredictable due to Passivation (Sudden death)
    - Very sensitive to deep discharge
    - Longer charging times preferable

Choosing the right battery for my application

- Valve Regulated (VRLA)
  - Gel
    - Expect 12 to 20 years of service life in a substation application and a 10 to 20% reduction in UPS application
    - Flat plate and Tubular plate available
    - All inside cell connections are immersed in Electrolyte, greatly reduces the risk of negative bridge corrosion.
    - Mostly made with new lead (Greatly reduces the risk of negative plate self discharge and the need for catalysts)
    - Superior resilience to deep discharge
    - Superior heat dissipation
    - Less sensitive to heat and dry out
    - Less subject to thermal runaway
    - Excellent for solar application.
    - Higher internal resistance than thin flat plates in AGM

Buying the right battery for my application

- Specification Essentials
  - Battery technology…Vented: Alloy and Plate type. VRLA: AGM or GEL and Plate type
    - If flat: quantity and plate thickness. If Tubular ask for dry fill process
    - Electrolyte specific gravity must be stated
  - Design Life
  - Dead top
  - Formation method (Cell or Tank) (Tank preferred)
  - Delivered at 100% capacity
  - Discharge test at the factory with results sent to Engineering for release prior to shipping
  - Warranty (How many years full on post seal leaks, how many years full on the whole battery)
    - In flooded ask for 5 year full and 10 years on post seal leaks
    - In VRLA ask for 3 year full and 5 year on post seal leaks
  - Accepted brands (Do not be shy)
  - Container UL 94
  - Manufacturer shall: Size the battery according to Proper IEEE Recommended practice for the battery type, Supply sizing rationale and use the following factors: 25% Aging, 15% Design factor and assume worst case room temperature at:…….
  - Rack shall be 1 tier 2 steps
  - State if batteries are private labeled or not + Location of manufacturing

Battery selection related decision

- What are the right battery technologies for my application?
- How will I choose the best battery for my needs?

6. Charging needs for my battery & application

- Basic needs
  - AC Fail
  - Rectifier fail
  - High Volt DC (Battery)
  - High Voltage shutdown (Cyclical)
  - Low Volt DC (At least 2 programmable levels) (Battery)
  - Segregated Positive and Negative Ground Fault
  - Low current alarm
  - High current alarm
  - High ripple Alarm
  - Temperature compensation (Based on battery temperature)
    - Probe failure alarm
    - Hi / Low Battery temperature alarm with charger cyclical shutdown
  - Downloadable Test results and Event log with date & time stamp
  - Maximum 100% current limit with an adjustable range from at least 20 to 100%
  - Segregated current limit settings for float and equalize
  - Automatic Equalize (Activated on demand)
  - Battery Eliminator filtration with a maximum ripple energy of 1 Watt below 3000 Hz.
  - Rectifier High and Low Voltage
  - Charger Internal high and low Temperature
  - Upgradable control board

Charging needs for my battery & application

- Other needs!
  - Digital Ampere/hour meter
  - Float current monitor
  - Battery Continuity Tester
  - Battery Service Test
  - Form C Contacts
  - Read write communication...MODBUS...Web page...DNP...IEC 61850

Charging needs for my battery & application

Charger Specification

- **Charger certified , built and tested to:**

  UL1012: Power Units Other Than Class 2
  CSA-C22.2 No.107.1: General Use power Supplies
  NEMA PE 5: Utility Type Battery Charger
  IEEE 946: IEEE Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations
  EN61000-4-4: IEC Electrical Fast Transient/Burst
  ANSI/IEEE C37.90.1: Surge withstand capability
- Capable of recharging a completely discharged battery to 90% of its capacity in 12 hours
- To reduce harmonics on the input line for 3 phase chargers, the design must be 6 pulse controlled SCR for chargers 175 A and below. For 3 phase chargers 200A and above, 12 pulse design must be used.
- For superior safety and reliability, the charger shall be equipped with a “Surveillance” device, this device shall be fed by its own DC-DC supply coming from the battery and operate with a different firmware than the main control board. The “Surveillance” device shall communicate with the control board through an internal communication bus network, should any of the two devices fail, the healthy circuit shall de-energize a form C contact for immediate intervention.
- Static regulation is to be (+/-) 0.5% RMS voltage from 0 to 100 % full load having a +10 % / -12% input voltage variation and +/- 5% frequency.
- Digital display and Interface with 0.5% +/- 1 digit accuracy
- 5 year Warranty from the date of shipping

Charger related decisions

- What are the needs of my battery
- What are the requirements of my application
- Do I want to specify a 30 year old charger for the needs of the next 20 years?
- Do I want my charger to test my batteries
- How can I procure a modern system without breaking the bank?

Monitoring & testing apparatus

Stationary battery monitoring systems allow automation of many activities that would otherwise have to be performed manually. Measurements can be taken and recorded with greater frequency and with consistent accuracy while the battery system remains on line. Out of tolerance conditions can often be captured and alarmed in near real time. Analysis methods will vary from manufacturer to manufacturer.

The advantages of automated systems are their ability to collect, store, report, and analyze data. A distinct advantage of the automatic system is its ability to monitor these parameters continuously.

The limitations of automated battery monitoring include physical battery maintenance tasks and visual inspections. Battery maintenance is essential and must be performed in accordance with well-documented maintenance practices.

Recomended	BMS	Charger	Manually
Battery Voltage	X	X	
Float voltage		X	
Equalize Voltage		X	
Charger current	X	X	
Ground fault	X	X	
Individual cell Voltage	X		
Mid Point		X	
Equalize Duration		X	
Float Current	X	X	
Ripple voltage	X	X	
Ripple current			X
Ambiant temperature	X	X	
Pilot cell temperature	X	X	
Individual cell temperature	X		
Intarconnection resistance	X	X	
Individual cell Ohmic measurement	X		
Electrolyte level	X	X	
Coup de fouet	X	*	
Battery continuity	Y	X	
Battery capacity test			X
Battery service test		X	
Visual checks			X
Rack inspection			X
Battery visual inspection			X
Battery cleaning			X
Verifying connection torque		X	X
Adequacy of ventillation		X	

Monitoring & testing apparatus decisions

- If we are going to monitor or test...
  - How will it be done:
    - BMS?
    - Charger?
    - Both?

7. System architecture

- Needs and risk analysis to determine architecture and quality of components
- Available solutions
- Common configurations

Needs and risk analysis to determine the architecture and quality of the components

- The complexity of the DC system architecture will derive from the financial investment required to achieve maximum reliability and on the consequences of failure.
- The question then becomes:
  - How to define the application criticality and implications of system failure
  - To achieve this lets analyze the following consequences to a possible failure
    - Loss of critical assets
    - Loss of revenue
    - Other losses and accidents

Needs and risk analysis to determine the architecture and quality of the components

- Loss of critical assets
  - Switchgear
  - Substation Transformer
  - Lube pump
    - Turbine
  - Vital data
  - Scada system
- How much $

Needs and risk analysis to determine the architecture and quality of the components

- Loss of revenue
  - Process interruption
  - Production interruption
  - Salaries paid without return
  - Loss of quality control
- How much $

Needs and risk analysis to determine the architecture and quality of the components

- Other losses and accidents
  - Injuries
  - Loss of life

Needs and risk analysis to determine the architecture and quality of the components

- Is the DC system budget in line with the cost of failure?

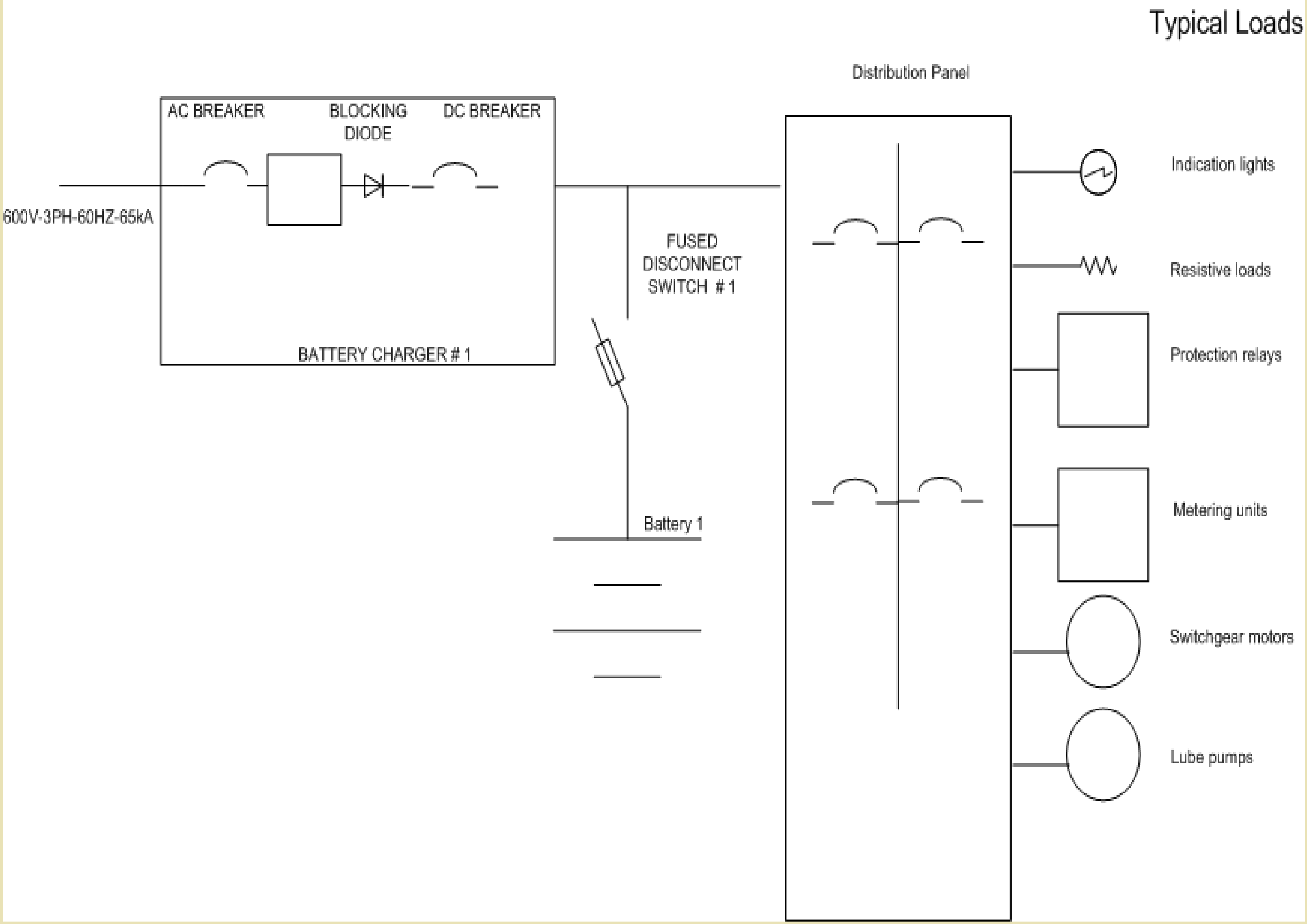
Needs and risk analysis decisions:

- How to optimize the use of DC system's budget
- Do I need to ask for more $

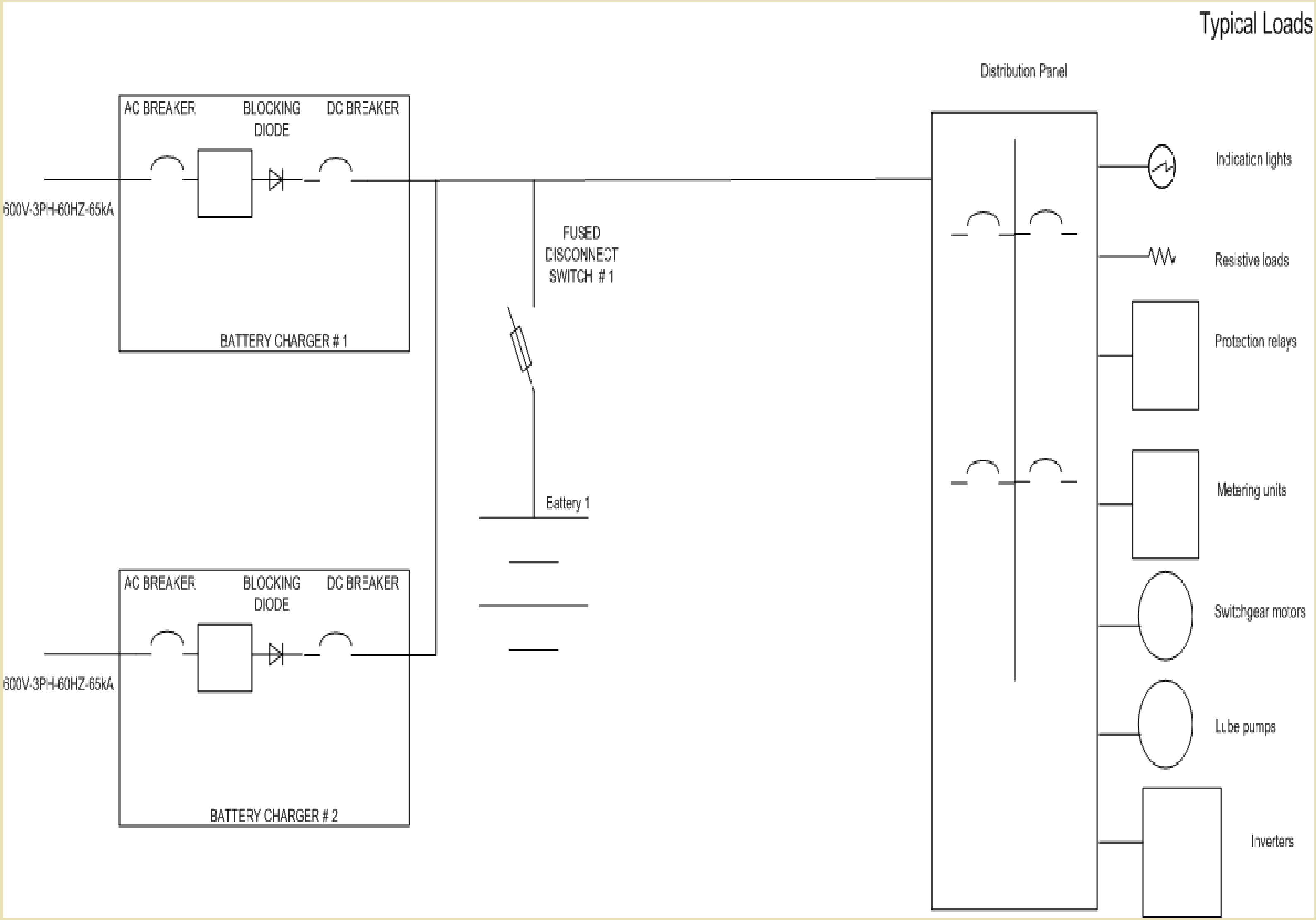
Available solutions

- Common configurations
  - Single charger / Single battery
  - Redundant chargers / Single battery
  - Redundant charger & battery with DC transfer switch
  - Load transfer capabilities and cross ties

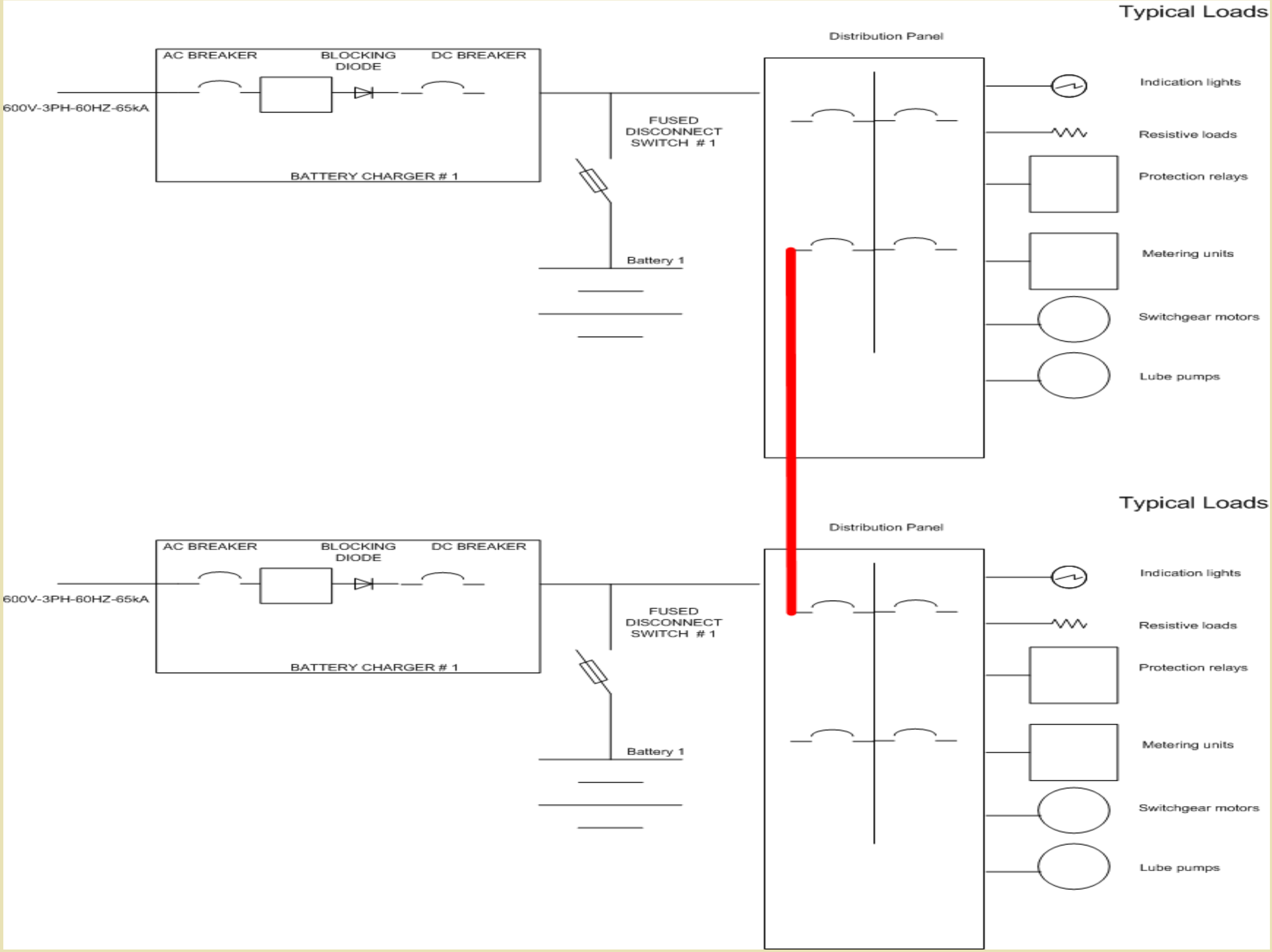
Single charger / Single battery



Redundant chargers / Single battery



Redundant systems:
2 chargers & 2 batteries with tie breakers



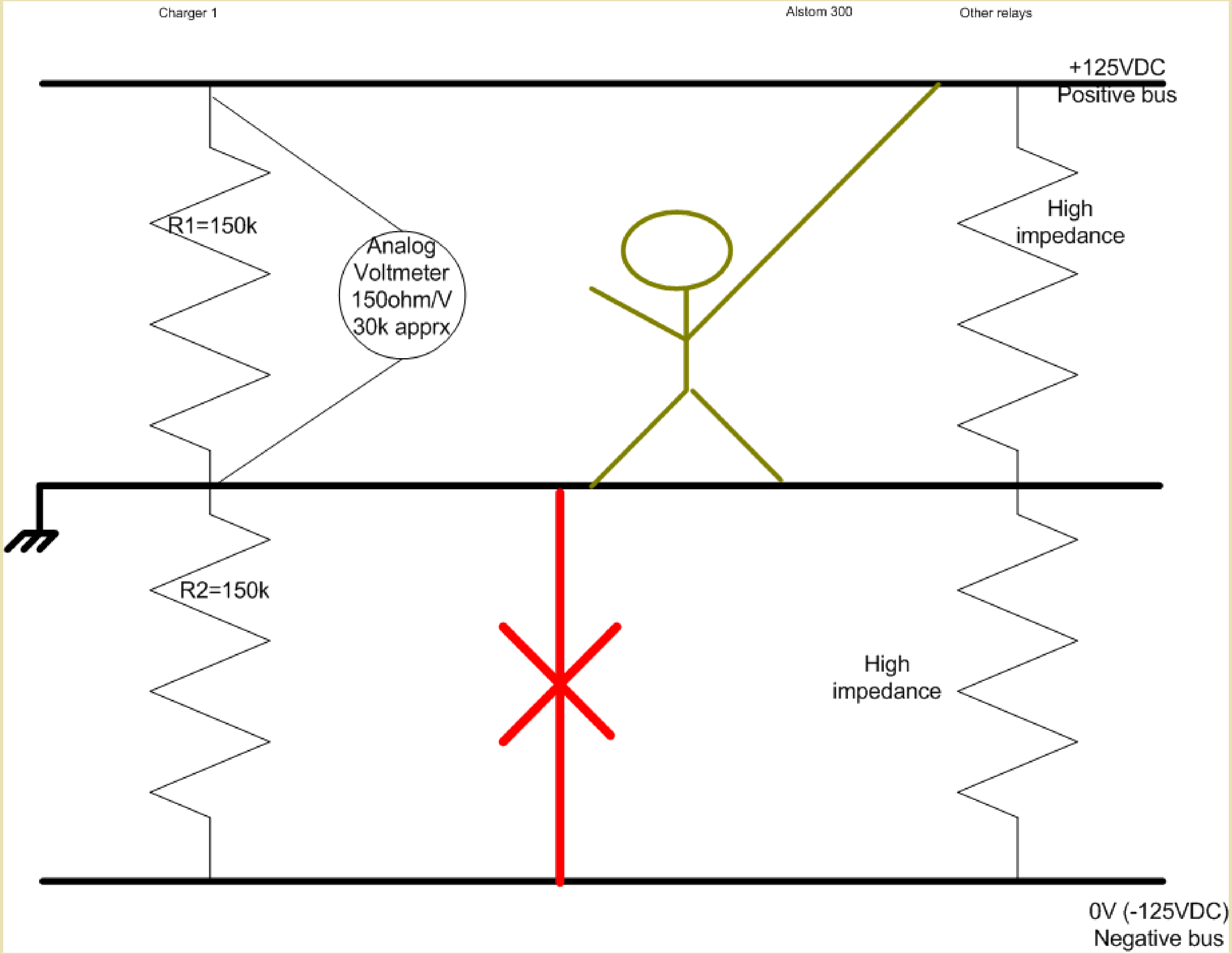
System architecture decision

- What is the best system architecture based on the criticality of the application

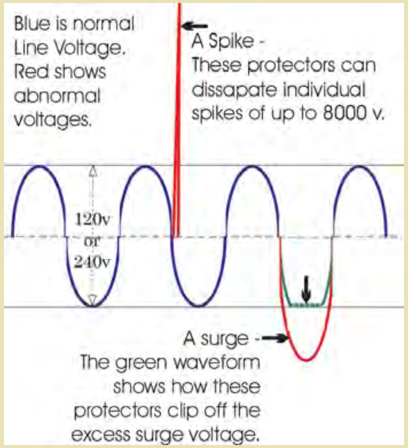
8. System Protection and coordination

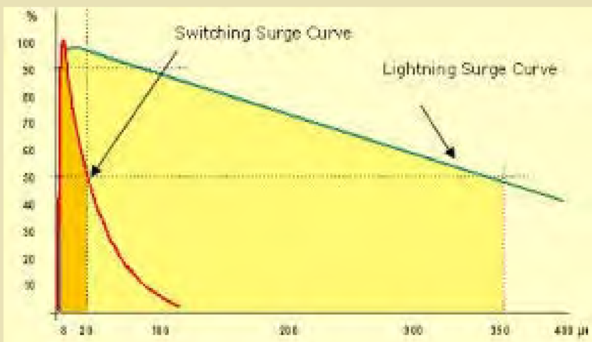
- Grounding and grounding detection
- Surges and noise
- Short-circuit: Battery, chargers, inductive loads
- Fuses or circuit breakers

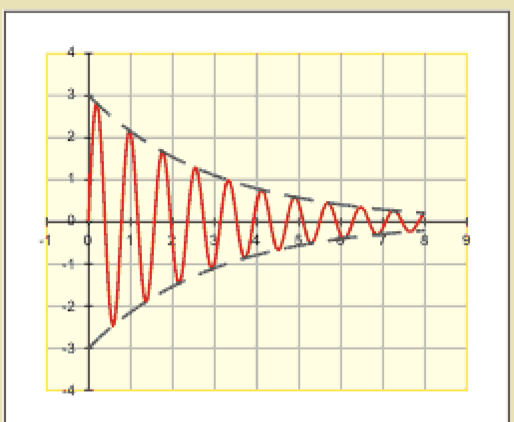
Grounding and grounding detection

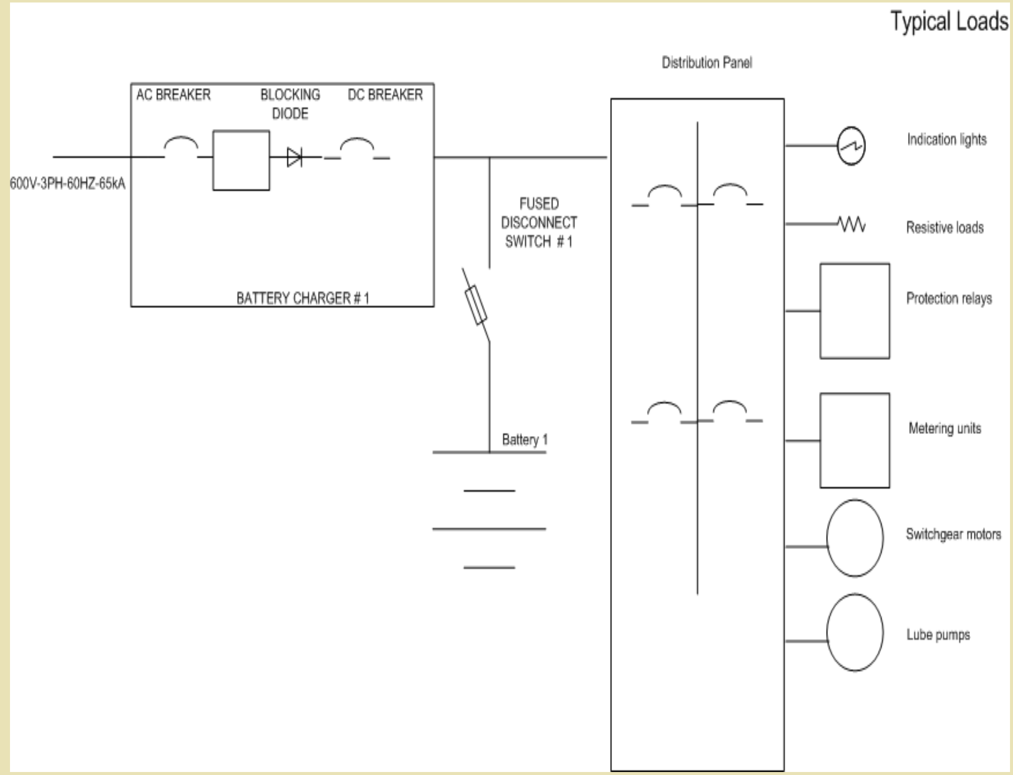


Surges and noise





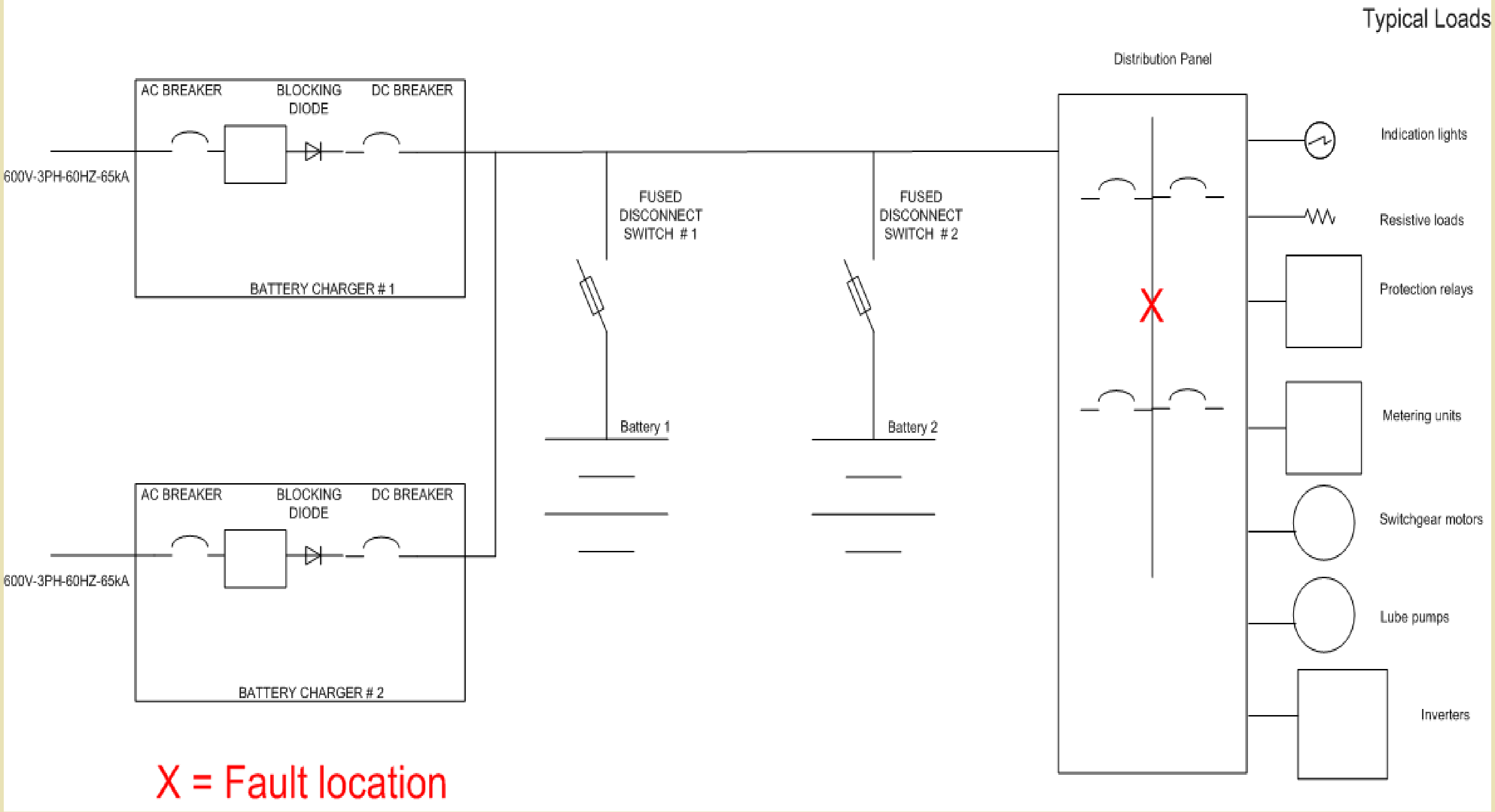




System Fault

To define minimum protection fault current ratings, we need to evaluate the contribution in the fault of each of the DC components

Fault: Battery, Chargers and Inductive loads



Isc total= Isc ch1 + Isc ch2 + Isc batt1+ Iscbatt2 + Isc inductive loads

Battery Fault

- Depending on the battery technology, plate thickness and number, specific gravity (in the case of Lead acid batteries) available fault current may vary.
- Check with battery manufacturers for the exact fault current.
- Time constant: consider ≈ 10ms
- Typical 350AH battery fault current at its terminals:
  - VLA 0.33” thick Flat calcium plate battery with 1.215 SG: 3200A
  - Tubular VLA 0.35” thick plate battery with 1.215 SG: 3400A
  - AGM VRLA : 4361A
  - Gel VRLA: 3750A
  - Ni-Cd Medium performance: 3200 A

Charger Fault

- Capacitors are a source of large instantaneous currents
- Consider time constant ≈ 10 ms
- Ex. 8 x 10,000uF-200VDC- ESR:20mΩ

  with line impedance of 0.1Ω

As a rule of thumb take 15-20 times the full current rating
time constant ≈ 25ms
Ex. 500A battery charger with a 3.5% Z transformer impedance may deliver up to
10 000A during a short circuit until its own protection gets into action to interrupt.

Fuses and / or circuit breakers

Fuses, circuit breakers, switches, bus bars, cables and other equipment need to operate safely and reliably during fault:

Breakers and Fuses

<u>Need to open SELECTIVELY</u>

Cables, switches, bus bars...

<u>Need to WITHSTAND the fault energy</u>

Fuse or circuit breaker?

Both provide over-current, short circuit protection, selective coordination and arc flash protection.

Breakers can provide remote monitoring, adjustability, reset and control.

Semiconductor fuses for ex. can provide sub-cycle fault protection and long term overload capacity

Standards

- IEEE 946: Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations
- IEEE 1375: Guide for the Protection of Stationary Battery Systems
- IEEE 1584 empirical equations are used to calculate arc-flash levels
- ANSI/IEEE C37.40 (1993), "Standard Service Conditions and Definitions for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories"
- IEC 60909: Short-circuit currents in three-phase-a.c. systems
- IEC 60947: Low-voltage switchgear and control gear
- IEC 60127 family: requirements applicable to fuses
- UL 489 and CSA 22.2-5-09 Harmonized Standards: Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

9. Case study

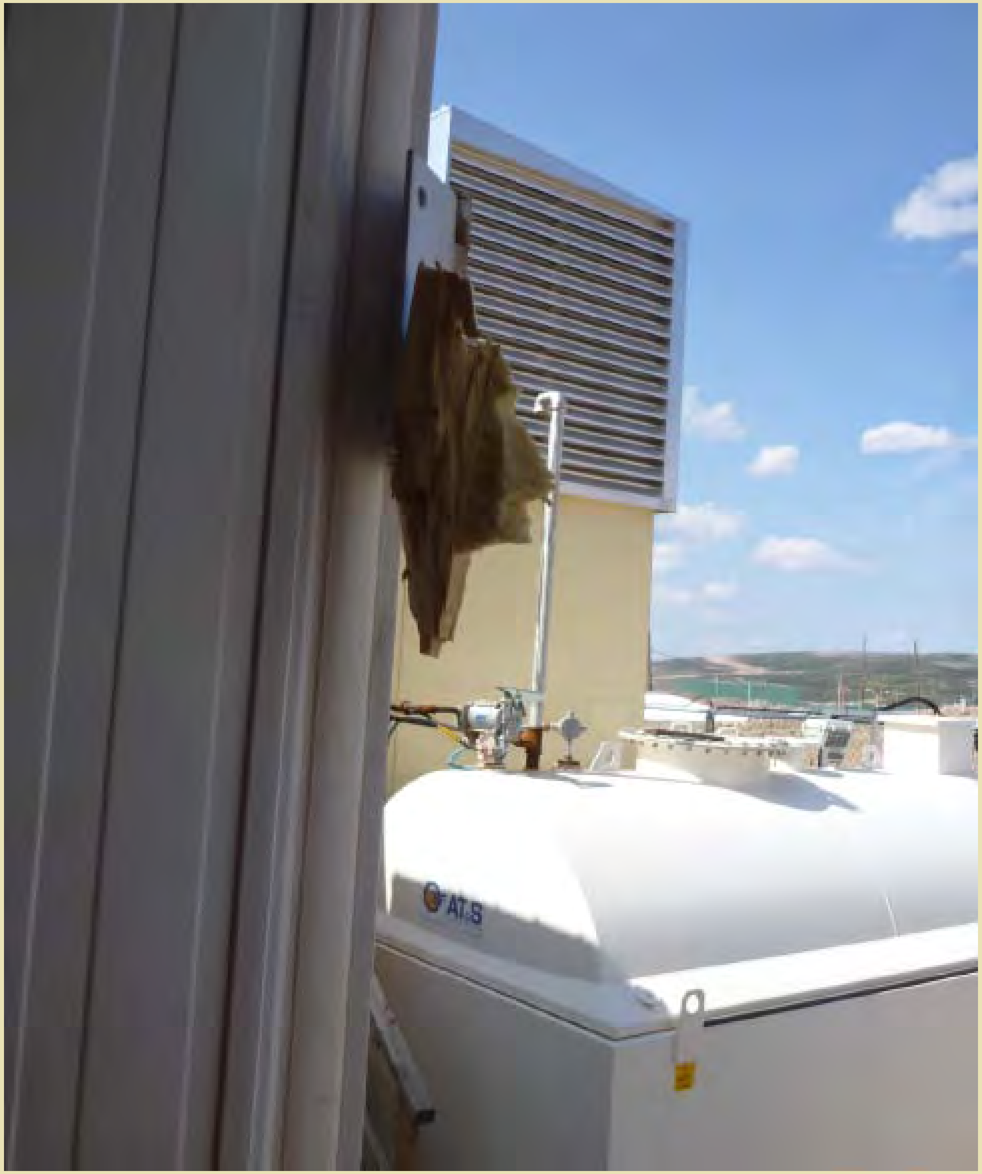
- Situation
  - Small industrial substation
  - Customer has limited "Substation Knowledge" assumes consultant will take care of everything
  - Consultant has limited battery and charger knowledge assumes Substation integrator will know what the backup needs of the substation will be.
  - Substation integrator assumes that the custom switchgear and panel builder will know the backup needs of the substation
  - Panel builder is in a competitive bid situation and decides to design and build battery charger himself and gets the most economical battery that has the sufficient Ampere / hour rating.

Result:

Result:

Result:

Result:



Result:

Result:

Result:

Result:

10. CONCLUSION

- ASK THE RIGHT QUESTIONS = GET THE RIGHT ANSWERS = MAKING THE RIGHT CHOICE
- A CAREFULLY WRITTEN SPECIFICATION IS YOUR BEST PROTECTION AGAINST GREED

- Ampere hours are not all created equal
- A carefully planned system is your best warranty that you are getting the best return on investment
- A carefully planned maintenance, monitoring and testing program is your best ally against system failure.

For more information

- IEEE standards, recommended practices and guides.
- Attend as many stationary battery events as possible: Battcon, Intelec, Infobatt, .
- More than 12 years of papers archived on the Battcon website
- Become a member of the IEEE stationary battery committee: http://www.ewh.ieee.org/cmte/PES-SBC

References:

- IEEE 946: Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations
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- UL 489 and CSA 22.2-5-09 Harmonized Standards: Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
- IEEE P450/D6, January 2010 Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications
- IEEE Std 1106™-2005 Recommended Practice for Installation, Maintenance, Testing and Replacement of Vented Nickel-Cadmium Batteries for Stationary Applications
- IEEE Std 1188™-2005 Recommended Practice for Maintenance, Testing, and Replacement of Valve-Regulated Lead- Acid (VRLA) Batteries for Stationary Applications
- IEEE Std 1491™-2012 Guide for Selection and Use of Battery Monitoring Equipment in Stationary Applications
- Dr. Wieland Rusch: FLOODED (VLA), SEALED (VRLA), GEL, AGM TYPE, FLAT PLATE, TUBULAR PLATE: THE WHEN, WHERE, AND WHY. HOW DOES THE END USER DECIDE ON THE BEST SOLUTION?. 2006 Battcon proceedings
- Dr. Wieland Rush: UNDERSTANDING THE REAL DIFFERENCES BETWEEN GEL AND AGM BATTERIES - *YOU CAN'T CHANGE PHYSICS 2007 Battcon Proceedings*
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Thanks for attending !

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