RESCUE SYSTEMS FOR ROPE ELEVATORS

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ABSTRACT

It is a nightmare for every elevator user to remain imprisoned in an elevator car. The most frequent reason for such an event is a power failure. The biggest advantage of a hydraulic elevator is the possibility of an easy rescue operation by using a simple battery operated auxiliary-valve in order to bring the lift to the nearest down floor. Recently it has also become possible to install such a system in a rope lift. In case of a power failure, a self triggering system will energize the main motor using a battery. By means of a special electronic equipment, the battery energy is transformed into the alternating current which is necessary to run the motor. The door motor can be operated by the same energy source, which will give the passengers the possibility ofleaving the car when it reaches the landing.

1. INTRODUCTION

Nowadays about half of the elevator installations are fitted out with hydraulic power units. One major reason for that, besides other advantages, is that with the hydraulic power unit it is technically easy to lower the lift car automatically to the next stop in case of a power failure. During the past years equipments have been developed and put on the market which make possible a similar rescue run for rope elevators. Due to the latest technical developments of electronics, such devices are very efficient and economical, and they will surely be used frequently on the future markets for elevators.

Basically a rescue system is a redundant drive control, which, in the ideal case, shall be able to guarantee the running of an elevator independently of the normal control panel and power supply.

In practice this ideal case can at the moment only be achieved approximately because in the present concept the operating of the emergency system is limited to the use in case of a power failure. If parts of the electronics fail or in case of an error in the safety circuit, the rescue run is not automatically set off but it is prevented.

In the future it might be possible to trigger off a rescue run in case of a failure in the parts which are not relevant for a safe operation of the elevator. But a rescue run in case of a failure of the door contacts will only be possible if a redundant door contact system is built in. At present this is technically possible but not economical.

In the following we shall describe a rescue system which uses a battery as energy source. This is the only system which can technically be realized easily and is economical enough to win a wide market.

An alternative is a rescue system with a diesel engine and generators like are usually used in hospitals and other large plants. In the following we will not consider these plants.

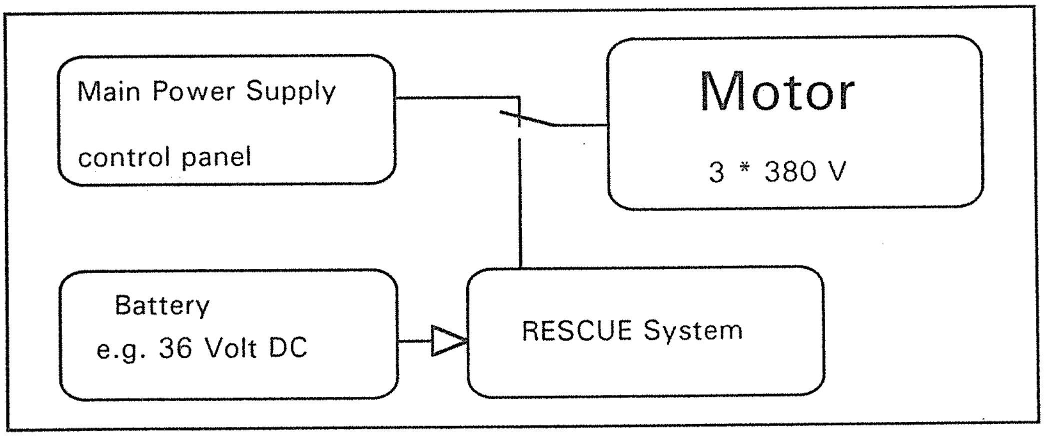

Chart 1. Schematic diagram of a rescue system for an elevator motor

A special electrical equipment is necessary to run an elevator motor with a battery. Basically it is necessary to convert the direct current of the battery into a three-phase alternating current because an common elevator motor can only be operated with this type of voltage. Another important factor to consider is that the nominal voltage of the battery source is lower than the normal mains voltage.

Below we briefly want to outline the general electrical basics for the operation of an elevator motor with a reduced voltage. This explanation is essential for the understanding of a rescue system.

2. DRIVING CONDITIONS OF A COMMON ELEVATOR MOTOR

Usually an asynchronous motor with squirrel cage rotor is used as driving element for an elevator. The number of revolutions of such a motor depends on the frequency of the specified mains voltage.

The equation for the number of revolutions is:

number of revolutions n = constant c x frequency f

This proves that the number of revolutions goes along with the frequency, and consequently the number of the revolutions of the motor can be adjusted by a change in frequency.

The motor has to have a certain torque in order to run the elevator. This torque depends on the magnetic flux.

torque t = constant c x magnetic flux

This means that in order to guarantee the desired torque, the magnetic flux has to be as large as the one obtained through the normal mains supply even when the battery voltage source is low.

The magnetic flux on the other hand depends directly on the quotients of voltage and frequency.

A constant flux and thus a constant torque is achieved by a simultaneous and proportional adjustment of the voltage and the frequency.

We can show this in the following formula:

$$\text{magnetic flux} = \text{constant c} \; \frac{\text{voltage v}}{\text{frequency f}};$$

If we enter, as an example, a voltage as normally supplied by the mains, we will come to the following equation:

$$\text{magnetic flux} = \text{constant c} \; \frac{\text{voltage 400 volt}}{\text{frequency 50 Hz}} = c * 8$$

If we enter, for example, a voltage typical of a set of batteries, we will get the following equation:

$$\text{magnetic flux} = \text{constant c} \frac{\text{voltage 24 volt}}{\text{frequency 3 Hz}} = c * 8$$

The result shows that the frequency of the voltage with which the motor is supplied, must not be as usual 50 Hertz but only 3 Hertz.

If we, for example, supply an elevator motor with a voltage of 24 volts only, the frequency of this voltage must not be more than 3 Hz. This also means that the velocity of the lift has to be reduced accordingly. An elevator which at a frequency of 50 Hz achieves a speed of 1 m / sec. would with 3 Hz only achieve a speed of about 6 cm / sec. Only under these conditions the same torque can be generated in the motor as if it were supplied by the same voltage of the mains.

The current necessary for operating the elevator is always equivalent to the torque. This means that in case of a certain relation of the tension to thefrequency, the torque equals the nominal torque and consequently the current equals the nominal current. From this it can be seen that the battery has to supply a current equal to the nominal current of the motor.

Of course, the above details can only be calculated in this way for an idealized motor like the one on which our example is based. Under real conditions we would have to consider a big number of deviations to our model. Especially, we would have to take into account that in the lower frequency range, that is the range under 5 Hz, the ohmical part of the coil resistance of the stator has a strong influence. Therefore, in this range we have to consider a voltage offset to the voltage of the motor in order to equalize this influence. If this is not possible because the voltage is supplied by a constant voltage source (battery), we have to allow a reduction in the torque.

Even though these additional influences are strong, we do not want to further discuss them here because they are not generally unfavourable for the running of the motor. When using a battery normally not the full torque is needed.

3. THE OPERATION OF AN EMERGENCY SYSTEM

The control circuit of the rescue device is permanently on "stand by" and constantly controls the mains supply. When the rescue system recognizes a failure in the voltage of the mains for a period of a few seconds, it starts working. In this case the rescue system has to have priority over the mains supply. This is carried out by the mains separation contactors which will interrupt the mains supply.

Afterwards it is controlled if the lift is in a precise floor level position or not. This is done by means of a floor level switch . If the lift is in floor level position, the door motor is supplied with a voltage which leads to a complete opening of the doors.

If, on the other hand, the elevator is not in floor level position, after a short delay the door motor is supplied with the needed voltage and the door will close. Then the safety circuit and the closing of the door have to be controlled and assessed by the corresponding supervising circuit. Only when the safety circuit has been closed, the main contactors driving the motor can switch on.

Through the relevant contacts of the main contactors, the mechanical brake can be opened, and the moving of the lift is initiated. In order to keep the moving time of the lift as short as possible, we should choose the direction of movement which needs the smallest possible motor torque to start and move.

Normally the elevator is not so heavily loaded that the lift and the counterweight are fully balanced. From this we can draw the conclusion that the lift can be more easily moved into one direction than into the other one. In order to find out for which direction the needed torque is lower, the rescue system has to make test starts into both directions.

After the system has chosen the direction, the rescue run starts. If it comes to the rare case that the torque is the same for both directions, the rescue run is performed downwards. As soon as the lift arrives to a floor a structurally planned floor level switch closes. That is the signal for stopping the run, which is performed by the switching off of the main contactors. Through this the mechanical brake is switched off and blocks the lift in the reached position.

Afterwards the door motor is supplied with voltage again so that the doors can open. After the complete opening of the doors, the control circuit turns off the main separation contactor and returns to the "stand by" position.

4. DESCRIPTION OF THE DIFFERENT CONSTRUCTION BLOCKS

Rescue systems for rope elevators consist of the following components:

4.1. Battery

For our purposes ordinary lead batteries are suitable. The batteries shall have the highest possible life and have to be able to supply the needed current to run the motor. As the necessary current supply to the motor normally only lasts less than one minute, batteries with a capacity of about 5 amp/h (ampere/hours) are usually sufficient enough. The needed current would only be about 20 amps, which is equivalent to approx. 0.4 Amph for one minute. But due to their internal resistance, batteries of such a small capacity are not able to supply the current needed in a short time. Furthermore we have to consider that batteries lose capacity by aging. Therefore it can be recommended to choose batteries which can supply the needed current for at least ten minutes.

4.2. Battery charger

The battery charger has to constantly keep the batteries in a charged condition. The batteries shall be charged with a constant voltage according to the number of cells. The charging condition has to be checked in regular intervals to avoid an overcharge.

In order to be able to do so it is necessary to interrupt the charging and to measure the voltage of the battery under load conditions. In this case it is favourable to use special electronic devices which have been developed for the measuring of an optimized charging of the batteries and also to ensure their long life.

4.3. Contactors and relays

It has to be guaranteed by means of a relay circuit that in no case the mains voltage and the rescue system voltage will be short-circuited. A short-circuit would inevitably destroy the device and possibly the batteries. So, in order to be sure that this does not happen, we fit in an electrical - or even safer a mechanical - blocking of the relevant relays and contactors.

The contactors switching the current of the motor have to be equiped with the suitable contacts. The calculation should be based on the nominal current of the motor.

4.4. Control circuit

The main contactors may only be switched on when the safety circuit is closed. In the rescue system, like in any elevator control, the mains voltage of the main contactors runs through the saftey circuit.

The mechanical brake has to be switched by the motor contactors. This is true in case of mains supply as well as for battery supply. Thus the rescue system has to provide the voltage for the safety circuit, for the motor contactors, for the relays, for the magnetic coil of the mechanical brake and, if the system is equiped with them, also for the blocking magnets.

This can be achieved by selecting the necessairy supply voltage of the contactors and the magnet coils to the voltage of the battery. In this case the battery voltage can be used for a direct supply of the coils. Otherwise the battery voltage has to be increased to the needed voltage with a voltage converter.

4.5. Integration into the control system

A rescue system is normally part of the basic equipment of an elevator. But it is also not too difficult to build it in later. The instructions to be followed are attached to the description of the elevator. But if the rescue system is built in later on, this has to be done by a specialist in any case. It is a relatively big operation because also the safety system is concerned. It is easier and more advantageous to build in the rescue system, when renewing the complete control system.

4.6. Frequency generator for the traction motor

The frequency generator is the essential part of the rescue system. This frequency generator cnvertes the battery current into three-phase current which is necessary for running the motor. This conversion takes place in a so-called inverter. This inverter consists of a control circuit and a power section. In the control circuit part the control signal for the 6 power transistors of the power section is generated.

A three-phase mains supply consists of three independent sinus-shaped currents; between each sine shape a phase shift of 120 °can be observed. By this phase shift of 120 °the rotating magnetic field is created in the motor. In a rescue system such a three-phase current shall be generated as easily as possible.

Generally speaking, a sine wave can only be generated in a electrical generator. Electronically we can only achieve approximately the same results. In this case the area of the sine wave is copied by pulses of different length but of the same amplitude. The pulses are integrated by the inductance of the motor.

Like this we can come relatively close to the quality of a original sinus generated in a electrical generator. The more pulses can be produced in a certain time unit, the more we can approach to a sine wave and the better the motor can consequently convert the current into torque. The system becomes more complex the more pulses are requested, the more complex the system will be.

Thus for a rescue system usually a solution with very few pulses per time unit is chosen. As mentioned above for a rescue system not the whole torque is necessary. One pulse per half-sine-wave is sufficient in order to make the system work. We can imagine that the half-sine-wave is replaced by a square pulse.

Practice has shown that this solution normally is sufficient for our case. The advantages of this solution are, amongst others, that it works on very simple electronics, which are very reliable and emit few line disturbances. But on the other hand the relatively big drop in the power of the motor and consequently the reduced torque have to be regarded as disadvantages.

4.7. Control of the door motor

In the elevator construction business, we practically come across many different types of door motors. A direct current motor needing the same voltage as the battery, would be the ideal condition for running a door motor with a rescue system. In this case a relay to control the door would be enough.

But the situation will become more complicated if the door motor needs another voltage or a supply with three-phase current. Then the battery voltage needs to be transformed accordingly. With a chopping circuit the direct voltage can be changed to an alternating voltage, which can thereupon be converted to the needed voltage level by a transformer. By rectifying the alternating voltage, the needed direct voltage to run a door motor can be achieved. In case three-phase current is necessary, another frequency generator can be used. But usually it is the simpler way to generate a rotating field with a motor-capacitor. Although this method is only applicable to small motors, it is usually sufficient for common door motors.

4.8. Movement monitoring

Additionally to the adaptations in the control system, a rescue system also needs movement monitoring to control the moving of the lift car. Through the movement monitoring device the rescue system can decide into what direction to move. For doing so two test runs, one upwards and one downwards, are necessary.

The elevator keeps to the chosen direction during the whole run. Pulse switches can be used as sensors to obtain the signals. It is an advantage if the rescue system can use the same pulse sensors which are used in the motor regulator system.

4.9. Restrictions on the use of the rescue systems:

Usually the rescue system switches on automatically as soon as it comes to a power failure. But this is not always permitted. When the system is set on inspection control, the rescue system must be switched off. The same rule applies when the main switch is turned off.

In order to ensure the switching off of the rescue system, it is necessary to equip the two switches with one single auxiliary contact each and to switch off the rescue system with these switches.

Naturally, the rescue system can as well not work when the safety circuit is interrupted.

5. APPLICATION TO GROUPS OF ELEVATORS

Basically the principle of rescue systems can be applied to one single elevator as well as to an elevator which is part of a group of elevators. A separate rescue system should then be used for each elevator.

Even though theoretically it would be possible to use one rescue system for several elevators, it is not economical to do so because it would be very complicated technically. In this case the rescue system would have to be switched from one elevator to the other which would make necessary a very complicated electronic system. Another disadvantage would be that the passengers in the last elevator would have to wait for a very long time before the rescue run could start, because each lift needs a certain time for the rescue run.

But on the other hand it would be advantageous if all rescue systems of a group of elevators could be supplied by the same set of batteries. Here some money could be saved because the maintenance and renewal of the batteries cause high operating costs. In such case it would be sufficient to use batteries which are strong enough to supply a group of lifts and to adapt the charger accordingly. As normally the charger is part of the rescue system, you should contact the producer of the rescue system in case there is no information in the manuals.

6. CONCLUDING REMARKS

In the past years, rescue systems have been applied with great success, especially in countries with a defective power network. This is the only possibility to free the passengers safely and fast in case of a power failure. Thus it is an active method to help immediately.

There is also one way of passive help which has come into frequent use in recent years. This is the method of a direct telephonic communication to a central control office in case of a breakdown.

But this is more or less a psychological kind of help to the elevator users. Active help cannot be given by the central control office.

Because of the above-mentioned reasons, in the future the active rescue system should be used side by side with the passive telephonic communication system