INTERNATIONAL STANDARD

ISO 37182

First edition
2022-06

Smart community infrastructures — Smart transportation for fuel efficiency and pollution emission reduction in bus transportation services

Infrastructures urbaines intelligentes — Transport intelligent pour l'efficacité énergétique et la réduction des émissions polluantes dans les services de transport par autobus

Reference number
ISO 37182:2022(E)

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 268, *Sustainable cities and communities*, Subcommittee SC 2, *Sustainable cities and communities - Sustainable mobility and transportation*.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Massive energy consumption is one of the unavoidable issues that every modern city faces. To effectively provide transportation services for citizens and city visitors, cities need to continuously consume energy. There are significant benefits if energy consumption is reduced, even if the reduction amount is small at any given time or place.

In transportation operations, small efforts provide significant energy savings. Railway operations have options that can easily save energy. Modifying run curves in a train schedule is a typical example which minimizes energy consumed while running a train. This method has been used in railway operations for a long time.

In bus operations, it does not appear to be as easy to make such savings. Bus transportation services have tried to reduce energy or fuel consumption with experience accumulated over a long time. The best way to achieve fuel efficiency is to continually drive a bus at a speed up to and including the limit designated in each section on its route and to keep running at a constant speed. This method, while dependent on the bus driver's conduct, is still effective. Using telecommunication systems enables fuel efficiency to be achieved more successfully, by processing information on bus driving practices and then transmitting this to other places. These practices have already been shown to result in significant fuel efficiency in bus driving, even if such efforts are made locally or by individual bus drivers. However, as previously mentioned, widespread employment of this method will result in huge energy savings. Additionally, in engine-driven bus operations, there will also be a reduction in GHG, NOx/SOx and particle emissions. Bus transportation is the largest passenger service network, utilizing huge numbers of buses. This effort will contribute to a reduction in air pollutants emitted from these vehicles.

ISO Guide 82 has been taken into account in the development of this document with regards to addressing sustainability issues.

Smart community infrastructures — Smart transportation for fuel efficiency and pollution emission reduction in bus transportation services

1 Scope

This document describes criteria to organize smart transportation to save fuel in bus transportation services where the reduction of energy consumption is intended. Smart transportation aims not only at fuel efficiency, but at pollutant emission reduction for engine driven buses, as well as the financial stabilization of bus transportation services for citizens and city visitors.

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 terminology databases for use in standardization at the following addresses:

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

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

3.1
bus driving
running of a bus vehicle service for passenger transport purposes by a licenced bus driver

Note 1 to entry: Types of buses include commuter buses, bus rapid transit (BRT), inter-city buses and highway buses.

3.2
fuel
energy source of fossil fuel which is consumed by driving buses

Note 1 to entry: Examples of fossil fuels include petroleum and natural gas.

3.3
digitalized tachograph
on-board record of *bus driving* (3.1), which is digitally recorded during the driving after departure from a bus dispatch office until return thereto

3.4
crew report
document prepared by a bus driver on completion of a work schedule designated by his or her supervisors, in order to inform the supervisors of any issues while on duty, including incidents, accidents, bus-mechanical malfunctions and troubles in passenger services, especially while driving the bus

3.5
daily driving report
document prepared by combining a tachograph and a *crew report* (3.4), which also contains an evaluation of the manner in which the bus driver drove during the work schedule

4 Concept of smart transportation for fuel efficiency in bus transportation services

4.1 General

This clause describes the general criteria required for smart transportation to save fuel in bus transportation services. Bus operation driving procedures for fuel efficiency have not been quantitatively improved or upgraded for a long time. It has been passed on from generation to generation, by individuals or informally by the bus company without having specific policies in place. The technique of successfully reducing fuel consumption in bus driving is not a prescribed policy, but rather an informal practice by individuals. The most important skill is to drive the bus and not exceed the speed limit set in each section on a running route, but to keep running at a constant speed. This method has been fostered through the experience of bus drivers. Unfortunately, there has been no way to quantitatively evaluate how bus drivers follow these procedures and enforce proper practice for fuel efficiency. That condition has changed with electronic and telecommunication systems that have been developed to enable such evaluation by digitally combining a tachograph to record the bus running movement, in addition to a crew report that is normally prepared by hand by a bus driver on completion of a driving work schedule. Tachographs are not often mounted on board buses to record bus drivers' driving manners. Also, paper tachographs do not provide information on the details of driving manners taken in each section, on each route or on each service line. Digitalized tachographs can be transmitted and enable the driver's supervisors to know how the drivers drove their buses at any point or section over their entire route, which is indicated in the daily driving report containing evaluation results on bus driving manners. The tachograph, which is numerical, is analysed for evaluation by calculating the scores on driving manners at every point and section set to watch how many times and how long time the drivers deviated from the allowable ranges of the monitoring parameters, which are suggested in 5.4 and 5.5. The supervisors may, if necessary, intentionally weight the calculation by using weighting coefficients to stress and request careful driving at specific points and sections.

Once a bus driver submits a digitalized tachograph and a digital version of a crew report to their supervisors by transmitting through wireless communication, the data will then be automatically calculated in a simple algorithm to provide an evaluation of how the bus driver drove over the entire route. The drivers can then be shown where they should improve their driving and follow the advice given by their supervisors. The goal is not to penalize drivers for mistakes or poor driving manners. Rather, the goal is to improve the drivers' skills. This method is based on targeting motivation and ambition, with the aim of effectively enhancing driving manners that lead to a reduction in fuel consumption.

One significant benefit is that no special training of bus drivers is required to reduce fuel consumption, which also leads to a reduction in chemical pollutant emissions from engine-driven buses and financially benefits the bus transportation business. There are many bus companies that are not able to operate without being subsidized. A reduction in operating costs for the bus company will result in a reduction of public money needed for subsidies. Annex A introduces typical successful cases where smart transportation was adopted in a bus company with five bus dispatch offices.

4.2 Applicable city issues

The criteria for smart transportation described in this document are appropriate to address the city issues of large fuel consumption in bus transportation services, chemical pollutant emissions if buses are engine-driven, and financial stabilization of bus transportation business that provides citizens and city visitors with rides as regional and inter-city transportation.

4.3 Satisfaction of the United Nations Sustainability Development Goals (SDGs) by smart transportation

Smart transportation satisfies the following UN SDGs: goal 3 “Good health and well-being”, goal 7 “Affordable and clean energy”, goal 8 “Decent work and economic growth”, goal 9 “Industry, innovation and infrastructure", goal 10 "Reduced inequalities", goal 11 "Sustainable cities and communities", goal 12 "Responsible consumption and production", goal 13 "Climate action" and goal 15 "Life on land".

5 Adoption and implementation of smart transportation for fuel efficiency in bus transportation services

5.1 Objectives

Smart transportation for fuel efficiency in bus transportation services should be adopted and implemented by following the procedure in 5.3.

5.2 Target vehicles

The target vehicles are buses that are engine-driven by consuming fuel.

5.3 Procedure to adopt smart transportation

5.3.1 General

Smart transportation can be adopted into currently organized bus transportation services by following the procedure in this subclause. When employing smart transportation in new bus services, skip 5.3.2 but use digitalized tachographs that are forwarded to the bus driver's supervisor through wireless communication.

5.3.2 Transfer of tachographs

The tachograph on board shall be digitally recorded for submission to the bus driver's supervisor through wireless communication and evaluation of the bus driving manner employed by a bus driver.

5.3.3 Preparation and submission of crew reports

A bus driver should prepare a crew report in digital version at the time designated by their supervisor, normally on completion of the designated driving work schedule, and submit this to their supervisor.

5.3.4 Combination of digitalized tachographs and crew reports

To evaluate the bus driving manner employed by a bus driver, the digital data of the tachograph recorded automatically and the crew report prepared by the bus driver should be combined after collection of the tachograph and receipt of the crew report.

5.3.5 Evaluation of bus driving manners

A driver's practices shall be evaluated by comparing the parameter values on the driving manner recorded in the tachograph with allowable ranges in the parameters indicating driving skill. The parameters and the allowable ranges depend on every section on a driving route of a service line. The typical parameters and how to set the allowable ranges are described in 5.4 and 5.5, respectively.

5.3.6 Notice of the evaluation results to bus drivers and advice on their driving manners

The evaluation of a bus driver's practices of driving a bus is processed right after the driver's duty is finished. The result is forwarded by the bus driver's supervisor to the bus driver in order to personally advise the driver on their driving manner. An example of the evaluation results indicated in a daily driving report is shown in Annex B, which also includes a tachograph and a crew report.

5.3.7 Improvement of bus driving skill

The bus driver should recognize his or her mistakes and poor driving manners and consider how to improve these by carefully checking the evaluation results and advice, which their supervisors provided by reviewing their driving manner.

NOTE Bus drivers usually know how they should properly drive a bus on the route designated by their supervisor in advance of service driving, since they have already been trained in the proper driving manner by actually driving a bus on the route with their supervisors.

5.3.8 Confirmation of fuel consumption reduction

By comparing the amounts of fuel refuelled before and after adopting smart transportation, the reduction in fuel consumption by individual bus drivers or by a bus dispatch office to which the drivers are attached can be confirmed.

5.4 Parameters and their allowable ranges to evaluate driver practices when driving a bus

Parameters are used to evaluate bus driver practices when driving a bus. The typical parameters are listed below. The allowable range in each parameter should be set independently for each section of the route on which a bus runs:

NOTE 1 Section means part of a lane for bus services, which is between corners, traffic signals or bus stops where traffic conditions and regulations remain the same.

— maximum speed (e.g. local roads, highways, bus lanes or roads);

— number of times the speed limit set for bus driving in service is exceeded;

— time duration of exceeding the speed limit set for bus driving in service;

— number of times the engine revolution limit is exceeded;

— time duration of exceeding the engine revolution limit;

— number of sudden starts;

NOTE 2 Sudden stops are acceptable to avoid collisions and traffic accidents.

— number of rapid accelerations;

NOTE 3 Heavy or sudden braking is acceptable to avoid collisions and traffic accidents. However, rapid deceleration is used as a parameter for the evaluation from the viewpoint of fuel efficiency.

— number of rapid decelerations;

— time duration of rapid deceleration;

— time duration of idling or staying while leaving the engine revolutionized after stopping or before moving.

5.5 Setting the allowable range in the parameter

The allowable range in each parameter to evaluate driver practices when driving a bus should be set depending on the local state or situation and specific conditions in every section of the driving route on a service line.

The following parameters affect the allowable range:

— speed limit;

— other traffic restrictions applied to a target section;

— road characteristics (e.g. gradient, curve radius or linearity, corner angle, lane or road width, clearance, pavement adhesiveness, visibility, traffic lane formation).

6 Maintenance of the quality of smart transportation for fuel efficiency in bus transportation services

6.1 General

To maintain the intended performance of smart transportation for fuel efficiency in bus transportation services, and to confirm its effectiveness, the parameters in 6.2 shall be periodically observed.

6.2 Parameters to be observed

The parameters for comparing smart transportation performance are as follows (use appropriate units for observation):

— fuel consumption on the target route on a service line where smart transportation is installed;

— fuel consumption by the bus dispatch office servicing the target route;

— fuel consumption in the city or area with the target routes.

6.3 Modification of smart transportation

When no change is found in the value of the parameters designated in 6.2, modify the evaluation conditions for bus driving practices as laid out in 5.4 and 5.5. To correct the evaluation parameters and their allowable ranges, confirm anything unexpected at planning or irregular due to the specific situation of the route where smart transportation is installed. Modify the current conditions of the smart transportation system operated, especially the parameters in 5.4, by making sure that the irregular conditions are acceptable.

Annex A
(informative)

Effectiveness of smart transportation for fuel efficiency in bus transportation services

Table A.1 shows how much fuel a bus company saved by adopting smart transportation in Tokyo, Japan. It seemed a difficult task to save energy in bus operations, especially in a city with heavy traffic congestion, since the buses in such an area are repeatedly stopping and starting. Against expectations, however, fuel efficiency was accomplished by applying smart transportation. The results benefitted the bus transportation business financially, removing the need for subsidizing. In this case, therefore, smart transportation solved at least three city issues: fuel efficiency, chemical pollutant emission reduction and financial support to regional bus services. The fuel efficiency was achieved on every service line by individual bus drivers working for their respective bus dispatch offices, resulting in advantages for citizens and also for the atmospheric environment in the city.

Table A.1 — Fuel efficiency in bus operations for a year by smart transportation

Bus dispatch office	Running distance 1 000 km/y	Fuel consumed kl/y	Average running distance[a] km/l	Fuel saved kl/y	Saved cost for fuel USD/y[b]	Emission reduction estimated kg/y			
						CO	HC[c]	NOx	PM
Kichijoji	3 217	1 227	2,62	22	14 000	139	5,28	33,0	1,1
Musashi-Sakai	5 679	2 144	2,65	63	41 800	397	15,1	94,5	3,2
Komae	5 042	1 806	2,79	56	35 700	353	13,4	84,0	2,8
Noborito	4 696	1 883	2,49	58	40 300	365	13,9	87,0	2,9
Machida	4 174	1 382	3,02	33	19 900	208	7,92	49,5	1,7
Total	22 808	8 442	2,70	232	151 700	1 462	55,6	348	11,6

[a] The average distance when running a bus with 1-l fuel.

[b] Exchange rate of 110 JPY/USD.

[c] Hydrocarbons.

Annex B
(informative)

Example of a daily driving report, including a tachograph, a crew report and bus driving manner evaluation results

Figure B.1 provides an example of a daily driving report used by a public transportation bus company, which contains a tachograph and a crew report. The former is automatically recorded on board while the latter is prepared by a bus driver on completion of the driving work schedule. These digital documents are transmitted through wireless communication from the bus to the bus driver's supervisors and combined to include the evaluation results on the bus driving manner employed by the driver during the designated work schedule. After finishing work for the day, the driver reports to the supervisors, who then presents the driver with the evaluation.