
**Agricultural and forestry
machinery — Environmental
requirements for sprayers —**

**Part 5:
Aerial spray systems**

*Matériel agricole et forestier — Exigences environnementales pour les
pulvérisateurs —*

Partie 5: Systèmes aériens de pulvérisation

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Contents

	Page
Foreword.....	iv
Introduction.....	v
1 Scope.....	1
2 Normative references.....	1
3 Terms and definitions.....	2
4 List of significant hazards.....	2
5 Requirements.....	3
5.1 General.....	3
5.2 Sprayer tanks.....	3
5.2.1 Materials.....	3
5.2.2 Tank openings.....	3
5.2.3 Emptying.....	4
5.2.4 Tank contents indicator(s).....	4
5.2.5 Agitation.....	4
5.2.6 Filling pre-mix tank.....	4
5.3 Hoses and lines.....	5
5.4 Spray boom.....	5
5.4.1 Design and location.....	5
5.4.2 Adjustment.....	5
5.5 Safety measures.....	5
5.6 Filters.....	6
5.7 Nozzles/atomizers.....	6
5.8 Measuring systems.....	6
5.8.1 General.....	6
5.8.2 Provisions for connecting test equipment.....	7
5.9 Volume/area adjustment system.....	7
5.10 Distribution and control of spray drift.....	7
5.10.1 Distribution.....	7
5.10.2 Control of spray drift.....	8
5.10.3 Swathe marking/mapping.....	8
5.11 Cleaning.....	8
5.11.1 Cleaning devices at the sprayer.....	8
5.11.2 Water tanks.....	8
6 Instruction handbook/Operator's manual.....	8
7 Markings.....	9
Annex A (informative) Guidelines, aerial deposition models and nozzle drop size category websites.....	10
Bibliography.....	11

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 document 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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 6, *Equipment for crop protection*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 144, *Tractors and machinery for agriculture and forestry*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

A list of all parts in the ISO 16119 series can be found on the ISO website.

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

Significant areas are sprayed globally by fixed wing and rotary aircraft in order to overcome serious pest threats to agriculture and forestry. Aerial application is used where difficult terrain or crop (forests) dictate as well as for timely application to large areas, in order to maximize efficient use of crop protection products and minimize environmental impact. This document specifies requirements and methods for verification, design and performance which are often unique from other sprayer equipment. This does not cover aircraft safety and design criteria for air worthiness and aircraft registration nor pilot or operator requirements all of which will be specified separately by countries or regions. Industry stakeholders such as the USA National Agricultural Aviation Association (NAAA) and their partner National Agricultural Aviation Research and Education Fund have provided input to the development.

This document is a type-C standard as stated in ISO 12100:2010.

This document is of relevance, in particular, for the following stakeholder groups representing the market players with regard to machinery safety:

- machine manufacturers (small, medium and large enterprises);
- health and safety bodies (regulators, accident prevention organizations, market surveillance, etc.).

Others can be affected by the level of machinery safety achieved with the means of the document by the above-mentioned stakeholder groups:

- machine users/employers (small, medium and large enterprises);
- machine users/employees (e.g. trade unions, organizations for people with special needs);
- service providers, e.g. for maintenance (small, medium and large enterprises);
- consumers (in case of machinery intended for use by consumers).

The above-mentioned stakeholder groups have been given the possibility to participate at the drafting process of this document.

The machinery concerned and the extent to which hazards, hazardous situations or hazardous events are covered are indicated in the Scope of this document.

When requirements of this type-C standard are different from those, which are stated in type-A or type- B standards, the requirements of this type-C standard take precedence over the requirements of the other standards for machines that have been designed and built according to the requirements of this type-C standard.

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Agricultural and forestry machinery — Environmental requirements for sprayers —

Part 5: Aerial spray systems

1 Scope

This document specifies requirements and the means for their verification for the design and performance of aerial fixed wing and rotary aircraft spray systems for agriculture, forestry, turf, and vegetation control in transport access ways (such as gas and electric lines) with regard to minimizing the potential risk of environmental contamination during use, including misuse foreseeable by the manufacturer.

It is intended to be used with ISO 16119-1:2013, which gives general requirements common to all the sprayer types covered by ISO 16119. When requirements of this document are different from those stated in ISO 16119-1:2013, the requirements of this document take precedence over the requirements of ISO 16119-1:2013 for machines within the scope of this document.

This document does cover safety of aerial spray equipment not covered by ISO 4254 series.

This document is not applicable to sprayers manufactured before the date of its publication, or unmanned aerial vehicles (such as drones).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1401:2016, *Rubber hoses for agricultural spraying*

ISO 5681:2020, *Equipment for crop protection — Vocabulary*

ISO 5682-1:2017, *Equipment for crop protection — Spraying equipment — Part 1: Test methods for sprayer nozzles*

ISO 5682-3:2017, *Equipment for crop protection — Spraying equipment — Part 3: Test method to assess the performance of volume/area adjustment systems*

ISO 5682-4:2021, *Equipment for crop protection — Spraying equipment — Part 4: Test methods for agitation of sprayer tanks*

ISO 9357:1990, *Equipment for crop protection — Agricultural sprayers — Tank nominal volume and filling hole diameter*

ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 13440:1996, *Equipment for crop protection — Agricultural sprayers — Determination of the volume of total residual*

ISO 16119-1:2013, *Agricultural and forestry machinery — Environmental requirements for sprayers — Part 1: General*

ISO 22368-3:2004, *Crop protection equipment — Test methods for the evaluation of cleaning systems — Part 3: Internal cleaning of tank*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5681:2020, ISO 12100:2010 and the following apply.

ISO and IEC maintain terminological 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 fixed wing aircraft

aircraft with fixed wings approved by local or national authority equipped for the application of plant protection products and fertilizers on crops, including forestry and grasslands

3.2 rotary aircraft

helicopter (rotary propelled) aircraft approved by local or national authority equipped for the application of plant protection products and fertilizers on crops, including forestry and grasslands

3.3 global navigation satellite system GNSS

generic term for satellite navigation systems that provide autonomous geospatial positioning with global coverage

[SOURCE: ISO/TS 11356:2011, 3.2]

4 List of significant hazards

Table 1 specifies the significant hazards, the significant hazardous situations, and significant hazardous event(s) covered by this document that have been identified by risk assessment as being relevant for this type of machine with regard to environmental contamination, and which require specific action by the designer or manufacturer to eliminate or to reduce environmental contamination.

Attention is drawn to the necessity to verify that the environmental requirements specified in both ISO 16119-1:2013 and this document apply to each significant hazard presented by a given machine and to validate that the risk assessment is complete.

Table 1 — List of significant hazards

	Hazard	Hazardous situation/event	Clause/subclause of this document
4.1	Spillages	Filling, filters	5.2 ; 5.2.6 ; 5.5
		Mixing of plant protection product	5.2.6 ; 5.11.1
4.2	Contamination of the water supply	Filling	5.2.6 ; 5.11
4.3	Leakages	Transport and application	5.2.6 ; 5.6 ; 5.2
4.4	Overfilling	Filling	5.2 ; 5.2.4 ; 5.2.6
4.5	Dispersal of spray mix residues or plant protection products	Drainage	5.2.3 ; 5.2.4 ; 5.11.1
		Cleaning and rinsing	5.2.3 ; 5.5 ; 5.11

Table 1 (continued)

Hazard		Hazardous situation/event	Clause/subclause of this document
4.6	Accidental leakages	Accidental opening of tank outlet Hose leaks	5.2.4 ; 5.4 ; 5.2
4.7	Over-dosing	Heterogeneous mixing	5.2.5
....		Overlapping	5.10 ; 5.9
		Sprayer adjustment/control	5.10
		Sprayer maintenance/service	5.8.2 ; 6
		Unintended deposition	5.5
4.8	Unintended spraying outside the target area	Deposition outside the target area	5.5 ; 5.10
		Spraying stop control	5.7
4.9	Drift	Spraying	5.10
4.10	Dispersal of spray mix	Intervention on the sprayer during application or service	5.9 , 5.10 ,
4.11	Dripping	Spraying stop control	5.7
4.12	Aircraft collision (wire strikes)	Aircraft working	5.5

5 Requirements

5.1 General

General requirements common to all sprayer types are covered by ISO 16119-1:2013.

5.2 Sprayer tanks

The total tank volume shall be at least 5 % more than its nominal volume for open top filling, to prevent spillage as a result of overfilling. For filling via hose connections, such as auto closing fill valves and closed transfer dry-breaks, the total tank volume shall be at least 1 % more than its nominal volume. Compliance shall be checked by inspection and measurement.

5.2.1 Materials

Materials used shall be resistant to plant protection products (PPP) and approved by the manufacturer for intended use. Compliance shall be certified by the manufacturer of the tank material.

5.2.2 Tank openings

The filling hole and inspection port diameter or width shall be at least 300 mm for spray tanks with a nominal volume smaller than 300 l and preferably greater than 450 mm for bigger spray tanks. Alternate means to inspect tanks may be used for tanks with smaller fill openings. To limit the risk of access into the tank, any tank opening greater than 400 mm in diameter — or, if it is rectangular, of more than 400 mm × 300 mm — shall be provided with a grating which can only be removed by the use of tools. The openings in the grating shall not exceed the above-mentioned dimensions. Compliance shall be checked by inspection, functional testing and measurement.

Filling hole lids and inspection openings shall seal sufficiently to avoid spillage.

5.2.3 Emptying

5.2.3.1 Tank emptying device

An emptying device shall allow the complete emptying of the residual in the tank when the aircraft is parked in a horizontal position. Complete emptying of the residual is considered to have been achieved when there are no visible puddles at the bottom of the tank after 5 min drainage. Compliance shall be checked by inspection and functional testing.

The tank outlet shall be guarded against accidental opening.

5.2.3.2 Residual volume

The volume of total residual volume as defined in ISO 13440:1996, 2.1 shall not exceed 2 % of the nominal tank volume. The volume of total residual shall be determined in accordance with ISO 13440:1996 for the horizontal position only as it is readily available for aircraft. Compliance shall be checked by measurement in accordance with ISO 13440:1996.

5.2.4 Tank contents indicator(s)

The indication of contents shall correspond to ISO 9357:1990. It shall be compatible with PPP and readable from the pilot or operator's position and from where the tank is filled. Turning of the head is acceptable.

Other means of checking the contents of the tank are allowed if they achieve equivalent accuracy and are readable from the same positions. Compliance shall be checked by inspection.

5.2.5 Agitation

Tanks shall be designed (e.g. including recirculation/agitation systems) to ensure an even concentration of mixture. The maximum allowable mixture concentration deviation is ± 15 % when tested in accordance with ISO 5682-4:2021. Compliance shall be checked by functional testing and measurement in accordance with ISO 5682-4:2021.

5.2.6 Filling pre-mix tank

A ground placed filling supply shall be available at the flight site (mixing/loading site) to enable proper pre-mixing of the spray liquid and filling of the aircraft spray tank. The ground filling supply shall be equipped with:

- measuring equipment like scale or flow measurement device for metering the plant protection product.
- a tank with an appropriate shape and filling opening suitable to mix the spray liquid without spillage, equipped with a tank content indicator corresponding to ISO 9357:1990, clearly readable from the operator's position.
- a tank agitator providing a uniform concentration of PPP in the spray liquid (max ± 15 % deviation when tested in accordance with ISO 5682-4:2021);
- tank, hoses and valves that tightly close and do not leak;
- device(s) for collecting accidental leakages;
- non-pressurized filling devices shall be designed to avoid any return of liquid from the tank to the filling supply, e.g. include vacuum break design or air gap separation.

Compliance shall be checked by inspection, functional testing and measurement.

5.3 Hoses and lines

The bending radius of hoses shall be within limits recommended by the hose manufacturer. Hoses fitted or supplied with the sprayer shall be in accordance with Type A of ISO 1401:2016. Compliance shall be checked by inspection and measurement according to ISO 1401:2016 (Type A).

They shall be recommended for agricultural crop protection product use. All pressurized hoses shall be directly and durably marked with the maximum working pressure. Pressure (spray boom) lines shall be equipped with quick-acting shut-off devices that allow suction back return to the spray tank for instant de-pressurization of the spray boom, unless liquid flow is controlled by starting and stopping the pump. Compliance shall be checked by functional testing and inspection.

5.4 Spray boom

5.4.1 Design and location

Spray booms shall have the option for non-uniform location of nozzles on propeller driven fixed wing aircraft to adjust for propeller wash and fuselage air turbulence on the spray.

For fixed wing aircraft the spray boom location shall be located in a position providing sufficient distance from the trailing edge of the wings to avoid air turbulence for normal operational spraying. For rotary aircraft the boom should preferably be forward of the rotor axis or equivalent design in order to minimize rotor wake effect. Nozzles shall be positioned to avoid wing tip or rotor vortices for agricultural applications. Deep canopy spraying, such as forestry spraying, may require nozzles and boom be positioned to utilize wake turbulence to achieve penetration and deposition on interior surfaces. Compliance shall be checked by inspection.

The pressure drop between the measuring point on the spray boom and hydraulic pressure nozzles/atomizers (including anti-drip device) or the orifice plate for the last open nozzle shall not exceed 10 % of the pressure shown on the pressure indicator. This test shall be performed at maximum flow rate as indicated by the manufacturer. For non-pressure-based nozzles/atomizers the pressure drop shall be measured to the inlet of any flow restrictor determining flow. These tests may be conducted with the spray boom dismantled from the aircraft. Compliance shall be checked by measurement to method above.

5.4.2 Adjustment

It shall be possible to adjust the number and location of nozzles to optimize the spray pattern distribution. Compliance shall be checked by inspection.

5.5 Safety measures

Spray systems shall have an emergency stop with immediate accessibility to the pilot. In the case of aerial spraying, the forward movement of the aircraft cannot be instantly stopped nor the pressure in the system instantly changed. The emergency stop procedure is to divert away from the hazard using the aircraft's control stick and rudder and turn the spray-off using the spray handle.

Fixed wing aircraft shall be equipped with wire strike cutters, or deflectors or equivalent protective scheme, to reduce probability of loss of aircraft and spray operation control.

All operational controls shall have ergonomic considerations for location and ease of use from the normal position of the pilot and/or operator. If an emergency dump valve control is present, it shall have significantly different look and feel from other controls and shall have two dissimilar actions to initiate to prevent unintended operation.

Installed radio communication and avionics shall conform to necessary local or national air traffic regulations for transit to and from the flight site as well as the spray location.

Compliance for safety measure requirements shall be checked by inspection.

5.6 Filters

A strainer shall be included in the filling system and shall have a mesh size less than 2 mm. Compliance shall be checked by inspection and measurement.

On the pressure side, the liquid going to the nozzles shall be filtered by means of central filter(s) or filters in the lines of boom sections. The size of filters shall correspond to the size of nozzles fitted on the sprayer. The pilot or operator shall be able to detect blockages, for example by an appropriate positioning of the central pressure filters and pressure indicator(s). Compliance shall be checked by inspection.

Filters shall be accessible and filter insets shall be removable or flushable. It shall be possible, with the tank filled to its nominal volume, to clean central filters without any spray liquid leaking out except for that which may be present in the filter casing and any connected lines. Compliance shall be checked by functional testing.

5.7 Nozzles/atomizers

It shall be possible to fix nozzles/atomizers in predetermined positions. Each nozzle/atomizer shall be equipped with a fast closing anti-drip device (e.g. a check-valve). It shall be possible to easily shut off the flow from each nozzle immediately during an operational stop or emergency stop, e.g. with a fast closing anti drip device or nozzle valve. The flow rate of each individual nozzle, measured in accordance with ISO 5682-1:2017 when demounted from the sprayer, shall not deviate by more than 5 % from the data of the manufacturer's published flow rate tables. Compliance shall be checked by inspection and measurement.

Nozzle/atomizer spray quality (drop size) category shall be available for nominal operational speeds from the nozzle manufacturer's published material or other publications (see [Annex A](#)).

5.8 Measuring systems

5.8.1 General

Aerial sprayers shall be equipped with indicators for volume application rate, the control setting and, if present, for the rotational frequency (RPM) of rotary atomisers. Compliance shall be checked by inspection.

The working pressure, atomiser RPM (where relevant), the volume application rate and the control setting shall be readable from the pilot or operator's position. Turning of the head is tolerable. Compliance shall be checked by inspection.

Sprayers shall be fitted with a pressure indicator of 63 mm minimum diameter for analogue devices, and, the accuracy of the pressure indicator shall be at least:

- $\pm 0,2$ bar for working pressures between 1 bar (included) and 8 bar (included);
- $\pm 0,5$ bar for working pressures between 8 bar and 20 bar (included);
- ± 1 bar for working pressures more than 20 bar.

Compliance shall be certified by manufacturer of the pressure indicator.

The pressure indicator shall be readable. The pressure indication shall be stable. The scale or resolution of the pressure indicator shall be:

- every 0,2 bar for working pressures less than 5 bar;
- every 1,0 bar for working pressures between 5 bar (included) and 20 bar (included);
- every 2,0 bar for working pressures more than 20 bar.

Compliance shall be checked by inspection.

Unless otherwise specified in this document, each measuring system of the sprayer, e.g. flow rate, flight speed, pressure, except for the tank contents indicator(s) shall measure within a maximum error of $\pm 5\%$ of the true value. Compliance shall be certified by manufacturers of measuring systems.

5.8.2 Provisions for connecting test equipment

Means shall be provided to test the pressure indicator, either

- on the sprayer with a connection of a 1/4" (13,157 mm) or 3/8" (16,662 mm), pitch 1,337 mm, or metric, M12 or M18, pitch 1,5 mm inner thread, or
- it shall be possible to demount the pressure indicator from the aerial sprayer without need to demount other parts of the sprayer

Means shall also be provided to connect a flow meter between the pump and the pressure regulator without damaging any hoses or removing the couplers from the hoses. Compliance shall be checked by inspection.

5.9 Volume/area adjustment system

Flow adjustment is required, at minimum, to compensate for changes in aircraft flight speed.

Pressure adjustment devices shall maintain a constant working pressure at constant revolutions of the spray pump. After switching off/on the spray boom and its individual sections during spraying operation, the working pressure shall return to its original value within $\pm 5\%$. This applies also if the pressure has been adjusted in the meantime.

Volume/area adjustment systems shall meet the following requirements.

- a) After 3 s of variations in operating conditions, the measured volume application rate shall be within $\pm 10\%$ of the mean volume application rate in the new constant operating conditions.

NOTE Changes in operating conditions are effected for instance by varying the aircraft speed and switching off sections of the spray boom.

- b) During repeated adjustments of the same volume application rate (l/ha), the coefficient of variation calculated from 7 measurements shall not exceed 3 % using the CV calculation in ISO 5682-3:2017, Clause 6.
- c) The acceptable deviation from the measured volume application rate (l/ha) or respective flow rate (l/min) from the values required shall be $\pm 6\%$ for the mean deviation using the Δ calculation in ISO 5682-3:2017, Clause 6.

The test of the volume-area adjustment system shall be carried out in accordance with ISO 5682-3:2017. Compliance of requirement a) and b) above, shall be checked according to ISO 5682-3:2017, 5.1, and 5.2. Requirement c) shall be checked according to ISO 5682-3:2017, 5.4:

These tests may be conducted with the spray boom dismounted from the aircraft.

5.10 Distribution and control of spray drift

5.10.1 Distribution

The flow rate of each nozzle/atomizer of the same type and size, when mounted on the spray boom, shall not deviate by more than 5 % from the mean flow rate of all the nozzles on the boom. Compliance shall be checked by inspection, functional testing and measurement.

ISO 16119-5:2023(E)

The distribution and pattern uniformity for different nozzles/atomizers and/or flying speeds can be checked with, for example, methods ASTM E642 or ASABE S386.2 or similar methodology to determine uniformity of spray deposition.

NOTE AGDISP or AgDRIFT are examples of models to select nozzles and parameters that maximize on target and minimize off target deposition (see [Annex A](#)).

5.10.2 Control of spray drift

The sprayer shall be designed considering the need to reduce spray drift as much as practicable. Open nozzle/atomizer locations should be less than 75 % of each wing semi-span or rotor diameter to avoid wingtip vortices or helicopter rotor down wash for agricultural applications. Compliance shall be checked by inspection.

5.10.3 Swathe marking/mapping

The aircraft shall be equipped with either swathe GNSS-based electronic indication or auto flagger swathe marking equipment to eliminate the need for ground-based swathe marking personnel that could be exposed to plant protection products during application. Compliance shall be checked by inspection.

GNSS swathe displays shall be easily readable by the pilot in normal operational position.

It is strongly recommended that aircraft should be equipped with a GNSS system capable of logging aircraft position and capable of visually displaying and logging spray on/off. This system should include a display to indicate whether the application is on line. The system should be compatible with appropriate mapping software to facilitate viewing of spatial spray records.

5.11 Cleaning

5.11.1 Cleaning devices at the sprayer

Aerial sprayers shall have available an internal or external tanks cleaning system. A water tank cleaning system shall be provided at the flight mixing/loading site or when suitable with the aerial sprayer for rinsing. Compliance shall be checked by inspection.

The tank cleaning system shall remove plant protection product adhered to the inner surfaces of the tank as specified on the plant protection product cleanout label. Compliance shall be checked by measurement in accordance with ISO 22368-3:2004.

5.11.2 Water tanks

A water tank shall be provided at the mixing/loading site for rinsing the aerial sprayer tank and boom. It shall supply a volume of at least 10 % of the nominal spray tank volume.

The water tank system shall be designed so that it can be connected with the sprayer in such a way that the rinsing of the pipes as well as the dilution of the residual in the tank is possible without spillage.

An “on-board” internal tank shall have a volume of at least 3 % of the spray tank. Compliance shall be checked by inspection.

6 Instruction handbook/Operator's manual

In addition to the applicable requirements given in ISO 16119-1: 2013, the operator's manual for aircraft spray systems shall, as minimum, include:

- any applicable local or national guidelines for Best Application Practices, e.g. National Aerial Applicators Association (NAAA),^[8] Professional Operating Guidelines or FAO aerial guidelines (see [Annex A](#));