INTERNATIONAL STANDARD

ISO 23117-1

First edition
2023-06

Agricultural and forestry machinery — Unmanned aerial spraying systems —

Part 1: Environmental requirements

Matériel agricole et forestier — Systèmes de pulvérisation aériens sans pilote —

Partie 1: Exigences environnementales

Reference number
ISO 23117-1:2023(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO 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).

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This document was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry,* Subcommittee SC 6, *Equipment for crop protection*.

A list of all parts in the ISO 23117 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

The increased popularity of unmanned aircraft systems (UAS), also known as unmanned aerial vehicles (UAV) or drones, and the continued advances in flight control, flight duration, and payload potential are improving the utility of UAS for agricultural purposes. UAS use in agriculture is a rapidly changing field, with unmanned aerial spraying systems (UASS) already in use in East-Asian applications, for example in rice, bush and tree crops. UASS has the potential to provide an aerial spray system when handheld/portable, terrestrial vehicles, or manned aircraft would be hazardous. However, spraying from UASS can impact the surrounding environment in various ways such as misapplication, accidents during the application, improper design, inadequate weather condition, etc. It is important to consider biological and ecological considerations in plant protection. This document gives the minimum requirements for UASS with particular emphasis on minimizing the potential risk of environmental contamination. This document does not cover UAS safety and design, requirements for registration of UAS or requirements for the remote pilot: these are specified by individual countries or regions. However, where UAS design is closely related to the environment protection, limited technical information is included.

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

The structure of safety standards in the field of machinery is as follows:

— type-A standards (basis safety standards) giving basic concepts, principle for design, and general aspects that can be applied to machinery;

— type-B standards (generic safety standards) dealing with one safety aspect or one type of safeguards that can be used across a wide range of machinery:

  — type-B1 standards on particular safety aspects (e.g. safety distances, surface temperature, noise);

  — type-B2 standards on safeguards (e.g. two-hands controls, interlocking devices, pressure sensitive devices, guards);

— type-C standards (machinery safety standards) dealing with detailed safety requirements for a particular machine or group of machines.

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

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

Agricultural and forestry machinery — Unmanned aerial spraying systems —

Part 1: Environmental requirements

1 Scope

This document, when used together with ISO 16119-1, specifies the requirements and the means for verification of the design and performance of unmanned aerial spraying systems (UASS) mounted on unmanned aircraft systems (UAS) for application of plant protection products (PPPs) in agriculture, forestry, turf and amenity areas, with regard to minimising the potential risk of environmental contamination during use, including misuse foreseeable by the UASS manufacturer.

The requirements of this document take precedence over those of ISO 16119-1. The ISO 23117 series does not cover human safety aspects of UASS's or safety aspects concerning UAS's, remote pilots or bystanders.

This document is not applicable to UASS mounted on UASs with a maximum take-off mass greater than 150 kg.

This document is not applicable to UASSs manufactured before the date of its publication.

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 4102, *Equipment for crop protection — Sprayers — Connection threading*

ISO 5681, *Equipment for crop protection — Vocabulary*

ISO 5682-2:2017, *Equipment for crop protection — Spraying equipment — Part 2: Test methods to assess the horizontal transverse distribution for hydraulic sprayers*

ISO 8169, *Equipment for crop protection — Sprayers — Connecting dimensions for nozzles and manometers*

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

ISO 10626, *Equipment for crop protection — Sprayers — Connecting dimensions for nozzles with bayonet fixing*

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

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

ISO 19932-2:2013, *Equipment for crop protection — Knapsack sprayers — Part 2: Test methods*

ISO 21384-4, *Unmanned aircraft systems — Part 4: Vocabulary*

ISO 25358:2018, *Crop protection equipment — Droplet-size spectra from atomizers — Measurement and classification*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5681, ISO 21384-4 and the following apply.

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

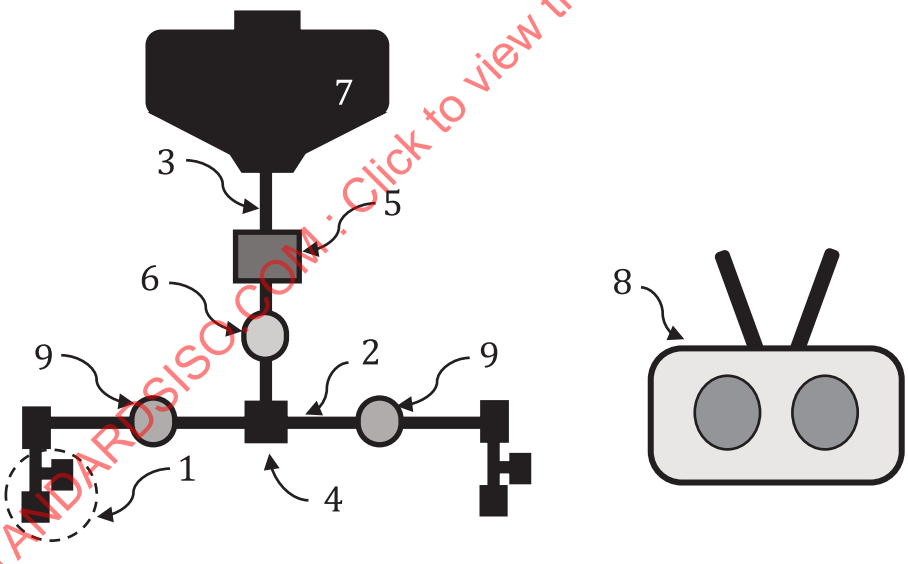
— ISO Online browsing platform: available at https://www.iso.org/obp

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

3.1
unmanned aircraft system
UAS
aircraft and its associated elements which are operated remotely or automatically

3.2
unmanned aerial spraying system
UASS
spraying system, including hardware such as spray tank, pump, hoses, nozzles/atomizers etc., necessary for the application of a spray liquid from a UAS, as well as hardware and software necessary for the remote and/or automatic control of the application

Note 1 to entry: See Figure 1.



Key

1	nozzle/atomizer, and anti-drip device	6	pump
2	spray boom	7	spray tank
3	hose	8	remote control device
4	hose connector	9	spray pressure/flow rate control device
5	valves		

Figure 1 — Example for layout of an unmanned aerial spraying system(UASS)

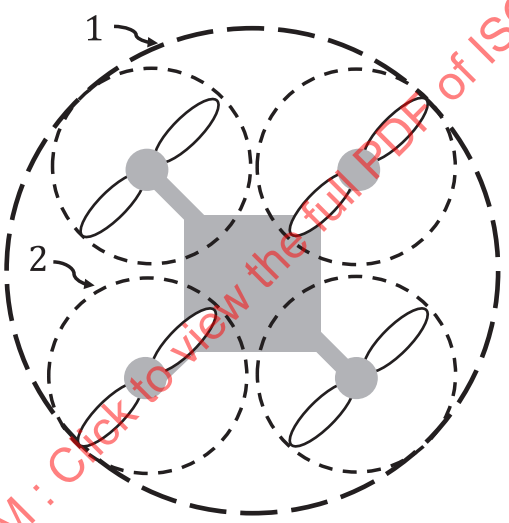
3.3
manual spray control mode
mode of UASS operation in which a remote UASS operator controls the spray application in real time using a remote control device

3.4
automatic spray control mode
mode of UASS operation in which an automatic device controls the spray application based on pre-determined spray application parameters and automatic navigation of the UAS

3.5
characteristic dimension
diameter of the smallest circle, the circumference of which envelops the paths of all the rotor tips placed on the horizontal plane

Note 1 to entry: See Figure 2.

Note 2 to entry: In case of a single rotor UAS, the characteristic dimension is equal to the diameter of the main rotor. In case of a fixed wing UAS, the characteristic dimension is equal to the wing span.



Key
1 characteristic dimension
2 path of rotor tip

Figure 2 — Definition of characteristic dimension

3.6
maximum mass of UASS
mass of UASS when the spray tank is filled to its nominal tank volume of PPPs as stated in the instruction handbook

Note 1 to entry: Mass of UASS is changing as spraying PPPs is progressed:

Max. mass of PPPs ≤UAS payload – dry mass of UASS

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 UASS manufacturer to eliminate or to reduce environmental contamination.

Verify that the environmental requirements specified in both ISO 16119-1 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
4.1	**Spillages**	Improper filling	5.1.3, 5.2.2, 5.2.3, 5.2.5.1, 5.2.5.2, 5.2.5.3
		Mishandling of spray tank and/or UASS	5.1.3, 5.2.1.1, 5.2.1.4, 5.2.1.5, 5.3.2.2, 5.4.1
		Failure of UASS	5.3.1, 5.4.1
4.2	**Leakages**	Mishandling of UASS	5.4.1, 5.4.2
		Damage and failure of UASS	5.4.1, 5.4.2, 5.4.4
		Failure of UASS	5.1.4, 5.3.1
		Failure to follow manufacturer procedures	5.2.5.3
4.3	**Dispersal of spray mixture residues**	Drainage(cleaning and rinsing)	5.1.5, 5.2.1.4
4.4	**Incorrect application rate**	Inadequate swath width	5.1.1, 5.1.2, 5.3.2.2, 5.6
		UASS maintenance/service	5.2.5.2, 5.8
		Inadequate UASS adjustment/control	5.1.1, 5.1.2, 5.2.1.2, 5.2.1.3, 5.2.3, 5.2.4, 5.2.5.2, 5.3.2.1, 5.6
		Inadequate spray pressure or nozzle flow rate control	5.1.1, 5.1.2, 5.10
4.5	**Spray drift**	Deviation from the intended spray track	5.1.1, 5.1.2, 5.6
		Environmental conditions	5.9
		Inadequate flying altitude	5.1.1, 5.1.2, 5.6, 5.9
		Too high nozzle height	5.1.1, 5.1.2, 5.6, 5.9
		Too fast flying speed	5.1.1, 5.1.2, 3, 5.6, 5.9
		Inadequate spray control/adjustment of UASS	5.1.1, 5.1.2, 5.3.2.1, 5.3.2.2, 5.4.3, 5.6, 5.10

5 Requirements

5.1 General

5.1.1 UAS

The UASS shall be attached to a UAS capable of flying in automatic spray control mode following pre-defined flight lines with pre-defined height and speed, although manual spray control mode can be used.

Compliance shall be checked by inspection.

5.1.2 Data logging

The UASS shall be equipped with a system capable of logging and recording its position data during all flight time as well as spray control signals, for example on/off of pump, flow rate of the spraying system.

Compliance shall be checked by functional test.

NOTE Spray control signal of UASS can differ due to local or national regulation.

5.1.3 Pre-mix filling supply

If a ground placed filling supply is used at the flight site (mixing/loading site) to enable pre-mixing of the spray liquid and filling of the UASS spray tank, the pre-mix filling supply shall be equipped with:

— measuring equipment such as appropriately scaled flow measurement device for metering the PPPs;

— 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, clearly readable from the operator's position;

— a tank agitator providing a uniform concentration of PPPs in the spray liquid;

— tank, hoses and valves that tightly close and do not leak;

— device(s) for collecting accidental leakage.

Filling devices shall be designed to avoid any return of liquid from the tank to filling supply, e.g. include vacuum break design or air gap separation.

Compliance shall be checked by inspection.

NOTE 1 Pre-mix filling supply is not part of UASS but can be used for assisting UASS spraying in field.

NOTE 2 The small spray tank sizes of UASSs usually mean rapid emptying so a spray tank agitator to ensure an even distribution of PPPs in the spray tank whilst spraying is not generally required.

5.1.4 UASS Materials

Materials used shall be resistant to PPPs and approved by the manufacturer for intended use.

Compliance shall be certified by the UASS manufacturer.

NOTE The chemical resistance of UAS materials to PPPs is also an important factor to consider.

5.1.5 Volume of total residue

The total residual volume in the UASS shall not exceed 4 % of the nominal spray tank volume.

Compliance shall be checked on horizontal position of the UAS only, according to ISO 13440.

5.2 Spray tank

5.2.1 General

5.2.1.1 If the spray tank is designed to be replaced for refilling of spray liquid; the spray tank, filled with water to the nominal volume, shall not leak after being dropped vertically from a height of 0,7 m to a horizontal concrete surface.

Compliance shall be checked by functional test and visual inspection.

5.2.1.2 The spray tank shall be designed to reduce surging of the contained liquid by the use of baffles or appropriate design.

Compliance shall be checked by functional test.

5.2.1.3 The spray tank shall allow pressure compensation as it empties, without any leakage of spray liquid.

Compliance shall be checked by functional test.

5.2.1.4 The spray tank emptying device shall allow complete emptying of the residual liquid in the tank in a controlled manner without spillage or accidental discharge. 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 minutes of drainage. It shall be possible to collect the spray liquid at the outlet without contaminating the environment or equipment parts of the UASS or UAS.

Compliance shall be checked by the functional test, with a suitable collector used to check that there is no spillage during emptying.

5.2.1.5 The position of spray tank shall allow its easy replacement (with a pre-filled spray tank) or access for filling while still attached to UAS. Both of these filling options shall ensure that there is no spillage.

Compliance shall be checked by functional test.

5.2.2 Dimension

The total spray tank volume shall be at least 5 % greater than the nominal tank volume that is declared by the UASS manufacturer to minimise risk of spillage from overfilling.

Compliance shall be checked by measurement.

5.2.3 Tank contents indicator(s)

The tank contents indicator shall correspond to ISO 9357. It shall be durable and easily readable. The nominal volume level on the spray tank shall be clearly marked.

Compliance shall be checked by inspection.

The volumetric contents gauge of the spray tank shall have a scale with a maximum reading error of ±10 % up to a filling level of 5 l and ±5 % above.

Compliance shall be tested in accordance with ISO 19932-2:2013, 5.3.5.

5.2.4 Material

The spray tank shall be made of translucent material so that the spray liquid level is visible.

Compliance shall be checked by inspection.

5.2.5 Spray tank filling hole, strainer and lid

5.2.5.1 The diameter of the tank filling hole shall be in accordance with ISO 9357:1990, Table 1.

Compliance shall be checked by inspection and measurement.

NOTE If the spray tank is filled from a connected pre-mix filling supply according to 5.1.3, this requirement does not apply.

5.2.5.2 A strainer with a mesh size below 2 mm shall be installed in an easily accessible location of the spray hose upstream of the pump. The depth of the strainer shall be large enough to prevent overflow at the filling hole when tested by the procedure. The strainer shall be supplied by the UASS manufacturer.

Compliance shall be checked by functional test.

5.2.5.3 Spray tank opening lid shall be able to be fitted and removed without the use of a tool and shall ensure a closed position without leaks during normal operation.

Compliance shall be checked by functional test.

5.3 Hoses, connectors and spray booms

5.3.1 Hoses and connectors

Hoses and connectors shall be secured and have sufficient fastening strength to prevent unintentional disconnection of hoses. There shall be no visible leakage from hoses and connectors.

Compliance shall be checked by inspection and functional test.

5.3.2 Design and location

5.3.2.1 The bending radius of hoses shall be within limits recommended by the hose manufacturer. Hoses shall not have any deformation, such as twisting and folding, that will restrict liquid flow.

Compliance shall be checked by inspection.

5.3.2.2 A spray boom, if present, shall be designed to prevent unintentional folding or detaching during the spraying operation.

Compliance shall be checked by functional test.

5.4 Nozzle/Atomizer

5.4.1 Nozzles/atomizers shall be appropriately mounted to prevent unintentional detachment during the spraying operation.

Compliance shall be checked by functional test.

5.4.2 Each nozzle/atomizer shall be fitted at a predetermined position and equipped with a fast acting anti-drip device. The amount of dripping shall not exceed 1 ml per nozzle during a period of 2 min, starting 1 s after the spray stop control has been activated while UASS is spraying at its maximum flow rate.

Compliance shall be checked by measurement.

5.4.3 Nozzles/atomizers flow rate and operating pressure data as well as spray quality (droplet size) category in ISO 25358 shall be available in the nozzle manufacturer's published material or other publications.

Compliance shall be checked by inspection.

5.4.4 Where the spraying system is equipped with connections for hydraulic energy nozzle tips, it shall be possible to adjust the spray characteristics to the different application conditions to minimize the use and/or environmental impact of PPPs by mounting hydraulic energy nozzle tips of dimensions in accordance with ISO 8169. Horizontal booms with flat fan nozzles with bayonet fixings shall have nozzle mountings in accordance with ISO 10626.

Where the spraying system uses rotary atomizers, it shall be possible to adjust the spray characteristics to the different application conditions to minimize the use and/ or environmental impact of PPPs.

Compliance shall be checked by functional test.

5.4.5 The flow rate of individual nozzles/atomizers measured when mounted on the UASS, shall not deviate by more than 10 % from the intended flow rate of each nozzle/atomizer mounted.

Compliance shall be tested by measurement in accordance with ISO 5682-2:2017, 6.5.

5.5 Filters

5.5.1 Spray liquid going to the nozzles/atomizers shall be filtered on the pressure side. The mesh width of these filters shall correspond with the size of the nozzles/atomizers to be used according to the recommendation of the nozzle/atomizer manufacturer.

Compliance shall be checked by inspection.

5.5.2 Filters shall be installed at a freely accessible place. The operator shall be capable of removing and cleaning filters, while wearing appropriate protective gloves, and without being contaminated by spray liquid or causing environmental contamination.

Compliance shall be checked by inspection and functional test.

5.6 Remote control device

The operator shall be able to control the spray application using a remote control device that provides means for selecting the spray control mode (automatic or manual) and for starting and stopping the spray in either spray control mode.

In automatic spray control mode, the spray application shall start and stop at predefined positions and the application rate shall remain constant independent from the flight speed.

In manual spray control mode, the remote control device shall provide means and information necessary for spraying control such as pump on/off and flow rate of the spraying system.

Compliance shall be checked by functional test.

5.7 Measuring systems

Spray control signals that allow the spray volume flow rate to be monitored with a maximum error of 3 % shall be viewable by the operator during operation regardless of spray control mode. These shall be displayed on the remote-control device.

Compliance shall be checked by inspection.

5.8 Cleaning

The sprayer should be designed and constructed to allow its complete emptying with thorough cleaning, easily, and without contaminating the environment.

5.9 Control of spray drift

The UASS shall be designed to reduce spray drift as much as possible by considering:

a) type, configuration and location of nozzles/atomizers;

b) sensors (lidar, radar, barometric and/or GNSS) to determine distance from the target being sprayed;

c) rotor numbers and rotor positions;

d) flying speed limitations.

NOTE 1 In manned aerial spray applications in agriculture, using a spray boom mounted underneath the aircraft open nozzle/atomizer locations are usually less than 75 % of the characteristic dimension of the aircraft to avoid the entrainment of spray droplets into wingtips or rotor vortices that can increase spray drift.

NOTE 2 Refer to ISO 25358 for nozzle spray quality and the OECD report[4] for literature review on spray drift (and efficacy and deposit measurement).

5.10 Spray liquid pump(s)

Flow rate and pressure provided by the pump(s) shall be sufficient for the range of spray parameters (number and size of nozzles/atomizers, flight speed, volume application rate) specified by the UASS manufacturer.

Compliance shall be checked by measurement.

5.11 Provisions for connecting test equipment

A connection having a 1/4 inch inner thread according to ISO 4102 shall be provided to connect a pressure indication for verification of the system pressure indicators and operational range.

Compliance shall be checked by inspection.

6 Verification of the environmental requirements and/or protective measures

Verification of the requirement given in Clause 5 may be made by means of inspection, calculation, or testing. The means of verification are either self-evident or verification is made via the additional means given in Table 2.

Table 2 — Additional means of verification of environmental requirements and/or protective measures given in this document

Subclause	Verification of	Compliance method			Procedure/reference
		Visual inspection	Test performance checking	Measurement	
5.1.1	Automatic spray control mode	X			
5.1.2	Data logging		X		
5.1.3	Pre-mix filling supply	X			
5.1.4	Material				By certification
5.1.5	Technical residue			X	ISO 13440
5.2.1.1	Spray tank strength	X	X		
5.2.1.2	Anti-sloshing		X		
5.2.1.3	Pressure compensation		X		
5.2.1.4	Emptying spray tank		X		
5.2.1.5	Position of spray tank		X		
5.2.2	Nominal volume			X	
5.2.3	Tank contents indicator	X			ISO 9357
5.2.3	Gauge scale		X		ISO19932-2:2013, 5.3.5
5.2.4	Material	X			
5.2.5.1	Diameter of filling hole	X		X	ISO 9357:1990, Table 1
5.2.5.2	strainer		X		
5.2.5.3	Tank opening lid		X		
5.3.1	Connector security	X	X		
5.3.2.1	Hose deformation	X			
5.3.2.2	Spray boom		X		

Table 2 *(continued)*

Subclause	Verification of	Compliance method			Procedure/reference
		Visual inspection	Test performance checking	Measurement	
5.4.1	Nozzle mounting		X		
5.4.2	Anti-drip device			X	
5.4.3	Nozzle flow rate data	X			
5.4.4	Nozzle connection		X		ISO 10626
5.4.5	Nozzle flow rate deviation			X	ISO 5682-2:2017, 6.5
5.5.1	Mesh of filter	X			
5.5.2	Filter handling	X	X		
5.6	Remote control device		X		
5.7	Measuring system	X			
5.10	Liquid pump			X	
5.11	Connecting test	X			

7 Instruction handbook

In addition to the requirements of this document and ISO 16119-1, instruction handbooks for UASS shall include:

— data on spray distribution and spray pattern uniformity for different layouts of nozzles/atomizers and/or flying speeds at specified nozzle height (see References [2] and [3] or ISO 24253-1 as reference).

— recommendations on proper operation (spraying during flight) condition, nozzle/atomizer quality information, guides on nozzle/atomizer selection for PPPs and range of flying speed and flying height for practical support of the remote pilot in control of spray drift

— reference(s) to any applicable local or national guidelines for safe UAS flight;

— reference(s) to any applicable local or national guidelines for Best Application Practices for UASSs;

— references for spray droplet size at operational conditions (for example nozzle/atomizer manufacturer literature).

Environmental conditions, particularly wind speed and direction, play a significant role in spray deposition and distribution so data used should be that applying to the environmental conditions in which the spray application is to be undertaken.

NOTE 1 Spray deposition and distribution in a crop canopy are likely to be significantly different to that achieved on collectors in the absence of a crop or if only mounted horizontally on the ground.

8 Marking

UASS shall be marked legibly and indelibly with the following minimum information:

— the name and full address of the manufacturer and, where applicable, an authorized representative of the manufacturer;

— year of construction, i.e. year the UASS was manufactured;

— designation of series or type;