Methods of improving the power supply reliability of industrial site

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Abstract. Ensuring reliability is one of the most important problems in the creation and operation of any technical system. It is especially relevant for complex systems such as power supply systems. A modern industrial site from the power supply point of view is a complex technical system of hazardous industrial facilities, the technological processes continuity and safety of which directly depends on the power supply reliability. Electricity receivers of the considered industrial site in terms of power supply reliability belong to the second category. The task of ensuring the power supply reliability includes a whole range of technical, economic and organizational measures aimed at reducing damage from disruption of the electricity consumers’ normal operation. In addition, in modern market conditions, the power supply reliability is inextricably linked with the economic performance and industrial enterprises energy security. The paper proposes to modernize the industrial site power supply circuit, using the existing standby diesel power plant, which would automatically provide the industrial site power supply in automatic mode in case of disappearance, decrease, increase in voltage level, phase failure, and the phase sequence violation of the three-phase supply voltage on the busbar sections TP-1, TP-2 site. It is obvious that with the existing power supply scheme of the industrial site, the manual switching sequence, control over the backup diesel power plant operation, the normal power supply scheme restoration, it takes an average of 2.5 hours, which is not desirable, especially in winter. Therefore, it is necessary to introduce at the industrial site production control devices for the reserve automatic transfer, which ensure the power supply restoration to the industrial site in automatic mode.

1. Introduction

Ensuring reliability is one of the most important problems in the creation and operation of any technical system. It is especially relevant for complex systems such as power supply systems [1-10]. The task of ensuring the power supply systems reliability includes a whole range of technical, economic and organizational measures aimed at reducing damage from disruption of the electricity consumers normal operation, such as:

- selection of criteria and quantitative characteristics of reliability;
- reliability tests and predicting the operating equipment reliability;
- the optimal structure selection of the designed (reconstructed) power supply systems according to the reliability criterion;
- ensuring the specified technical and operational characteristics of consumers' work;
the development of the most efficient in terms of reliability, operating system software (substantiation of preventive maintenance modes, norms of spare elements and methods of troubleshooting).

In addition, in modern market conditions, the power supply reliability is inextricably linked with the economic performance and industrial enterprises energy security.

2. **Theoretical, experimental, technical and technological methods**

All Union State Standard 27.002-95 «Reliability in technology. Basic concepts, terms and definitions» defines reliability as «an object’s ability to keep the values of all parameters characterizing the ability to perform the required functions in specified modes in time». With regard to electric power systems and, in particular, to power supply systems, it is necessary to take into account their large dimension (in terms of the number of elements and interconnections between them), dependence on adjacent technical systems (fuel and energy complex and technology of the consumer enterprise) and the continuity in time of production processes, distribution and consumption of electricity.

Therefore, the power supply reliability should be understood as the continuous electricity provision to consumers of a given quality in accordance with the power consumption schedule and according to the scheme that is provided for long-term operation.

Electricity receivers of the considered industrial site in terms of power supply reliability belong to the second category. The industrial site is a structural unit of a large industrial enterprise in the city of Salavat.

The industrial site contains:

- a radio relay station that receives and transmits data to the CDS (central dispatch service) in terms of volume, temperature, pressure, etc. pumped gas in main gas pipelines (MG);
- technological communication center (TCC) performing maintenance, repair of telephone communication equipment between the enterprise division facilities, gas distribution stations (GDS), automobile gas filling compressor stations (CNG filling stations), etc.;
- seasonal gas boiler house providing heat supply, hot water supply of the site buildings;
- gas station, mechanical repair shops, garages, warehouses, welding and turning areas;
- security service (SS) performing control functions inside the access mode, the state of the fire and security alarm system, video surveillance.

Let us consider the power supply of an industrial site according to the scheme shown in Figure 1.

It is seen from Figure 1, the main step-down substation-1 110/35 kV power supply is carried out by the local power authority (LPA) through a double-circuit overhead line 110 kV from the regional substation located at a distance of 20 km, and the main step-down substation-2 35/10 kV power supply is carried out by the local power authority through a double-circuit overhead line 35 kV at a distance of 10 km from the main step-down substation-1 110/35. Moreover, double-circuit overhead lines 110 kV and overhead lines 35 kV are on the same power transmission line support.

The industrial site power supply from the main step-down substation-2 35/10 kV is carried out through two separate power lines on reinforced concrete vibrated racks (VR 110) with aerial non-insulated cables. The industrial site is located at a distance of 0.5 km from the main step-down substation 35/10 kV.

It is obvious that LPA double-circuit overhead lines (110/35 kV and 35/10 kV), located on one power transmission line support, cannot be independent, mutually redundant.

If an LPA double-circuit power transmission line has been damaged, requiring the disconnection of both circuits (for example, a break in a lightning protection cable, simultaneous destruction of circuit insulators), then the power supply to the consumer is interrupted during the repair work, which is unacceptable. An accident with one source of power supply (PS) should not in any way affect the PS provision from another source.
If an accident occurs, e.g., a breakage of the lightning protection cable of a 110 kV power transmission line during non-working hours, there is a power outage at the site. At most industrial sites of the main gas pipelines line production management; at least a standby diesel power plant (DPP) operating in manual mode is installed. There is no permanent engineering staff at the site. Production start-up, DPP switch-on, power supply restoration to the site during off-hours, weekends, holidays is carried out by an emergency recovery team, and assembled according to an emergency response plan. According to the emergency response plan the emergency recovery team collection time is 2.5 hours.

![Industrial site power supply diagram](image-url)

**Figure 1.** Industrial site power supply diagram.
Under adverse weather conditions in winter a sustained interruption in site power supply can lead to defrosting of heating networks, heat consumption networks, water heaters of supply ventilation units located in industrial site buildings and workshops, a break in telephone communication, lack of video surveillance, control over fire and security alarms of buildings, etc.

3. Conclusion
The paper proposes to modernize the industrial site power supply circuit, using the existing standby diesel power plant, which would automatically provide the industrial site power supply in automatic mode in case of disappearance, decrease, increase in voltage level, phase failure, and the phase sequence violation of the three-phase supply voltage on the busbar sections TP-1, TP-2 site.

Currently, in the event of an emergency power outage during non-working hours, weekends, holidays emergency power supply is carried out as follows:

- In the event of a voltage failure at both high-voltage inputs TP-1 and TP-2, the dispatcher of the technological communication center and the security service report to dispatchers in the directions about the absence of electricity at the site;
- The collection of operational-repair personnel is carried out. The power plant is being launched; the personnel are acting in accordance with the instructions for transferring the industrial site power supply to a backup source;
- The control over the power supply restoration according to the normal scheme is carried out by light signaling in RU-10 kV. in the first and second busbar sections or specified by telephone from the dispatcher of local power authority.

It is obvious that with the existing power supply scheme of the industrial site (Fig. 1), the manual switching sequence, control over the backup diesel power plant operation, the normal power supply scheme restoration; it takes an average of 2.5 hours, which is not desirable, especially in winter. Therefore, it is necessary to introduce the linear production management of main gas pipelines automatic transfer switch (ATS) devices, which ensure the power supply restoration to the industrial site in automatic mode.

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