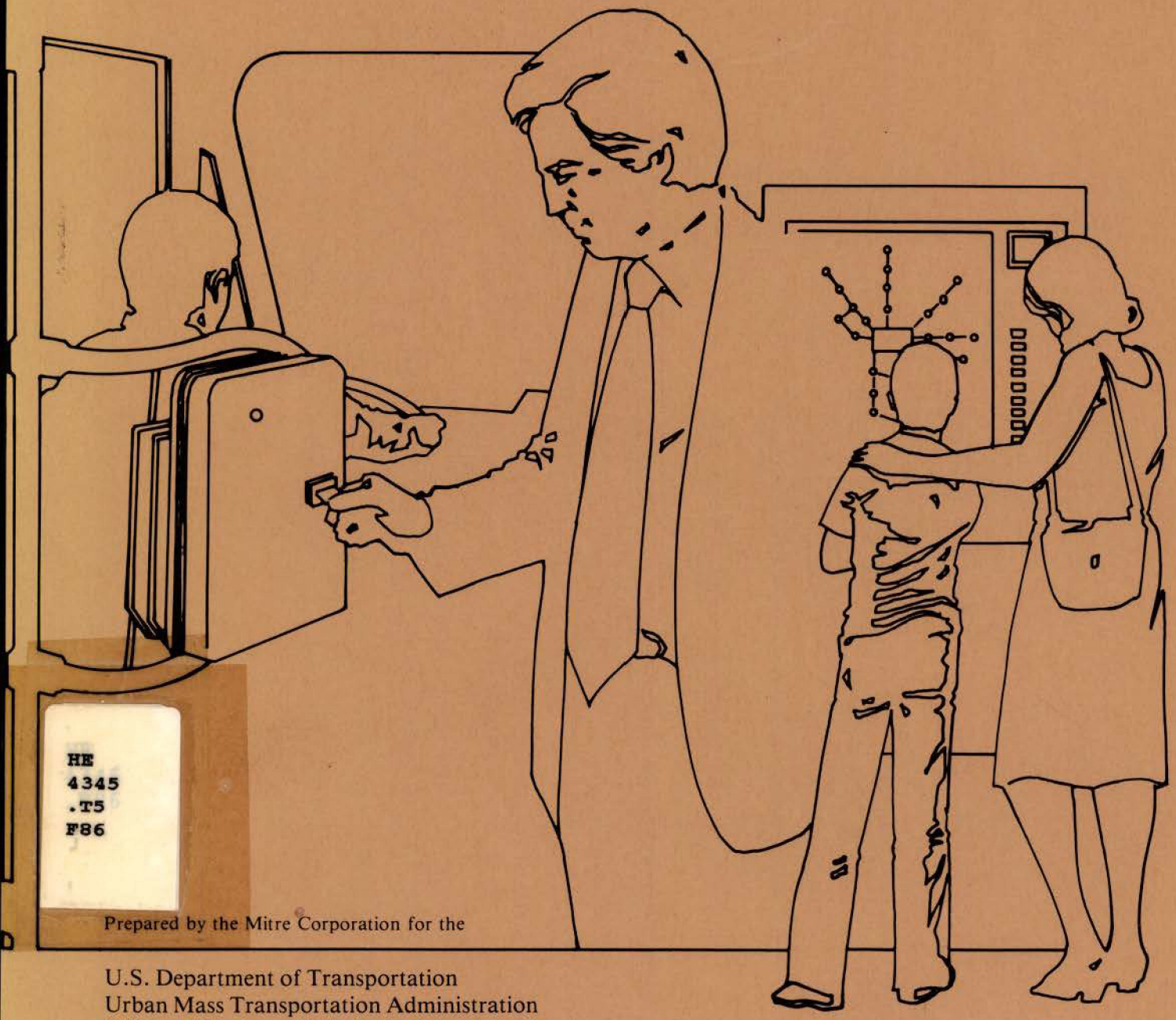
Self-Service Fare Collection

Functional Specifications



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16. Abstract

Self-service fare collection (SSFC), used very successfully in Europe, is a fare collection system that makes the passenger responsible for establishing and paying the correct fare. To demonstrate potential advantages of self-service fare collection in the United States, the Office of Service and Methods Demonstrations, Urban Mass Transportation Administration, has decided to implement a SSFC demonstration at several U.S. transit properties.

This specification provides the general guidelines for the functional, environmental, and performance requirements for SSFC hardware that would be required for a successful SSFC operation.

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Fare Collection Self-Service Validation Equipment Vending Machines	Available to the Public through the National Technical Information Service, Springfield, Virginia 22161.

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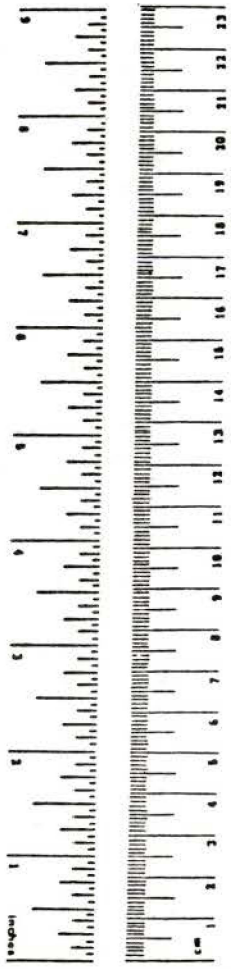
METRIC CONVERSION FACTORS

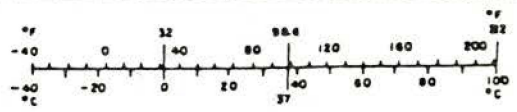
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.08	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1. SCOPE

This specification defines the operational and performance requirements for a Self-Service Fare Collection (SSFC) system. A self-service fare collection system allows the passenger relatively unrestricted access to the transit service and transfers the fare determination and payment responsibilities from agents and drivers to the passengers. Responsibility for fare inspection and enforcement has been given to special personnel who randomly check for fare payment compliance.

To successfully operate a SSFC system, passengers must be provided with sufficient information to enable them to purchase tickets and passes, to use the transit system, and to understand their responsibilities with regard to fare payment and enforcement. Passenger information and ticket and pass distribution are but two of the functional components of a SSFC system. Additional SSFC functions include:

- Ticket validation
- Ticket and pass inspection
- Enforcement
- Maintenance
- Revenue collection
- Passenger, fraud, and revenue data collection
- Accounting and audit control.

The interrelationship of these various system functions of SSFC is very complex (Figure 1). For example, ticket vending machines in the distribution system provide more than tickets to passengers; they provide information to passengers about fare structure, system routes, how to purchase tickets, etc. They also provide data to transit personnel about maintenance, revenue collection, and ticket sales. All of the system functions interact with others in similar ways.

This specification provides the general guidelines for the functional, environmental, and performance requirements for SSFC system hardware that is required to perform the various system functions. A detailed description of the general system requirements, discussing the various SSFC functions, is given in a separate report.* Although passes and pass distribution are shown as part of the overall self-service fare collection system, these areas and their associated system components are not discussed in detail in this report.

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*Sulek, Joan D., "Self-Service Fare Collection-System Requirements", MTR-79W00321, The MITRE Corporation, McLean, Va., November 1979.

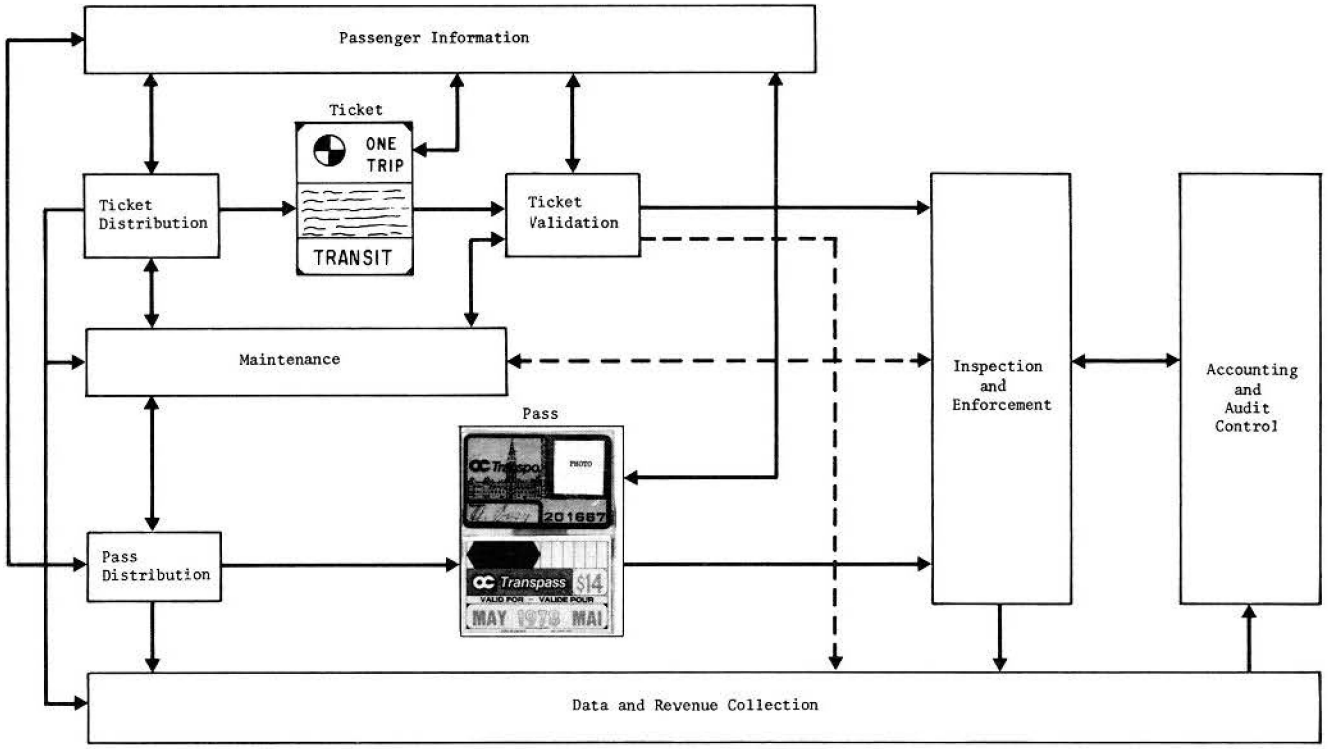

FIGURE 1. FUNCTIONAL SYSTEM DIAGRAM FOR THE SSFC SYSTEM

2. SELF-SERVICE FARE COLLECTION SYSTEM DESCRIPTION

Most fare collection systems in the United States today require a vehicle driver or station agent to handle fare collection and/or fare payment enforcement. Self-service fare collection transfers the responsibility from the drivers and agents to the passengers and special enforcement personnel.

Passengers are required to determine and pay the correct fare before taking a transit trip; responsibility for enforcement has been given to special personnel who randomly check for fare payment compliance. These procedures require that a passenger be able to prove that he has paid the fare.

2.1 Operational Configurations

Procedures for fare collection, fare payment and fare enforcement vary depending on the operational configuration of the self-service system. The five operational configurations of self-service systems considered are:

- Wayside Vending and Validation
- Wayside Vending and On-Board Validation
- Selected Location Vending and On-Board Validation
- Driver Monitored On-Board Validation
- Minimal Hardware

Each of these configurations has its own operating characteristics and hardware requirements.

2.1.1 Wayside Vending and Validation

The distinguishing characteristic of this configuration is the location of ticket vending and validating equipment at all or most transit stops. Passengers must purchase and validate tickets before boarding the vehicle.

Equipment requirements for this configuration normally include:

1. Single-trip ticket vendors located at all or most transit stops. Validation of tickets is performed automatically as tickets are vended.

2. Multi-trip ticket vendors located at main stops or at high volume locations. Tickets are not validated when issued.

3. Validators at all or most stops for validation of multi-trip tickets. Validators may be incorporated in the single and multiple trip vendors. Separate validators may be installed for additional coverage at high volume locations.

4. Agent operated multi-trip ticket and pass vending equipment.

2.1.2 Wayside Vending and On-Board Validation

The distinguishing characteristic of this option is the location of ticket validating equipment on-board the transit vehicle; vending would take place from machines off-vehicle as in the all wayside option.

Equipment requirements for this configuration normally include:

1. Single-trip ticket vendors at all or most transit stops. Validation of tickets is not performed as tickets are vended.

2. Multi-trip ticket vendors located at main stops or at high volume locations. Tickets are not validated when issued.

3. One or more validators per vehicle for validation of all tickets on-board. Usually two validators per vehicle entrance are used.

4. Agent operated multi-trip ticket and pass vending equipment.

5. Driver operated control equipment for validators.

2.1.3 Selected Location Vending/On-Board Validation

This option is essentially a modification of the previous option and is distinguished by a more limited complement of automated vending equipment or by a configuration without automated vending equipment.

Equipment requirements for this configuration normally include:

1. Single-trip and multi-trip vendors in selected areas; e.g., high volume stops, transfer points, secure areas. Vending machines are not required for this option. Tickets are not validated as they are vended.

2. One or more validators per vehicle for validation of all tickets on-board. Usually two validators per vehicle entrance are used.

3. Agent operated multi-trip ticket and pass vending equipment.

4. Driver operated control equipment for validators.

2.1.4 Driver Monitored On-Board Validation

This option is distinguished by the absence of ticket vending equipment and by the use of a single validator located near the vehicle driver. Ticket sales are conducted by drivers, agents, concessionaires, etc.

Equipment requirements for this option normally include:

1. One validator per vehicle for validation of all tickets on-board.

2. Agent operated multi-trip ticket and pass vending equipment.

3. Driver operated control equipment for validators.

2.1.5 Minimal Hardware

The distinguishing characteristics of this option are the absence of any self-service ticket vending and validation equipment, limited provision for prepayment, and unrestricted passenger access.

Equipment requirements for this option normally include:

1. Driver operated receipt (ticket) issuing machine which provides a proof-of-payment with validation information.

2. Agent operated pass issuing equipment.

2.2 System Components

Each of the configurations discussed in Section 2.1 uses one or more of the following system components to collect fares or to indicate fare payment:

- Tickets and passes
- Ticket Vendors
- Validators
- Driver and/or agent operated equipment

The extent to which these system components are used is dependent on the selected configuration and the size of the transit system.

2.2.1 Tickets and Passes

The ticket or pass is the actual proof-of-payment document that the passenger uses when making a transit trip.

Tickets may be purchased in two forms--single-trip and multi-trip--from several sources:

- Ticket vendors
- Vehicle drivers
- Transit company agents
- Concessionaires

Passes may be purchased which cover a variety of time periods and a variety of discount categories--from daily to annual periods and from student to handicapped categories. Passes are normally purchased from transit company agents or concessionaires. However, daily or tourist type passes are sometimes sold through vendors. The various types of tickets available for use by a transit property are discussed in the Appendix.

2.2.2 Ticket Validators

A ticket validator is used by passengers to validate or cancel previously purchased tickets. The passenger inserts a ticket into the validator and the validator automatically performs a sequence of operations including printing of trip information on the ticket and/or cutting or punching of the ticket. After the validator completes its operations, the passenger removes the validated/cancelled ticket from the validator.

2.2.3 Ticket Vendors

A ticket vendor is a hardware device that is used by passengers to purchase tickets or passes. A passenger selects the type of ticket he wishes to purchase, inserts a sufficient amount of money, and receives his ticket from the machine. Depending on the type of machine, a vendor may dispense several types of tickets at different prices or one type of ticket at a single price. Vendors may also dispense change.

All vendors have secure areas for tickets and cash and all vendors store data on ticket sales and cash received.

2.2.4 Driver and/or Agent Operated Equipment

There are two types of equipment in this category:

- Ticket issuing equipment
- Control equipment

Ticket issuing devices are not used by passengers directly. The machines issue tickets or passes on command from the driver or ticket agent; acceptance of money is not required. The machines are normally used to issue types of tickets that are not available through passenger operated ticket vendors or where ticket vendors are not being used.

Control equipment is normally used in conjunction with ticket validators. Control equipment provides date/time information, zone number, route number, direction of travel, and any other variable information that must be periodically changed in the validators on the vehicle.

2.3 Operational Environment

The operational environment includes but will not be limited to areas discussed in the following sections.

2.3.1 Vehicles

On-board self-service fare collection equipment will be capable of installation and use on all types of transit vehicles now in service in the United States including motor buses, trolley buses, articulated buses, light rail vehicles (trams), and heavy and commuter rail vehicles.

2.3.2 Stations and Stops

Wayside self-service fare collection equipment will be capable of installation and use at all stations or stops that would normally be used by transit vehicles discussed in Section 2.3.1. This includes stations or stops that are not protected from extreme weather conditions.

2.3.3 Passengers

Self-service fare collection equipment and tickets will accomodate use by all transit riders that would normally use a transit system.

3. GENERAL REQUIREMENTS

General requirements that are applicable to all SSFC equipment include--environmental, design and construction, security, human factors, reliability, maintainability, and identification and serialization. Equipment specific requirements are discussed in Section 4.

3.1 Environmental

The self-service fare collection equipment shall meet environmental requirements stated in this specification. This environmental specification covers the wide range of operating environments found in U.S. cities.

3.1.1 Temperature

Self-service fare collection equipment will be directly exposed to sunlight under many operating and storage conditions. Therefore, the nominal temperature range over which the equipment shall operate is: -35°C to 60°C.

Self-service fare collection equipment, not operating, shall be able to withstand temperatures of -40°C to 85°C during a storage period of 72 hours.

Any system components that may receive significant amounts of heat from the vehicle (engine compartment, brakes, transmission, etc.) shall be able to operate at temperatures of up to 120°C.

3.1.2 Thermal Shock

Self-service fare collection equipment shall be able to withstand sudden temperature changes due to operating conditions at the installation site. Equipment shall be capable of operating under temperature shock conditions of 3°C per minute over any 6°C portion of the specific operating temperature range.

3.1.3 Vibration

All equipment shall be capable of operating under the following sinusoidal conditions: 0.5 g's from 5 Hz to 2,000 Hz.

Equipment that is to be mounted on-board vehicles shall be capable of operating after an exposure of up to 10 minutes to a sinusoidal condition of 2 g's from 5 Hz to 2,000 Hz. The direction of excitation shall be along three mutually perpendicular axes.

If vibration or shock isolators are included in the design, they shall be considered part of the equipment and subject to the specifications.

3.1.4 Mechanical Shock

Self-service fare collection equipment shall be capable of surviving drops on hard level surfaces in the unpacked, non-operating condition or a kick from an average male adult while the equipment is operating. Therefore, self-service fare collection equipment shall be capable of surviving acceleration pulses of 10g peak value with an approximate duration of 10 milliseconds along each of three mutually perpendicular axes.

3.1.5 Relative Humidity

All equipment shall be capable of operation in relative humidities from 5 percent to 95 percent over the temperature range specified in Section 3.1.1. This shall include condensation and ice formation.

3.1.6 Rain, Hail and Snow

Equipment which is exposed to the external environment shall not suffer any degradation in performance when operated in the following maximum climatic conditions with a 32 kilometer per hour wind :

- Rain falling at the rate of 7.5 cm/hr
- Snow falling at the rate of 4.0 cm/hr
- Hail falling at the rate of 2.5 cm/hr

External self-service fare collection equipment shall operate with an accumulation of up to one foot of snow on top of the machines.

3.1.7 Wind and Ice Loading

External equipment shall be capable of withstanding wind and/or ice loadings as follows:

- Wind--up to 160 kilometer per hour
- Ice--up to a 1.25 cm coating

3.1.8 Water Leakage

Equipment that is mounted on the interior of vehicles shall operate without any degradation within four hours of being sprayed with a 10°C water mist from all directions at an equivalent rate of 0.6 cm per hour with a velocity of 15 meters per second for a maximum of 15 minutes.*

3.1.9 Salt Spray

Equipment which is mounted in the external environment shall be designed to operate without corrosion and without loss of system performance due to salt spray which might splash from the pavement due to road salting or due to the proximity of bodies of salt water.

3.1.10 Sand and Dust

Equipment shall not suffer any degradation in performance when exposed to sand and dust conditions as follows:**

- Sand--Air temperature: 37°C
  Wind: 32 kilometers per hour
  Grain size: 0.2 millimeter diameter to 0.3 millimeters diameter
  Density: 6.1×10^{-9} kilograms/cubic meter
- Dust--Air temperature: 21°C
  Wind: 32 kilometers per hour
  Grain size: 0.04 millimeter diameter to 0.10 millimeters diameter
  Density: 6.1×10^{-9} kilograms/cubic meter

The maximum exposure time shall be six hours.

3.1.11 Fuels, Solvents, and Fumes

Any equipment which is mounted such that it will be exposed to the following subtances shall not suffer any degradation to performance as a result of that exposure:

- Any vehicle oils and additives
- Brake, power steering and transmission hydraulic fluids
- Engine coolants
- Diesel fuel
- Freon and degreasers
- Soap, steam, and washing solvents

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*Vehicle interiors are sometimes cleaned with water spray.

**Dust penetration caused by vacuum cleaning systems has been known to disable some radio equipment.

3.1.12 Sunlight

Radiant heating from and exposure to direct sunlight shall not degrade the performance of self-service fare collection equipment operation nor shall it damage the finish of any enclosures.

3.1.13 Electromagnetic Interference

Self-service fare collection equipment shall meet performance and reliability requirements while under the influence of radiated and/or conducted interference from the vehicle and/or the external environment.

3.1.13.1 Vehicle Environment

Self-service fare collection equipment will be mounted on many types of transit vehicles--rail, light rail, bus, trolley coach; both old and new. All equipment shall have the necessary shielding and grounding to operate on all vehicle types. Known sources of electromagnetic interference include:

- Vehicle power collectors
- Vehicle electrical system (lighting, solenoids, relays, etc.)
- Voice communication equipment
- Vehicle ignition system

3.1.13.2 External Environment

Self-service fare collection shall operate satisfactorily when located near sources of electromagnetic interference such as:

- Vehicle traffic
- 60 cycle power lines (overhead or buried)
- High rise buildings
- Light rail or heavy rail transit lines
- Radio/TV transmitters

3.2 Design and Construction

Design and construction of self-service fare collection equipment shall fully consider its intended use as a fare collection system in various transit environments. The

contractor's responsibilities regarding design shall include but not be limited to:

1. The design of equipment and appropriate mountings and enclosures to:

   a. Reduce the adverse effects of vibration, shock, and environmental conditions

   b. Discourage vandalism, thefts, and break-ins

   c. Prevent unauthorized access to internal components

   d. Facilitate access by authorized personnel

   e. Promote operational simplicity

   f. Ensure safety

2. The design of interconnections for subsystems to include:

   a. Necessary cabling and connectors capable of meeting expected environmental conditions

   b. Concealment of connections to prevent safety hazards and tampering

   c. Necessary circuit protection

   d. A mistake-proof system hook-up

3. The design of on-board equipment to operate directly from the vehicle power system during all normal operating conditions without interfering with the operation of the vehicle.

3.2.1 External Design

All components that are required to perform the functions of a ticket vending machine shall be contained within one enclosure.

All components that are required to actually validate tickets shall be contained within one enclosure. However, certain control functions (zone control, time control, etc.) may be contained in a separate enclosure.

The external materials and finishes of the SSFC equipment shall be such that the wear and punishment of continuous public exposure and regular cleaning with strong detergents shall not adversely affect the appearance or functions of the equipment. This public exposure shall include both normal and abusive use. The enclosure shall discourage vandalism, and the finish shall resist corrosion, abrasion, wear, and scratching. Repair of the finish shall be easily accomplished while the SSFC equipment is mounted at its location. The finish shall not crack, peel, fade, or separate from the surface in the environment described in Section 3.1.

All areas of high wear such as coin slots and ticket slots shall utilize high-wear resistance material. All buttons to be actuated by the passenger or operator shall have high durability and a failure rate of no more than one failure in 1,000,000 actuations.

All backlighted displays shall be lighted by at least two lamps connected in parallel. The surface of displays shall resist abrasion and breakage.

A kick from an average male adult shall not cause an enclosure to dent or detach from its mounting, the surface to crack, or the SSFC equipment to lose its functionality.

3.2.2 Weight and Size

Any one ticket vending machine designed to operate in the wayside environment shall not weight more than 300 kilograms including enclosure. Ticket vending machines designed to operate in the mobile environment shall not weight more than 100 kilograms.

Any one ticket validator shall not weigh more than 20 kilograms.

All fare collection equipment shall be designed to meet the space requirements as specified by the transit property.

3.2.3 Acoustical Noise

The noise level of the SSFC equipment shall not exceed 60 dB(A)* at a distance of 45 centimeters from the equipment except where the proper functioning requires an audible signal to be generated. Such audible signals shall not exceed 85 dB(A)*.

On-board equipment shall not emit noises that will cause undue annoyance to the vehicle operator.

3.2.4 Electrical/Electronic Wiring Design

The SSFC equipment wiring design shall consider each wire's energy requirements and each wire's susceptibility to inductive and electrostatic coupling. The design shall minimize internal electromagnetic interference and susceptibility.

The SSFC equipment will operate on a variety of vehicle types and/or in a variety of urban environments. The materials and construction methods shall provide inherent attenuation to electromagnetic emanations. In addition, all necessary shielding and grounding shall be provided to allow satisfactory operations in the environment.

3.2.5 Code Compliance

Self-service fare collection equipment shall be designed to comply with the Underwriter Laboratory's Safety Standard for Vending and Amusement Machines--ANSI/UL 751-September 1975; and equipment shall comply with all other applicable design codes, local ordinances, and standards.

3.3 Security

Since SSFC equipment will contain items of high value (money, tickets, electronic components), the equipment shall meet security requirements stated in this specification. For security purposes, the vending machine functions shall be segregated into access areas controlled by a hierarchy of locks.

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*dB re $20\mu N/M^2$

3.3.1 Money

All money, coinage and bills, shall not be accessible to anyone except authorized personnel. Vaults containing money shall be secured in the equipment and unauthorized access shall be difficult and shall not be possible without doing visible damage to the SSFC equipment. Authorized personnel shall have access to the money vaults and they shall require no more than one minute to remove and replace a money vault. Contents of the money vaults shall not be accessible in the field without the use of special equipment.

Money handling and storage subassemblies shall not be accessible or removable except by authorized personnel. Any attempts to remove coinage or to divert the normal flow of coinage shall disable or visibly damage the mechanisms.

3.3.2 Tickets

If ticket stock has value, then the ticket stock shall be stored in locked containers within the ticket vending machines. Unauthorized personnel shall not be able to issue tickets or to have access to tickets.

3.3.3 Vandalism and Break-Ins

SSFC equipment shall be designed to discourage vandalism and to resist break-ins. The external construction of the equipment shall be designed to prevent damage from kicking, hitting, abrasion, scratching, etc. The finish shall be such that paint and other types of materials are easily removable. Coin, bill and ticket slots shall be designed to minimize damage from foreign objects that may be inserted.

The SSFC equipment shall be designed to prevent unauthorized access to the internal parts of the machine. Attempts to enter a machine illegally shall trigger an alarm (Section 4.2.16).

3.3.4 Accounting

All money vaults shall have serial numbers for accounting purposes.

All ticket vending machines shall record on visible, non-resettable counters the following information:

- Total money accepted
- Total tickets sold

Other data to be recorded may be stored by other methods (Section 4.2.12).

3.4 Human Factors

SSFC equipment shall be designed to be consistent with accepted human factors engineering practices. Guidelines for design include the following references:

1. "Specifications for Making Buildings and Facilities Accessible to, and Usable by, the Physically Handicapped" American National Standards Institute, Inc., ANSI A117.1-1971.

2. "Human Engineering Design Criteria for Military Systems, Equipment and Facilities:, MIL-STD 1472A, 31 December 1974.

3. Dreyfuss, H. The Measure of Man: Human Factors in Design, Whitney Library of Design, New York, 1970.

4. McCormick, Ernest J., Human Factors Engineering, McGraw-Hill Book Company, New York, 1970.

5. Damon, A., H.W. Stout and R.A. McFarland, The Human Body in Equipment Design, Harvard University Press, 1966.

These are guideline documents only, the contractor shall be responsible for meeting all rules and regulations concerning human factors engineering.

3.4.1 Passengers

The SSFC equipment shall accommodate the 5th to the 95th percentile of the broad range of passengers that use public transportation. The range of patrons paying fares will include commuters; shoppers; children over six; the elderly; the handicapped; and people with communications difficulties including the foreign-speaking, the illiterate, and people with hearing difficulties. These requirements may be met by supplying different types of machines or by supplying similar types of machines with differences in design or mounting criteria.

All displays, switches, and ticket, coin, and bill slots, shall be positioned to accommodate these passengers. Machines which will be accessible by passengers in wheelchairs shall have switches and tickets, coin, and bill slots no more than 122 centimeters above the floor level; displays shall not be more than 138 centimeters above the floor level.

The information and graphic displays shall explain the basis of operation of the SSFC equipment to all categories of users. Some information shall be written in Braille or in foreign languages as required by the system requirements.

The positioning and design of ticket, coin and bill slots shall minimize the passenger's confusion as to their function.

Passenger operations shall not require skills or coordination that excludes any segment of the population. Operation shall be simple to understand; and an inexperienced, average patron should be able to understand the ticket purchasing and validating process by following instructions given on the machine, from ticket agents or by drivers.

3.4.2 Driver

All on-board, driver operated equipment shall meet the following requirements with the operator in his normal, seated position in the vehicle.

All indicators and displays shall be positioned for easy viewing; all controls should be positioned for easy access by the operator. The operator shall not have to stand to perform any of his functions.

The average operator shall be able to perform all SSFC functions required with less than 30 minutes of training. Interactions with SSFC equipment shall require only skills and coordination that transit operators normally possess to perform their routine functions. All interactions with SSFC shall be minimized as not to interfere with other operator duties and functions.

3.4.3 Maintenance and Servicing Personnel

The interior of ticket vending machines shall be designed to allow easy and safe access to serviced items and subassemblies. Adequate space shall be available to fit keys, to grasp, lift, and turn internal components, and to remove and replace subassemblies, ticket containers, materials, ticket stock, and money vaults. The weight of subassemblies and money vaults that must be lifted during servicing shall not exceed 16 kilograms.

Adequate space for the use of tools shall be available as required. Special tools which may be required by maintenance and servicing personnel shall be provided by the contractor. Tools required to service and repair machines in the field shall be small enough to fit into a maintenance tool kit.

3.4.4 Safety

SSFC equipment mounted on vehicles shall not increase the likelihood of physical harm to passengers or users. Enclosures shall have no sharp edges or protuberances in areas exposed to passengers in any type of falling accident. Equipment shall in no way cause harm to the passenger.

Equipment shall be designed and mounted such that placement on vehicles does not degrade the safety of vehicle operation. Mounting of equipment shall not interfere with the visibility of the operator. Equipment shall not interfere with operator access to and from his normal driving position; and shall not restrict the operator's normal body movements while driving.

Maintenance personnel shall not be exposed to electrical shock hazards or physical harm without adequate warning signs.

Equipment shall conform to appplicable safety codes.

3.5 Reliability

Reliability of SSFC equipment shall be measured in terms of mean-time-between-failures (MTBF). The MTBF goal for each equipment type and failure type is stated below. Under no circumstances shall there be a failure that affects the safety of passengers or users.

The contractor shall perform a reliability analysis of each subsystem and identify "weak-link" subsystem components. "Weak-link" components shall be easily accessible and replaceable by maintenance personnel to ensure minimum down-time.

All on-board equipment is expected to operate on an average of seven days per week and twelve hours per day.

All wayside equipment is expected to operate seven days per week and 24 hours per day.

3.5.1 Validators

Assuming normal preventive maintenance procedures, the reliability of specific functional areas of SSFC validator operations shall be no less than the following:

1. Failure that causes the entire vehicle to be removed from service--MTBF-50,000 hrs

2. Failure that causes the loss or mutilation of a passenger's ticket--MTBF-10,000 hrs

3. Failure of an individual validator (e.g., Printer out of order)--MTBF-5,000 hrs

4. Failure that partially disables a validator (e.g., one printwheel failure or clock failure) --MTBF-1,500 hrs

3.5.2 Vendors

Assuming normal preventive maintenance procedures, the reliability of specific functional areas of SSFC vendor operations shall be no less than the following:

1. Failure of a vehicle mounted vendor that causes the entire vehicle to be removed from service --MTBF-50,000 hrs

2. Failure that causes the loss of a passenger's money and/or ticket--MTBF-25,000 hrs

3. Failure that requires the entire vendor to be removed to the shop--MTBF-10,000 hrs

4. Failure that requires removing and replacing a subassembly--MTBF-5,000 hrs

5. Failure that partially disables the vendor but allows other machine functions to continue (e.g., coin or bill acceptor fails)--MTBF-1,500 hrs

3.5.3 Related Equipment

There are two other categories of equipment which can affect the overall system reliability:

- Validator control equipment and
- Agent operated ticket and pass issuing equipment

3.5.3.1 Validator Control Equipment

Since validator control equipment affects the operation of all validators on-board a vehicle it must be very reliable. Assuming normal preventive maintenance, the reliability of specific functional areas of validator control equipment operations shall be no less than the following:

1. Failure that causes the entire vehicle to be removed from service--MTBF-50,000 hrs

2. Failure that causes all vehicle validators to be "Out of Service" but requires less than 15 minutes to repair after arrival of repair team--MTBF-25,000 hrs

3. Failure that causes all vehicle validators to be partially disabled (time, date, zone) but still validate ticket--MTBF-5,000 hrs

4. Failure that causes one vehicle validator to be "Out of Service"--MTBF-5,000 hrs

3.5.3.2 Agent Operated Equipment

The MTBF for agent operated ticket and pass issuing equipment shall be no less than 5,000 hours, assuming normal preventive maintenance procedures.

3.6 Maintainability

The maintainability of SSFC equipment shall be measured in terms of the mean-time-to-repair (MTTR) a piece of equipment. To reduce the MTTR to a minimum, the contractor shall design equipment to facilitate repair incorporating such features as:

- Simplification of design and construction (subassemblies, modules)
- Identification of parts and subassemblies
- Accessibility to parts and subassemblies
- Appropriate test points and/or test aids
- Minimization of hazards to maintenance personnel

The contractor shall establish and fully document a multi-echelon maintenance program to permit the transit property to minimize the MTTR of SSFC equipment.

3.6.1 Mean-Time-to-Repair

The MTTR shall be calculated based on average times to perform the following repair tasks by a trained maintenance technician:

- Gain access to the machine
- Isolate the malfunction or failure
- Repair the malfunction or failure
- Adjust and calibrate as needed after repair
- Test the machine after repair to ensure proper operation
- Secure the machine

The MTTR shall include only the time to repair the SSFC machine. It shall not include the travel time required by technicians to arrive at the machine site or the vehicle location. The MTTR applies only to the time required to return the unit to service on site or on-board the vehicle. Repair time of unit when it is removed from operational service shall not be included in the MTTR.

3.6.1.1 Validators

The MTTR for a validator or the time to restore service by removing and replacing a validator shall not exceed 15 minutes.

3.6.1.2 Vendors

The MTTR for a ticket vendor shall not exceed 30 minutes. The mean-time-to-restore service by removing and replacing the vendor shall not exceed 60 minutes.

3.6.1.3 Related Equipment

The MTTR for validator control equipment shall not exceed 15 minutes.

The MTTR for agent operated ticket vending equipment shall not exceed 30 minutes.

3.6.2 Levels of Service

The maintainability of the SSFC equipment shall be based on a multi-echelon maintenance program.

Level 1

Station agents and/or inspectors shall remove coinage, bills, and ticket jams as they occur during operation of ticket vendors. They shall also remove foreign objects that may be inserted into validators. Drivers of vehicles shall not be required to perform this maintenance function.

Level 2

Preventive maintenance shall be performed on a scheduled, periodic basis by field-level maintenance personnel. Tasks to be performed shall be limited to calibration, inspection, cleaning, and lubrication. Parts may be changed if inspection indicates the need for replacement. Drivers, station agents, and inspectors may be responsible for a daily operational check of equipment before it is placed into service.

Level 3

Field maintenance of machines out of service shall be performed by field-level maintenance technicians. The tasks of the transit technician shall be limited to the isolation of the components that failed, and the replacement of the failed components. Also, removal and replacement of the entire SSFC machine shall be required if repair in the field is not possible.

Level 4

Shop maintenance shall include the repair of failed components and machines that could not be repaired in the field. This type of repair work will take place in a service shop environment where appropriate facilities are available such as tools, test equipment and work benches. This service shop may or may not be operated by the transit property.

Level 5

Factory support and service shall be limited to refurbishment of propriety components and repairs that are beyond the normal skills of transit maintenance personnel or local repair facilities.

3.6.3 Component Interchangeability

All components, subassemblies, and piece-parts of any SSFC equipment shall be interchangeable with corresponding items from another SSFC unit of the same type or from a stock of spare parts.

3.7 Identification and Serialization

All coinage processors, bill processors, controllers, money vaults, and ticket containers shall contain identification plates with serialized numbers which will allow the transit property to precisely control the inventory. In addition, each enclosure shall have an identification plate which contains a serialized number.

If the SSFC equipment uses an electronic system to record and maintain accounting information, the money vault serial numbers should be automatically recorded electronically along with other accounting information.

Information and identification plates shall be mounted for easy access by maintenance personnel and shall be as inconspicuous as possible to passengers and users.

4. EQUIPMENT SPECIFIC SYSTEM REQUIREMENTS

The self-service fare collection system is comprised of several subsystem components, each with its own set of applicable specifications. General system requirements which are applicable to all subsystem components are discussed in Section 3.

4.1 Validator Subsystem

The specifications for the validator subsystem shall be applicable to all ticket validators that will be used in a SSFC system.

4.1.1 Functional Requirements

To operate effectively ticket validators shall perform certain required functions. Additional functions which enhance the performance of the ticket validator subsystem are optional. Ticket validators shall perform the following functions as required by transit property performance specifications:

- Accept multiple types of tickets
- Detect valid and/or invalid tickets (optional)
- Print validation information on tickets
- Indicate acceptance and/or rejection of a ticket by an audible tone (optional)
- Cut, clip, or punch tickets
- Indicate status of validator
- Count and store number of validations performed (optional)
- Allow for easy removal of tickets by passengers.

If these functions are required by transit property performance specifications, the functions shall be performed in accordance with the requirements set forth in Section 4.1.2 through 4.1.11.

4.1.2 Ticket Handling

Ticket validators shall allow the passenger to insert and remove his ticket with a simple movement of one hand. Validators shall allow the insertion of tickets in one of two orientations, horizontally into the side or vertically into the top, as specified by the transit property.

Ticket validators shall accept a variety of ticket types (e.g., single-trip, multi-trip) as long as the tickets are the same width.

The ticket validator shall accept all tickets that are in reasonably good condition and not mutilated to an extent greater than would result from typical passenger handling. This includes storage in a purse, wallet, or pocket. Tickets may be wet or damp.

The ticket validator shall not damage a passenger's ticket by tearing, embossing, cutting, folding, or punching unless required by the transit property specifications.

4.1.3 Ticket Verification (Optional)

If required, ticket validators shall check transit tickets upon insertion to verify that the ticket is valid (not counterfeit or no value left). Invalid tickets shall not be validated.

4.1.4 Printing

All ticket validators shall print validation information on tickets as specified in the following sections.

4.1.4.1 Validation Information

The exact information to be printed on a ticket by the validator will be specified by the transit property. However, the validator shall always print the following data fields:

- Validator number
- Date
- Time

Optional data fields for printing which will be selected by the transit property may include:

- Zone number
- Route number
- Bus number
- Direction of travel (Inbound/Outbound)
- Name of station (Metro Station or bus stop)
- Gate number (Metro Stations)

Examples of printing on tickets by validators is shown in the Appendix. As shown in the Appendix, there are many formats for printing on tickets.

4.1.4.2 Print Location

The number of characters and the position of printed characters will be specified by the transit property. All printed characters shall be positioned so that the geometric center of the characters shall coincide with the positions set forth by the transit property specifications. The geometric center of a character is the intersection of the diagonals of the character envelope (Figure 2). The angular deviation between the vertical center line through the geometric center of the character and the true vertical of the print position shall not exceed $\pm$ 1.2 degrees (Figure 3). The dimensions of the character envelope shall be determined by the transit property. All characters shall be printed within the character envelope specified by the transit property specifications.

4.1.4.3 Character Set

The character set used for printing shall be as specified by the transit property specification.

4.1.4.4 Character Font

The character font used for printing shall be as specified by the transit property specification. The type of printing--dot matrix or solid segment--may be selected by the transit property or the contractor.

4.1.4.5 Printing Quality

All characters printed shall meet minimum printing quality requirements.

4.1.4.5.1 Character Closure

Line segments of printed characters or symbols shall be closed and completed as shown in Figure 4 for character fonts printed with solid line segments. There shall be no characters printed that contain a line segment that has been broken or that contain a portion of a character that has not been printed--void portion of the character.

Character fonts which use dot matrix segments shall not have any missing dots and all dots shall be complete, closed, aligned, and filled (Figure 5).

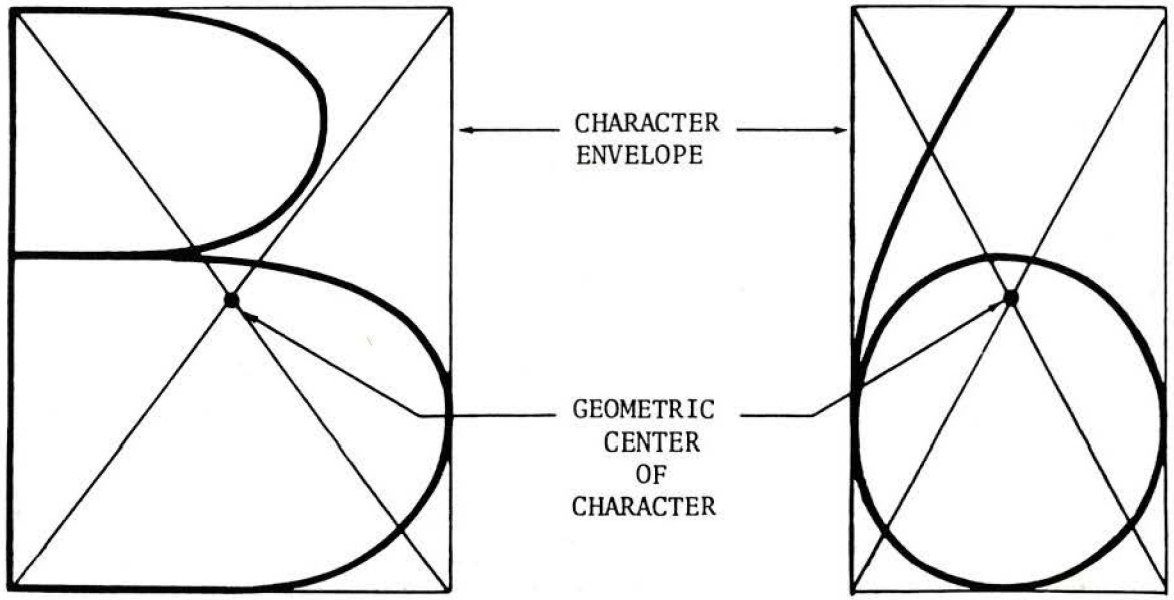
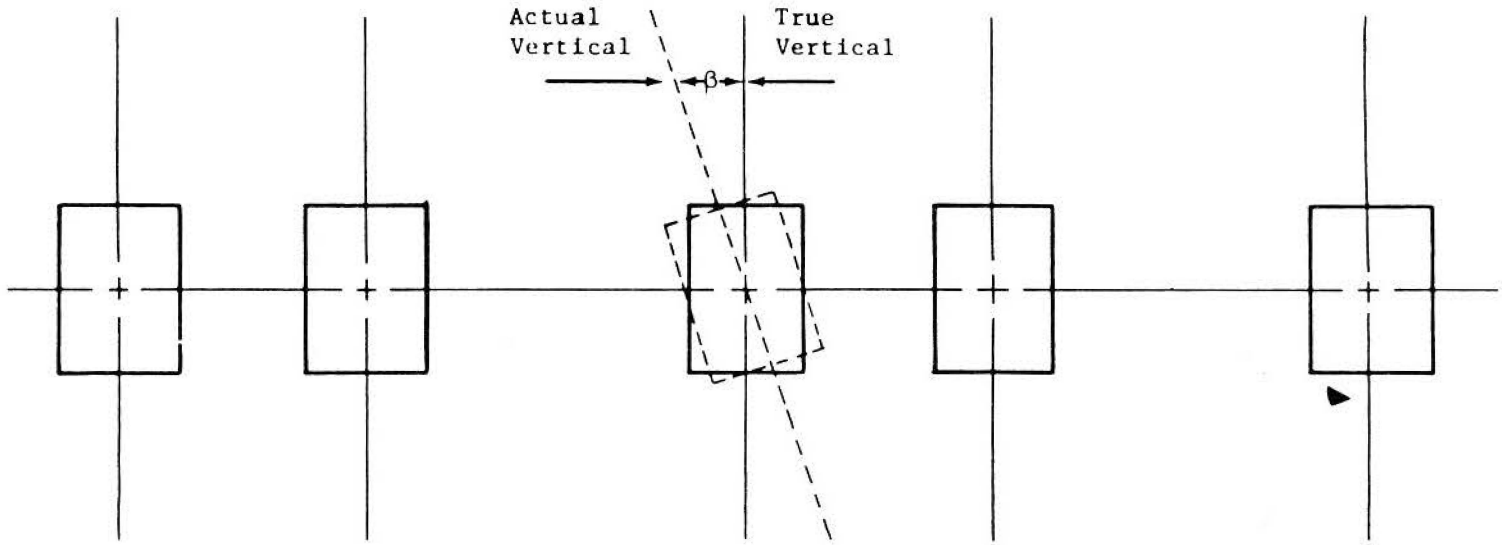


FIGURE 2. GEOMETRIC CENTER OF CHARACTERS



β shall not exceed ±1.2 degree

FIGURE 3. ANGULAR VARIATION

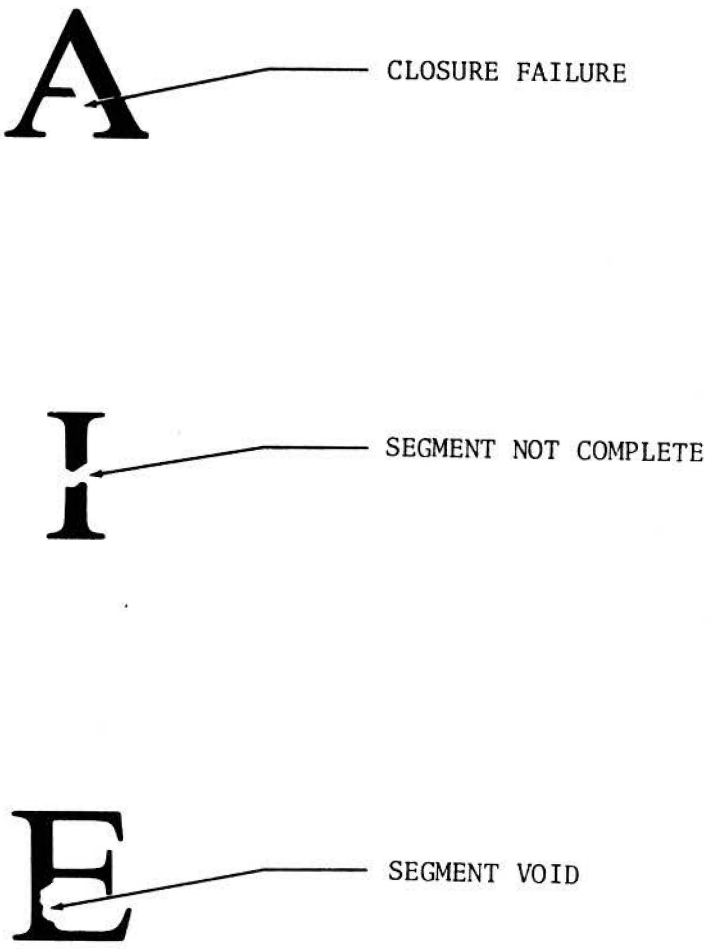


FIGURE 4. LINE SEGMENT CHARACTER QUALITY FAILURES

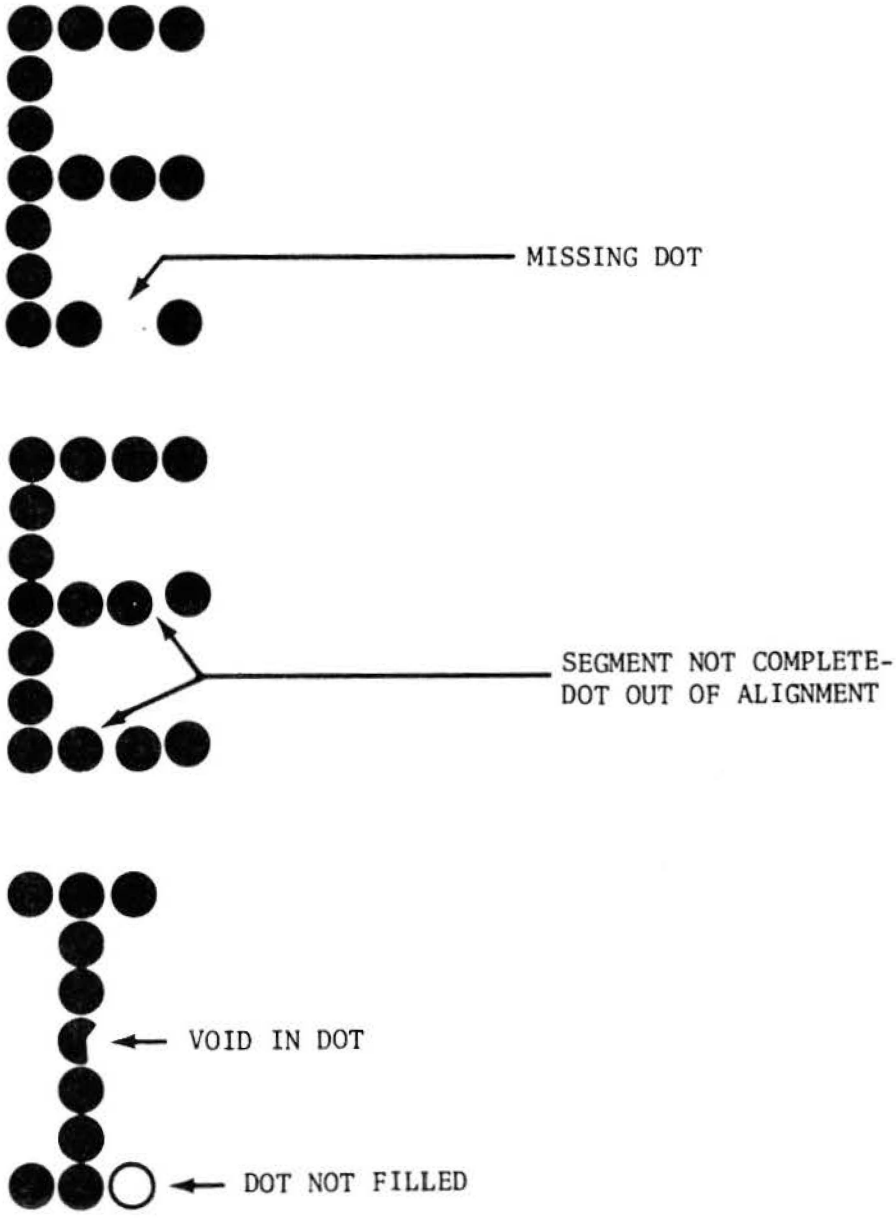


FIGURE 5. DOT MATRIX CHARACTER QUALITY FAILURES

4.1.4.5.2 Character Uniformity

Printed characters shall have sufficient contrast as compared to the brightness of the ticket graphics to make them easily readable. Contrast shall be uniform throughout the entire print. No character line segment or dot shall be heavier and more pronounced than any other printed line segment or dot. Outlines of printed characters shall not be blurred to the degree that the character print cannot be read at a distance of 30 centimeters from the surface of the ticket.

4.1.4.5.3 Extraneous Markings

There shall be no extraneous marks placed on the ticket as a result of the printing operation. The printing shall not smear, blur, or transfer in handling. Characters images shall not be placed onto the ticket in a location not specified for character printing.

4.1.4.5.4 Physical Considerations

Printing shall not degrade the physical condition of the ticket. Under no circumstances, unless specified by the transit property specifications, shall the printing operation produce raised character images on the reverse side of the ticket or make holes in the ticket.

4.1.4.6 Inking

If ink is used in the printing process, it shall be contained in or on a ribbon, roller, or similar device. There shall not be any requirement for liquid ink to be added. To refill the machine with ink, the roller or ribbon shall be changed. To minimize the time required to change the ink roller or ribbon, it shall be contained in a cartridge that can be removed and replaced easily. Ink ribbons or rollers shall operate effectively for at least 25,000 printing cycles. One print cycle is performed for each ticket validation and includes the printing of all required information.

4.1.4.7 Transit Property Compatibility

The printing requirements of each transit property may differ somewhat from the requirements of this specification. This specification defines the required level of performance for printing. The specific characteristics of a given transit property's system will be identified in that property's printing format specification.

4.1.5 Ticket Cutting and Punching

If required, the validator shall cut and/or punch tickets during the validation. The cutting or punching process shall not tear, shred, fray, or damage the ticket. The cut surface or punched hole shall have clean concise edges. The size and location of any holes that will be punched in a ticket shall be defined by the transit property specification.

On multi-trip tickets that require multiple, sequential cuts or punches, the cuts or holes shall be aligned so only the trip indicator for the trip being validated is removed. Multiple cuts shall be aligned such that jagged edges along the cut portion of the ticket do not occur.

Validators shall not validate, cut, or punch a ticket more than once per ticket insertion. Tickets must be removed from the validator before another validation can occur. Knives used for cutting and/or punching shall be self-sharpening.

4.1.6 Chad Containment

Chad (cuttings from tickets) shall be contained within the validator. Under no circumstances shall chad be released or dropped into the bus or external environment. The containers for holding chad shall be of sufficient size to hold the chad from at least 5,000 ticket cuttings.

To prevent spillage of chad into the validator mechanism there shall be an interlock mechanism in the validator so that the validator cannot be removed from the mounting stanchion unless the chad container is first removed, or the chad container shall be designed so as to prevent spillage.

There shall be an interlock mechanism in the validator to prevent the operation of the validator unless the chad container is installed.

4.1.7 Ticket Counting (Optional)

As required, validators shall contain a non-resettable four-digit counter for registering the number of tickets validated. If tickets are coded, additional counters may be required to count the various categories of coded tickets.

4.1.8 Alarms (Optional)

If required, validators shall sound alarms or audible tones when:

- A valid is accepted and validated
- A invalid ticket is detected

If both alarm functions are required, the audible tones shall be distinctly different. At no time shall the audible tones exceed the sound levels stated in Section 3.2.2. The validation indication may be the sound made by the printer mechanism when the printing is accomplished.

4.1.9 Failure Modes

A ticket validator shall prevent the insertion of tickets and indicate "out of service" if:

- The validator is turned off
- The chad container is missing
- The printer mechanism fails
- The cutting mechanism fails

The validator shall not indicate "out of service" for the following reasons unless specified by transit property or unless the driver turns off the validator:

- A clock failure
- A failure of a print location to register the correct information

Failure of one validator on-board a vehicle or at any given location shall not affect the operation of any other validator on-board or at that location.

4.1.10 Power Requirements

On-board validators shall be able to operate from power supplied on all vehicle types used by U.S. transit properties. Voltage ranges include:

- 12 VDC $\pm$ 20%
- 24 VDC $\pm$ 20%

Wayside validators shall operate from power supplied which may include voltage ranges of:

- 12 VDC ± 20%
- 24 VDC ± 20%, or
- 120 VAC ± 10%, 60 Hz, 1ø, 3-wire system.

The exact voltage requirements shall be specified by the transit property.

Power consumption of validators shall be minimized so as to operate as efficiently as possible. When validators are not being used (no printing or cutting) they shall not consume more than 50 watts of power. When printing or cutting, power peaks shall not exceed 300 watts for longer than 250 milliseconds.

4.1.11 Emergency Standby Power

Standby power is not required unless the validator has an internal clock or solid-state memory. If the validator has an internal clock, sufficient standby power shall be supplied for continuous operation of at least 72 hours. Standby power shall ensure the operation of the clock and maintenance of memory information during low voltage conditions of the power supply (e.g., vehicle start cycle). Standby power shall operate only the clock or solid-state memory; no other mechanisms need be powered during a power failure.

4.2 Vendor Subsystem

The specifications for the vendor subsystem shall be applicable to all ticket vendors that will be used in a SSFC system.

4.2.1 Functional Requirements

To operate efficiently and effectively, vendor subsystems shall perform certain required functions. Additional functions which enhance the vendors subsystem operation are optional. Therefore, ticket vendors shall perform the following functions as required by transit property performance specifications:

- Provide information for operation of ticket vendor
- Accept 5¢, 10¢, 25¢, 50¢, and/or $1.00 U.S. coins
- Accept $1.00 and/or $5.00 U.S. currency notes (optional)
- Indicate acceptance of money

- Provide change for various transactions* (optional)
- Detect invalid, counterfeit, or foreign notes and coins and reject them
- Print information on tickets
- Cut, clip, punch or emboss tickets (optional)
- Vend ticket(s) upon acceptance of correct amount of money
- Count and store the number and type of transactions performed
- Provide secure storage for money and tickets
- Allow for easy retreval of tickets and monies by passengers
- Indicate status of vendor to patron and transit personnel
- Allow for convenient restocking, data collection, and maintenance by transit personnel.

If these functions are required by the transit property performance specifications, these functions shall be performed in accordance with the requirements set forth in Sections 4.2.2 through 4.2.16.

4.2.2 Operating Information

Operating directions for ticket vendors shall be located on the front of the machine. Directions shall be simple, step-by-step, and easy to understand by the passengers who will be using the machine (Section 3.4.1). As required by the transit property, operating instructions may be listed in more than one language (e.g., Spanish and English) or in Braille.

Directions for operation shall include at least:

- How much a ticket costs
- Where to insert the money
- Where to retrieve tickets and/or returned money
- Order of operation performance
- Who to ask or where to go for aid.

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*Due to the reliability and maintainability problems associated with changemaking features, it is recommended that vendors require exact change. Ticket pricing and fare structures should be designed such that even amounts of money are required for purchasing tickets. For example, if a transit property wishes to give a discount for a multi-ride ticket where the single-trip fare is $0.50, then an eleven ride ticket should be sold for $5.00 not ten ride tickets for $4.50.

Additional information that could be required may include:

- Map of the transit system
- Types of coins and/or bills accepted
- Types of tickets available elsewhere
- Scheduling information.

4.2.3 Coin Acceptance and Handling

Vendors shall accept standard U.S. coinage, as required by the transit property specification, which may include:

- Nickel (5 cents)
- Dime (10 cents)
- Quarter (25 cents)
- Half dollar (50 cents)
- Dollar (1 dollar).

Except for the dollar, all coins are the standard U.S. coinage that has been minted since 1970. The Susan B. Anthony dollar coin was issued in July 1979 and it differs from the older style "silver dollar". Specifications of the new dollar coin and other U.S. coins are listed in Table 1. Additional information, if required, can be obtained from the U.S. Department of the Treasury.

Vendors shall allow the passenger to insert coins with one hand. All denominations of coinage shall be inserted into one coin slot on the vending machine.

Vendors shall have a coin acceptance rate of at least 95 percent for all valid U.S. coinage. All other coinage, including coin-like items, forgeries, counterfeits, slugs, and foreign coinage, shall be considered bogus.

The value of each valid coin shall be determined automatically; no value shall be assigned to items detected as bogus. There shall be no noticeable delay between the acceptance of a coin and the displaying of the indication to the passenger that the coin has been accepted; rejected coins and items shall be returned immediately.

Coinage shall be temporarily stored in escrow after acceptance and until:

- The transaction is completed; or
- The transaction is cancelled.

TABLE 1 - U.S. COIN SPECIFICATIONS

Coin Type[1][2]	Type Of Edge	Diameter mm	Diameter Inches	Thickness mm	Thickness Inches	Weight Grams	Weight Grains
One Dollar	Milled	26.42	1.040	1.98	0.078[4]	8.505	131.25
Half Dollar	Milled	30.61	1.205	2.18	0.086	11.340	175.00
Quarter Dollar	Milled	24.26	0.955	1.70	0.067	5.670	87.50
Dime	Milled	17.91	0.707	1.35	0.053	2.268	35.00
Nickel[3]	Smooth	21.21	0.835	1.98	0.078	5.000	77.16

[1] All coins are round.

[2] All coins except the nickel are a three-layer composite--Outer cladding is 75% copper, 25% nickel, bonded to a core of pure copper.

[3] Nickels are composed of a homogeneous alloy--75% copper, 25% nickel.

[4] Dollar thickness determined by actual measurement.

It shall not be possible to insert additional coinage while the vendor is vending tickets or cancelling a transaction.

After the transaction is completed, coinage shall be collected in a secure vault with an effective capacity of at least 3.3 cubic decimeters. This vault shall be secured in the vendor and unauthorized access to the vault shall be difficult and shall not be possible without doing visible damage to the ticket vendor. Authorized personnel shall have access to the money vault and they shall require no more than one minute to remove and replace the money vault.

It shall not be possible for any personnel to access accepted coinage without doing visible damage to the vendor. Vendors shall prevent the retrieval of coins through the coin insertion slot.

Improper assignment of value to coinage is considered a fault. Faults of this type shall not occur at a rate of more than one in ten thousand.

4.2.4 Bill Acceptance and Handling (Optional)

Vendors shall accept valid, properly inserted bills of the United States of America. Overall acceptance rate of bills shall be at least 90 percent. The denominations of bills to be accepted, if any, shall be determined by the transit property and may include the $1 bill and/or $5 bill. Proper insertion means that whole, unfolded bills are entered one at a time with the correct orientation. The patron shall be able to insert the bill with a simple movement of one hand.

Any entry other than stated above shall be considered bogus. The value of each bill shall be determined automatically; no value shall be assigned to bogus items. Acceptance or rejection of a bill shall not take more than two seconds.

There shall be no noticable delay between the acceptance of a bill and the displaying of the indication to the passenger that the bill has been accepted; rejected items shall be returned immediately.

If acceptance of more than one bill type is required, the use of one bill acceptor for both types of bills is preferred. Vendors shall be able to escrow at least two bills per transaction. Bills shall be temporarily stored in escrow after acceptance and until:

- The transaction is completed
- The transaction is cancelled.

It shall not be possible to insert additional bills while the vendor is vending tickets or cancelling a transaction.

After the transaction is completed, bills shall be collected in a secure vault, separate from the coinage, with a capacity of at least 450 bills. If more than one type of bill is accepted by the machine, separate vaults shall be maintained for each bill type. Vaults shall be secured in the vendor and unauthorized access to the vault shall be difficult and shall not be possible without doing visible damage to the ticket vendor. Authorized personnel shall have access to the money vault and they shall require no more than one minute to remove and replace the money vault.

It shall not be possible for any personnel to access accepted bills without doing visible damage to the vendor. Vendors shall prevent retrieval of bills through the bill insertion slot.

4.2.5 Changemaking (Optional)

If required by the transit property, vendors shall have changemaking capabilities which meet the following criteria.

Changemaking shall occur only as the transaction is being completed. No change shall be returned at any other time.

Coins for change may be taken from a coin storage area or from coins which were inserted by patrons and recycled for changemaking purposes.

4.2.6 Ticket Handling

Vendors shall issue new tickets to passengers after the correct amount of monies has been inserted into the machine. Issuance shall consist of feeding tickets from a secure container into position for cutting, embossing, printing, encoding, and/or delivery to the passenger. Issuance shall be automatic after the correct monies have been inserted.

Vendors shall issue and handle tickets under all conditions stated in Section 3.0.

4.2.6.1 Ticket Types

The types (i.e., Single-trip, Multi-trip, Day Pass) and values of tickets to be issued by a vendor shall be determined by the transit property. However, under no circumstances shall a vendor be required to issue more than four types of tickets.

Vendors which issue only one type of ticket shall have the ability to issue up to ten different values (i.e., 10 different zones, half-fare) of that type of ticket, if specified by the transit property specifications.

4.2.6.2 Ticket Stocking and Storage Techniques

Vendors shall issue tickets from an internal storage container. Ticket stocking and storage techniques shall be specified by the transit property specification. Ticket stocks are discussed in the Appendix. Ticket storage techniques may include:

1. Blank Roll Paper--tickets are printed, cut, and issued from blank, roll paper.

2. Pre-Printed Roll Stock--tickets are cut and issued from a pre-printed roll of ticket stock.

3. Individually Stacked Tickets--tickets are issued from a stack of pre-printed, pre-cut tickets. Printing by the machine on the ticket may or may not be required.

4. Leporello Piled (fan-folded) Tickets--tickets are cut and issued from a stack of pre-printed, fan-folded tickets. Printing by the machine on the ticket may or may not be required.

Regardless of the ticket storage technique used, the ticket capacity of the vendor shall be as specified in Section 4.2.8.

4.2.7 Ticket Printing

Information printed on tickets by vendors shall meet the specifications as described in Section 4.1.4. The exact information to be printed on a ticket shall be specified by the transit property.

4.2.8 Ticket Capacity

Vendors which issue single-trip tickets only shall have a capacity of at least 3,000 tickets.

Vendors which issue only one type of multi-trip ticket shall have a capacity of at least 2,000 tickets.

Vendors which issue more than one type of ticket shall have a capacity of at least 1,000 tickets per ticket type.

4.2.9 Ticket Embossing (Optional)

As required by transit property, the vendor shall emboss tickets as they are issued. The embossing may be used as a verification that the ticket was issued by a machine and is valid--not stolen or counterfeit.

Embossing shall not degrade the physical condition of the ticket. It shall not tear, rip, fray, puncture, or otherwise damage the ticket; embossing shall only produce the required raised image.

4.2.10 Ticket Cutting and Punching (Optional)

As required by the transit property, the vendor shall cut and/or punch tickets during the issuing process. The cutting or punching process shall not tear, shred, fray, or otherwise damage the ticket. The cut surface or punched hole shall have clean, concise edges. The size and location of any holes that will be punched in a ticket shall be defined by the transit property specification.

Guillotining (cutting) of tickets from rolls or stacks of continuous feed ticket stock shall not damage tickets. Cuts shall be perpendicular to the sides of the ticket providing 90° corners.

The length of tickets cut from blank stock shall not vary from the transit property specified length by more than $\pm$ 4 millimeters.

Tickets which are pre-printed and/or perforated shall be cut along the designated location and the cut shall not be misaligned from the designated cutting line by more than $\pm$ 3 millimeters.

Knives used for cutting or punching shall be self-sharpening.

4.2.11 Chad and Paper Waste Containment

Chad and paper waste--cuttings and paper scraps from tickets--shall be contained within the vendor. Under no circumstances shall chad or paper waste be released into the external environment. The container for holding chad and paper waste shall be of sufficient size to hold the waste from at least 10,000 ticket cuttings.

The chad and paper waste container shall be easily removed for cleaning and emptying. There shall be an interlock mechanism to prevent the operation of the vendor unless the container is installed.

4.2.12 Ticket and Money Accounting

Vendors shall store the following information:

- Number of each ticket type sold
- Number of each coin type received
- Number of each bill type received
- Total amount of change dispensed
- Total value of all tickets sold
- Total amount of money received.

Regardless of the method used for data storage, the last two items on the list shall also be stored in non-resettable electomechanical counters. The data storage medium shall be specified by the transit property specifications.

If electronic, magnetic or solid-state storage is used, provisions for data removal, transfer, and/or transmission shall be provided by the contractor.

4.2.13 Failure Modes

Vendors shall prevent the insertion of money and indicate "out of service" if:

- The machine is out of tickets
- The issuing mechanism fails
- The machine is turned off
- The chad and paper waste container is missing
- The money storage vaults are full
- The money acceptors fail.

Vendors shall not indicate "out of service" for the following reasons:

- The machine is out of change
- The machine is out of one type of ticket.

Vendors shall indicate "Exact Change Only" when the machine is out of change.

Vendors shall indicate "Empty" over the selection button for any ticket type that has an empty container. If a passenger selects a ticket type that has an empty container, the vendor shall ignore that command to vend and return all money inserted by the passenger.

Failure of one vendor at any given location shall not affect the operation of any other vendor at any other location.

4.2.14 Power Requirements

Vendors shall be able to operate from power supplied which may include voltage ranges of:

- 120 VAC $\pm$ 10%, 60 Hz, 1θ, 3-wire system
- 240 VAC $\pm$ 10%, 60 Hz, 1θ, 3-wire system
- 208 VAC $\pm$ 10%, 60 Hz, 3θ, 4-wire system

The exact operating voltage requirements shall be supplied by the transit property.

Power consumption of the ticket vendor shall be minimized to operate as efficiently as possible.

4.2.15 Emergency Standby Power

Standby power is not required unless the vendor has an internal clock or memory that requires power to maintain operation. If the vendor has these functions, sufficient standby power shall be supplied to maintain continuous operation for 72 hours.

Emergency power shall operate only the clock or the memory; no other mechanisms need to be powered during a power failure.

4.2.16 Alarms (Optional)

As required by transit property specifications, vendors shall contain alarms or indicators of problem areas as discussed in the following sections.

4.2.16.1 Machine Defect Indicators

Alerts and defects shall be indicated on panel located inside the machine. These indicators may be used by maintenance personnel in the performance of their duties. Remote indication of malfunctions may be desirable.

4.2.16.2 Break-In Alarm

Vendors shall contain an alarm device which detects an unauthorized entry or break-in attempt. Upon detection of this condition, the vendor shall sound a loud audible alarm such as a built-in siren. A remote indication of the break-in or unauthorized entry shall register at a central point that the transit property designates.

The remote indication shall be capable of transmission by cables, phone lines, or radio.

4.3 Agent Operated Equipment

This equipment is used by transit agents and concessionaires to issue multi-trip tickets and/or passes. Most equipment in this category is normally used to issue passes only. Specifications for agent operated equipment shall be applicable to all equipment of this type that will be used in a SSFC system.

4.3.1 Functional Requirements

Agent operated equipment shall perform the following functions as required by transit property performance specifications:

- Accept inputs from operator
- Display information
- Compute cost of sale
- Print required data on pass or ticket
- Cut, punch, or emboss tickets
- Provide feedback to operator, e.g., error information
- Issue pass or ticket on command
- Store accounting data.

If these functions are required by transit property performance specifications, the functions shall be performed in accordance with the requirements set forth in Section 4.3.2 through 4.3.11.

4.3.2 Data Input

Before passes can be issued by the agent operated equipment, the equipment may require the entry of certain types of information such as:

- Passenger's name
- Passenger's address
- Pass number
- Type of Pass (Student, Half-fare, Elderly)
- Length of pass validity (Week, Month, Year)
- Area of pass validity (Route numbers, Zone numbers).

The method of entry for this information may be through a keyboard or other method, e.g., magnetic stripe on pass I.D. The type of information to be entered before a pass can be issued shall be provided by the transit property.

As part of the data entry process, certain command functions may be required by transit property specifications:

- Reset or clear machine
- Cancel transaction
- Clear last entry
- Display price of pass
- Issue pass.

There shall not be any noticeable delay between the entry of data and acceptance of data. Entered information shall be displayed as it is entered.

4.3.3 Display

Information displays shall be easy to read from a distance of 50 centimeters.

The characters set of the display shall include:

- Numbers--0-9
- Alphabet--A-Z
- Special Characters--$,+,_,.,:,;,*,&, and comma.

The display shall display a minimum of one line with 40 character positions.

4.3.4 Printing

All agent operated equipment shall print information which meets the specifications stated in Section 4.1.4. The exact information to be printed on a ticket or pass shall be specified by the transit property and may include:

- Name of passenger
- Address of passenger
- Number of I.D. portion of pass
- Serial number of pass
- Price of pass
- Time of issue
- Date of issue
- Dates of validity
- Areas of validity
- Place of issue
- Serial number of issuing machine
- Logo or design of transit property

4.3.5 Ticket Handling

Issuing equipment shall issue new tickets or passes on command from the operator. Issuance shall consist of feeding tickets or passes from a secure container into position for printing, cutting, encoding, and/or delivery to the operator.

Issuing equipment shall issue and handle tickets and passes under conditions stated in Section 3.

4.3.6 Ticket Stocking and Storage Techniques

Issuing equipment shall issue tickets from an internal storage container. Ticket stocking and storage technique shall be specified by the transit property. Ticket stocks are discussed in the Appendix. Ticket storage techniques may include:

1. Blank Roll Paper--tickets are printed, cut, and issued from blank roll paper.

2. Pre-printed Roll Stock--tickets are printed, cut and issued from a pre-printed roll of ticket stock. Pre-printed information may include logos, design, passenger information, and data fields.

3. Leporello Piled (fan-fold) Stock--tickets are printed, cut, and issued from a stock of pre-printed, fan-folded tickets. Pre-printed information may be the same as above.

Regardless of the ticket storage technique used, the issuing equipment shall have a capacity of at least 2,000 tickets.

4.3.7 Ticket Cutting and Punching

As required by the transit property the machine shall cut and/or punch tickets and passes during the issuing process. The cutting or punching process shall not tear, shred, fray, or otherwise damage the ticket. The cut surface or punched hole shall have clean, concise edges. The size and location of any holes that will be punched in a ticket shall be defined by the transit property specification.

Guillotining (cutting) of tickets from rolls or stacks of continuous feed stock shall not damage tickets. Cuts shall be perpendicular to the sides of the ticket providing 90^{o} corners.

The length of tickets cut from blank stock shall not vary from the transit property specified length by more than $\pm$ 4 millimeters.

Tickets which are pre-printed and/or perforated shall be cut along the designated location and the cut shall not be misaligned from the designated cutting line by more than $\pm$ 3 millimeters.

Knives used for cutting or punching shall be self-sharpening.

4.3.8 Chad and Paper Waste Containment

Chad and paper waste shall be contained within the issuing machine. Under no circumstances shall chad or paper waste be released into the external environment. The container for holding chad and paper waste shall be of sufficient size to hold the waste from at least 10,000 ticket cuttings.

The chad and paper waste container shall be easily removed for cleaning and emptying. There shall be an interlock mechanism to prevent the operation of the issuing machine unless the container is installed.

4.3.9 Ticket Sales and Accounting

Issuing machines shall store the following information:

- Number of each ticket or pass type sold
- Total number of tickets and passes sold
- Total value of all tickets sold.

Regardless of the method used for data storage, the last two items on the list shall also be stored in non-resettable electro-mechanical counters.

If electronic, magnetic, or solid-state storage is used, provisions for data removal, transfer, and/or transmissions shall be provided. Any special equipment required for data collection shall be provided by the contractor.

4.3.10 Power Requirements

Issuing machines shall be able to operate from a 120 VAC ± 10%, 60 Hz, 1ø, 3-wire system. Under no circumstances shall the unit require more than 15 amperes of current for operation.

4.3.11 Emergency Standby Power

Standby power is not required unless the issuing machine has an internal clock or memory that requires power to maintain operation. If the vendor has these functions, sufficient standby power shall be supplied to maintain continuous operation for 72 hours.

Emergency power shall operate only the clock or the memory; no other mechanisms need to be powered during a power failure.

4.4 Driver Operated Equipment

This equipment is used by vehicle drivers to control validators. The specification for driver operator equipment shall be applicable to all equipment of this type that will be used in a SSFC system.

4.4.1 Functional Requirements

Driver operated equipment shall perform the following functions as required by transit property performance specification:

- Turn validators on/off
- Provide date/time information to validators
- Provide date/time readout to driver
- Provide bus number to validators
- Provide route number to validators
- Provide zone/zone change information to validators
- Place individual validators in/out of service
- Provide validator status information to driver.

If these functions are required by transit property performance specifications, the functions shall be performed in accordance with the requirements set forth in Section 4.4.2 through 4.4.4.

4.4.2 Data Input

There shall be a method of entering the required input information into validator control equipment such as:

- On/Off--key lock switch
- Date/Time--thumbwheel switches
- Zone Number--thumbwheel switches
- Bus Number--thumbwheel switches
- Route Number--thumbwheel switches
- Zone Change--push-button switch
- Data Input--push-button switch
- Validator Selector--thumbwheel switch
- Validator In/Out of Service--push-button switch

These are recommended methods for data input; the actual method shall be specified by transit property.

4.4.3 Power Requirements

Control equipment shall operate from power supplied by standard transit vehicles including:

- 12 VDC $\pm$ 20%
- 24 VDC $\pm$ 20%.

Under no circumstances shall a control unit consume more than 50 watts of power.

4.4.4 Emergency Standby Power

Standby power is not required unless the control unit has an internal clock that requires power to maintain operation. If the control unit has a clock, sufficient standby power shall be supplied to maintain continuous operation for 72 hours.

Emergency power shall operate only the clock during a power failure.

5. QUALITY ASSURANCE AND TESTING

5.1 Responsibility for Testing

The manufacturer of SSFC equipment shall be responsible for the performance of all tests to assure compliance of the equipment to be delivered with the requirements of this Specification.

5.2 Tests

Tests shall be conducted for the purpose of demonstrating and evaluating the requirements specified herein. The contractor shall be responsible for developing test procedures and submitting them for approval.

5.2.1 Design Verification Tests

Tests shall be conducted on the first production unit for the purpose of verifying the adherence of the design to all aspects of the requirements, with emphasis on the functional performance, ability to operate under environmental extremes, reliability, and maintainability. Deviations will be handled in accordance with the provisions of the Contract.

5.2.2 Product Verification Tests

Product verification tests shall be conducted on subsequent SSFC units to verify that the functional requirements of the specification have been satisfied. These tests shall be performed on SSFC units which:

1. Have been built to released drawings under formal change control

2. Have successfully passed the outgoing quality assurance tests

3. Incorporate corrections for failures identified during design verification tests, including corrections for critical and major deficiencies discovered during product inspections.

5.2.3 Subsystem Integration Tests

Subsystem integration tests shall be performed to verify the operational interconnections of the units.

5.2.4 Burn-In Tests

Each SSFC unit shall pass a burn-in test consisting of ten continuous hours of operation without a failure.

5.2.5 Acceptance Tests

Acceptance tests shall be performed subsequent to installation on the vehicle or site and prior to acceptance by the transit property.

5.3 Inspections

Inspections to appraise the manufacturability, reliability, maintainability, use, integration, compatibility, human factors, safety, and operational characteristics of self-service fare collection equipment shall be conducted.

5.3.1 Design Inspection

The design inspection shall be held prior to the completion of design verification tests to appraise the manufacturability, reliability, and maintainability of SSFC equipment.

5.3.2 Product Inspection

The product inspection shall be held prior to the production run of SSFC equipment and prior to the completion of the product verification test to appraise all performance requirements.

5.4 Defects

Self-service fare collection equipment found defective in the course of inspections and tests shall be rejected. Defect classification is subject to transit property approval.

1. Critical Defect--a critical defect shall be a defect considered serious enough to require correction at the earliest possible time, but which is not critical enough to warrant a delay of the release to manufacturing. A major defect identified prior to release for production must be corrected before delivery of SSFC equipment.

2. Minor Defect--these are defects resulting in convenience changes and may not require immediate attention but shall be incorporated along with other routine changes.

6. DELIVERY

Preparation for delivery shall be according to the best commercial practices. The actual method and mode of delivery shall be set by the transit property.

7. APPLICABLE DOCUMENTS

The following documents are applicable to this specification to the extent specified herein and form a part of this specification.

7.1 MITRE Documents

7.1.1 Environmental Specifications for Automatic Fare Collection (AFC) Equipment, MTR-6600, Supplement 1., October 1974.

7.2 Design Codes

7.2.1 Safety Standard for Vending and Amusement Machines, September 1973, ANSI/UL751, ANSI C33.81.

7.2.2 Specifications for Making Buildings and Facilities Accessible to, and Usable by, the Physically Handicapped, ANSI A117.1-1961(R1971).

7.2.3 National Electrical Safety Code, November 1977, ANSI C2.

7.2.4 National Electronic Code, January 1978, ANSI/NFPA No. 70-1978.

APPENDIX - TICKET TYPES, STOCKS, AND PRINTING

Tickets are an important part of a self-service fare collection system since they perform two important functions:

1. They provide the passenger with proof of fare payment.

2. They provide needed information to passengers and transit personnel.

To perform these functions effectively tickets must be able to accept printing from vendors and validators; withstand handling by passengers in various environments for the length of the ticket life; and provide information to passengers, agents, drivers, and inspectors.

There are two basic categories of tickets--single-trip and multi-trip. Examples of both categories are shown in the following pages with examples of vendor and validator printing. The ticket stock for the tickets vary from ticket to ticket and transit property to transit property. These differences in ticket stock are due to the different functional requirements of various ticket types. For example, multi-trip tickets must last longer than single-trip tickets; tickets which are to be cut must be of different stock than tickets which are to be folded.

All of the examples are from European transit properties. A description of the function of the ticket is given and, where known, a description* of the ticket stock is given. The actual stock to be selected by an U.S. transit property shall be designed to withstand the environment of passenger transit.

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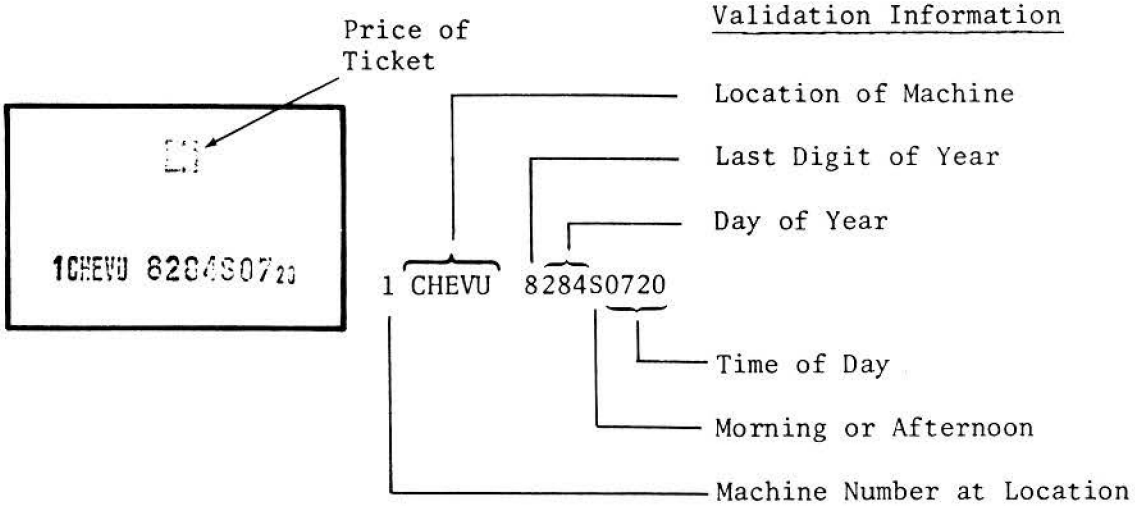
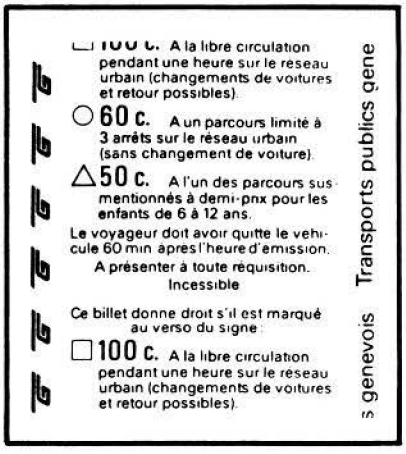
*Personal communication with Robert Hubbard and Jack Buxton, Jr. of Globe Ticket Company, July 1979.



Single-trip ticket* issued by Transports Publics Genevois. This ticket is validated and cut from roll stock when it is issued and is valid for one hour from the time of issue--ticket must be used immediately. The stock is pre-printed on the reverse side as shown below.

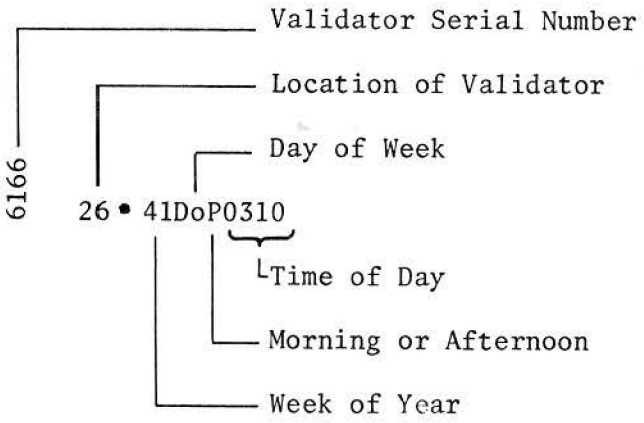


White stock similar to cash register tape, black ink pre-printing.

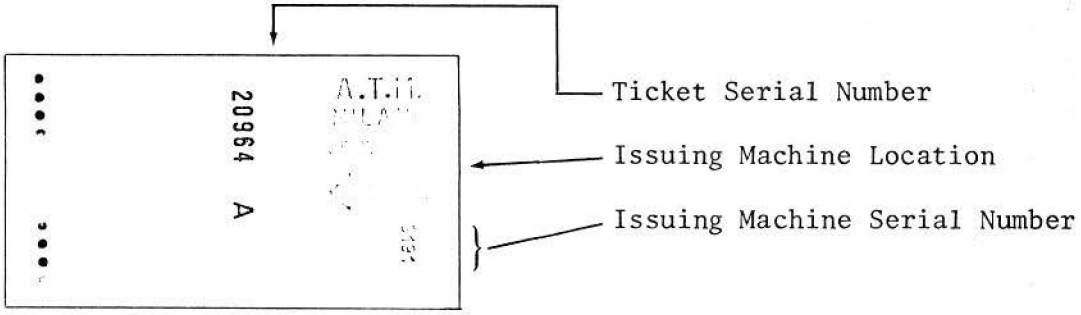
*Tickets depicted above and on the following pages are not to scale.

Validation Information

Three Color Printing-
Orange, Green, Black

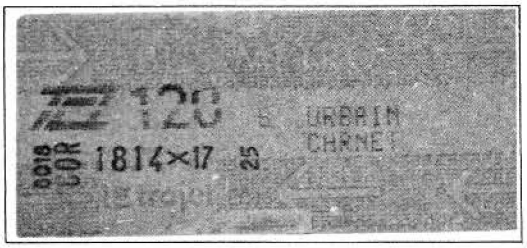


This preprinted single-trip ticket sold by concessionaires for Azienda Trasporti Municipali-Milano. The ticket is valid for 70 minutes after is is validated and it must be validated when the transit system is used. This type of ticket may be purchased at any time.



This ticket is similar to the one above except it is purchased from a ticket vending machine. All information is printed on blank roll stock and cut to the correct size when the ticket is issued. The ticket must be validated when used.

Validation Information

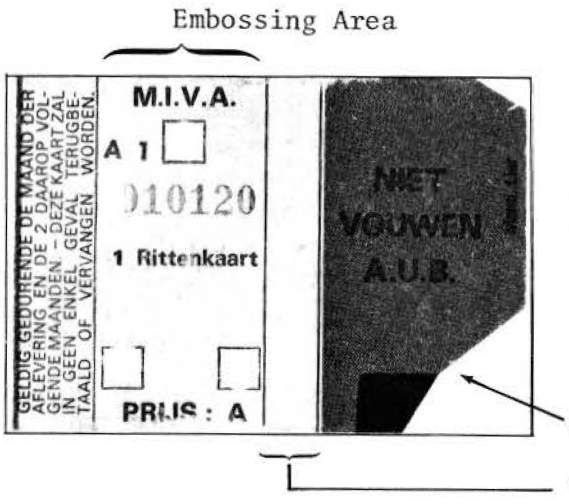


One Color Printing-Gray on Orange Stock

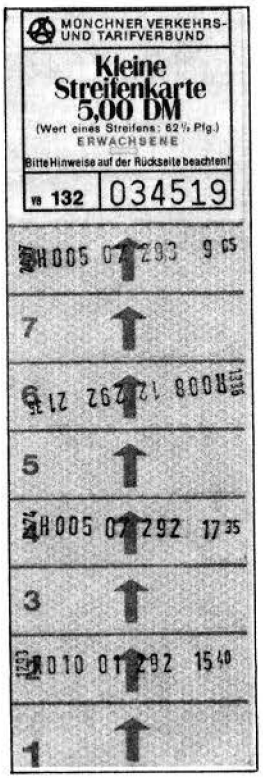
Single-trip ticket issued by machines for use on the Lyon, France Metro or bus system. Tickets are pre-printed on roll stock, must be validated when used and are valid for one hour after validation.

Two Color Printing-Black and Orange

Single-trip ticket issued by a machine for use on Münchner Verkehrs- und Tarifverbund system. The ticket is cut from a roll of pre-printed 7 point, 90 pound white index stock. As the ticket is issued the value is printed on it. The ticket must be validated by the passenger.



This single-trip ticket is issued by a machine for use on the Maatschappij voor het Intercommunaal Vervoer te Anwerpen (MIVA) system. This ticket is issued from a stack of pre-printed tickets and it must be validated before use. The area indicated in black is clipped and removed when the ticket is validated. This ticket is also embossed with the transit property logo as it is issued.



Embossing Area

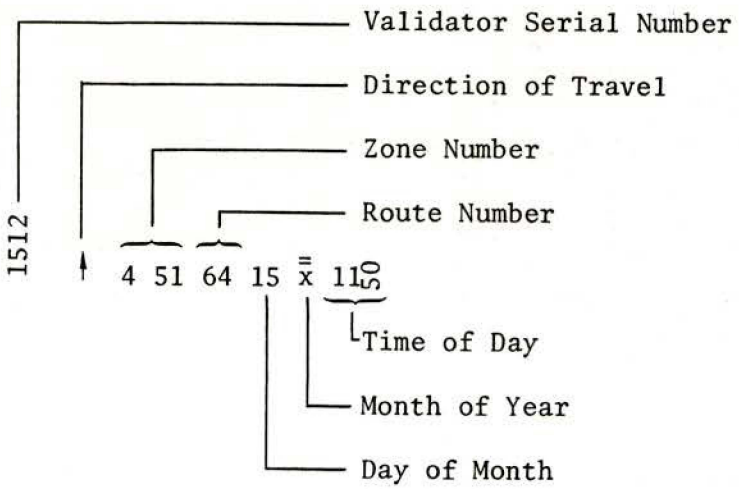
Validation Information

0474 H005 07 292 1735

- Validation Serial Number
- Direction of Travel (Inbound/Outbound)
- Zone Number
- Time of Day
- Day of Year
- Route Number

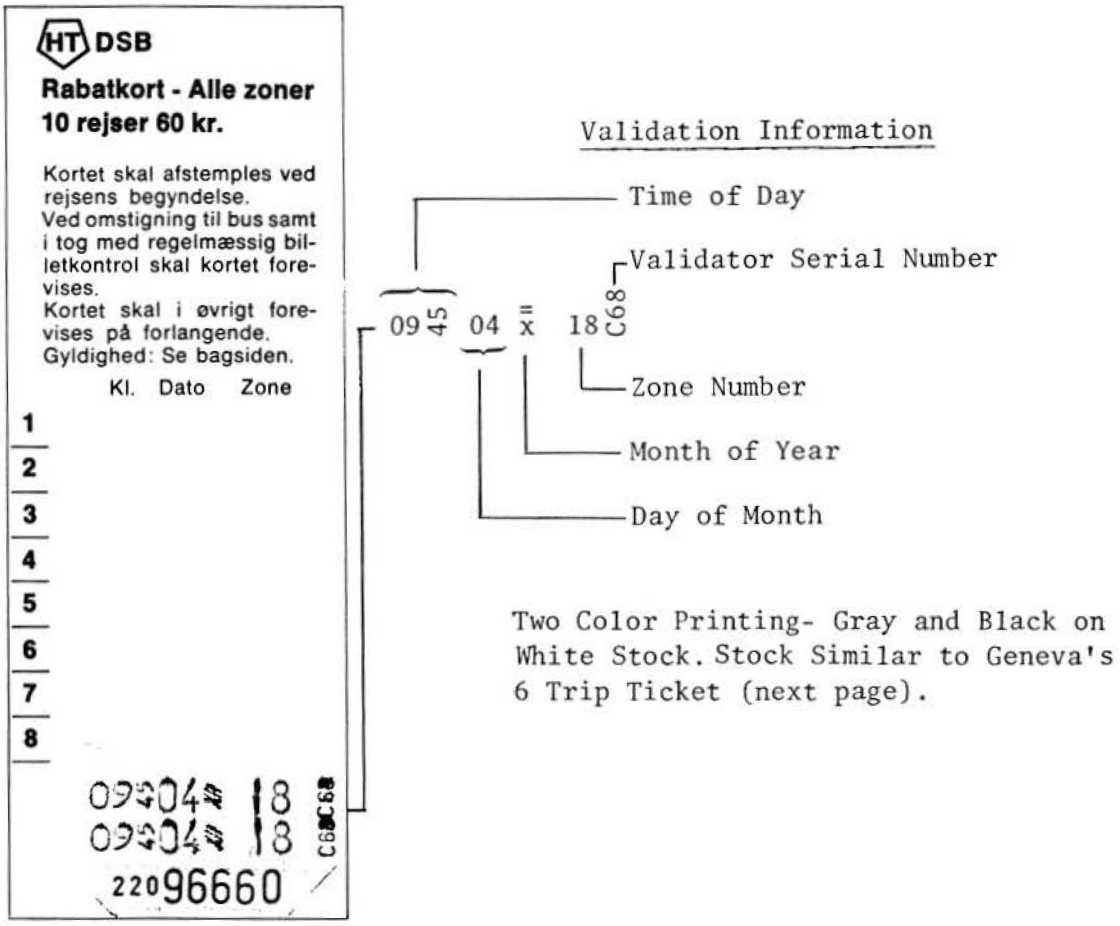
Three Color Printing-Dark Blue on Light Blue Background, and Black. All Printed on White 9 Point, 110 Pound Index Stock

This multi-trip ticket is issued by a machine for use on the Münchner Verkehers- und Tarifverbund system. This ticket is cut from pre-printed leporello stock and when issued it is embossed with the logo of the issuing authority. This ticket must be calidated at the time of use for the correct number of zones to be traveled. This type of ticketis folded as it is used to ensure correct validation.



Two Color Printing- Blue and Black on White Stock

This multi-trip ticket is issued by a machine for use on the Rheinishche Bahngesellschaft system in Düsseldorf. This four-trip ticket is issued from a stack of pre-printed tickets and it must be validated for each trip as needed. Two trips are shown on the ticket above; there are two additional trips on the reverse side.

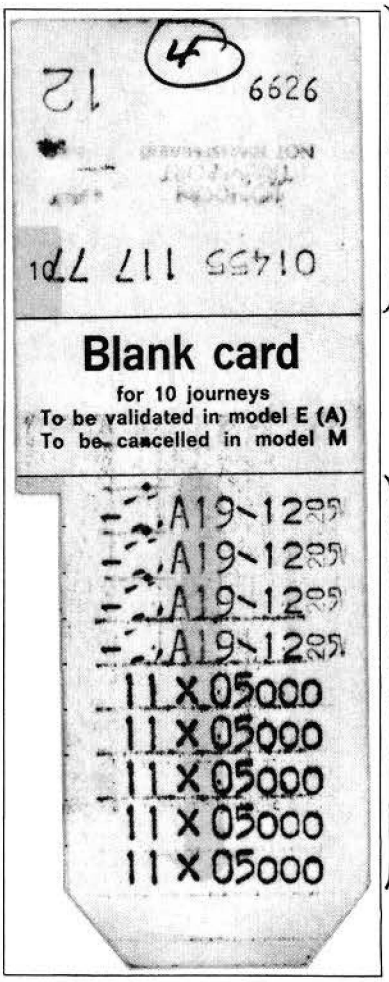


Two Color Printing- Gray and Black on White Stock. Stock Similar to Geneva's 6 Trip Ticket (next page).

This multi-trip ticket is issued by a machine for use on the Hovedstadsområdets Trafikselskab system. This type of ticket is issued from a stack of pre-printed, pre-cut tickets. As each trip is validated the validator prints validation information on the ticket and cuts a piece of the ticket. This particular ticket was valid for 10 trips; two have been used. Different tickets which are valid for a different number of zones or trips are printed in different colors--yellow, blue, green, etc.

Two Color Printing-
Black and Green

Six-trip ticket issued by a machine for Transports Publics Genevois. Ticket is issued from a stack of pre-printed, pre-cut, 17 point, coated one-side, solid bleach sulfate stock. Ticket must be validated by passenger for each trip. Ticket is cut and printed by validator each time it is used.



Upper Part

Lower Part

Example of multi-trip ticket proposed by London Transport. This ticket is sold by bus drivers, agents, or concessionaires and it is printed on 11 point, 150 pound white tag stock. When a passenger purchases the ticket, the seller validates the entire ticket by inserting the upper portion of the ticket into a vendor-validator. As the passenger uses each trip, he must validate (cancel) on-board the vehicle each trip on the lower portion of the ticket.

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