What is claimed is:

1. A railroad equipment state determination apparatus comprising:

a storage that stores a plurality of operation data associated with a prescribed operation performed by railroad equipment that is driven by a motor from a stopped state to perform the prescribed operation and then comes into the stopped state again;

an evaluation criteria setting section that sets evaluation criteria based on the plurality of operation data stored in the storage; and

a determination section that determines whether new operation data resulting from the prescribed operation newly performed by the railroad equipment is abnormal based on the evaluation criteria.

2. The railroad equipment state determination apparatus as defined in claim 1, wherein

the storage stores the operation data in association with operation dates, and

the evaluation criteria setting section sets the evaluation criteria based on the operation data for a predetermined number of days nearest the operation date of the new operation data.

3. The railroad equipment state determination apparatus as defined in claim 1 or 2, wherein

the operation data includes data of operation time of the prescribed operation,

the evaluation criteria setting section sets an operation time threshold condition for determining that the operation time is abnormal as one of the evaluation criteria, based on distribution of the operation times included in the operation data, and

the determination section determines whether the operation time included in the new operation data is abnormal based on the operation time threshold condition.

4. The railroad equipment state determination apparatus as defined in any one of claims 1 to 3, wherein

the operation data includes data of operation time of the prescribed operation,

the determination section performs:

calculating an operation time abnormality relating to the new operation data, based on the operation time included in the new operation data and the distribution of the operation times included in a predetermined number of the operation data before the prescribed operation associated with the new operation data; and

determining whether the new operation data is abnormal based on whether the operation time abnormality satisfies a given operation time abnormality threshold condition, and

the evaluation criteria setting section sets the operation time abnormality threshold condition as one of the evaluation criteria, based on the operation time abnormalities calculated in the past.

5. The railroad equipment state determination apparatus as defined in claim 1 or 2, wherein

the operation data includes data of quantity of electricity required for the prescribed operation,

the evaluation criteria setting section sets an quantity of electricity threshold condition for determining that the quantity of electricity is abnormal as one of the evaluation criteria, based on distribution of quantity of electricity included in the operation data, and

the determination section determines whether the quantity of electricity included in the new operation data is abnormal based on the quantity of electricity threshold condition.

6. The railroad equipment state determination apparatus as defined in claim 1, 2, or 5, wherein

the operation data includes data of the quantity of electricity required for the prescribed operation,

the determination section performs:

calculating an quantity of electricity abnormality relating to the new operation data, based on the quantity of electricity included in the new operation data and distribution of the quantity of electricity included in a predetermined number of the operation data before the prescribed operation associated with the new operation data; and

determining whether the new operation data is abnormal based on whether the quantity of electricity abnormality satisfies a given quantity of electricity abnormality threshold condition, and

the evaluation criteria setting section sets the quantity of electricity abnormality threshold condition as one of the evaluation criteria, based on the quantity of electricity abnormalities calculated in the past.

7. The railroad equipment state determination apparatus as defined in any one of claims 1 to 6, wherein

the operation data includes data of drive transition information indicating drive information of the motor at each timing during the prescribed operation,

the evaluation criteria setting section sets statistic transition information that indicates transition of statistics determined by statistically computing the drive information at each timing during the prescribed operation as one of the evaluation criteria, based on the drive transition information included in the operation data, and

the determination section performs:

calculating transition of a degree of abnormality relating to the new operation data by comparing the drive transition information included in the new operation data with the statistic transition information at each timing during the prescribed operation;

calculating a total degree of abnormality by synthesizing the transition of the degree of abnormality; and

determining whether the new operation data is abnormal based on the total degree of abnormality.

8. The railroad equipment state determination apparatus as defined in claim 7, further comprising a total abnormality storage that stores the total degrees of abnormality calculated in the past, wherein

the evaluation criteria setting section sets a total abnormality threshold condition for determining that the new operation data is abnormal as one of the evaluation criteria, based on the total degrees of abnormality stored in the total abnormality storage, and

the determination section determines whether the new operation data is abnormal based on whether the total degree of abnormality of the new operation data satisfies the total abnormality threshold condition.

9. The railroad equipment state determination apparatus as defined in claim 7 or 8, wherein

the prescribed operation includes a displacement operation of displacing a moving part by the railroad equipment, and

the drive transition information is information that indicates transition of the drive information with a displacement position of the moving part at each timing during the prescribed operation.

10. The railroad equipment state determination apparatus as defined in claim 7 or 8, wherein

the prescribed operation includes a displacement operation of displacing a moving part by the railroad equipment, and

the drive transition information is information that indicates transition of the drive information with a lapse of time from start to end of displacement of the moving part at each timing.

11. The railroad equipment state determination apparatus as defined in any one of claims 7 to 10, wherein the drive information is information of torque or current.

12. The railroad equipment state determination apparatus as defined in any one of claims 1 to 11, wherein the railroad equipment is any of switch machine, railroad crossing gate, and platform door.

13. A railroad equipment state determination method comprising:

an evaluation criteria setting step of setting evaluation criteria based on data that is an accumulation of operation data associated with a prescribed operation performed by railroad equipment that is driven by a motor from a stopped state to perform the prescribed operation and then comes into the stopped state again; and

a determination step of determining whether new operation data resulting from the prescribed operation newly performed by the railroad equipment is abnormal based on the evaluation criteria.

Claims

[Claim 1]

A railroad equipment state determination apparatus comprising:

a storage unit that stores a plurality of pieces of operation data corresponding to drive information of a motor relating to one cycle of operation of railroad equipment in which a mechanical part in a stopped state performs the operation with the motor as a power source and then turns into the stopped state;

an evaluation criteria generation unit that generates evaluation criteria operation data relating to the one cycle of operation, based on the stored plurality of pieces of operation data;

an abnormality transition calculation unit that sequentially associates and compares the new operation data of the railroad equipment with the evaluation criteria operation data from the start to end of the one cycle of operation, thereby to calculate transition of the degree of abnormality in the one cycle of operation relating to the new operation data;

a total abnormality calculation unit that synthesizes the transition of the degree of abnormality to calculate total degree of abnormality relating to the one cycle of operation; and

a determination unit that determines whether the new operation data is abnormal by comparing the total degree of abnormality with a given determination criteria.

[Claim 2]

The railroad equipment state determination apparatus as defined in claim 1, further comprising:

a total abnormality storage unit that stores the total degrees of abnormality calculated in the past; and

a determination criteria setting unit that sets the given determination criteria based on the stored total degrees of abnormality.

[Claim 3]

The railroad equipment state determination apparatus as defined in claim 2, wherein

the storage unit stores the operation data in association with an operation date,

the total abnormality storage unit stores the total degree of abnormality in association with accompanying information of the operation relating to the total degree of abnormality, the accompanying information including at least one of the operation date, operation time, operation environment information, and weather information,

the evaluation criteria generation unit generates the evaluation criteria operation data based on the operation data for a predetermined number of latest dates, and

the determination criteria setting unit extracts, from the total degrees of abnormality stored in the total abnormality storage unit, the total degree of abnormality satisfying a predetermined proximity condition to the accompanying information relating to the new operation data, and sets the determination criteria based on the extracted total degree of abnormality.

[Claim 4]

The railroad equipment state determination apparatus as defined in any one of claims 1 to 3, wherein

the operation includes at least a displacement operation of displacing a moving part by the mechanical part,

the operation data is data in which transition of the drive information of the motor in the one cycle of operation is associated with a displacement position of the moving part, and

the abnormality transition calculation unit performs the sequential comparison based on the displacement position of the moving part in the one cycle of operation.

[Claim 5]

The railroad equipment state determination apparatus as defined in any one of claims 1 to 3, wherein

the operation includes at least a displacement operation of displacing a moving part by the mechanical part,

the operation data is data in which transition of the drive information of the motor in the one cycle of operation is associated with a lapse of time from start to end of displacement of the moving part,

the evaluation criteria generation unit normalizes the stored plurality of pieces of operation data on a time axis to generate the evaluation criteria operation data in which time of the one cycle of operation is set as a predetermined normalized time, and

after the normalization of the new operation data on the time axis, the abnormality transition calculation unit performs the sequential comparison based on the lapse of time in the one cycle of operation.

[Claim 6]

The railroad equipment state determination apparatus as defined in claim 5, further comprising:

an evaluation criteria operation time generation unit that generates an evaluation criteria operation time based on an operation time relating to the one cycle of operation in each of the stored plurality of pieces of operation data; and

an operation time determination unit that determines that the new operation data is abnormal if the operation time relating to the new operation data satisfies a predetermined abnormal time length condition based on the evaluation criteria operation time.

[Claim 7]

The railroad equipment state determination apparatus as defined in any one of claims 1 to 6, wherein the drive information is information of torque or current.

[Claim 8]

The railroad equipment state determination apparatus as defined in any one of claims 1 to 7, wherein the railroad equipment is any of switch machine, railroad crossing gate, and platform door.

[Claim 9]

A railroad equipment state determination method comprising:

an evaluation criteria generation step of generating evaluation criteria operation data relating to one cycle of operation, based on accumulated operation data corresponding to drive information of a motor relating to the one cycle of operation of railroad equipment in which a mechanical part in a stopped state performs the operation with the motor as a power source and then turns into the stopped state;

an abnormality transition calculation step of sequentially associating and comparing the new operation data of the railroad equipment with the evaluation criteria operation data from the start to end of the one cycle of operation, thereby to calculate transition of the degree of abnormality in the one cycle of operation relating to the new operation data;

a total abnormality calculation step of synthesizing the transition of the degree of abnormality to calculate total degree of abnormality relating to the one cycle of operation; and

a determination step of determining whether the new operation data is abnormal by comparing the total degree of abnormality with a given determination criteria.