ISO TC 268/SC 1

Date: 2018-11-30

ISO/NWIP 3716X

ISO TC 268/SC 1/WG 3

Secretariat: JISC

Smart community infrastructures — Smart transportation using fuel cell LRT

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Document type: International Standard
Document subtype:
Document stage: (20) Preparatory
Document language: E

C:\Users\chiba\Downloads\Smart transportation using fuel cell LRT_c(Sf Oct31, 18)c(H, Oct. 31, 18)dcld.doc STD Version 2.1c2

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Foreword

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This document was prepared by Technical Committee ISO/TC 268, Sustainable development in communities, Subcommittee SC 1, Smart community infrastructures

Introduction

Light rail transit (LRT) has a history of over 100 years and plays an important role in urban public transportation. Because of smooth driving, comfortable rides and larger passenger capacity compared with bus vehicles, LRT has been widely adopted in many cities across the world. Conventional LRT is powered with electricity supplied from the outside of vehicles. Although LRT has achieved high energy efficiency, good operation stability and zero emission, there still exist some shortcomings therewith. The electric energy is supplied to LRT vehicles through catenaries and pantographs. The setting-up of catenaries and sub-stations calls for considerably high capital cost, takes long construction time and spoils urban views. Even though LRT is powered with electricity, a large portion thereof from power grids is generated by burning non-recoverable fossil fuels such as natural gas and coal. In the process of the power generation, greenhouse gases (GHGs) and small particles are still emitted into the air. Thus, “zero-emission” is not in a real sense in this case (see Annex A). The voltage of electricity would depend on power grids and service lines, resulting in poor interconnection availability in rail service networks by LRT. Furthermore, once grid power fails, the services would be suspended on the whole LRT lines. In addition, there is also LRT applied with energy storage technologies including batteries and super capacitors but their working distances per charge are not long enough for commercial services.

Fuel cell LRT solves such problems with conventional LRT, as pointed out above. Normally, hydrogen fuel cells are adopted as power sources for fuel cell LRT. It is not necessary to equip pantographs on rolling stock, hung catenaries or build up substations, resulting in beautiful urban view preservation with open sky, construction cost reduction, construction time saving and safety improvement by using no high voltage grids in a city. Furthermore, fuel cell-powered vehicles emit only water, to say nothing of no GHGs or small particles. Such LRT does not rely on grids for power supply any more. Thus, the vehicle can run on tracks with grids different in voltage and on non-electrified service lines, as long as the track gauges are the same. Moreover, thanks to the on-board power source, fuel cell LRT has high resilience, even when the grid power fails. Fuel cell LRT also has an advantage of longer running distances than other on-board energy storage LRT currently. Only one hydrogen refuel station can supply hydrogen sufficient to be consumed in quite long distance services by fuel cell LRT.

This document describes a procedure by smart transportation with fuel cell LRT to realize city centers and suburban areas that have zero-emission of GHGs and small particles and nice urban views without busy sky bothered with catenary cables, while smart transportation can save construction time without setting-up overhead catenaries, reduce construction cost and perform high interconnection ability between tracks different in catenary voltage.

Smart community infrastructures — Smart transportation using fuel cell LRT

1 Scope

This document specifies a procedure to realize city centers and suburbs with zero-emission of greenhouse gases (GHGs) and small particles, free of catenaries to maintain original urban views and easy LRT transportation facilities installation.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
Fuel cell LRT

LRT using hydrogen fuel cells only as a power source

NOTE LRT (Light rail transit) means transportation systems using light rolling stock with steel tires on segregated tracks (e.g. elevated, ground and/or underground).

3.2
Conventional LRT

LRT using catenaries or third rails to collect power

4 General

Fuel cell LRT uses hydrogen fuel cells as a power source to drive the vehicles. Compared with conventional LRT, fuel cell LRT has specific advantages. What hydrogen fuel cell LRT emits is pure water only. No small particles or GHGs are given. As an energy carrier, hydrogen can be used to store and deliver energy. Electricity left during off-peak hours or over-generated for some reasons can be stored in a form of hydrogen by water electrolysis. Then, the fuel energy stored can be used on demand by generating electricity in fuel cells equipped on LRT vehicles. Fuel cell LRT runs independently without power supply from grids. The elimination of overhead catenaries creates good urban views with clear sky. Also, the construction of catenaries and substations is unnecessary. Therefore, the services by fuel cell LRT can be deployed more quickly than those by conventional LRT, when starting services on new lines. Furthermore, the LRT has high interconnection ability between tracks different in catenary voltage. Fuel cell LRT has high resilience, since the power is not from grids that are normally so long but from on-board fuel cells locally placed on vehicles. Due to the higher energy capacity of hydrogen fuel cells compared with regular batteries, fuel cell LRT can run for a distance longer than battery LRT. What is more, the time needed for hydrogen refueling is much shorter than that for battery recharging.

One of the goals of this smart transportation is to run fuel cell LRT by still keeping the equivalent level in service performance and quality of conventional LRT or improving them further compared thereto. Fuel cell LRT systems in cities will contribute to solving city challenges, such as pollution problems, busy urban views, safety and interoperability of rolling stock on tracks with different catenary voltages or easy arrangements for service networks.

The fuel or hydrogen to be used for fuel cell LRT is produced by consuming electricity. If a hydrogen refueling station for the LRT can be furnished with generators working only with renewable energy resources, namely, sunlight, wind and biomass and the hydrogen produced in this way is supplied to the LRT vehicles, the LRT system provides perfect zero-emission transportation services in its network. This is another challenge or goal to be achieved in the future.

Smart transportation should contribute to develop a city and overcome such city issues by satisfying the purposes designated in ISO 37101: 2016 [3], still aiming at satisfying some Sustainable Development Goals by United Nations, especially Goal 7 “Ensure access to affordable, reliable, sustainable and modern energy for all,” Goal 8 “Promote inclusive and sustainable economic growth, employment and decent work for all,” Goal 9 “Build resilient infrastructure, promote sustainable industrialization and foster innovation,” Goal 11 “Make cities inclusive, safe, resilient and sustainable,” Goal 12 “Ensure sustainable consumption and production patterns,” Goal 13 “Take urgent action to combat climate change and its impacts” and Goal 15 “Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss.”

5 Operation of fuel cell LRT transportation systems

5.1 Objectives

As mentioned in Clause 4, fuel cell LRT operation designated by this document solves the specified city issues by achieving the same operation work as that carried out in conventional LRT operation. This Clause describes how fuel cell LRT transportation systems shall be organized to operate by satisfying the requirements designated in 5.2.

5.2 Minimum requirements to organize fuel cell LRT transportation systems

Basically, all procedures to operate fuel cell LRT should not necessarily be the same as those for conventional LRT, since fuel cell LRT has specific work, namely, refueling of hydrogen.

When operating fuel cell LRT vehicles through between LRT lines and conventional non-electrified rail tracks, fuel cell LRT operation shall not disturb current rail services on conventional non-electrified lines.

5.2.1 Recharging

Hydrogen refueling should be arranged dependently on round trip and standing-by time of individual LRT dispatches. The hydrogen amount to be usually stored in a hydrogen refueling station shall be large enough to supply to LRT vehicles in order to run in the service distance planned. Renewable energy resources should be highly recommended for perfect zero emission by the operation.

5.2.2 Scheduling/dispatching

Operation scheduling and LRT vehicle dispatching shall be optimized and organized to perform the properties of fuel cell LRT, including its specific work, namely, hydrogen refueling.

5.2.3 Maintenance work

To the maximum extent practical, all maintenance work, such as cleaning, inspecting and overhauling vehicles, shall be completed not to avoid specific work for fuel cell LRT, namely, hydrogen refueling. Fuel cell LRT uses power supplied in a way different from that of conventional LRT. The operation procedures, including hydrogen refueling, can be different from conventional LRT.

5.2.4 Passengers' services

All passenger's services, including fare payment, in-/out-coming, coach accommodations and passenger capacities, shall not be inconvenient or poor compared to those by conventional LRT.

5.2.5 Driving conditions

Fuel cell LRT shall be operated even under the weather and climate conditions, in which conventional LRT can be operated.

Fuel cell LRT shall be operated under the same traffic regulations and LRT driving conditions as those with conventional LRT.

5.2.6 Driving skills/performance

No specific skills or experiences shall be required to drive fuel cell LRT.

5.2.7 Emergency responses

Follow local regulations designated on emergency responses. Emergency response procedures for fuel cell LRT may be different from conventional LRT.

NOTE NFPA 130: 2017, "Standard for Fixed Guideway Transit and Passenger Rail Systems" [4], and EN 45545 series, "Fire Test to railway components" [5] to [11], will provide useful information on protection of rail operation and services from fire disasters.

5.2.8 Energy saving

The operation schedule and running performance of fuel cell LRT shall be optimized and controlled in order to save hydrogen consumption.

NOTE ISO 37161: 201X [12], Smart community infrastructures — Guidance on smart transportation to save energy consumption in transportation services in cities, suggests on how to save energy in transportation services.

6 Maintenance of the quality of fuel cell LRT transportation systems

6.1 General

To keep the performance of fuel cell LRT transportation systems in conditions planned, and confirm the effectiveness thereof, periodically observe the parameters listed up in 6.2.

6.2 Parameters to be observed

To make sure of performance of fuel cell LRT transportation systems, observe parameters indicated below to compare by using appropriate units:

—distance of tracks without catenary cables, which are created by installing fuel cell LRT;

—number of substations closed or removed by installing fuel cell LRT, in case conventional LRT is fully replaced with fuel cell LRT.

6.3 Modification of smart transportation

When finding no changes or decreases in the value of the parameters designated in 6.2, change the conditions of the smart transportation system in 5.2. To correct the transportation conditions, confirm anything unexpected at planning or irregular due to specific local situations taking place in the area where smart transportation was installed. Modify the current conditions of the smart transportation system operated, by making sure if the irregular conditions are acceptable.

Annex A
(Informative)

Advantages provided by operating fuel cell LRT [2]

Actually, no carbon dioxide emission is given by fuel cell LRT as shown in Figure A.1. Carbon dioxide emission by 100-km operation of conventional LRT by consuming electricity is 324 kg, which is generated by burning fossil fuels.

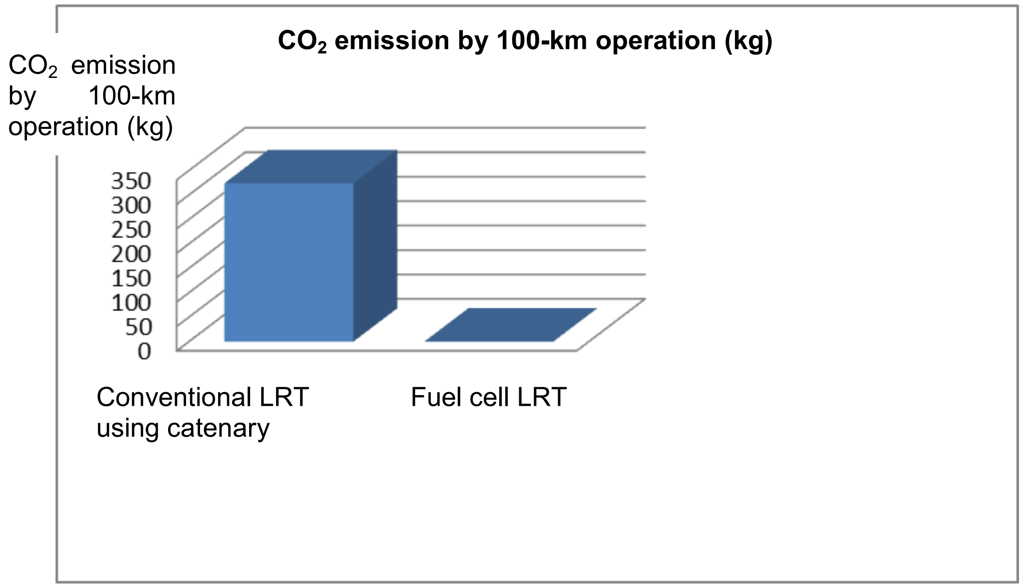

Figure A.1 — Decreases in carbon dioxide emission into the atmospheric environment by replacing conventional LRT with fuel cell LRT

NOTE The hydrogen fuel used for fuel cell LRT here is produced from renewable resources.

Bibliography

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[2] *A guideline for introducing electric bus*, Ministry of Land, Infrastructure, Transport and Tourism, Japan, June 2016, http://www.mlit.go.jp/common/000213732.pdf

[3] ISO 37101: 2016, *Sustainable development in communities - Management system for sustainable development - Requirements with guidance for use*

[4] NFPA 130, *Standard for Fixed Guideway Transit and Passenger Rail Systems*

[5] EN 45545-1, *Fire Protection of railway Vehicles — Part 1: General*

[6] EN 45545-2, *Requirement for fire behaviour of materials and components*

[7] EN 45545-3, *Fire resistance requirements for fire barriers and partitions*

[8] EN 45545-4, *Fire safety requirements for railway rolling stock design*

[9] EN 45545-5, *Fire safety requirements for electrical equipment*

[10] EN 45545-6, *Fire control and management system*

[11] EN 45545-7, *Flammable liquid and flammable gas installations*

[12] ISO 37161: 201X, *Smart community infrastructures — Guidance on smart transportation to save energy consumption in transportation services in cities*

[13] ISO 14044: 2006, *Environmental management - Life cycle assessment - Requirements and guidelines*

