Methods for maintaining the continuity of power supply in hospitals

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Abstract. This paper presents alternative solutions to ensure power supply of critical consumer, such hospitals. In a hospital it is extremely important to have a power supply without any interruption. This is the reason of the using various solutions that ensure continuity of power supply. In this paper it is presented a solution used in a hospital in Romania. Here is used a generator controlled by microprocessor capable of taking over power supply in case there are problems with power supply from the national power grid.

1. Introduction

Knowing the current need for stability and continuity in the power supply of critiques equipment, it tends increasingly to use more alternative sources of electricity as a back-up method in power supply [1], [2]. Alternative solutions to traditional methods of producing electricity offer stability in operation of the equipment [3]. Knowing that such equipment can feed including surgery rooms, medical emergency reception centres, intensive care and resuscitation centres, etc., we can say that the implementation of these automated systems save lives [4].

Alternative methods of producing electricity must meet the following technical and economic considerations:

- reach the current and nominal power in very short time (between 0.1 to 120 seconds), depending on the type of alternative source.
- can be operated and / or put back into operation quickly by qualified staff
- provide as much as possible operational autonomy as well
- provide stability in operation from technical standpoint and electricity supplied
- have a relatively low cost of implementation and operation

From a technical standpoint we recommend the use of two types of elective alternative sources, namely:

a) Electrical sources UPS - inverter which provides a very fast coupling in load, between 0.1 - 0.5 seconds. The installed power is between 250 VA ÷ 90 kVA. The high power can provide a greater autonomy of unloading operation in both linear voltage 230V and 400V as well. This type of sources use batteries gel (mainly with nominal voltage of 12V DC) which has the following characteristics: require no maintenance operations provides maximum safety against leaks, can support up to 800 cycles of operation, and ensure longevity and reliability in operation. The advantage of this type of alternative electrical source consists in fast task switching and disadvantage group consists in using of batteries that can be discharged without possibility of supplementary charge.
b) Electric generator which provides a coupling in the load between 60-300 seconds. Coupling time depends on the type of fuel, temperature of the ambient temperature of the engine block during standby engine output heat electric power generator - mostly installed power ranges from 650 VA ÷ 300 KVA. The advantage of this type of alternative source is that we can increase the operating time as long as there is fuel in the tank. Even recommend switching to more fuel tanks, tanks that can be fed in functioning.

In the electrical systems of major importance it is recommend using both types of electrical energy sources. Of course you can use other types of sources that keep mandatory features described namely: quick-coupler pregnancy, high power cut, high autonomy of operation.

Also the operation mode and the input / output to / from the load are very important. Knowing that it is difficult to balance two alternative power sources in parallel does not recommend starting simultaneously these types of equipment.

Always the first source that feed the electrical equipment must be source-in the task. Depending on the necessity it is possible to command the second source to enter in compensation with the first, but it all depends on the installed power of the first sources and power requirements of the consumer. Always has to be a balance between power generated by the power source and absorbed by the consumer.

Depending on the consumer it can be made a calculus of power of alternative sources, such as their technical characteristics and functioning and especially the installed power.

It is not recommended to use alternative power sources without knowing the entire assembly, not to endanger the optimal functioning of the equipment.

Also always recommended calibration and optimal setting of these sources (given that some have a wide range of settings), according to the type of consumer, environmental and binding according to the main system power supply.

In the following an optimal implementation in operation for generating electrical systems major is presents.

2. The electric generator group
The electric generator groups a fixed or mobile autonomous electricity production, which ensure independent power supply, emergency, if the main electrical supply interrupted [5-10]. The group is made up of a diesel engine which drives a synchronous generator capable of providing an output of at least 1.5 times the normal amount of power consumed routinely and automatically transfer the load equipment that monitors network parameters main engine and the generator ensuring command sequences automatic START - STOP.

2.1. Automatic load transfer equipment
It is the "brain" of the generator and is equipped with a microprocessor and it has multiple inputs and multiple outputs that enable it to perform the following functions:

a) Measure and display the voltage primary source. If any phase voltage main power is out of the (± 10%) U_{nom} is starting command for the generator start cycle.

b) Measure and display engine for the following parameters: battery voltage (V), engine coolant temperature (°C), lubricating oil temperature (°C), lubricating oil pressure (kPa), engine rotation speed (revolutions/minute), cumulative total number of operating hours, the number of starting attempts, fuel level in the buffer tank, the fuel level in the tank outside.

c) Measure and display synchronous generator following parameters: line and phase voltages (V), the phase currents (A), active powers (KW), total apparent power (KVA), total reactive power (KVAR), total active energy (KWh), total reactive energy
(kVARh), total power factor, the percentage of rated output (%), the level of excitation of the generator, frequency (Hz).

d) The following cases are ordered protection for stopping the engine while the onset of light signals: oil under reduced pressure, overheats coolant, packaging or excessive speed, start attempt failed, too low or to high values of frequency, too low or to high values of output voltage, generator overload, generator short circuit

e) The motor-warning for the following parameters: coolant temperature dangerously high, dangerously low coolant temperature, engine oil level too low, dangerously low engine oil pressure, dangerously low fuel level in the tank buffer, unsafe voltage batteries

f) Operating mode selection. There are three modes of operation: local manual control, local automatic control, and automatic remote control.

g) Diagnosing failures

  PLC must display the diagnosis and to identify the nature of functional errors. Errors must be preserved in memory, supporting in obtaining a history of behavior of the generator, following the last or the last reset.

  The main parameters or components that are aimed at the diagnosis failures: failure lubrication oil pressure, coolant temperature detection, voltage batteries, motor rotation speed detection, microprocessor or memory automatically, DC power transducers, unexplained unscheduled stoppages, failure speed regulator, failure voltage regulator, failure synchronous generator, incorrect starting sequence, failure starter, failure generator, fuel electric valve control relay, guillotine intake air control relay.

h) Generate startup sequence

i) Generate stop sequence

  To explain the generation sequences mentioned, considered the case supplying a hospital. According to the figure1, KN represents mains contactor, KG emergency contactor and Kins auxiliary source realized islanding consumer class 15 for others. Islanding is necessary to use a low cost generator, with a power that permit the supply only consumers in class 15 using a backup solution from another transformer station that does not belong to the hospital with a switch manually controlled or remotely by a human operator, overload protection and short circuit.

  The starting sequence is as follows:

  - The main source fall after 5-10 seconds commands the starter.

  - If the engine does not start, longer command the starter twice more with break between starts about 10 seconds.

  - If the engine speed reaches 15% of rated speed, ordering off the starter. If this condition is not achieved, destroying the starter.

  Interruptions of mains voltage distribution can last from less than a second to several minutes or longer. If interruptions between two seconds and two minutes are common, caused by minor incidents distribution system, the extended more than two minutes, are due to events such as storms, lightning, earthquakes, fault lines of high voltage switchgear (110, 230 KV) underground cable disruption due to construction etc.

2.2. Diesel Engine

  Are used, four-stroke engine with direct injection and turbocharging, in particular to be able to take 100% of nominal load in a single operation, diesel fuel must have an average octane number higher than 35.
**Figure 1.** Power supply system for a hospital

**Figure 2.** Schematic Diesel group - synchronous generator
The power supply circuit comprises:
- A buffer tank with a maximum capacity of 200 l,
- A tank outside, of higher capacity necessary to assure autonomy according to the group,
- An automatic pump, coupled with a manual pump, for filling the buffer tank from outside the tank.

The buffer tank is placed at a height above the engine, based on the required circuit pressure of the injection.

Lubrication circuit comprises a container and a mini-pump to ensure sufficient pressure.

The cooling circuit comprises a radiator, a fan and a pump attached to the cooling water circulation. The heating standby circuit contains a heater (corded) which ensures the maintenance of internal motor temperature around 40°C. The electric starting system is composed of the group of batteries, electric starter and an independent electronic charger.

Battery capacity should allow three repeated attempts to start a current of 1000 A minimum at 0°C.

Electronic charger powered from the mains with a charging current of 10A minimum, must provide 80% of the rated load in 4 hours and 100% within 12 hours.

Speed controller includes:
- An electronic PID control to adjust motor speed by injection,
- A tachometer generator mounted on the motor shaft which produces a voltage proportional to motor speed, as input to the controller,
- A mechanical device security (guillotine for air inlet) to stop the engine immediately in case of needed.

System for noise limitation is made of specific devices for sound insulation in areas of the air supply and the special acoustic panels and panels for engine room. Allowable noise level for these areas is approximately 75 dB.

2.3. Synchronous generator
For synchronous generator driven by the diesel engine, the permissible voltage variation to variation in the slow load power provided is up 1% of nominal voltage \(U_{\text{nom}}\). The most critical regime is characterized by varying the instantaneous voltage generator when suddenly loading or unloading the generator occurs. Loading suddenly the generator with a high current, lead to a rapid decrease of the terminal voltage.

If this drop exceeds 25% - 35% \(U_{\text{nom}}\) may occur two cases: the generator get out of synchronism, or is command stopping the group. For this regime the maximum allowable voltage variation is 5% \(U_{\text{nom}}\). It is considered that a maximum of 1.8 \(I_{\text{nom, generator}}\) is acceptable if the number of starts is higher than 10 starts / day.

3. Conclusions
Electricity is produced and transported away from the place where we use so often, its supply interruption occurs. Continuity of power supply is important and sometimes critical for some users. An electric generator group provides important sources of power supply, in particular when large consumers or productive units where interruptions can cause high problems. Whether banks, hospitals, hotels, guesthouses, restaurants, residential buildings, corporate headquarters, production facility or private residence, by lack of electricity can be absolutely no access to a resource required daily. Diesel generators maintenance costs are lower, are reliable, robust and resilient over time.

The electric generator groups represent modern solutions to ensure continuity of power supply regardless of the consumer who require uninterrupted electrical energy supply.
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