COMMON FUND FOR COMMODITIES

TECHNICAL DEVELOPMENTS FOR INSTRUMENT TESTING

CHAPTER 8.3

ANNEX A: POWER SUPPLY

Project CFC/ICAC/33

Commercial Standardization of Instrument Testing of Cotton with particular consideration of Africa

This project is co-funded by the European Union and the Common Fund for Commodities

Activity D.1.2.: Development of a list of requirements for an integrated power supply system for laboratories

Project CFC/ICAC/33

This project is co-funded by the European Union and the Common Fund for Commodities

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Activity D.1.2.: Development of a list of requirements for an integrated power supply system for laboratories

Extract from project document: “One basic and key requirement for a laboratory is to access to a permanent, stable electricity supply to run its equipments. However, local electricity generators are often used in many locations, and these devices were mainly installed to produce power for ginning plants that require a lot of power, but not in specific requirements that are needed for laboratories and their equipments (instrument, conditioning systems, balances …). The aim is to form a basis for the development of a simple and universal system based on given technology to improve the reliability of the electricity supply for SITC instruments.”

Bibliography: GOURLOT J-P., GALLET P. and PAYET L., 2010, Rapport “Activity D.1.2.: Development of a list of requirements for an integrated power supply system for laboratories”, Project CFC/ICAC/33, 19 p.

Content

1 - Introduction

During expertise tours in the laboratories, it appeared clear that laboratories do not always benefit from a stable, permanent and safe power supply for their equipments.

Consequently, electric devices and or electronic boards can be / are damaged and laboratories have to face to higher maintenance costs and losses in operational capacities driving into delays for the classification of their productions.

The purpose of this activity is then to provide some practical advises to better set a proper power supply to laboratories.

2 - Description of the technical objective

In this activity, we focus on the provision of technical requirements and logics in order to provide electricity to classing laboratories, meaning those whose activity is devoted to a classification process using SITC (Standardized Instrument for Classing Cotton).

Laboratories equipped with other instruments may design their electrical installations on this report, but they will have to adapt those findings accordingly, for instance, in using specific protection tools for securing these other instruments.

This document develops technical designs able to handle a proper power supply for the laboratories in its routine activity as well as when a main power failure occurs and when this power failure ends.

For doing so, several situations were envisaged in this document. It will upon the Heads of Classing Organizations to decide which situation to choose, knowing that each of these situations has practical and financial consequences.

3 - Definitions

3.1 - An Uninterruptible Power Supply (UPS) = onduleur

Definition from http://en.wikipedia.org/wiki/Uninterruptible_power_supply,

“An **uninterruptible power supply** (**UPS**), also known as a **battery back-up**, provides emergency power and, depending on the topology, line regulation as well to connected equipment by supplying power from a separate source when utility power is not available. It differs from an auxiliary or emergency power system or standby generator, which does not provide instant protection from a momentary power interruption. A UPS, however, can be used to provide uninterrupted power to equipment, typically for 5–15 minutes until an auxiliary power supply can be turned on, utility power restored, or equipment safely shut down.

While not limited to safeguarding any particular type of equipment, a UPS is typically used to protect computers, data centers, telecommunication equipment or other electrical equipment where an unexpected power disruption could cause injuries, fatalities, serious business disruption or data loss. UPS units come in sizes ranging from units which will back up a single computer without monitor (around 200 VA) to units which will power entire data centers or buildings (several megawatts).”

Practically, UPS are made of electronic boards to regulate the power characteristics and of batteries which will deliver energy in case of a main power supply failure. If frequent power shutdowns or fluctuations are expected, it is recommended to use an Uninterruptible Power Supply (UPS) to prevent loss of data or other related problems.

3.2 - Voltage stabilizers

Voltage stabilizers can be used for converting the 110/120V to 220V/240V or vice versa. These can also be used for regulating power. Other words exist to name these devices as regulator, voltage stabilizer, dual voltage stabilizers, dual voltage converters…

These devices are used where there is a lot of fluctuation in the power. They protect equipments from damage due to power fluctuation.

Practically, these items mainly contain electronic boards.

3.3 - Other definitions

- Air Management System (AMS) or High Volume Air Conditioning (HVAC) = Centrale de Traitement d'Air (CTA): the AMS is the system which is maintaining characteristics of the ambient air in a laboratory within given tolerances for both temperature and relative humidity at least in the case of testing cotton fibres. It is composed by a "command system" and a "power system".
    - The command system, mainly composed by electronic boards, is
        - measuring air characteristics such as temperature and relative humidity,
        - comparing this data to pre-set values
        - commanding actions to the "power system"
    - The "power system", mainly composed powerful equipment (ventilators, cold groups …) is:
        - Getting requirements from the "command system"
        - Adjusting valves or gates to change the air characteristics according to the demand.

4 - <u>Existing power generation in Africa for feeding the laboratories</u>

4.1 - Listing of the situations

The list of laboratories found during the activity "C.1.1.1. Listing of the laboratories" was used as a basis. Additionally, we made our survey by trying to in answer the following questions:

- Is any power supply public grid available for the laboratory?
- Is the laboratory in town or in the countryside? Is the laboratory close to a gin having its own power supply to supply its needs?
- Is the power supply permanent or erratic? What is the estimated frequency of the power failure?
- How important is the power installed and used by the laboratory?

- Is the power supply stable? Is there any peak?...
- When available, is the general power generator available for the whole building or is the power generator available solely for the laboratory?
- Is UPS available for each instrument or is it a central one for all the installed equipments?
- Are the instrument manufacturers providing UPS for their own instruments?

We also based our research on the basis of what can be observed during our expertises in the laboratories in both regions of Africa where Regional Technical Centers (RTC) are installed. The collected answers in addition to the next paragraph's answers helped in defining the typical required needs in terms of power supply to the laboratories.

4.2 - List of the encountered problems

The main problem in Africa remains the non-stability of power supply; the power production does not always meet the demand, in particular in dry seasons when power is produced thanks to dams. In consequence, most of the companies installed power supply generator to partly fix this problem. However, with or without power supply, there always exist moments where the power goes off suddenly, increasing the risk of provoking lots of breakdowns when power comes back even though the installed systems showed a quite good robustness along times.

When the power comes back, a peak demand of electricity is noticed because, most of the equipments staying ON during the power breakdown, they are trying to be the first to be ON again. In these conditions, we observe large fluctuations in the power voltage and currents that could alter many electric and electronic boards. Thus these electronic devices and boards suffer the most and they have to be protected a particular way. We observe that UPS are usually used to protect individual instruments and devices.

With the observed practice in Africa, there seem to be quite a few problems of "internal" electrical problems, such as ground defaults, in the electric installations; we conclude that the required types of electric protection used in such case are existing most of the time in Africa, even though we can observe very special / strange assemblies sometimes.

4.3 - List of machineries taken into account in this work

This study is focused on the laboratory buildings only. This is taking into account the specific needs of a typical laboratory where are installed the following items:

- One Air Management System (AMS) containing three systems: 1) the command system with regulation sensors, 2) the AMS power system and 3) independent controlling / checking sensors,
- One or several SITC Instrument(s),
- Some additional computers to collect / centralize the acquired data,
- One air compressor,
- Lights,
- Possibly some additional measuring instruments.

4.4 - List of items excluded from this schematic

Even though offices are usually installed around the laboratory itself for insulation purposes, electricity demand and protection are NOT designed in the attached findings; they have to be thought IN ADDITION TO and in the same manner as the one we describe in this document.

So, are excluded from the actual study:

- Comfort split system to cool down offices,
- Lights for offices, halls, exterior of the building,
- Computers in offices,
- And any additional item fed by electricity.

5 - Situations taken into account

From the above collected information, we isolate two main situations from that analysis:

- Situation 1, labeled “Grid” hereafter: a public power grid is available onto which the installed laboratory is connected. As there is a probability of power failure, the laboratory also could (or not) rely on an additional emergency power generator.
- Situation 2 labeled “Generator” hereafter: In remote places, (diesel) power generators are the only solution to feed the laboratory in electricity. However we have to keep in mind that this generator is generally used for feeding more than the laboratory itself.

Those two situations are covering all the cases that we observed in Africa. However, other situations may exist for which solutions have to be studied and found following the way we used in this document.

5.1 - Situation 1 “Grid”: Power grid with additional emergency power generator since frequent power shutdowns are expected

In Figure 1, the electricity is from the grid down to individual items. Here the word “grid” means the cable that link the laboratory to the supply. It could mean that a specific cable is getting the power directly from the public grid itself through a counter, or could be a specific cable devoted to the laboratory from any place in the installed electrical assembly on site; however it has to be an independent distribution system. A global protection should be calculated and installed at that first level.

On the way to the independent items from the grid, there could be a commutator (manual or automatic) to change the source of electricity between the grid and a emergency power generator. Another protection should be calculated and installed at that level as well.

Then, the distribution of the power to the individual items starts. At each new line separation, electrical protections have to be calculated accordingly and installed to protect the items underneath. It is important to note that AMS is separated into three branches in order to adapt the protection to the given power of each individual item.

Please note the installation of UPS for the instruments and of a stabilizer for the AMS command system:

- A UPS is required for partly continuing the work in progress on the instrument and for saving collected data when a power failure happens; in these conditions, the analysis cycle can end without damaging the piece of equipment;

- This means that the whole AMS system will be turned OFF safely when the power failure appears. As said earlier, the voltage stabilizer will only remove any electricity peak and will not maintain that system running.

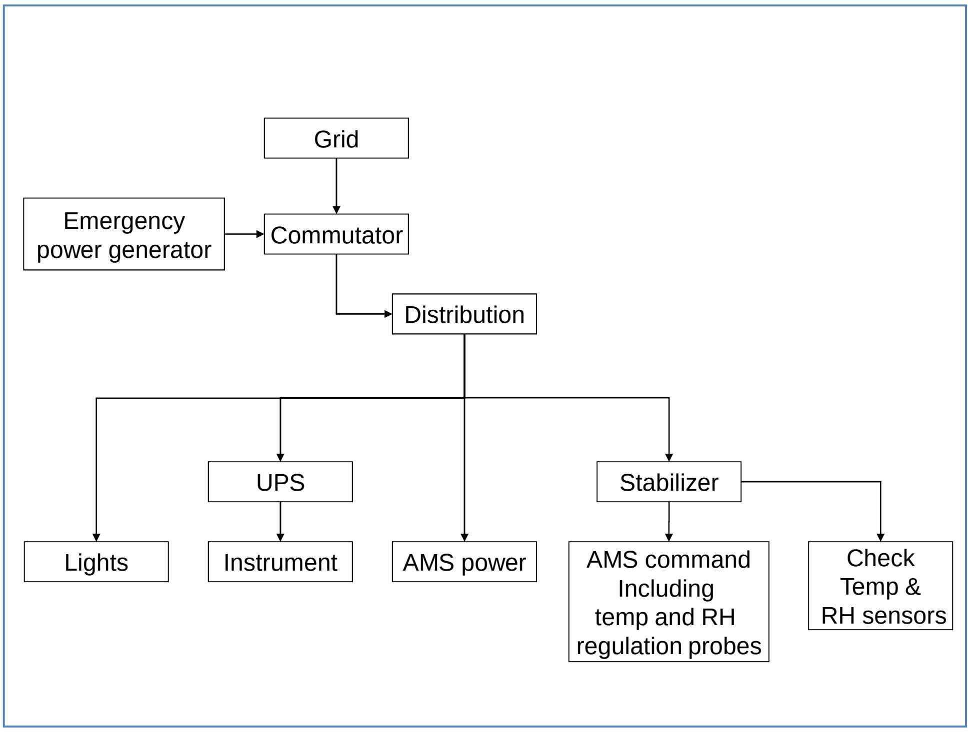


Figure 1: Schematic of electricity distribution in a laboratory fed by the grid.

5.2 - Situation 2 “Generator”: Diesel power generator only

In Figure 2, the electricity is from a power generator down to individual items at all times. This generator is at least feeding the laboratory in electricity. It could mean that a specific cable is getting the power directly from the generator itself through a counter, or could be a specific cable devoted to the laboratory from any place in the installed electrical assembly on site; however it has to be an independent distribution system. A global protection should be calculated and installed at that first level.

Then, the distribution of the power to the individual items starts. At each new line separation, electrical protections have to be calculated accordingly and installed to protect the items underneath. It is important to note that AMS is separated into three branches in order to adapt the protection to the given power of each individual item.

As above, please note the installation of UPS for the instruments and of a stabilizer for the AMS command system:

- A UPS is required for partly continuing the work in progress on the instrument and for saving collected data when a power failure happens; in these conditions, the analysis cycle can end without damaging the piece of equipment;
- This means that the all AMS system will be turned off safely when the power failure appears. The voltage stabilizer will only remove any electricity peak at the restart removing any risk of damage in the installation.

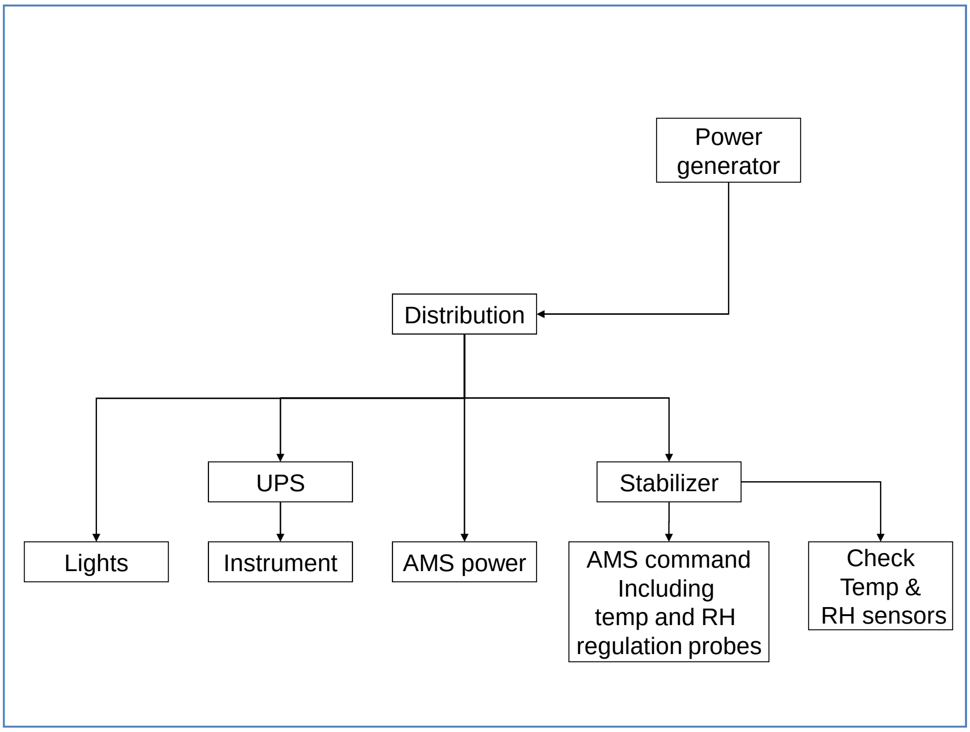


Figure 2: Schematic of electricity distribution in a laboratory fed by a generator.

When electricity is produced by a generator, in addition to erratic failures, it is required to periodically stop the generator for maintenance operations. This is another additional stop that has to be care of in the protection calculation.

6 - Categories within the situations

Before defining an electric chart, we observed that various types of UPS may exist on the market. So we got in touch with the instrument manufacturers who produce fiber testing equipments. According to the manufacturers of the SITC, there are two main categories of UPS we can retain to plan our electrical schematic:

- Category 1 "Simple UPS": Built-in UPS in SITC for insuring a safe stopping of the machine: Protects computer system, motors, and power supplies, but NOT the blower;
- Category 2 : "Full UPS": Built-in UPS in SITC for insuring a safe last sample testing by the machine: Protects computer system, motors, and power supplies, and allow the functioning of the blower.

7 - Schematics

In all combinations of situation * category, the example of electrical schematic (Figure 3) is intended to fix most of the observed critical and usual situations we studied. It starts from a point where electricity is available from the grid or from a generator through an electrical line, one cable, which is composed of five conductors having each a given "role" in the electrical assembly. Each of the five conductors has to keep its role all the way down to the final fed items.

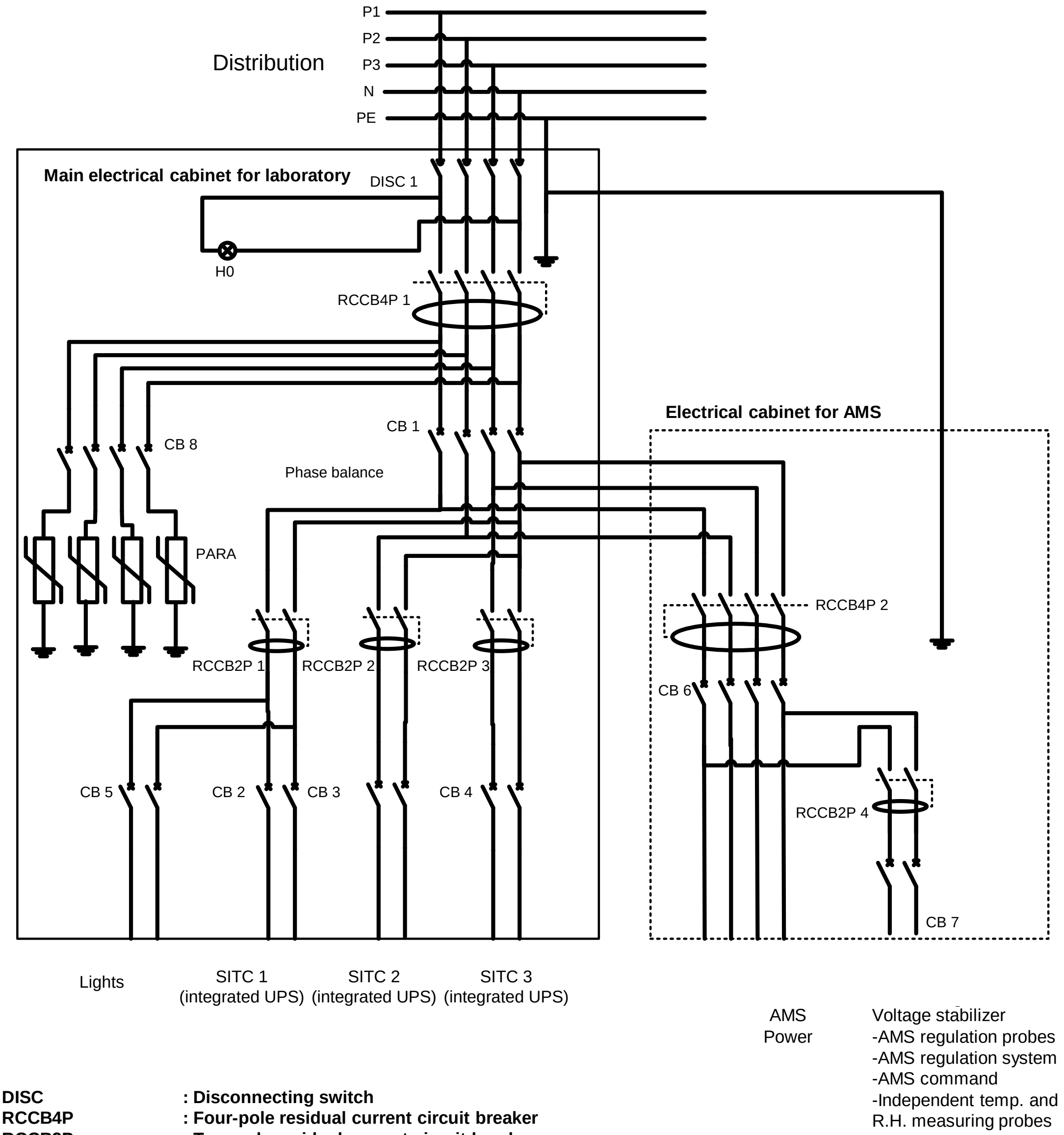
At its entrance into the laboratory, this line is protected by various means having their own advantages and complementarities, such as para-surtenseur, disconnecting switch and different types of circuit breakers. This does not forbid existing protecting items up-stream to the source of electricity as long as these items are set accordingly to the downstream demand. It should be remembered at that level that office equipments should NOT be taken on that line but in parallel to that line to avoid contaminations or un-due load on the laboratory line.

Then the line is divided up in two main streams: one for feeding the measuring devices and the other for feeding the AMS parts. This division is required because of the important difference in terms of current consumption by the measuring equipments versus the AMS, and because of the need to calculate specific and according protecting elements.

On the line going to the instruments, a great care has to be brought to get a phase balance in the system, meaning that the current consumed by each downstream equipment has to be evenly distributed between the phase connectors in order to avoid un-due internal electricity failure. On each line going to the instrument, a circuit breaker is installed to isolate that instrument from the assembly when required and set properly. Due to the low level of electrical consumption, lights installed into the laboratory could be connected to one phase only.

On the other line going to the AMS, two types of circuit breaker are installed. One additional protection is also installed to protect the command system of the AMS and the independent controlling sensors.

Some additional protection items may be added in the case of appearance of very large tension peaks in the feeding of electricity; if so these additional items should be placed at the entry of the assembly or at the entry of the most sensitive component(s) of the assembly.



DISC	**: Disconnecting switch**
RCCB4P	**: Four-pole residual current circuit breaker**
RCCB2P	**: Two-pole residual current circuit breaker**
CB	**: Circuit breaker**

Main electrical cabinet for whole laboratory

DISC 1: Disconnecting switch to be sized up considering total electrical power of the whole laboratory (AMS, SITC, lights, compressor, etc…)
RCCB4P 1: 300mA differential breaker with rated capacity to be sized up considering total electrical power of the whole laboratory
CB 1: Circuit breaker to be sized up considering total electrical power of the whole laboratory
CB 5: Circuit breaker to be sized up considering electrical power of laboratory lighting.
RCCB2P 1 to 3: Allow balance of the 3 phases of power grid (L1, L2, L3). 30mA residual current circuit breakers with rated capacity to be sized up considering electrical power of every SITC, fed with single phase.
CB 2 to 4: Allow balance of the 3 phases of power grid (P1, P2, P3). Circuit breakers to be sized up considering electrical power of every SITC, fed with single phase.
PARA: Para-surtenseur.

Electrical cabinet for Air Management System (AMS)

RCCB4P 2: 30mA residual current circuit breaker with rated capacity to be sized up considering total electrical power of AMS.
CB 6: Circuit breaker to be sized up considering total electrical power of AMS.
RCCB2P 4: 30mA residual current circuit breaker with rated capacity to be sized up considering electrical power of AMS regulation probes, AMS regulation system, AMS command and AMS temperature and relative humidity probes.
CB 7: Circuit breaker to be sized up considering electrical power of AMS regulation probes, AMS regulation system, AMS command and AMS temperature and relative humidity probes.

Base: LABD12v5_PHG.VSD

Figure 3: Example of electrical circuit for laboratory power supply.

8 - The according technical requirements for such a system

The items in Figure 3 are standard ones and some are coming with the equipment to be installed in the laboratory. As said earlier, instrument manufacturers provide various kinds of UPS for protecting their instruments.

In addition to the traditional equipment in the laboratory (AMS, measuring devices, compressor, …), the items of the electrical assembly are:

- Current /voltage stabilizer,
- UPS,
- Disconnecting switch,
- Circuit breakers,
- Two-pole and four-pole residual current circuit breakers.

All these items have to be sized up considering:

- Total electrical power of the whole laboratory (AMS, number of SITC, lights, compressor, etc…),
- Electrical power of laboratory lighting,
- Electrical power of every SITC, fed with single phase,
- Electrical power of the compressor,
- Total electrical power of AMS,
- Electrical power of AMS control/command system, AMS regulation system, and AMS temperature and relative humidity probes,
- The presence of the UPS in the system.

Depending on the level of materials protection (category1 “Simple UPS” or category 2 “Full UPS”), you might note the following recommended specifications *(note from Uster Inc. documentation):*

- *"Line Interactive" or “AVR” (automatic voltage regulation) for maximum protection against line transients - under voltages (brownouts) and over voltages (spikes).*
- *Minimum output power rating of 1200VA – 780 Watts at 120 Volts 50-60 Hz.*
- *Must be TÜV certified or bear the CE mark for European countries and be UL listed for North America.*
- *Run time of 10 minutes or greater.*
- *When ordering an UPS, one should take care about the working voltage and frequency of the measuring device as a function of the local electricity characteristics.*

9 - Operations to be performed at power failure or switch off and restart

Having such a schematic implemented in the laboratory is not enough to insure that the components will be safe in case of power failure and restart: we have to insure that all devices will be safely isolated from the electrical assembly at any moment.

So we design charts in all combinations situation * category when power goes OFF or ON. In the following paragraphs, the state (OFF or ON) for each equipment in the lab is studied and described for these combinations according to the situation of the power supply:

- Situation 1 “Grid”, Category 1 “Simple UPS”

- Situation 1 “Grid”, Category 2 “Full UPS”
- Situation 2 “Generator”, Category 1 “Simple UPS”
- Situation 2 “Generator”, Category 2 “Full UPS”

It is important to remind that the power generator necessitates daily / periodic maintenance for the two last cases, which leads to normal and periodic shut down of the generator which could be seen as a planned power failure.

Then in all combinations, when the power comes back, we show the order in which instrument should be put on gradually to avoid peak consumptions of electricity possibly driving to problematic breakage of components.

9.1 - Situation 1 “Grid”, Category 1 “Simple UPS”

To read these charts, it should be noticed that every component of the laboratory could be OFF (Y axis for this component is stated as 0) or ON (Y axis for this component is stated as 1) as a function of the time (time axis X of the chart), meaning at any specific moment. However, for complex components such as the AMS made of several items (ventilators, cold group, humidifier, pumps …), it may be required that these items will not all start at the same moment; this is shown as a slope in the following charts.

The charts are showing the sketch of events for any component (list on the right of the figure) at any given time by displaying their positions on their respective OFF/ON axis. There is no scale on the time axis as a failure may last between some seconds to several days.

Figure 4 shows the case where:

- grid is available
- where a simple UPS system is installed in the SITC
- when the power failure is long enough to allow the generator to be turned ON (manually or automatically) for feeding the laboratory.

At first, the power supply comes normally from the grid. So all components of the laboratory are fed and are ON (SITC, AMS, lights, compressor (not seen here)), while the UPS and the generator are OFF.

At power failure from the grid, AMS goes OFF, the SITC’ UPS is allowing a short time to be used to safely finish the on-going test and to save the latest data. However as the UPS is not powerful enough to insure the last testing, its corresponding data has to be removed or not taken care of. The operator then has to stop the testing machine.

The emergency power generator is then turned ON (manually or automatically); then the AMS is started gradually, the light are turned ON and the SITC could be turned ON to heat up its electronic boards. However, the operator has to wait that the surrounding conditions of the labs are normal again before testing samples.

When the power from the grid is back again, it may appear some disturbances, but the laboratory can continue to proceed with analysis, while the emergency power generator can be turned OFF (manually or automatically).

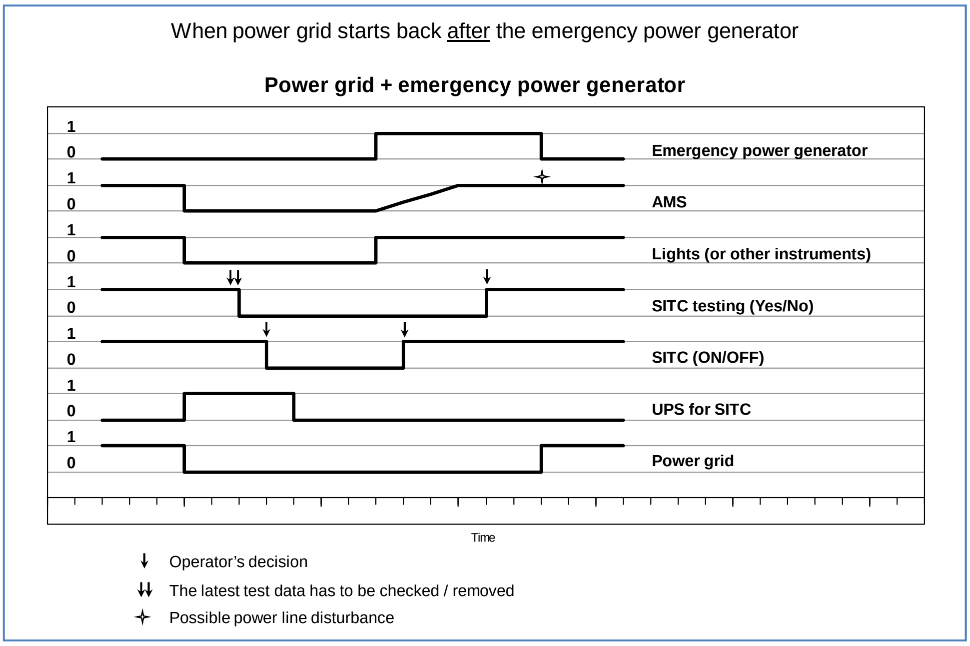


Figure 4: Sketch of events for situation "Grid" and category "Simple UPS" when the generator has time to be used safely.

Figure 5 shows the case where:

- grid is available
- where a simple UPS system is installed in the SITC
- when the power failure is NOT long enough to allow the generator to be turned ON (manually or automatically) for feeding the laboratory.

At first, the power supply comes normally from the grid. So all components of the laboratory are fed and are ON (SITC, AMS, lights, compressor (not seen here)), while the UPS and the generator are OFF.

At power failure from the grid, AMS goes OFF, the SITC' UPS is allowing a short time to be used to safely finish the on-going test and to save the latest data. However as the UPS is not powerful enough to insure the last testing, its corresponding data has to be removed or not taken care of.

As the power failure is short enough, the operator has no time to stop the testing machine; lights in the laboratory are turned back ON, and the AMS is restarted gradually, the emergency power generator has no time to be turned ON (manually or automatically). However, the operator should wait that the surrounding conditions of the labs are normal again before testing samples depending on the duration of the power failure.

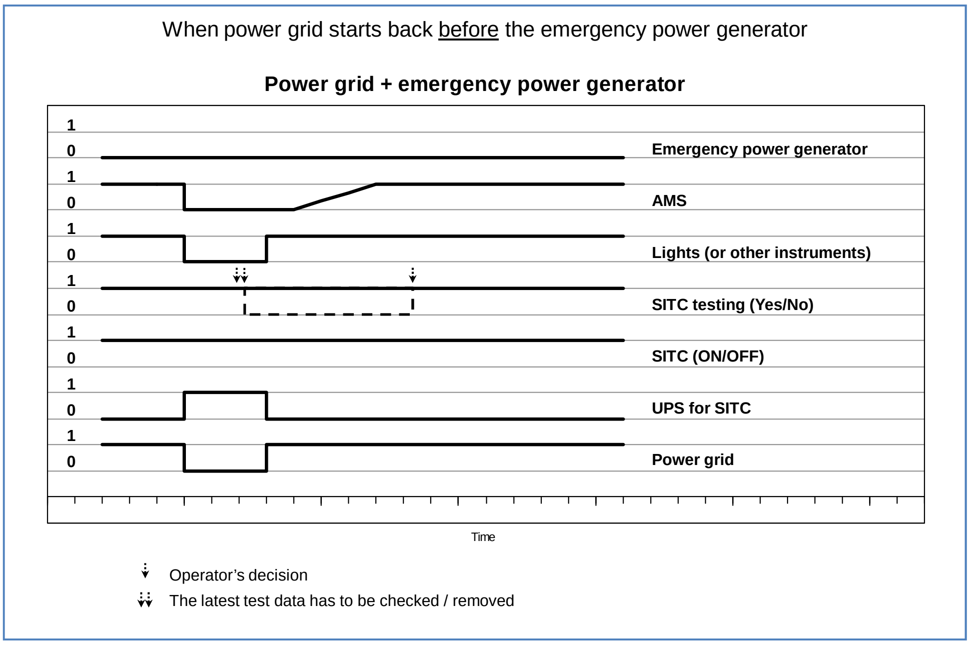


Figure 5: Sketch of events for situation "Grid" and category "Simple UPS" when the generator has no time to be used safely.

9.2 - Situation 1 "Grid", Category 2 "Full UPS"

Figure 6 shows the case where:

- grid is available
- where a full UPS system is installed in the SITC
- when the power failure is long enough to allow the generator to be turned ON (manually or automatically) for feeding the laboratory.

At first, the power supply comes normally from the grid. So all components of the laboratory are fed and are ON (SITC, AMS, lights, compressor (not seen here)), while the UPS and the generator are OFF.

At power failure from the grid, AMS goes OFF, the SITC' UPS is allowing a short time to be used to safely finish the on-going sample test and to save the latest data. As the UPS is powerful enough to insure the last testing, its corresponding data could be kept. The operator then has to stop the testing machine.

The emergency power generator is then turned ON (manually or automatically); then the AMS is started gradually, the light are turned ON and the SITC could be turned ON to heat up its electronic boards. However, the operator has to wait that the surrounding conditions of the labs are normal again before testing samples.

When the power from the grid is back again, it may appear some disturbances, but the laboratory can continue to proceed with analysis, while the emergency power generator can be turned OFF (manually or automatically).

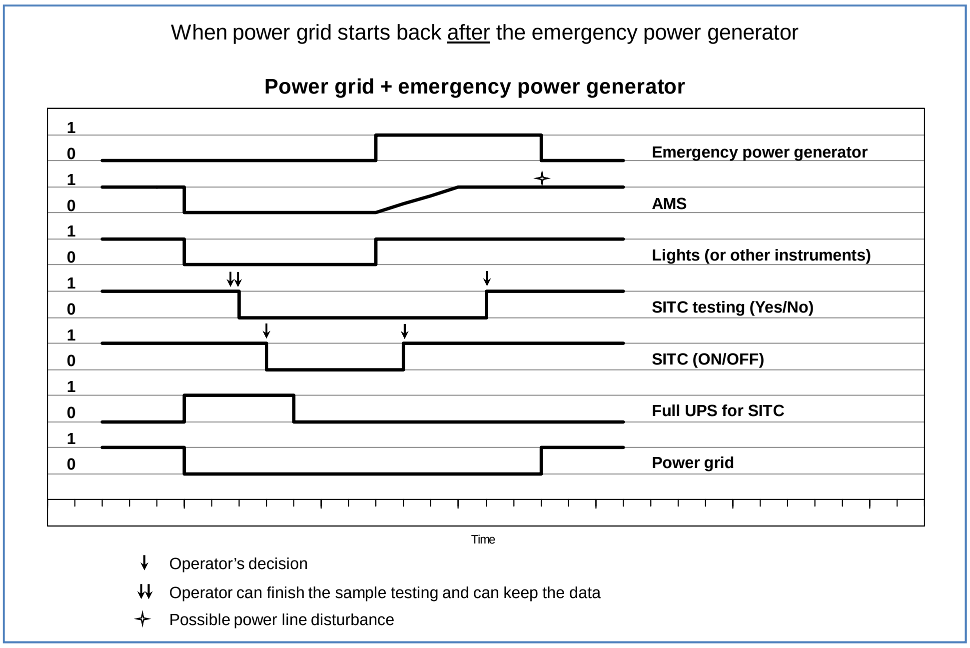


Figure 6: Sketch of events for situation "Grid" and category "Full UPS" when the generator has time to be used safely.

Figure 7 shows the case where:

- grid is available
- where a full UPS system is installed in the SITC
- when the power failure is NOT long enough to allow the generator to be turned ON (manually or automatically) for feeding the laboratory.

At first, the power supply comes normally from the grid. So all components of the laboratory are fed and are ON (SITC, AMS, lights, compressor (not seen here)), while the UPS and the generator are OFF.

At power failure from the grid, AMS goes OFF, the SITC' UPS is allowing a short time to be used to safely finish the on-going sample test and to save the latest data. As the UPS is powerful enough to insure the last testing, its corresponding data could be kept.

As the power failure is short enough, the operator has no time to stop the testing machine; lights in the laboratory are turned back ON, and the AMS is restarted gradually, the emergency power generator has no time to be turned ON (manually or automatically). However, the operator should wait that the surrounding conditions of the labs are normal again before testing samples depending on the duration of the power failure.

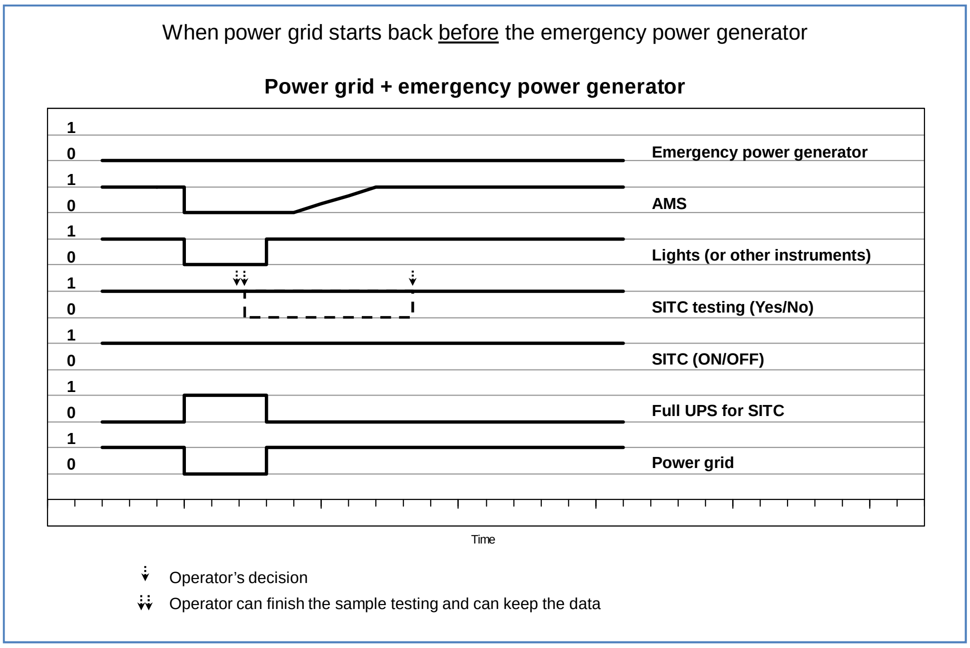


Figure 7: Sketch of events for situation "Grid" and category "Full UPS" when the generator has no time to be used safely.

9.3 - Situation 2 "Generator", Category 1 "Simple UPS"

Figure 8 shows the case where:

- grid is not available and a power generator produces the required electricity
- where a simple UPS system is installed in the SITC.

At first, the power supply comes normally from the generator. So all components of the laboratory are fed and are ON (SITC, AMS, lights, compressor (not seen here)), while the UPS and the generator are OFF.

At power failure from the generator, AMS goes OFF, the SITC' UPS is allowing a short time to be used to safely finish the on-going test and to save the latest data. However as the UPS is not powerful enough to insure the last testing, its corresponding data has to be removed or not taken care of. The operator then has to stop the testing machine.

When the power from the generator is back again, the AMS is started gradually, the light are turned ON and the SITC could be turned ON to heat up its electronic boards. However, the operator has to wait that the surrounding conditions of the labs are normal again before testing samples.

Note: for periodic maintenance of the power generator, the best would be to safely stop the AMS before the generator is turned OFF.

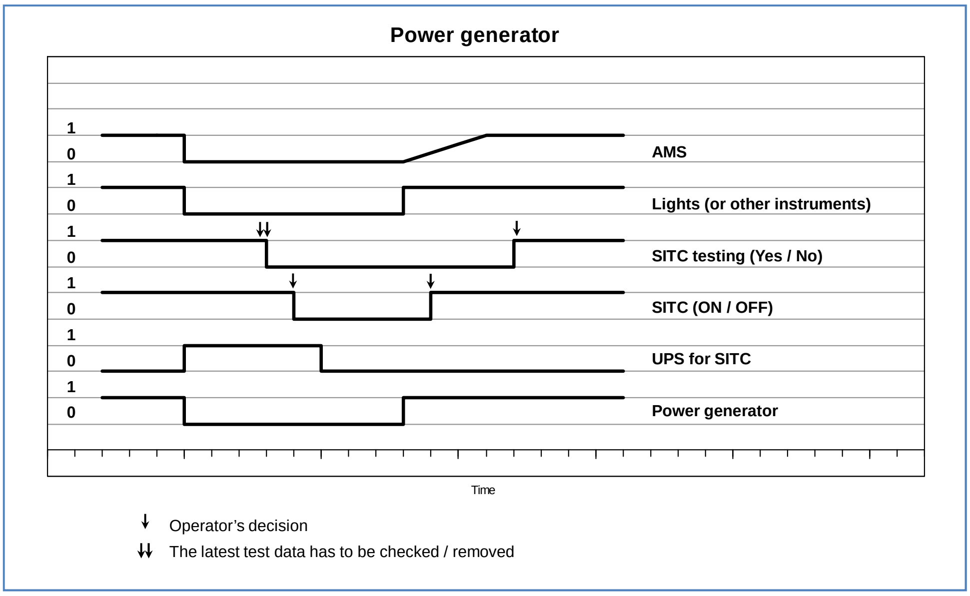


Figure 8: Sketch of events for situation "Generator » and category "Simple UPS".

9.4 - Situation 2 “Generator”, Category 2 “Full UPS”

Figure 9 shows the case where:

- grid is not available and a power generator produces the required electricity
- where a full UPS system is installed in the SITC.

At first, the power supply comes normally from the generator. So all components of the laboratory are fed and are ON (SITC, AMS, lights, compressor (not seen here)), while the UPS and the generator are OFF.

At power failure from the generator, AMS goes OFF, the SITC' UPS is allowing a short time to be used to safely finish the on-going sample test and to save the latest data. As the UPS is powerful enough to insure the last testing, its corresponding data could be kept.

When the power from the generator is back again, the AMS is started gradually, the light are turned ON and the SITC could be turned ON to heat up its electronic boards. However, the operator has to wait that the surrounding conditions of the labs are normal again before testing samples.

Note: for periodic maintenance of the power generator, the best would be to safely stop the AMS before the generator is turned OFF.

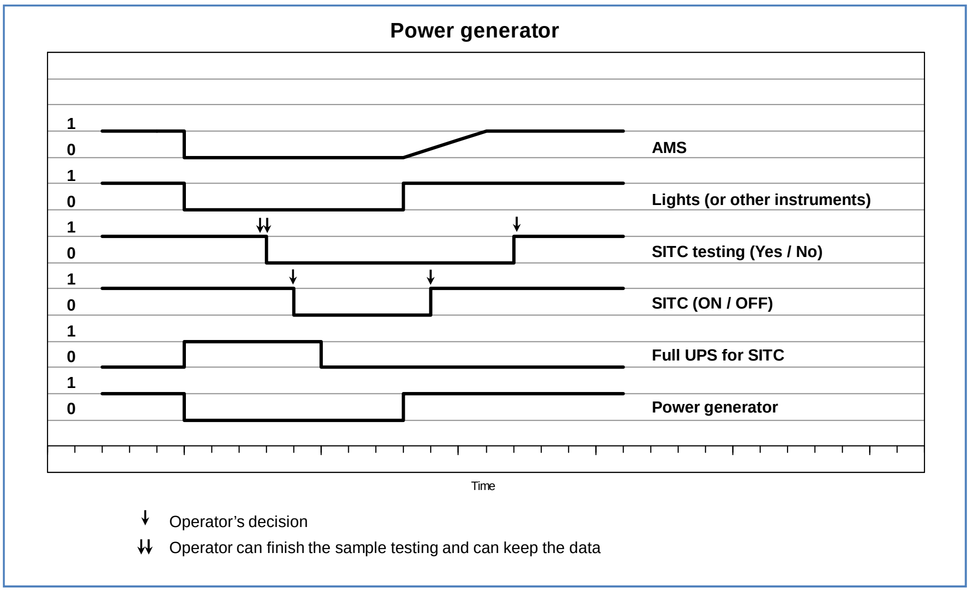


Figure 9: Sketch of events for situation "Generator » and category "Full UPS".

10 - <u>Conclusion</u>

As first advice, taking care of the electrical assembly from its source is the best warranty that all the instruments and connected devices will not suffer from any electrical chock. As second advice, taking care on how the protection work together with the way the measuring devices should be stopped / restarted could insure a longer life for them. Finally, calculating all protection elements is to be done by experts in this domain to insure a safe use of the proposed assembly and of the sketch of events to stop / start connected items.