Inspection scheme and disposal measures for abnormal vibration and noise of EMU

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Abstract. There are different forms of abnormal vibration and abnormal noise of the EMU, involving many types of components, and many components cannot be judged through visual inspection, and some components cannot even be visually inspected. This article analyzes the characteristics of different types of vibration or abnormal sounds, and provides suggestions for troubleshooting and treating measures to guide subsequent similar failures.

1. Introduction
The EMU is subject to track or airflow disturbances during the operation of the EMU and the vehicle will vibrate. If the vehicle or track-related components are loose or have other abnormalities, the vehicle vibration will increase. By summarizing the problems of abnormal vibration and abnormal sounds except for the impact of foreign objects during the past year, this article analyzes the characteristics of different types of vibration or abnormal sounds, and provides suggestions for troubleshooting and treating measures to guide subsequent similar failures.

2. Typical abnormal vibration or abnormal noise cases and treatment measures

2.1. Abnormal vibration caused by abnormal wheels
When there are defects inside the wheel, wheel polygons and dynamic imbalance exceeding the limit, abnormal vibrations will occur during operation with abnormal sounds¹⁻³.

2.1.1. Wheels with hard spots or internal defects due to rolling contact fatigue

Fig 1 Wheel with hard spots
Fig 2 Defects inside the wheel (before and after repairs)
Failure phenomenon description: During the high-speed operation of the EMU, vibration and abnormal noise are not noticeable in the carbody. When the EMU enters or leaves the garage, abnormal sounds can be clearly heard outside the vehicle at low speeds. When the wheels turn over the abnormal point, a low-pitched "squeak" sound is emitted, and the vibration and noise frequency is the wheel rotation frequency.

| Speed               | Frequency | Sound characteristics | Master control | Line characteristics | Vibration       |
|---------------------|-----------|-----------------------|----------------|---------------------|-----------------|
| All speed level     | Wheel rolling frequency | low-pitched "squeak" | Unrelated     | Unrelated          | Not obvious     |

Failure reason description: There are hard points at the wheel tread or internal defects caused by rolling contact fatigue, which causes the wheel to be out of round. The fault point is generally located near the rolling circle.

Troubleshooting: When the train enters or leaves the garage, the inspector can follow the faulty wheel outside the car, identify the faulty part of the wheel, and focus on the suspicious part after the train stops. This kind of wheel abnormality is generally difficult to detect only by visual inspection, and it is necessary to pay attention when wheel repairing.

On-site disposal measures: Wheel repair, when there are hard points on the wheels, the amount of feed can be increased appropriately.

2.1.2. Abnormal wheel shape

Symptom description: EMUs have low abnormal noise at low speeds, which can hardly be felt, and howling sounds at high speeds can be heard everywhere in the car. The vibration is not strong at each speed.

| Speed               | Frequency | Sound characteristics | Master control | Line characteristics | Vibration       |
|---------------------|-----------|-----------------------|----------------|---------------------|-----------------|
| All speed level     | High      | howling sounds        | Unrelated      | Unrelated          | Not obvious     |

Failure reason description: When the wheel is trimmed, the amount of feed is large, which causes the machine to shake. Generally, it occurs on the wheelset with a large amount of wheel trim.

Troubleshooting: Check the wheels after the train enters the garage. There are corrugated undulations on the wheel rims. It can be clearly felt the height by touching the hands. The same phenomenon exists on both wheels of the same wheel pair.

On-site disposal measures: wheel repair.

2.1.3. Wheel-to-wheel imbalance exceeded

Fault phenomenon description: Vibration is not obvious at low speed, and vibration is significantly intensified when the speed reaches above 260km / h. It is vertical vibration, and the vibration frequency
is the wheel rotation frequency. When standing on the floor above the bogie on the faulty wheel, the leg can obviously feel the vertical vibration. When standing for a long time it can obviously feel the legs numb. You can obviously feel the vibration attenuation away from the floor directly above the bogie. Vibration is transmitted to the car, which can excite seat, floor and roof vibration. No abnormal sound is emitted from the wheelset and seat and roof vibration can be heard in the car.

Table 3 Vibration characteristics caused by wheelset dynamic imbalance exceeding

| Speed          | Frequency                      | Sound characteristics                                      | Master control | Line characteristics | Vibration |
|----------------|--------------------------------|-----------------------------------------------------------|----------------|----------------------|-----------|
| Above 260km/h  | Wheel rotation frequency       | no abnormal sounds on the wheelset, mainly the sounds from the interior components | Unrelated      | Unrelated            | Strongly  |

![Fig 4 Vibration frequency characteristics](image)

![Fig 5 Vibration area](image)
Failure reason explanation: The wheel is unbalanced due to the accumulation of dust inside the wheel or poor assembly quality.

Troubleshooting: After confirming that there are no abnormalities in the floor, various parts of the equipment compartment and the air duct, you can use an endoscope to check for foreign matter accumulation in the wheel brake discs.

On-site disposal measures: Remove foreign objects inside the wheel brake disc or replace the wheel set.

2.2. Vibration due to abnormalities of the parts at bottom of the vehicle

When the parts at bottom of the vehicle are loose, it is prone to abnormal vibration due to the vibration excitation of the wheel pair or the external air flow. Such failures can only be excited when the vehicle reaches a certain speed.[4-5]

2.2.1. Abnormal vibration of wheelset excitation

Fault phenomenon description: The fault phenomenon is consistent with the wheel-to-wheel imbalance exceeding. The vibration area is located directly above the loose parts. Vibration is transmitted into the car, which can excite seat, floor and roof vibration. In the car, the vibration of the seat and roof can be heard.

Table 4 Vibration characteristics of parts at bottom of the vehicle excited by the wheel

| Speed          | Frequency          | Sound characteristics          | Master control | Line characteristics | Vibration     |
|----------------|--------------------|--------------------------------|----------------|----------------------|--------------|
| Above 260km/h  | Wheel rotation freq | Mainly the sounds of interior parts | Unrelated     | Unrelated            | Strongly     |

Failure reason description: The components are loose and excited by the wheel vibration. The main suspicious components are the floor, the traction motor air duct and the traction motor blower. See Figure 5 for relevant installation parts.

Troubleshooting: Check the floor, traction motor air duct, traction motor blower, and equipment compartment for any abnormality. The floor can be stepped on to determine whether the floor is loose or not and whether other components need to be removed or replaced.

On-site disposal measures: Reinforce or replace loose parts and repair the wheels.

2.2.2. Abnormal vibration caused by external airflow disturbance

Fault phenomenon description: The fault occurs in the main control car, the sound is most obvious at the floor of the driver's cab, and the vibration in the car is not strong. It is related to the running direction of the vehicle. When the speed reaches a certain level, the vibration of the abnormal components will increase, and the abnormal noise will be obvious. It appears as high-frequency metal impact sound, especially in the straight section.

Table 5 Vibration characteristics of parts at bottom of the vehicle being disturbed by airflow

| Speed          | Frequency          | Sound characteristics          | Master control | Line characteristics          | Vibration     |
|----------------|--------------------|--------------------------------|----------------|-------------------------------|--------------|
| Only appear when speed reaches a certain level | High frequency | Metal impact | Related | Obvious in the straight section | Not strongly |

Failure reason description: The component is loose and disturbed by the airflow.

Troubleshooting: Compare with other normal vehicles to check the faulty hood and body flash seam. Focus on checking the floor and relevant parts of the hood. A rubber hammer can be used to hit each windward part to check whether each part is trembling (Vibration sounds longer after tapping).

On-site disposal measures: Retighten loose parts, if necessary, add rubber pads to reduce vibration.

2.3. Abnormal noise caused by dampers

It mainly occurs in yaw damper and lateral dampers.

Fault phenomenon description: When the vehicle is crossing a turn or a turnout, standing at the side door, obvious abnormal noise can be heard when leaning against the door with ears. It is more obvious...
at low speeds with sound of crisp "click" and low "hum", but the vibration is not strong.

| Speed                          | Frequency       | Sound characteristics | Master control | Line characteristics | Vibration  |
|-------------------------------|----------------|-----------------------|----------------|---------------------|------------|
| All speed level, obvious at low speed | Same as damper | Crisp "click" and low "hum" | Unrelated | Turns or turnouts | No vibration |

Table 6 Abnormal sound characteristics of dampers

Fig 6 Yaw damper and lateral dampers loading position

Failure reason description: The internal bottom valve has a low roughness and is in close contact with the bottom valve seat, which results in a large internal oil pressure difference. When the valve is opened, high-pressure oil passes through and produces abnormal noise.

Troubleshooting: When the speed of the vehicle is low, stand at the side door, put your ear against the door, and pay attention to observation. If the abnormal noise is only emitted when the vehicle passes a curve or a turnout, it can basically be determined as an abnormal noise from an yaw damper or a lateral damper.

On-site disposal measures: This problem does not affect the normal operation of the vehicle, and the damper can be replaced if necessary.

2.4. Abnormal sound of axle end grounding device

Symptom description: There are abnormal sounds at each speed level, but it is difficult to hear in the car. The main reason is that when entering or leaving the maintenance garage at low speeds, when standing at the bogie, abnormal noises can be heard, which is manifested as a sharp sound when the vehicle starts. There is no vibration, and has nothing to do with the direction of the main control.
Table 7 Abnormal noise characteristics of axle end grounding device

| Speed                          | Frequency | Sound characteristics | Master control | Line characteristics | Vibration |
|-------------------------------|-----------|-----------------------|----------------|---------------------|-----------|
| All speed level, obvious at low speed, occur when start | High      | Sharp                 | Unrelated      | Unrelated           | No vibration |

Fig 7 Axle end grounding device

Failure cause description: There is friction between the carbon brush and the friction ring, there is sound under normal conditions, and there are loud sounds in some cases, but this sound generally appears briefly. After the grounding device is used for a period of time, the sound will disappear.

Troubleshooting: When the train enters or leaves the garage, the inspector can follow the faulty wheelset outside the car, and the car will make a sound when it starts. This problem cannot be directly checked and determined on the spot, because the components of the axle end grounding device are normal, which can be checked by replacing the axle end grounding device.

On-site disposal measures: This problem does not affect the normal operation of the vehicle. If necessary, the axle end grounding device can be replaced.

2.5. Abnormal sound of the valve body of the sanding device

Failure phenomenon description: The one-way check valve of the sand spreading device is only installed in the head and tail car. It is installed on the skirt side of the equipment compartment. The valve can be seen when the skirt is opened. No abnormal sounds can be heard in the car during operation, mainly due to the high-frequency “humming” sound that can be heard at the equipment compartment when parking with high voltage electricity in the garage.

Table 8 Abnormal noise characteristics of the valve body of the sanding device

| Speed              | Frequency | Sound characteristics | Master control | Line characteristics | Vibration   |
|--------------------|-----------|-----------------------|----------------|---------------------|-------------|
| Exist, regardless of speed | High      | "Buzz" sound           | Unrelated      | Unrelated           | No vibration |
Failure reason description: The sanding device check valve spool is poorly lubricated during assembly.

Troubleshooting: Turn on high voltage when parking in the garage, open the skirt of the head and tail car equipment compartment, and check whether there is abnormal noise at the check valve at the sand spraying cylinder.

On-site disposal measures: This problem does not affect the normal operation of the vehicle. If necessary, the check valve can be replaced.

2.6. Abnormal sound of air-conditioning compressor in driver's cab

Fault phenomenon description: The driver's cab air-conditioning compressor is only installed in the head and tail car, installed in the equipment compartment, you can see in the skirt. During the operation, abnormal noises can be heard, concentrated near the co-pilot in the driver's cab, and accompanied by vibration; failures are mainly detected during maintenance in the garage. Standing on the side of the skirt where the compressor is located, obvious abnormal noises can be heard. The abnormal sound has nothing to do with the speed, it also exists at a stationary state. It exists when the compressor starts. It is a high-frequency "click" sound, which has nothing to do with the main control.

Table 9 Abnormal noise characteristics of air-conditioning compressor in driver's cab

| Speed                  | Frequency | Sound characteristics | Master control | Line characteristics | Vibration |
|------------------------|-----------|-----------------------|----------------|----------------------|-----------|
| Exist, regardless of speed | High      | "click" sound          | Unrelated      | Unrelated            | With vibration |

Fig 9 Air conditioner compressor installation status of driver's cab after equipment compartment skirt is opened
Failure reason description: The internal cross slip ring of the compressor is poorly lubricated and wears out. Long-term use causes continuous wear and tear, and eventually produces abnormal noise. Or it is caused by the defect of the compressor itself.

Troubleshooting: You can judge by closing the cooling mode of the air conditioner in the driver's cab during operation, and open the skirt to determine the location during maintenance in the garage.

On-site disposal measures: This problem does not affect the normal operation of the vehicle. Replace the air-conditioning compressor in the driver's cab in a timely manner.

2.7. Abnormal noise when movable cover is closed

Failure phenomenon description: During the operation, abnormal sounds can be heard in the car, and the sound above the movable cover at the side wall of the car body is more obvious. The abnormal sound is the sound of metal collision. The abnormal sound is obvious at high speed, without vibration. It has nothing to do with the main control.

Table 10 abnormal noise characteristics of movable cover closing

| Speed               | Frequency | Sound characteristics | Master control | Line characteristics | Vibration    |
|---------------------|-----------|-----------------------|----------------|----------------------|--------------|
| Obvious at high speed | High      | Metal impact          | Unrelated      | Unrelated            | No vibration |

Fig 10 movable cover

Failure reason description: There is a gap between the movable cover roller and the slideway. Under the action of aerodynamic load during operation, the roller and the slideway produce abnormal noise. Or the movable cover is not closed.

Troubleshooting: Check whether there are similar abnormal noises in the moving movable cover one by one; check whether there is abnormal wear or loose parts on the cover slide.

On-site disposal measures: Reinforce loose parts or close movable covers.

3. Summary

There are various forms of abnormal vibration and abnormal noise of the EMU, involving many types of components, and many components cannot be judged through visual inspection, and some components cannot even be visually inspected, so this type of fault handling is more difficult. Through the above analysis of abnormal vibration and abnormal noise, the source of the fault can be determined quickly. If the fault has not been eliminated through the above measures in operation, it is recommended to determine the source of the fault through vibration or noise test and vibration or noise transmission.
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