The Impact of Electrified Railway on Oil Depot by Military Railway

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Abstract. Railway electrification transformation brought us transport efficiency, due to its high pressure, strong electromagnetic radiation characteristics also give the military oil depot brings great danger risk. The paper analysis the impact of electrified railway on oil depot by special military railway from the main line electrification, the military Line electrification, the length of special military railway , position , earth conductivity and the potential difference between earth and railway six respects. To provide a basis for doing the protection of the depot electrification project.

1. Introduction
Electrified railway has the characteristics of large traction quality, fast running speed, low transportation cost, reduction of environmental pollution and superior technical and economic performance. From 1961, China's first electrified railway baofeng railway was officially delivered and operated, and by the end of 2012, the operating mileage of electrified railway in China reached 48,000 km, ranking the first in the world. By the end of the 12th five-year plan for railway development, China's railway operating mileage will reach about 120,000 kilometers and the electrification rate will reach over 60%.With the development of China's railway electrification, most of the oil depot special line located along the railway has been electrified. Due to the characteristics of the electrified railway itself, the 27.5KV plus or minus 10% high pressure line on the contact network is directly introduced into the reservoir area, which poses a threat to the safety of oil depot, and also has a certain impact on the completion of the combat readiness and normal supply support tasks of the troops. In order to guarantee the safety of all kinds of war equipment under electrification, we must understand the influence mechanism of electrified railway on oil depot. This paper expounds the influence of electrification line on oil depot from the following aspects through field research.

2. Influence of Military Special Line Electrification on Oil Depot [1]
Because the electrified railway USES the contact network -- the rail circuit to supply power to the electric locomotive, the rail ACTS as a conductor in the power supply circuit, the electric locomotive picks up the flow through the contact network and returns back to the substation through the rail, forming a complete power supply circuit. In the rail - earth loop, there is leakage resistance between the track bed composed of sleeper and ballast and the rail, so the rail backflow through the leakage resistance generates rail - to - ground potential. The backflow of the rail through the leakage resistance causes the current flowing into the ground to increase the ground potential in the area.

Ac electric traction section. Traction current is via rail - earth regression substation, as shown in the figure below:
Figure 1. Schematic diagram of traction current reflux ($I_k$ Represents the current in the contact network; $I_g$ Represents the current in the rail; $I_i$ Represents the Ground current)

The regression current enters the ground from point B via the rail, which increases the potential of the rail to the ground. The current distribution in the rail is as follows:

Figure 2. Rail regression current distribution diagram ($I_{px}$, $I'_{px}$ Represents the regression current in orbit)

In the figure, the rail current in AB section is the vector sum of regression current and induction current, while the rail current outside AB section is regression current. That is to say, when the electric locomotive runs on the military special line of the electrified railway, the rail current between the electric locomotive and the substation is the vector sum of the rail return current and induced current, while the rail from the locomotive to the end of the military special line is the return current. According to the variation trend of rail current in the figure, the rail current is the largest at the ground end of the substation and the position of the locomotive.

Regression current in rail: $I_{dpx} = \frac{I}{2} e^{-\gamma_{px} x}$ [2]

Where: $I_{px}$ is the regression current in orbit (A); $I_i$ Represents the incoming current (A); $\gamma_p$ Represents the propagation constant (1/Km) of the "rail - earth" loop here.

It can be seen that the rail current changes along the x value in an exponential curve. The higher the value of x, the greater the rail potential to ground, and the smaller the rail potential to ground. X represents the distance between the electric locomotive and the loading and unloading platform of the oil depot.

When the electric locomotive is located near the loading and unloading platform of the special military line, x=0 indicates that the rail current at the loading and unloading oil platform in the reservoir area where the locomotive is located is the largest, and the current in the rail and the rail have the highest potential to the ground, which is the most harmful to the dangerous goods warehouse,
especially the oil depot.

3. The Influence of Positive Line Electrification on Oil Depot

The rise of the ground potential of the rail of military special line is caused by the superposition of the conduction component of the backflow of the rail of the positive line electrified railway and the induction component of the contact network current on the rail.

3.1. Conduction Component

The special line in the reservoir area is generally shorter, and there are many cases that are obliquely close to or perpendicular to the direct line railway. Therefore, the conduction component of the backflow of the positive line rail is the main reason for the increase of the potential of the special line rail to the ground.

The electric locomotive on the direct line railway is in continuous operation, which is generally divided into three situations: the locomotive is located on the left side of the contact point, the locomotive is located on the contact point, and the locomotive is located on the right side of the contact point.

![Figure 3](image1.png)

**Figure 3.** Track current distribution diagram of locomotive at the left side of point C ($I_k$ represents the current in the contact network; $I_g$ represents the current in the rail)

![Figure 4](image2.png)

**Figure 4.** Track current distribution diagram of locomotive at point C ($I_k$ represents the current in the contact network; $I_g$ represents the current in the rail)
According to the analysis of these three working conditions, as long as there is a locomotive running on the line, there is a current flowing through the dedicated line, but the direction and composition of the current are different. When the locomotive is at point C, the regression current shunt to the dedicated line is larger. When the locomotive is located to the right of point C, the current in the dedicated line is mainly the regression current, and there is no induced current in the contact network. The potential and current located at point C in the positive rail can be transmitted to the end of the special line into the ground along the special line and return to the substation via the earth.

3.2. Induction Component

The induced voltage on the rail of the railway military special line is due to alternating magnetic field generated by alternating current on the contact network. Through the mutual inductance M between the contact network and the rail, induced electromotive force is generated in the rail by the changing magnetic field, and thus induced current is formed in the rail, which is superimposed and propagated along the rail. This is the mutual sense between the contact network and the rail. The schematic diagram is as follows:

According to the principle of mutual inductance, the induction current on the rail is related to the length of induction, the frequency of contact network current, the conductivity of the rail, the grounding resistance and the earth conductivity.
3.3. Ground Potential and Current of Rail

Based on the above analysis of the rail return current and induced current, the rail ground potential and current of the military special line can be obtained by vector sum of the induction component and conduction component. The rail ground potential and rail reflux of the military special line are:

$$\overline{U}_x = \overline{U}_{mpx} + \overline{U}_{dpx}$$

Where: $\overline{U}_x$ represents the ground potential (V) of the rail of the special military line; $\overline{U}_{mpx}$ Represents the induction voltage component (V); $\overline{U}_{dpx}$ Represents the conduction voltage component (V)

$$\overline{I}_x = \overline{I}_{mpx} + \overline{I}_{dpx}$$

Where: $\overline{I}_x$ represents ground current (A) from rail of military special line; $\overline{I}_{mpx}$ Represents the induced current component (A); $\overline{I}_{dpx}$ Represents the conduction current component (A)

Because there is leakage resistance between the rail and the ground, the current in the rail takes conduction component as the main component, induction component is generally small, sometimes can ignore.

4. The Influence of Length of Military Special Line on Oil Depot

Trunk line electrification railway’s influence on the oil depot is associated with the length of the special military line, took the flow when the trunk line electrification railway electric locomotive, the branch line rail rail as the trunk line, the line on the rail there are rail backflow, the line current on the rail by stray current in the land along the rail assembled, exponential curve. That is, the longer the military special line, the smaller the rail potential to ground at the end of the military special line, and the shorter the rail potential to ground at the end of the military special line.

Through field tests, it is found that the length of military special line over 2 km is generally less affected. When the main line passes through the truck, the ground potential of the rail is relatively small when it is tested near the loading and unloading platform in the reservoir area, which is generally below 2 V. If the distance between the military special line and the loading and unloading oil platform is within 2 km from the joint gauge point, the influence is relatively large, and the actual test results show that the rail has high ground potential, and the maximum measured value can reach 18.6v.

Influence of relative position of military special line and direct line on oil depot

In the actual test of the ground potential of the steel rail at the end of the military special line when the main line passes the electrified locomotive, the following situations will occur in different oil depot:

1) when the locomotive has not reached the oil depot test point, the rail potential to the ground gradually increases; when the locomotive reaches the oil depot test point, the rail potential to the ground is the highest; when the locomotive is far away, the rail potential to the ground gradually decreases.

2) when the locomotive has not reached the test point of oil depot, the rail's potential to the ground does not increase significantly. When the locomotive reaches the test point of oil depot, the rail's potential to the ground is not the highest.

3) when the locomotive has not reached the test point of oil depot, the ground potential of the rail starts to rise, and gradually decreases when it reaches the highest level. When the locomotive passes the test point of oil depot, the rail potential is not high.

4) the potential distribution on the rail of the military special line, the potential of the contact point is high, and it gradually decays in line with the exponential curve, and decays to the minimum when it reaches the end of the military special line.

5) the potential distribution on the rail of the military special line, the terminal potential of the military special line is the highest, and it gradually decreases in line with the exponential curve.

The above situation will occur in different oil depot, which is caused by the difference of the
the main line railway, the loading and unloading oil platform of the oil depot, the oil storage area and the mutual location. Electrified railway power supply section length range from 10 km to a few tens of kilometers, the railway, winding catenary above railway erection, when the locomotive in the power supply section, rail by rail - earth loop flow back to the substation, flows through the earth return current caused by the stray current, the earth if by the way these stray current flows through a terminal area, will result in the reservoir of ground potential rise, after the reservoir of stray current intensity, direction and other factors will have different effect to rail to earth potential, through the reservoir area the stronger private sidings rail backflow of stray current, the higher the private rail to earth potential will be. If the flow direction is from the end of the military special line in the reservoir area to flow back to the substation, the ground potential of the rail at the end of the reservoir area will be higher than the potential of the joint. If the direction of the return current is from the joint point to the loading and unloading oil platform at the end of the military special line, the potential at the joint point is the highest, and the oil platform at the end of the military special line decreases gradually in line with the exponential curve.

The mutual position of railway military special line, main line, oil depot loading and unloading platform, oil storage area and so on has different influence on the flow direction of the return stray current in the ground.

The influence of the earth conductivity on oil depot
The earth conductivity is an important parameter in mutual inductance, the traction current in electrified railway catenary will on surrounding parallel with metal conductor produced by the principle of electromagnetic induction and the longitudinal electromotive force and inductive current, the size of the induced current is associated with mutual inductance, mutual inductance and the size of the associated with the size of the earth conductivity, can say, induction voltage and current is the dependent variable, the earth conductivity is the independent variable. The smaller the earth conductivity value indicates that the soil resistivity is high and the soil conductivity is poor, the higher the induction voltage will be. On the contrary, the higher the earth conductivity value indicates that the soil resistivity is small and the soil conductivity is good, the smaller the induction voltage will be. The earth conductivity has an influence on the stray current in the ground. The earth conductivity is small, the soil resistivity is high, the soil conductivity is poor, the potential gradient of stray current in the soil is large, the ground potential increases, and conversely the ground potential decreases.

Rail to earth potential are also associated with the earth conductivity, the conductivity is small, high soil resistivity, the conductivity of the soil is poor, the rail current to ground leak resistance will also increase, the rail current is not easy to leak to the ground, cause rail current is big, high potential, rail for small vice rail current, rail to earth potential.

Influence of rail on ground potential difference of military special line
The rail to ground potential difference, which is the voltage difference between rail and ground, is one of the key points for protecting electrified railway. Common rail to ground potential can reach dozens of volts, high speed and heavy duty railway can reach several hundred volts, when rail to ground potential reaches 60 V or above, it will cause harm to the human body, and will also cause damage to the signal equipment on the rail or other equipment associated with the rail.

Electrification railway private sidings military in the use of electric locomotive shunting operation, when walking on electric locomotive in the special line, the current rail can reach tens of amperes to hundreds of amperes, rail to earth potential can reach dozens of volts to hundreds of V, the harm of it mainly depends on when the voltage reaches a certain degree, will produce is the spark discharge phenomenon, the general rail to earth potential to reach a minimum of 2 V in contacts with other metal objects, it is obvious of edm, this for military railway private sidings to operate near the line workers, line on the use of precision instrument is very dangerous.

In military warehouse loading and unloading operations of dangerous goods, especially in the process of oil and other liquid dangerous goods warehouse handling, loading and unloading crane tube with pot mouth close distance, crane tube when loading and unloading oil and fuel tank mouth of the inevitable happens contacts, and both of the potential difference of different, very likely spark, and the dangerous goods such as fuel in the tank mouth site volatile concentration is very big, when the oil vapor concentration reaches explosion limit, rail and crane tube potential difference is 0.7 V, spark
energy just 0.15 mm focal, a serious threat to private sidings and warehouse security [3].

With the continuous development of railway electrification in China and the continuous advancement of railway electrification transformation of military special line, it is bound to produce hidden danger to the oil depot of military special line. Therefore, we should start from the influence of electrified railway on military special line, reduce the potential of rail to ground, reduce the rail reflux in the rail, and reduce the potential difference between rail and other metal objects, so as to eliminate the potential risk of electric spark, and provide guarantee for the safety of the loading and unloading operation of military special line oil depot under electrification.

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