

The Operation of Batteries

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8.1 INTRODUCTION

This chapter discusses aspects of the use of stationary batteries within the Deutsche Telekom AG. The names Deutsche Telekom or Telekom shall be used, although the responsibility for the area power supply for telecommunication networks was transferred to the Deutsche Telekom Immobilien und Service GmbH, (De Te Immobilien), a 100% subsidiary company of the Telekom, since January 1, 1996. At present, the DeTe Immobilien takes care of approximately 12,000 power supplies with a capacity overall of nearly 22 million Ah.

In the area of the Deutsche Telekom, most different battery systems are as shown in [Figure 8.1](#). Primary batteries mainly are used in measuring instruments. Alkaline secondary batteries (accumulators) have a great importance in the area of communication technology, such as on mobile phones as well as on cordless phones. Still they are used as starter batteries for mobile network substitute installations (generator sets).

Lead-acid batteries are used, for example, as

- Traction batteries in industrial trucks.
- Starter batteries for cars, heavy trucks, and stationary network substitute installations.
- Stationary batteries in power supply installations for telecommunication networks.

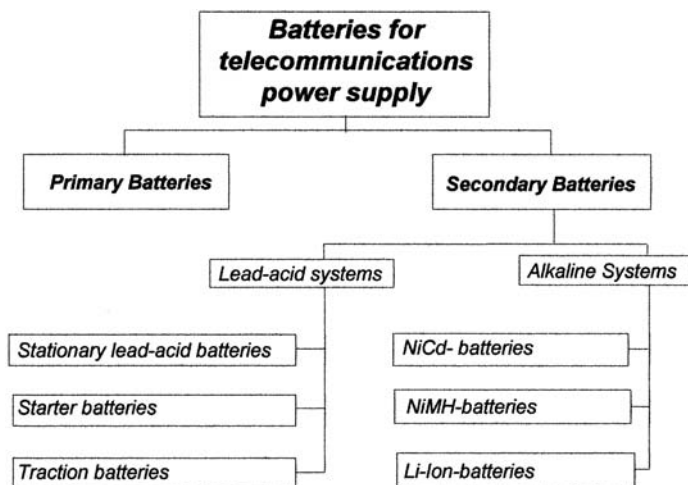


Figure 8.1 Overview of the batteries in use within Deutsche Telekom.

In Chapter 7 the series of the stationary batteries with Planté plates, tubular plates, and grid type plates as positive electrode are described in detail. In the following, stationary batteries are discussed.

8.2 THE DEVELOPMENT OF POWER SUPPLY FOR TELECOMMUNICATIONS

Batteries and telephones were developed in the first half of the 19th century. The power supply of the telephone consisted at the beginning of its development of primary batteries. Initially the batteries were placed in the telephone users' facilities and were called "Ortsbatterie" (stationary battery). In the course of further development, the batteries, now accumulators or secondary batteries, were installed in the central exchange office, in German im Amt, and therefore called "Amtsbatterie" (office battery). Until today the Amtsbatterie is retained from the subscriber.

In the early phase of the Ortsbatterie, the function of the telephone was dependent on the functionality of the battery at the subscriber's facility. The transition to the Amtsbatterie changed the situation in so far as an increasing number of connected subscribers were affected in case of battery failure. The battery became a central security element; continuous availability became necessary. Today, subscribers are responsible for the functionality of their equipment again when additional functions (cordless telephones, answering machines) are used which need a local power supply.

The direct current voltage which is necessary for the function of telephones was exclusively taken from a battery. When discharged by the consumer load by a switch the battery was disconnected from the consumer load. A second battery, in the meantime under charge, now was connected to the consumer load. The switch to the charger now connected the discharged battery. With this operating mode, which is

called “change battery operation”, the batteries had to perform a high number of cycles.

With the onward development of the components as well as the control and steering technology, the possibility was created to provide consumers with a voltage derivative from the mains. That in parallel with the consumer-switched battery guarantees interruption-free parallel operation (see Figure 8.2).

The telecommunication equipment, that essentially consisted at this time of relays, spools, electromechanical selectors, and valve amplifiers, had a current demand dependent on conversation as characteristic. The current peaked on a “day curve” in which the ratio between minimum and maximum amounted to 1:10. For a long time the rectifiers were dimensioned so that the batteries were discharged if the top current was demanded, and at low consumer current were loaded again. This operating mode is called “boosting operation”. The batteries assume an undefined loading condition. Therefore only a part of the nominal capacity is disposable at a mains failure. With the operating mode of stand-by parallel operation, the rectifiers are dimensioned for the maximum current plus charging current, so that the battery stands constantly in stand-by and will be discharged only in case of a mains failure. The battery is here under float condition to equalize capacity losses by self-discharge. The battery is always fully charged. The rectifier installations of the Deutsche Telekom are so dimensioned that the batteries are discharged only in the case of mains failure. This requirement on the battery postpones/avoids a high number of cycles (change battery operation or boosting operation) to constant long-time behavior under float condition.

Another important characteristic of the electromagnetic exchange technology is a voltage with close tolerance required for the functionality. In order to fulfill this demand, different circuits were applied, which guaranteed that the consumers were not exposed to the full voltage range of the battery (especially the charge voltage). The battery however always stood at disposal. Possible circuit variants are pick-up technology (Figure 8.3) and counter-voltage technology (Figure 8.4).

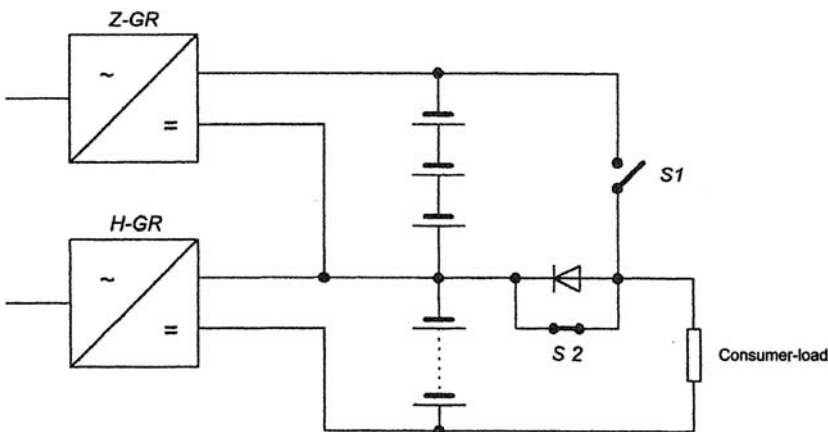


Figure 8.2 Power supply installation for parallel operation.

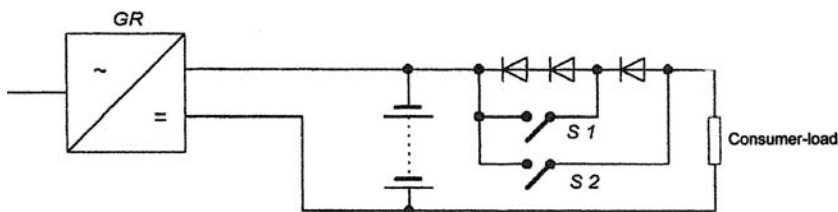


Figure 8.3 Power supply installation in the pick-up technology.

The principle of the circuit is based on the fact that at mains operation the consumers are switched parallel only with a part of the battery, with 27 cells with a 60-V power supply. The main rectifier is adjusted to an output voltage that corresponds to the float voltage of this part battery. The other cells get the charge voltage from the additional rectifier. In the case of mains failure consumers are switched with achievement of a corresponding voltage border to the total battery while S1 closes; meanwhile S2 opens. The decoupling diode makes possible the interruption-free switch.

With counter-voltage technology the entire battery gets the charge voltage of the rectifier. The necessary voltage reduction is reached over diodes switched in forward direction. With mains failure the diodes are bridged voltage dependent. In the end, the consumers are switched to the battery directly parallel. The performance moved by the diodes in heat causes poor efficiency.

The introduction of digital exchange technology brought numerous changes; among other things the output voltage of central power supply has a characteristic of a transfer voltage. Consumers are supplied by DC/DC converters, which have a large input voltage range. DC/DC converters are necessary because different voltages (5 V, 12 V, 27 V) are required for the function of the electronics of the exchange equipment. Consequently, rectifiers, batteries, and consumers could now be switched directly parallel, as shown in [Figure 8.2](#).

The recharging after a mains failure is performed by a boost charge for a fixed time period or with float voltage. With the application of the boost charge, the taken energy is loaded more quickly into the battery again and is more quickly available again. In addition, these batteries show better long-time behavior than batteries which were recharged under float conditions.

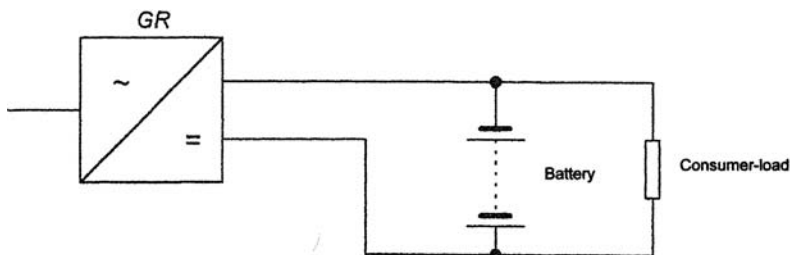


Figure 8.4 Power supply installation in counter-voltage technology.

With the decentralization of the exchange networks, separation of functional units into the surface, as well as the use of glass fiber, beside the batteries in the central office with high capacity, many batteries of inferior capacity had to be installed.

8.3 PRODUCT DEVELOPMENT AND PRODUCTS IN USE

The products which are used by telecommunications reflected the development of the industry in the area of stationary batteries. Big users like Telekom immediately tested many developments after the laboratory phase. The experience collected in practical use was evaluated, and knowledge about it went back in into the battery production. While in the early years of the central offices, batteries with Planté plates were used; these batteries were replaced by batteries with “narrow mounted” Planté plates. In the beginning of the 1970s the use of stationary batteries with positive tubular plates started. Stationary batteries with positive tubular plates of present production, especially in the capacity area up to 3000 Ah, clearly differ from those from the first production years. The container material hard rubber was replaced with SAN and pole sealing was modified many times to eliminate leakages and crevice corrosion. Still the connections between pole and covers must be shaped so that from plate growth resultant strengths cannot lead to rips in the covers or cover detachment of the container. An essential alteration was the lowering the amount of antimony of the plates. This was an advantage for the user because electrolyte loss was drastically lowered and the cycles for supplementing the electrolyte could be increased. In addition, an essential presupposition was created for the development of valve-regulated batteries.

Valve-regulated batteries have been use at Deutsche Telekom since the end of the 1980s. First these batteries were put into low scope purposes for testing. Their use was forced strongly with the extension of telecommunications in the “new countries” (area of the former GDR), so that today approximately 1700 locations (mainly cell capacities of 200 Ah up to 1500 Ah) with valve-regulated batteries are realized. Since these product series permit the use of batteries in applications in which the use of vented batteries is completely impossible, valve-regulated batteries of small capacity (bloc batteries up to 65 Ah) are used today in most facilities. Main focuses of use are converters for the transition from copper wires to glass fiber.

In the past the use of grid type batteries was restricted to operation tests. The collected experiences did not meet the expected results. Today, these products are more reliable in operation behavior; furthermore the use of grid type batteries is necessary in numerous applications on the basis of the low inside resistance and the good high current behavior.

To exchange equipment, peripheral facilities came with the introduction of digital exchange technology, for example, computer, printer, and other hardware components. This equipment needs mains without interrupt. To provide for these facilities in individual cases DC/DC converters or, usually, uninterruptible power supplies (UPS) are used. The UPS can be placed locally or centrally. The UPS are used mainly in order to bridge over short mains failure as well as for realizing a proper switch-off. Therefore the batteries in use must deliver a high current for a short time. Batteries with grid type plates fulfill this requirement optimally.

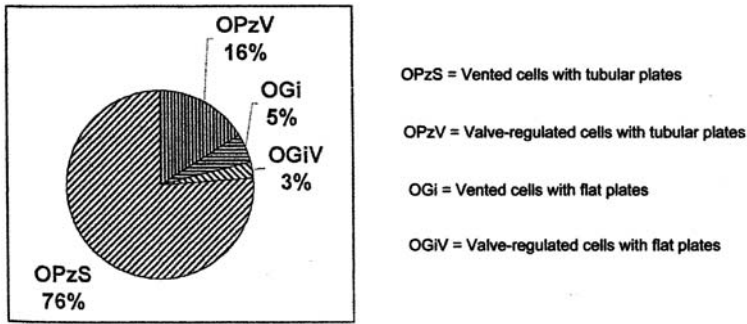


Figure 8.5 Shares of the series at the total stock.

Figure 8.5 gives an overview of the distribution of the series at the total stock. It is to be heeded that batteries with capacities up to 100 Ah are not considered.

8.4 CONCEPT OF ENERGY RESERVE

The basis of the conception and dimension of the power supply of a location is the “concept of energy reserve” of the Deutsche Telekom. It includes commitments to the general concept and the dimension of the components of the power supply on the basis of local conditions, including, in particular (a) importance of the telecommunication consumer, (b) power demands, and (c) attainability of the facility.

The importance of the telecommunication consumer depends on the consequences of a failure of the power supply for the connected subscribers. The importance is greater when more subscribers are affected by such failure, which determines whether the failure has an effect nationwide or only regionally. The demands of the consumer with the highest importance are decisive if different technical consumers are connected with a power supply.

The power demands of the consumer can be realized with a battery only for a certain time because of the limited energy reserve. The use of network substitute installations makes it possible to ensure a proper function even at long-lasting mains failure. For consumers nationwide, the energy reserve concept presupposes the use of network substitute installations on principle. With the introduction of digital exchange technology, a concentration of the components became possible on a small volume. The technology no longer used electromechanical components but pure electronics that could be concentrated in fractions of the previous volume. The limit of the concentration was the energy moved per volume and with it the loss performance attacking as waste heat. A completely new problem assumed shape, because the use of climate technology became necessary that had to be able to operate also in the case of mains failure. Either a network substitute installation is used or with smaller performances a battery supplies the DC/AC converter.

Attainability of the facility refers to the necessary time to reach the facility, even during bad weather conditions. The necessary time for the disturbance

elimination must be considered as well. Normally, the battery capacity is planned for a discharge time of 4 hours. In facilities with network substitute installations, the battery is calculated for a discharge time of 2 hours.

Batteries with capacities over 250 Ah are divided for operation and security reasons into two groups of the same capacity. Both batteries are switched continually parallel. Further batteries of same capacity can be switched parallel if expansion of the battery capacity is necessary. Extensions are possible up to five battery groups. It is also possible to switch parallel batteries of different capacities (maximum capacity ratio 1:2). In practice, this is without meaning however.

Besides the energy reserve concept recommendations exist for special applications, for example facilities with mobile phone networks, with which a superposition of the ranges exists, so that the cancellation of a single location has hardly any effect on the total function of the mobile phone network.

8.5 OPERATION CONDITIONS

Batteries in central exchange offices had optimal environmental conditions in the past (Figure 8.6). In the normal case, the battery was mounted in a big cellar area with an annual average temperature of 18 °C. The windows were lined up northward, so that no warming appeared in the summer. Radiators prevented temperature deviations in winter.

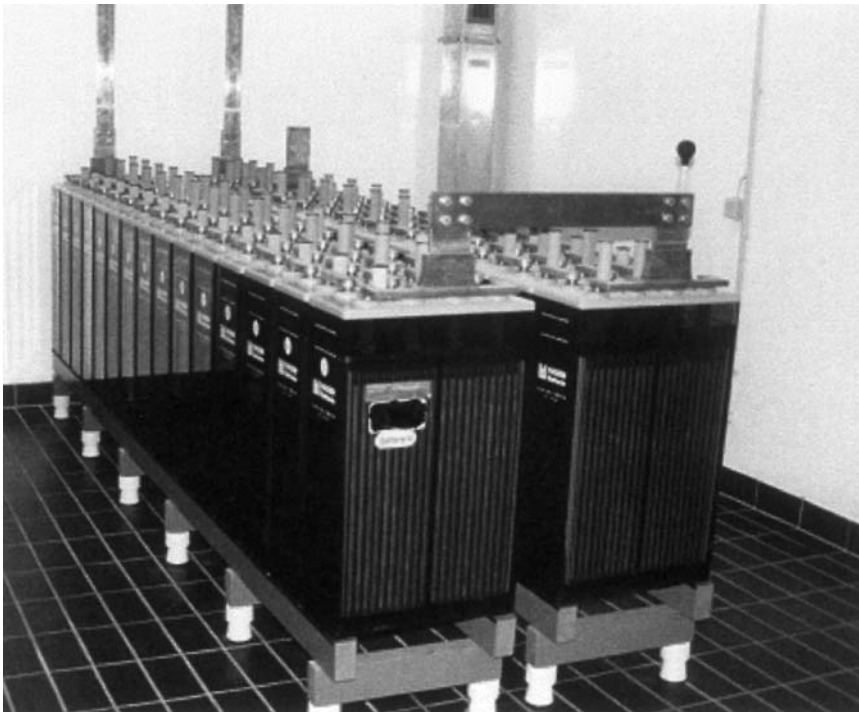


Figure 8.6 Classic battery area.



Figure 8.7 Multifunctional cubicle (MUK).

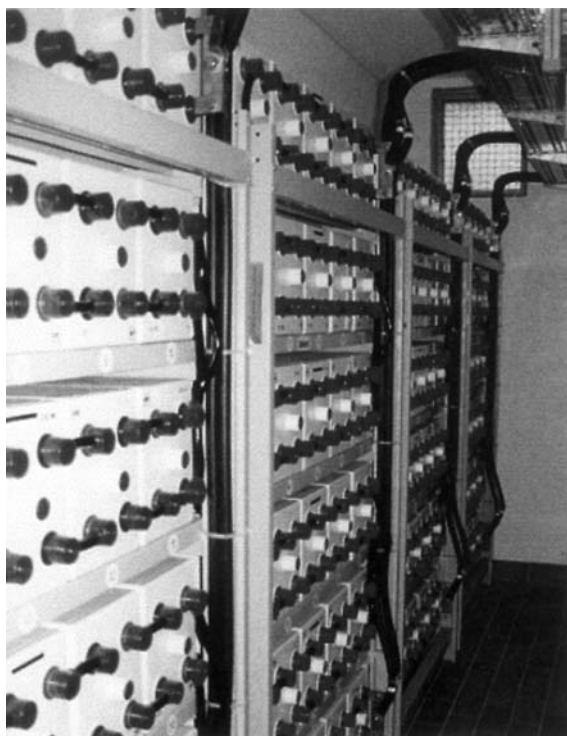


Figure 8.8 Battery area of the MUK.

With the introduction of digital exchange and glass fiber technology it became necessary to build up equipment outside the old central exchange offices. Of increasing scope, so-called character buildings, separately standing buildings with small bases, were developed and used. The environmental conditions for the batteries were no longer perfect since a certain temperature fluctuation appeared in these buildings and measures were met only against freezing.

With reunification, Deutsche Telekom got the big task to plan the extension of the telecommunication networks in the “new countries” within the shortest time possible and to manage an essential basis for further development. The high structural requirements had to be implemented in short time along with the technical ones so telecommunications equipment was first accommodated at main locations in containers and a large number in so-called multifunctional cubicles (MUK) (Figure 8.7)

They consist of assembled rings that are put on a strip foundation and are locked in front and behind (Figure 8.8). Exchange equipment and power supply, that is rectifiers and batteries with capacities up to 200 Ah, were put into one room together. The use of valve-regulated batteries (low gas emission, situation-independent mounting) became necessary. The accommodation of batteries of larger capacity takes place in a divided up area. To install batteries with a total capacity up to 4500 Ah in such a small area, again valve-regulated batteries were installed in horizontal position in steel racks. Because of the implementation of the building, the batteries are exposed to wide temperature fluctuations.

With the introduction of the glass fiber technology, local power supplies became necessary in large scope for the supply of intercession technical facilities and facilities for the transitions of fiberoptic to copper lines that lead to the participants and intensifiers to refresh the signals (light impulse) after a certain line length. In general, the necessary technology is installed into so-called Kabelverzweigerkästen (shortly KVz). The number of such facilities is approximately 18,000. Since these facilities must be able to function also at mains failure, a battery is applied in each case. Two variants exist for the accommodation of the battery. Either the battery is installed in the pedestal part of the KVz cabinets (Figure 8.9), or the batteries, which are used for the remote power supply of several of such facilities, are separately buried in a cable branch box (Figure 8.10). The battery becomes accessible when the cover of the cable branch caste (as can be seen in Figure 8.11 bottom right) is lifted up. The conditions to which batteries are exposed in the cable branch box comprise everything conceivable, including flooding with dirty water and mud and high temperatures. Nevertheless, the batteries work better than expected under these conditions.

8.6 BATTERY INSTALLATION

The installation conditions for batteries have changed over the years greatly. Today it is necessary to install the batteries to save space. This is possible by using metal battery racks and battery cabinets. It is to be heeded, however, that the specified ventilation and service ability of the batteries is ensured. A protection-leader connection must exist at the battery cabinets on principle. This demand is also put on battery racks for batteries with nominal tensions > 60 V DC. It is necessary that all construction elements be interconnected electrically leading together.



Figure 8.9 KVz cabinet with battery in the pedestal area.

All racks must be equipped with a particular coating, independent of the nominal voltage of the battery. For the admission of delivery at Deutsche Telekom, proof of the mechanical solidity, the chemical resistance against electrolyte, and the light insensibility of the coating through a production pattern examination have to be enforced at a neutral institute. In the end of the production process, each complete rack and all rack components are tested with a voltage of 4 kV; a protocol is prepared and is delivered with the rack.

Increasingly battery cabinets and battery fans find application in compact power supply installations. On installation, the fulfillment of the requirements of the ventilation is an essential admission criterion. Besides good accessibility of the batteries, a necessary electrolyte-resistive surface has great importance. On principle, for safety reasons acid-collecting tubes are also demanded under the installed valve-regulated batteries as for vented battery types.

8.7 PURCHASING AND QUALITY MANAGEMENT

The purchasing of batteries in use by Deutsche Telekom takes place over framework contracts. Through these it is guaranteed that only released batteries and released battery accessories are delivered to the Telekom. Further deliveries can be abandoned if there are problems with a certain product within a short time. The acceptance of the delivery to the Telekom is given if proof of the observance of “quality handicaps” is produced by a type pattern test and regular audits at the manufacturer. Tests of several years that are enforced in the central laboratory of the Telekom in Steinfurt are prerequisite for the transaction of the type pattern test. The quality handicaps are worked out in a form of technical delivery conditions for the individual series. It is important on this occasion that no particular products are



Figure 8.10 KVz cabinet with cable branch boxes.

described in the delivery conditions. The handicaps make it possible to select suitable products from all those offered.

On principle, the products that are used at the Telekom in the stationary area consist of DIN, German standard, and conformity products to make possible an interchangeability of the products of individual manufacturers. Increasingly, products that do not correspond to the handicaps of the DIN establish themselves at the market. This brings growing problems, because interchangeability is not always a given between the offered products, and the use of foreign products makes adaptations necessary.

In the past, each battery to be used at the Telekom was designed for production and the manufacture process was pursued. In the course of globalization of the markets, this expenditure is no longer justified. As well, the product itself stood in the center of the design planning with the enforced type pattern test. Today, very much time is spent on the examination of production conditions. On the basis of



Figure 8.11 Battery in the cable branch box.

much experience, conclusions can already be determined on the quality of the manufacturers' products.

At the site of use, an acceptance test takes place, with which the quality of the product, the installation, the date fidelity, and so on are judged in presence of the supplier. As a further measure, an information system has been activated, through which problems with the products in the application are reported. The consistent evaluation of this information gives information about operation holding. With an accumulation of problems, it is possible to abandon the further procurement and stop the release of a product.

8.8 MAINTENANCE ACTIVITIES IN BATTERY PLANTS

The scope and timing of maintenance procedures are established for the activities at the batteries.

- Capacity tests in principle are enforced with constant current and the results are reported. They become enforced with the acceptance at the site, 6 weeks before the end of the guarantee period, and then in certain intervals. The capacity test during the acceptance procedure can be fall out, if the supplier includes the protocol of the capacity test performed at the end of the manufacturing process. Capacity tests outside the guarantee are enforced at batteries of the series with tubular and Planté plates after 9 years and at valve-regulated batteries after 4 years, calculated from the date of putting into operation. At batteries with grid type plates, a capacity test is planned after 6 years. The date of the next regular capacity test is fixed depending on the result of the previous capacity test.
- Inspections are enforced at batteries every 6 months and the results are documented. With the inspection visual check of the total condition of the battery is carried out (judgment of plates, container, connectors, rack, and so on). Investigation of the temperature of pattern cells is made. With vented batteries the electrolyte density is measured at different cells. Afterward the total voltage and the voltage of individual cells are measured for vented and valve-regulated batteries. Then follows the discharge of the battery with the consumer load. After approximately 10 minutes the total voltage and voltage of individual cells are measured again. If irregularities arise with the inspection, they are evaluated accordingly and counter-measures are started.
- The cleaning of all cells is prescribed every 12 months.

8.9 OPERATION EXPERIENCE

Altogether it can be said that the collected experience corresponds in a high degree with the theory. [Figure 8.12](#) gives an overview of the total distribution of the disturbances covered on the series.

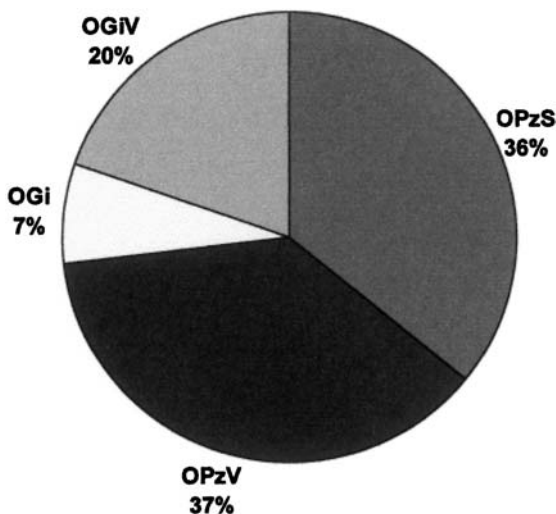


Figure 8.12 Distribution of the disturbance information absolute.

8.9.1 Vented Batteries

Vented batteries essentially show a stable behavior. With Planté plate batteries, whose use by Telekom is insignificant, 20 years of shelf-life is normal. Batteries with tubular plates are a largely uncritical product, with a typical shelf-life of 15–18 years. With these series often there is reason to select the “electrolyte consumption” that ascends with increasing age of the battery and not the actually capacity (must be $< 80\% C_N$). Recently there have sometimes been problems with growth on the plates. It has to be clearly distinguished from growth on the plates that is to some extent completely normal by aging and growth of the poles caused by crevice corrosion in the area of the pole bushing, a very critical defect.

There is not yet much experience available with grid type batteries of newest production. Products with high acid density have tended to have problems while being charged. Corresponding examinations should be enforced here.

8.9.2 Valve-Regulated Batteries

The introduction of valve-regulated batteries was accompanied by numerous problems. Many courses in the manufacturing process had to be changed and adapted for the particular case of the production of valve-regulated batteries.

Even bringing in these cells into a level rack is problematic. The containers are constructively identical with those of the vented batteries. If a cell is first put down on the front crossbar before the cell is pushed to the back, tensions appear in the container and damage occurs in the structure of the plastic. This leads inevitably to rips in the container if the valve is put in too tight, which causes it to open because the inside pressure is too high.

The attention to and adjustment of the correct product-specific charge voltage are of great importance with valve-regulated batteries. Furthermore, the

temperature-dependent charge voltage with unstable temperature conditions is a basic requirement for the reliable function of the batteries. With valve-regulated batteries, environmental temperatures are to be ensured above 0 °C. Frost damage may appear if the batteries are unloaded at frost or are exposed to frost in the unloaded condition, for example at mains-disconnected equipment in which monitoring circuits lead to a deep discharged battery.

Contrary to the generally represented opinion that valve-regulated batteries dry up if loaded after a discharge with boost charge, it is to be noted that these batteries always reach a comparatively high shelf-life. Also the widespread opinion is wrong that in case of defect there is no electrolyte leakage in valve-regulated batteries. In some cases a little electrolyte leakage is possible, leading to the corresponding consequences for the surroundings. As well the thesis is often represented that valve-regulated batteries tend to fail spontaneously. This observation cannot be confirmed for the area of the Telekom.

The causes of premature failing are corrosion appearances, errors at the valve, or wrong charge voltages.

A very close and open cooperation with the manufacturers has helped to improve the production quality.

8.9.3 Accidents

Accidents appear again and again. Fortunately there have been no cases with personal injury for several years. The security concept developed with the Telekom has made an essential contribution. It consists of the consistent transposition of the demands of the prEN 50272 (draft of European standard) and the fact that for all vented batteries ceramic vent plugs are required. Recombination vent plugs were not in use because of the lack of return-ignition security up to now. A new generation should be reignition safe. Results of examination are not yet available.

Often problems arise when unfamiliar companies work in the operation areas of Telekom. Cooperation and communication with these companies have to be carried out carefully.

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