Guidance on

Open Parachute Type Underwater Air Lift Bags

International Marine Contractors Association

www.imca-int.com

IMCA LR 007, D 016 – Rev. 4

July 2016

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This update of earlier IMCA and AODC guidance documents was prepared by IMCA, under the direction of its Diving Division Management Committee.

This document specifically supersedes IMCA D 016 Rev. 3, dated June 2007, which is now withdrawn.

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Date	Reason	Revision
1993	Initial publication	AODC 063
January 1999	IMCA review	Rev. 1
May 2003	Revised in light of further experience gained in the use of underwater air lift bags	Rev. 2
June 2007	To provide examples of different types of lifts	Rev. 3
July 2016	Major revisions to diagrams and to those sections dealing with the use of inverter lines and hold-back rigging	Rev. 4

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Appendices

1 Scope

This guidance addresses the initial and periodic examination, testing, certification and maintenance of open parachute type underwater air lift bags used to lift submerged objects.

This guidance also addresses the operational use of open parachute type underwater air lift bags and the safety precautions that should be taken during their use.

This document does not include guidance on totally enclosed lifting bags. Such bags are designed to support loads on or near the surface and so are not 'underwater air lift bags'.

This guidance does not apply to water-filled bags used as water weights for testing of other equipment.

This document updates IMCA D 016 Rev. 3 with changes which encompass:

- general small editorial updates;
- major revisions to those sections dealing with the use of inverter lines and hold-back rigging; and
- major revisions to diagrams.

2 Objectives

The objectives of this document are to provide clear lift bag guidance on:

i) fitness for purpose;

ii) examination and testing criteria;

iii) maintenance, which should be carried out to ensure the continuing integrity of each bag between its periodic tests;

iv) operational considerations;

v) safety precautions to be taken into consideration during their use.

3 Definitions

DMA	Dead man anchor or independent anchor point which, after assessment, is a suitable fixed point from which to restrain the load. When selecting a DMA it is the in-water weight of the DMA combined with the in-water weight of the load that should be used.
Dump line	This is attached to the dump valve inside the lift bag and is used in conjunction with the dump valve for fine control and adjustment of the bag buoyancy by the diver.
Dump valve	A high capacity dump valve is commonly fitted to the top centre of open parachute type underwater air lift bags. It is used in conjunction with the dump line for fine control and deflation of the bag buoyancy by the diver. *Note: The dump valve and dump line should not be considered an emergency venting system. The dump line should not be tied off to the load being lifted or elsewhere in the hope that such an arrangement will prevent any uncontrolled ascent of the bag. Dump valves fitted to parachute type underwater air lift bags are not capable of venting gas rapidly enough for this purpose.*
FoS	Factor of safety. Factor of safety values, i.e. the co-efficient of utilisation, can be found in codes such as DNV GL and Lloyd's Register and are based on the ratio between MBF and WLL/SWL.
Hold-back line/rigging	This is provided to restrain or hold-back the positive buoyancy of the lift bag when it is attached to the load. It should be attached in such a way as to prevent an uncontrolled ascent of the lift bag and load. One end of the hold-back line should be securely attached to a suitable fixed point and the other end should be attached either to the load itself or to the lift bag master link.
Inverter line	This is attached to the top of an open parachute bag. Its purpose is to invert and thus empty the bag if it becomes detached from the load being lifted. For all dynamic lifts (see 8.2) an inverter line should be fitted between the top of the open parachute bag and the load being lifted.
Manufactured attachment point	This is a strong point at or near the crown of the lift bag. It is the point at which an inverter line must be attached to the bag. It is essential that the manufactured attachment point and the selected inverter line are able together to invert any lift bag which has broken free from its load (see 7.2).
MBF/MBL	Minimum breaking force. Minimum breaking force is commonly referred to as minimum breaking load (MBL). The manufacturer guarantees that the wire rope will not break at a lesser value when new.
Suitable fixed point	A suitable fixed point is a point to which a hold-back line can be attached with confidence. Any suitable fixed point selected should have been subject to an engineering assessment to ensure that it is capable of resisting a snatch load caused by a rapidly ascending lift bag and load. In addition, the engineering assessment should confirm that the selected suitable fixed point is capable of arresting any uncontrolled ascent without being damaged, deformed or breaking. Live pipelines should not be considered as suitable fixed points.
WLL/SWL	Working load limit/Safe working load. WLL is the ultimate permissible load, assigned by the manufacturer of the item. The SWL may be the same as the WLL but may be a lower value assigned by an independent competent person taking account of particular service conditions.

4 Background

In some countries, national regulations require the initial and periodic examination, testing and certification of all items of lifting equipment. In 1993 AODC (the forerunner of IMCA) published guidance note AODC 063 – *Underwater air lift bags*. Until AODC 063 was published, there was no guidance available specific to the air lift bags used in the underwater industry. This early guidance document has subsequently been updated four times. The present version supersedes the text of IMCA D 016 Rev. 3.

The normal criteria for the testing of lifting equipment is to subject it to an overload test greater than its safe working load (SWL), but in the case of underwater air lift bags this is not currently considered to be reasonably practicable.

The testing of the rigging used with underwater air lift bags is defined in IMCA D 018 – *Code of practice for the initial and periodic examination, testing and certification of diving plant and equipment*, with additional information included specific to underwater air lift bags and set out in Appendix 2.

5 New Equipment

Whilst this guidance does not address underwater air lift bag design and manufacturing standards, generally the onus is on the manufacturer and/or supplier of equipment to ensure that the product is fit for the purpose for which it is to be used and can be used safely.

The manufacturer/supplier should provide the purchaser with the following information and certification:

i) The working load limit of the bag in fresh water;

ii) The upthrust of the lift bag. This should not exceed the stated fresh water working load limit, nor must it be less than 95% of the stated working load limit in fresh water;

iii) The factor of safety to which the underwater air lift bag is designed. The minimum factor of safety for an underwater air lift bag is 5:1 on its working load limit;

iv) The factor of safety to which the webbing slings for the underwater air lift bag is designed. The minimum factor of safety to which individual webbing slings are to be manufactured is 7:1 on the WLL of the sling;[1]

v) The design of the underwater air lift bag has been verified by a type test to the stated WLL (using the factor of safety in iii) above). The acceptable method of type test is by independent drop testing;

vi) The bag supplied conforms to the type test;

vii) Adequate information about the use for which the underwater air lift bag has been designed;

viii) Particulars of maintenance requirements.

The bag and its individual detachable lifting components, e.g. strops, rings and shackles, should each be suitably marked or labelled with a unique serial number and WLL. The lift bag should be supplied with a certificate stating the unique serial number, the manufacturing standard, its WLL and listing the component parts supplied with the bag.

Open parachute type bags should be fitted with a suitable manufactured attachment point (strong point) at or near the crown to allow an inverter line to be attached to the top of the bag (see 7.2).

A maintenance record for each bag should be established and become part of the planned maintenance system (PMS).

1 The recognised European Standard is EN 1492-1. Other standards may be in use outside the European Union.

6 Initial and Periodic Examination, Testing and Certification

The categories of competent person appropriate to carry out examination, test and certification of equipment are defined in Appendix 1. Examination and test criteria are defined in Appendix 2. The content of both these appendices has been extracted from IMCA D 018 – *Code of practice for the initial and periodic examination, testing and certification of diving plant and equipment*.

7 Operational Considerations

Underwater air lift bags are not just a handy tool, but also a major piece of lifting equipment and should be treated as such. They differ from conventional lifting equipment in that the loading comes from the upthrust generated by the volume of water displaced when the bags are filled with air. Lift bags should always be used in conjunction with a suitable lift plan and risk assessment.

7.1 Rigging

As they cannot be over-inflated, parachute type lift bags will not lift loads which are significantly greater than their designed safe working load. The parachute type has an open bottom and when full the air spills out. However, it is possible for the rigging and lift bag to be subjected to additional snatch loads. These can be imposed in various ways. Some examples are given below:

i) When the bag is used in water depths shallow enough for wave action to cause snatching and rapid changes in the dynamic loading;

ii) When the bag has lifted up the load and the top of the bag is on the surface and therefore exposed to wave action;

iii) When the lift bag is incorrectly rigged;

iv) When the lift bag becomes snagged, breaks free and induces a snatch load on the webbing strops and attachment points;

v) Where the lift is assisted by a crane and there is movement of the vessel causing changes in the dynamic loading.

These additional loads should be provided for in the 5:1 safety factor, discussed in section 5 iii).

Allowance should be made for the fact that sometimes more than one lift bag is attached to the same lift point and, therefore, there will be contact between the bags.

Incorrect rigging can also cause the SWL to be exceeded on attachment points due to the uneven distribution of the load. For example, where strops of different length are used, the load imposed on the shortest strop may be in excess of the design factor and could result in failure. It is essential that no lift bag be used that has modified or replacement components which are not approved by the manufacturer.

Inverter lines and hold-back lines are vitally important safety control measures for lifting operations that involve the use of open parachute type underwater air lift bags. It is important to be clear about the different purposes of these two lines.

7.2 Manufactured Attachment Points and Inverter Lines

Parachute bags should be fitted with a suitable manufactured attachment point at the top to allow an inverter line to be fitted to the bag. For all dynamic lifts (see 8.2) the inverter line needs to be long enough to attach to the load and invert and spill the gas from the bag if there is a failure on any part of the rigging and the bag breaks free and starts an uncontrolled ascent. The manufactured attachment point on the bag and the line itself should be strong enough to resist the snatch load caused by a rapidly ascending bag, bearing in mind that a longer inverter line will allow the bag to achieve a greater upwards velocity and, hence, will create a larger snatch load. For this reason the slack in the inverter line should be minimised (see 8.13, point 6).

It is recommended that manufactured attachment points are designed with an MBF not less than 1.5 times the WLL of the lift bag. It is also recommended that the attachment point label should state: "MBF not less than 1.5 times the WLL of the lift bag" (see Figure 3).

The user should choose an inverter line to resist any foreseeable snatch load that may be imposed if there is a failure of the rigging between the bag and the load. It is essential that the manufactured attachment point and the selected inverter line are able together to invert any lift bag which has broken free from its load.

The sole purpose of the inverter line is to invert and empty the bag if it becomes detached from the load being lifted. The inverter line is not intended to invert the parachute bag when it is still attached to the load and its rigging is still under tension. For all dynamic lifts the inverter line should always be attached to the load being lifted by the parachute bag. For static lifts the inverter line may be attached to the load being lifted or to a suitable fixed point (see Appendix 4, Figure 6).

An inverter line attached to a DMA or other fixed point during a dynamic lift cannot (and should not) be expected to act as the sole (or secondary) means to ground a buoyant lift bag and load that is heading for the surface. This occurs when the bag provides too much buoyancy for the load. In such circumstances it may be that the tension on the lift bag exerted by the load will make it very difficult or impossible for the inverter line to invert and empty the bag from the crown. The two most likely outcomes would appear to be as follows:

a) The runaway lift bag and load will track towards the DMA or other fixed point as the inverter line comes taut. It may then come under great tension and simply part, allowing the bag and load to ascend to surface (see Appendix 5 – Scenario 1);

OR

b) The out-of-control lift bag and load will track towards the DMA or other fixed point as the inverter line comes under tension. It may be that there will be sufficient tension in the inverter line to cause the bag to deviate somewhat from the vertical ('topple over') and so allow some gas to escape from the bottom of the lift bag. In such circumstances all positive buoyancy may be lost and the load may sink and be grounded again anywhere between the lift-off point and the DMA or other suitable fixed point. There would be a risk of harm to any divers or diving equipment in the area between the lift-off point and the DMA or other suitable fixed point (see Appendix 5 – Scenario 2).

This is why inverter lines should never be attached to anything but the manufactured attachment point at the crown of the bag and the load itself during dynamic lifts. It is the hold-back line that is used to prevent an uncontrolled ascent of the load being lifted, not the inverter line.

There have been incidents where the inverter line manufactured attachment point (the 'strong point') on a lift bag has been confused with the handling straps that are often attached to bags. It is vitally important to ensure that inverter lines are only ever attached to the manufactured strong point. If a lift bag becomes detached from the load being lifted and the inverter line has been erroneously attached to a handling strap rather than the manufactured strong point, the strap will simply break or tear out and the bag will continue its ascent to surface. It is recommended that manufacturers should clearly label manufactured attachment points to minimise the risk of any confusion (see Figures 2 and 3).

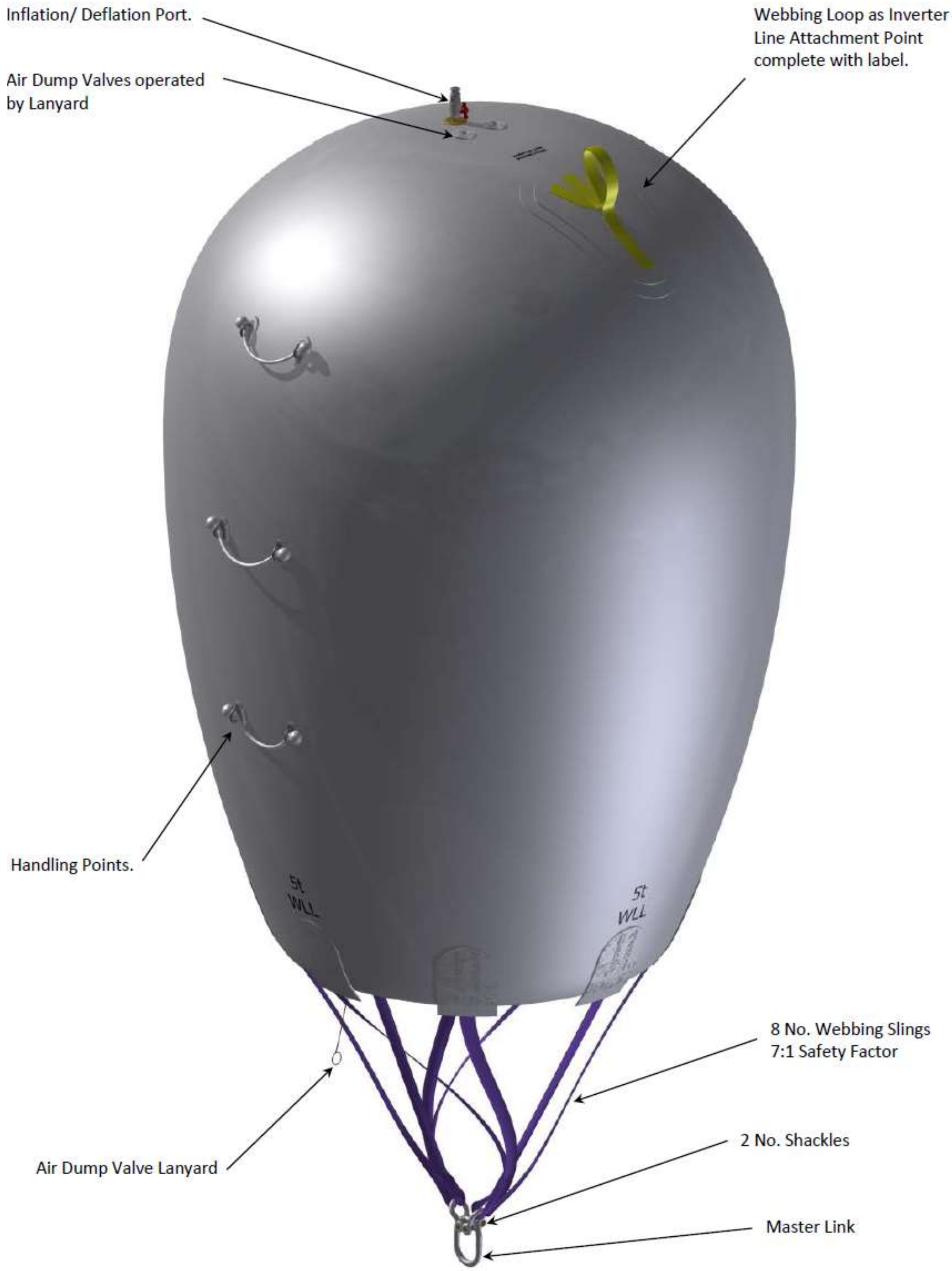


Figure 1 – Typical 5 tonne lift bag showing inverter line manufactured attachment point and handling points

Figure 2 – Typical manufactured attachment point for a 5 tonne lift bag

Figure 3 – Typical manufactured attachment point for a 10 tonne lift bag

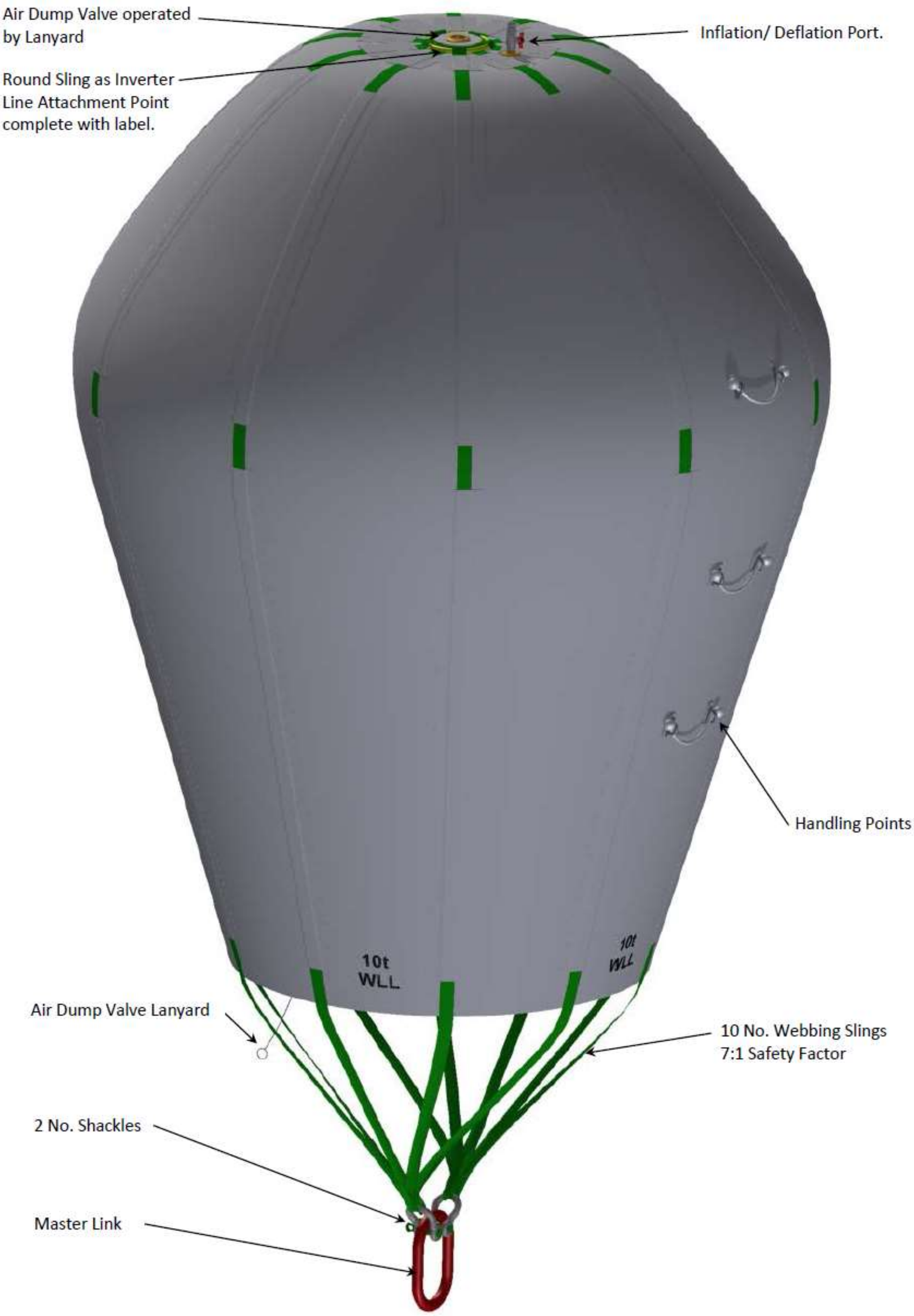


Figure 4 – Typical 10 tonne lift bag showing inverter line manufactured attachment point and handling points

Traditionally, some bags up to 50 kg WLL have not been manufactured with an inverter line attachment point. This is an unsatisfactory state of affairs as, for example, 25kg of upthrust can present a considerable danger to the diver in the event of a bag breaking free from its rigging. This guidance recommends that by 1 January 2018 all underwater air lift bags (including small bags up to 50 kg WLL) should be fitted with a suitable manufactured attachment point for an inverter line.

In the interim if it is proposed to use a small air lift bag (up to 50 kg WLL) without an inverter line to complete an underwater task, then a careful risk assessment should be undertaken to determine whether or not it is safe to proceed.

Note: It is possible for manufacturers to retrofit inverter line attachment points to existing air lift bags of up to 50 kg WLL. Owners of small bags with no manufactured attachment points may choose to have suitable attachment points retrofitted to the bags by the manufacturer or they may simply decide to replace their bags. Under no circumstances should anyone other than the lift bag manufacturer be permitted to retrofit inverter line attachment points to existing air lift bags. As noted above manufactured attachment points should be designed and marked to have an MBL of not less than 1.5 times the WLL of the lift bag.

Engineering consideration should be given to the material selected for use as the inverter line as it may be subjected to considerable snatch loading. Unnecessary slack in the inverter line should be avoided (see 8.13, point 6). Preliminary trials have indicated that, even with minimal slack in the lines, inverter lines have to resist snatch loads up to 1.5 times the upthrust of the lift bag. The trials appear to suggest that bullet-shaped bags ascend through the water faster than flatter bags and so generate the highest inverter line snatch loads. It is evident that different designs and shapes of bags will have different rates of acceleration and speeds of ascent through the water column. The pairing of lift bags with suitable inverter lines should therefore be risk assessed on a case-by-case basis.

The photograph below shows the inverting of a 2 tonne parachute bag after it was filled with air and the main rigging intentionally released at a depth of 4 metres.

Figure 5 – Inverter lines must resist strong forces

7.3 Hold-back Rigging

7.3.1 The Need for Hold-back Rigging

When planning lifting operations using underwater air lift bags, competent persons for lifting should always initially assume that hold-back rigging will be required. In virtually all circumstances hold-back rigging will need to be provided and attached to a suitable fixed point.

Hold-back rigging may only be omitted where a task specific risk assessment demonstrates that an uncontrolled ascent of the load cannot occur. For example, hold-back rigging may be considered unnecessary where the upthrust of the lift bag is known to be considerably less than the in-water weight of the load (there are circumstances where air lift bags are used to reduce the in-water weight of a load but not entirely overcome it, e.g. when a lift bag is used to help move the end of a heavy wire).

The precise nature and arrangement of suitable hold-back rigging will be dependent on the type of lift being carried out. Full details should be set out in the lift plans prepared by competent persons for lifting.

7.3.2 The General Arrangement of Hold-back Rigging

Suitable hold-back rigging should be fitted between the load being lifted and a DMA or other suitable fixed point that is not part of the load being lifted (see 8.7). This rigging should be arranged in such a way as to resist a snatch load caused by a rapidly ascending load and to stop an uncontrolled ascent. Hold-back rigging should not be attached to other adjacent subsea equipment or structures which could themselves be damaged or cause a hazard in the event of a failure. The position of hold-back rigging should be planned prior to the lift and consideration given to any adjacent objects/assets which could be influenced by a bag/load which suddenly comes up tight and vertical on this rigging.

Engineering consideration should be given to the material selected for use as hold-back rigging as it may be subjected to snatch loading. Consideration should be given to the length of the hold-back rigging to avoid unnecessary slack.

During the planning of underwater lifts using parachute type lift bags:

a) It is the in-water weights of the load and DMA(s) that should be calculated and used.

b) The in-water weight of the DMA(s) and load combined must always exceed the combined lift capacity of the lift bags (see 8.5).

   Where DMAs are not used, the strengths of other suitable fixed points (combined with the in-water weights of loads) must also exceed the total lift capacity of the lift bag or bags.

c) Engineering consideration should also be given to the density of the water or other liquid medium in which diving is planned to take place.

7.4 Use of Safety Factors

It may be prudent to include suitable factors of safety as part of the lift plan process.

8 Operational Guidance

Several sketches illustrating typical examples of subsea rigging of parachute bags are shown in Appendix 4.

8.1 Before lift bags are used in underwater engineering tasks, a proper assessment of the task to be performed should be made. This would normally take the form of a risk assessment and the development of an appropriate lift plan. This should include the following:

i) Calculations of the weight to be lifted or moved;

ii) Calculations of the size of the lift bag required (bags should be of the minimum size necessary to achieve the required lift);

iii) Calculations, where possible, to determine the centre of buoyancy and centre of gravity so that steps can be taken to prevent the object being lifted from spinning or turning over;

iv) References to any safety factors used;

v) The number and sizes of lift bags required;

vi) The positioning and attachment of the lift bag(s);

vii) Specification of the type of air bag lift to be carried out. This will help to determine the identification of a suitable securing point for the inverter line. Remember, for all dynamic lifts the inverter line should always be attached to the load being lifted by the parachute bag. For static lifts the inverter line may be attached to the load being lifted or to a suitable fixed point (see 8.2 for definitions of air bag lift types).

Note 1: If the weight of the object to be lifted or moved is unknown or the object is buried in mud, the load can only be estimated. Precautions should be taken before the lift bags are attached, to ensure that when they are inflated control of the load is not lost. The inverter line from the top of the bag, if secured to the load itself, would perform its function should the lift bag attachment fail. It would not, however, prevent the load from going up in an uncontrolled fashion if the bag was accidentally over-inflated. For this reason, hold-back rigging should normally be connected to a suitable fixed point (see 8.7).

Note 2: Extreme care should be taken when using lift bags to overcome seabed suction or free mechanically locked or snagged equipment. A hold-back strop and anchor should be available which is heavier than the upthrust created by the lift bag. This can be achieved by placing a DMA in the vicinity of the object and attaching suitable rigging from the object being lifted or moved to the DMA.

Note 3: Generally only open bottom parachute bags should be used where any form of ascent is planned or possible, such as vessel salvage or raising objects from the seabed. Fully enclosed bags should not be used for this purpose.

Note 4: Historically, there have been cases where significant variations between the stated and actual capacities of lift bags have been found, in some cases up to 20%.

8.2 Underwater air bag lifts are segregated into two general types – static and dynamic:

- **Static lift** – this is where an air lift bag is secured by hold-back rigging and used as a single lift point, commonly known as a 'skyhook'. The air lift bag has very positive buoyancy, but it is directly restrained to anchor points, therefore, the lift bag is fixed and the load is free to move vertically with the use of a suitably approved lifting device;
- **Dynamic lift** – this is where the air lift bag is used to lift the load directly, typically for the movement of loads between locations. The air lift bag and the load tend to be close to neutrally buoyant with a system of restraints in place. In such instances the lift bag and load are moved together.

See Appendix 4 for examples of both types of underwater air bag lifts.

8.3 Once the size/type and number of lift bags has been determined by the task specific assessment, the bag(s) will need to be inspected before use for the following:

i) A check of the serial numbers on all of the components with the number on the certificate;

ii) A check of the test date on the certificate;

iii) Visual inspection of all components, even if the lift bags are new;

iv) Visual inspection of the webbing strops and the stitching on the bags;

v) The 'dump valve' at the top of parachute bags should be checked to ensure that it is clean and can operate freely. The line attached to the 'dump valve' should be checked to ensure that it is attached correctly and will operate the valve when pulled;

Note: It is recommended that dump valve lines are made of different materials, colours and/or of different diameters, so as to be readily distinguishable by the divers from other lines that may be present;

vi) The inverter line should be checked to ensure that it is attached to the manufactured attachment point at the crown (top) of the parachute bag so that the bag will invert should there be a failure of any part of the attached rigging.

8.4 If it is found, during the task specific assessment, that the lift points cannot be distributed evenly along the load, a spreader bar should be used with padeyes at equal distances on top for the lift bag slings to be attached. There should also be padeyes on the bottom of the spreader bar to enable slings to be attached to the load.

Note: If spreader bars are used, test certificates will be required and the safe working load should be marked on the bar.

8.5 The use of dead man anchors (DMAs) should be included in the task-specific risk assessment prior to commencing operations that involve air lift bags. The in-water weight of any DMA should be sufficient so that the combined in-water weight of the load and any DMA is greater than the total lift force applied by the lift bag(s), thus preventing the possibility of an uncontrolled ascent of the load to the surface. Ideally DMAs should be positioned on the far side of the load from the deployment location to prevent divers from crossing load attachment points (see 8.22), although this may not always be possible to achieve.

8.6 If the load has been estimated, it may be necessary to provide residual lift capacity. In such cases, it may be preferable to use a series of small lift bags, rather than fewer large ones.

8.7 In normal circumstances hold-back rigging should be attached to a DMA or to a suitable fixed point. The hold-back rigging should be kept as short as practicable. Hold-back rigging may only be omitted where a task specific risk assessment demonstrates that uncontrolled movement (ascent or descent) of the load cannot occur. For example, hold-back rigging may be considered unnecessary where the upthrust of the lift bag is known to be considerably less than the in-water weight of the load (there are circumstances where air lift bags are used to reduce the in-water weight of a load but not entirely overcome it, e.g. when a lift bag is used to help move the end of a heavy wire).

8.8 The bag and/or the load should be monitored during inflation.

8.9 The preferred method of filling underwater air lift bags is by using a fit-for-purpose air line provided from the surface. Air line hoses can become very buoyant and should be restrained at depth allowing for a working tail. A lance fitted to the end of the air line filling hose will help to minimise diver contact with the rigging between the bag and the load. The lance should have a quarter turn valve to allow the diver to shut off the air flow quickly if required. The nozzle of the lance should have anti-suction diffusion holes. This is because hoses are normally vented and flooded on surface for recovery.

8.10 Consideration should be given to the inflation sequence to ensure that, during subsea inflation prior to 'lift', the number of bags which are partially filled at any one time is minimised. It is recommended that each bag be partially filled on site sufficiently to lift the bag so that each bag can be checked prior to full inflation.

8.11 The dump valve should be fitted with a dump line to enable it to be operated by the diver from a safe location. In some cases it may be necessary to extend the line to allow the diver to be in a safe position. This aspect should be taken into consideration when planning the work. Both the dump line and any extension should be easily identifiable and distinguishable from any other nearby line.

8.12 Prior to deployment of the lift bag a pre-use check should be carried out using the checklist in Appendix 3.

8.13 As a guide, divers should follow the rigging and inflation sequence set out below for every dynamic lift:

1. Connect the flooded bag securely to the load. The rigging between the bag and the load should be kept as short as practicable.
2. Confirm with the diving supervisor that the rigging between the lift bag and the load is secure prior to the introduction of any air into the canopy;

3. Connect the inverter line to the load;
4. Slowly inflate the lift bag with the minimum amount of air required to allow it to stand upright;
5. Check that the rigging is properly positioned and secure in the upright posture;
6. Adjust and 'snug-up' the inverter line so as to minimise slack in the line without distorting the bag or cutting into the canopy.

Note 1: This is a critical point in the inflation sequence. If the rigging is not properly secure and the bag detaches from the load the lift bag may not be protected from ascending to surface while the inverter line is being adjusted.

Note 2: Once the inverter line has been adjusted it should not be untied or otherwise interfered with by the diver again until the lift bag has been fully deflated;

7. Connect the hold-back rigging between the load being lifted and a DMA, or other suitable fixed point, that is not part of the load being lifted;
8. Check the length of the hold-back rigging to ensure there is no unnecessary slack;
9. Check the dump valve line for sufficient length and check the dump valve function;
10. Confirm to the diving supervisor that the bag is ready to be further inflated to lift the load;
11. Begin inflation of the lift bag. During inflation confirm that the air lift bag slings are free of twists and evenly loaded. Stop inflation and reset if twists are found;
12. Carry out the lift in accordance with the step-by-step procedures contained in the lift plan;
13. Continue to monitor the bag throughout the inflation sequence and lifting operation for possible leakage.

8.14 Premature deflation of lift bags and the unplanned settlement of loads may be caused by a bag or a dump valve leaking over a period of time, e.g. when lift bags are used to support pipelines for lengthy periods during grouting operations. A suitable programme of inspection, examination, testing, certification and planned maintenance will reduce the likelihood of such leakage. Nevertheless, lift bags should also be regularly monitored for leaks during use. During underwater operations it may often be difficult for the diver(s) to observe if bags or dump valves are leaking. Therefore, as an additional safeguard, the use of an ROV (if available) to help divers and supervisors monitor bags for leakage should also be considered.

8.15 Premature deflation and the unplanned lowering of loads can also occur if the dump valve is opened in error. To prevent such dangerous occurrences dump lines should be kept clear of any snagging hazards throughout the course of air bag lifting operations.

8.16 As a guide, divers should follow the deflation and de-rigging sequence set out below for every lift;

1. Check that the load has been deposited in the desired position and is stable and secure;
2. Check with the diving supervisor that it is safe to begin deflating the lift bag;
3. Deflate the lift bag in a controlled manner using the dump line;
4. When deflated, invert the lift bag from the crown to ensure that the bag is fully flooded and contains no air;
5. Disconnect the hold-back rigging;
6. Disconnect the rigging between the lift bag and the load;
7. Disconnect the inverter line;
8. Prepare the lift bag and rigging for return to surface or as directed by the diving supervisor.

8.17 Weather conditions should be taken into consideration prior to the deployment of lift bags. Current and visibility as well as the water depth should also be considered. Strong currents can exert strong sideways forces on lift bags. It may be necessary to partially deflate lift bags between tidal operations to prevent damage to lift bags and rigging. Partial deflation of bags before the onset of the strongest tidal currents may also reduce the likelihood of loads moving or dragging across the seabed.

8.18 When deploying two divers at one time on a project, the visibility in the area the divers are to work should to be taken into consideration. Poor visibility could be an additional hazard for the divers and should to be taken into account when doing the risk assessments.

8.19 The procedures should reflect the number of divers working on the same job. Strict controls should be in place to ensure that lift bags are not inflated or deflated until both divers have been informed and each knows where the other and their umbilicals are positioned in relation to the work area. The supervisor should never give the order to inflate or deflate the bags until the divers are ready.

8.20 Divers should never position themselves directly beneath loads that have been picked up by lift bags or any other lifting equipment. Alignment lines and tirfors are often used during dynamic lifting operations to move lift bags and loads into the required positions (see Figure 11). This minimises the need for divers to approach lift bag suspended loads closely.

8.21 Alignment lines and other kinds of rigging should not be considered as suitable substitutes for hold-back lines. Hold-back lines should always be able to prevent uncontrolled ascents of lift bags and loads on their own, regardless of the presence or absence of any other lines or rigging. Hold-back lines should never be removed because other lines and rigging have been put in place for other purposes. Unless a line has been subject to an engineering assessment confirming it is suitable for use as a hold-back line for a particular underwater air bag lifting operation it should not be used as a hold-back line for that lifting operation.

8.22 Advanced planning should ensure that the positions of vessels and diver deployment devices (baskets and bells) do not encourage divers to cross over items to be lifted, e.g. spool pieces. Divers should always position themselves whilst working with lift bags so that their umbilicals are never routed over or directly under lift bags and loads. In the event of a rigging failure the divers risk being pulled upwards or trapping their umbilicals. Divers should be aware of their umbilical position in relation to the work and never turn their backs on a dynamic load.

8.23 Consideration should be given to the hazards that may be caused by venting air lift bags beneath vessels. Small workboats may experience buoyancy/stability problems if large amounts of air rush to surface underneath them. The release of air bubbles could have undesirable effects on hydroacoustic reference systems operating on dynamically positioned vessels. Air could also find its way into water intake systems potentially causing engines to become overheated. Effective measures should be taken to ensure these problems are avoided.

8.24 Prior to the venting of air from underwater air lift bags consideration should also be given to the direction of the current and the location of the diving bell. Great care should be taken to avoid any contamination of the bell atmosphere with air released from lift bags.

9 Maintenance

When in service it is the responsibility of the end user (diving contractor) to ensure that the lift bag remains fit for purpose and safe to use.

Open parachute type underwater air lift bags and all their components should be maintained fully in accordance with the manufacturer's instructions and included in company planned maintenance systems (PMS). It should be a straightforward matter for users/owners of underwater air lift bags to access the manufacturer's complete instructions for maintenance on the internet.

- A maintenance record for each bag should be established and become part of the PMS. It is good practice to have certificate validity status tags attached externally to lift bags when stored.
- Before and after use, all bags should be examined by a competent person. If any defects or out-of-date certification are found, the bag should not be used until repaired and/or re-tested.
- Lift bags should be washed after use with fresh water and any grease or oil removed.
- The dump valve on parachute type bags should be cleaned and dried.
- Once cleaned, the bag should be laid out so that it is fully extended. It should then be inspected by a competent person.
- The competent person should mark and record any defects in the maintenance record for that particular bag.
- Any repairs should be carried out in accordance with the manufacturer's instructions. When repairs are completed, they must be entered into the maintenance record for that bag.
- When repaired or ready for storage the lift bags should be checked to confirm they are dry, packaged in line with the manufacturer's recommendations, and stored in a clean dry place.
- An example checklist for use prior to using a lift bag and after maintenance is provided at Appendix 3.

10 Training

Personnel (e.g. supervisors, engineers and divers) who use underwater lift bags should have a basic knowledge of the following:

i) Archimedes' Principle;

ii) hydrostatic pressure;

iii) absolute pressure;

iv) Boyle's Law;

v) underwater air lift bag failure modes and their effects;

vi) safe operational procedures during dynamic and static lifts;

vii) safe personnel and equipment positioning during air lift bag operations;

viii) safe inflation/deflation sequences.

With an understanding of these aspects, personnel should be more aware of what can be accomplished by the use of lifting bags, the dangers that are present and the need for caution and strict controls.

Training should be given to personnel involved in lift bag operations in accordance with the manufacturer's instructions and as set out in this guidance note. Training of surface personnel should include but not be limited to:

i) storage, examination and testing of lift bags;

ii) the deployment and rigging of lift bags; and,

iii) cleaning and maintenance of lift bags after use.

Training of divers should include but not be limited to:

i) the correct way to attach the inverter line used to invert the bag; and,

ii) the correct way to use the dump valve and the precautions to be taken before using it.

11 References

IMCA C 002 *Guidance on competence assurance and assessment: Marine Division*

IMCA C 003 *Guidance on competence assurance and assessment: Diving Division*

IMCA D 018 *Code of practice for the initial and periodic examination, testing and certification of diving plant and equipment*

Categories of Competent Person

Category 1

A diving or life support supervisor duly appointed by the diving contractor.

Such an individual will be competent to carry out or supervise a number of types of examination and test, but may not be appropriate for other tests unless he has had additional specific training.

A diving supervisor (qualified in line with the IMCA scheme) is regarded as being competent to carry out certain tests, e.g. pressure leak tests on pressure vessels, which may also be performed by any other competent person specialising in such work. This level of competence is justified by the supervisor's knowledge and experience of the sophisticated diving techniques used, together with the variety of plant and equipment necessary to implement them.

A life support supervisor (LSS) is also considered competent to carry out certain tests as defined in the detail sheets in IMCA D 018 – *Code of practice for the initial and periodic examination, testing and certification of diving plant and equipment*. To be eligible for promotion to LSS, a life support technician (LST) should be qualified in accordance with the IMCA scheme. He will be appointed in writing by his company and will have specific responsibility for the control of the saturation complex. Dependent on the offshore structure of the company, he may be subject to direct supervision by a more senior person.

Category 2

A technician or other person specialising in such work who may be an employee of an independent company, or an employee of the owner of the equipment (unless specific legal restrictions apply), in which case his responsibilities should enable him to act independently and in a professional manner.

Category 3

A classification society or insurance company surveyor, or Chief Engineer certificated in accordance with IMCA C 002 – *Guidance document and competence tables: Marine Division* (Job Category A06) but who may also be an 'in-house' chartered engineer or equivalent (unless specific legal restrictions apply), or person of similar standing.

Category 4

The manufacturer or supplier of the equipment, or a company specialising in such work which has, or has access to, all the necessary testing facilities. This may also be a technician employed by the owner of the equipment provided that he has been fully trained and certified for the specific operation and has access to all necessary equipment and facilities.

Underwater Air Lift Bags

When new

Examination/Test	Category of Competent Person
Manufactured in accordance with a recognised code or standard or to manufacturer's standard specification and fit for the purpose it will be used for	3 or 4
Function test at SWL	3 or 4

When in service

Examination/Test	Validity Period	Category of Competent Person
Thorough visual examination of body and strops, check integrity of shackles and master links, check operation of dump, relief and inlet valves, inverter and hold-back lines	6 months	1, 2, 3 or 4
Load test to maximum safe working load	12 months	2, 3 or 4
or		
Detailed visual inspection of canopy, lifting accessories and structure plus inflation test on canopy		4

Reference:

- IMCA D 016 – *Underwater air lift bags*

Note:

- Parachute type underwater air lift bags should be inflated for the 12-monthly inspection using a test plug. Care should be exercised during this exercise.
- Testing of lifting appliances and equipment is normally carried out as part of the integral system. If individual components have to be replaced such as strops or shackles then this does not require retesting provided the change is done on a like-for-like basis and the new component is supplied with its own examination and proof load test certificate.

Sample Air Lift Bag Pre-use Checklist

Identification number: ....

Safe working load: ....

Bag type: Parachute/enclosed *(delete as applicable)*

Load test expiry date: ....

Leak test expiry date: ....

Item to be checked		Acceptable Yes	No	Not fitted	Comments
1	**Check the general condition of the lift bag material**				
1.1	Review latest PMS record and check bag certificate validity				
1.2	Details on certificate agree with the identification number on the lift bag				
1.3	General condition/appearance of bag material/fabric and eyelets				
1.4	Check inside of the bag for damage or debris, check condition of the dump line				
1.5	Check all markings (e.g. SWL & ID number) are clearly shown on lift bag – not faded or otherwise illegible				
1.6	Check the integrity of any repairs/patches				
2	**Check the general condition of the rigging**				
2.1	General condition/appearance of rigging items				
2.2	Condition of all the web slings				
2.3	Condition of the stitching retaining the web slings				
2.4	Web slings are not crossed over or twisted				
2.5	Condition of the master link(s)				
2.6	Condition of the shackles				
2.7	All shackle pins are secured in place (e.g. screw pin shackles ty-wrapped)				
2.8	Web slings, shackles and master links are of an appropriate SWL for the bag				
2.9	Details on certificate(s) agree with identification numbers on rigging items				
3	**Check the functional items on the lift bag**				
3.1	Check the integrity of the inverter line attachment point(s) to the lift bag				
3.2	Check that the length of inverter line is adequate				
3.3	Confirm that the inverter line is clearly different from the dump line				
3.4	Condition/appearance of the dump valve				
3.5	Test the dump valve function – pull the dump line to test the valve action				
3.6	Confirm the dump valve is free from blockage/mud plugs				
3.7	Confirm the dump valve O-ring seal is in place				
3.8	Check that the length of the dump line is adequate				
3.9	Check that the end of the dump line is weighted				
3.10	Confirm that the dump line is clearly different from the inverter line				
3.11	Condition/appearance of the quarter turn valve(s)				
3.12	Function the quarter turn valve handle(s), confirm valve(s) opens and closes				
3.13	Confirm quarter turn valve(s) are free from blockage/mud plugs				
3.14	Condition/appearance of relief valve(s)				
3.15	Confirm relief valve(s) are free from blockage/mud plugs				

Checks completed by: .... Date: ....

Examples of Different Types of Underwater Air Bag Lifts

Note: The following sketches are indicative only, to illustrate different types of lift and rigging arrangements, and are not to scale. The sketches also indicate the minimal consequences of rigging failures and uncontrolled ascents when inverter lines and hold-back lines are used correctly.

Lower Load into Manifold/Tree Base – Static

- Both the inverter line and hold-back rigging may be secured to suitable fixed points.
- The bag provides a fixed lifting point from which the load can be either raised or lowered by mechanical means.

Note: The dump line should be routed and held well out of the way of the lifting appliance working envelope during static lifts. This is because there have been incidents where a lengthy free dump line has become caught in the chain of the lifting appliance being used. In such a situation when lowering begins the chain extends and the dump valve may operate as the dump line comes taut. The result is an uncontrolled descent of the load.

In this configuration lift bag rigging failure would result in the load and bag being grounded.

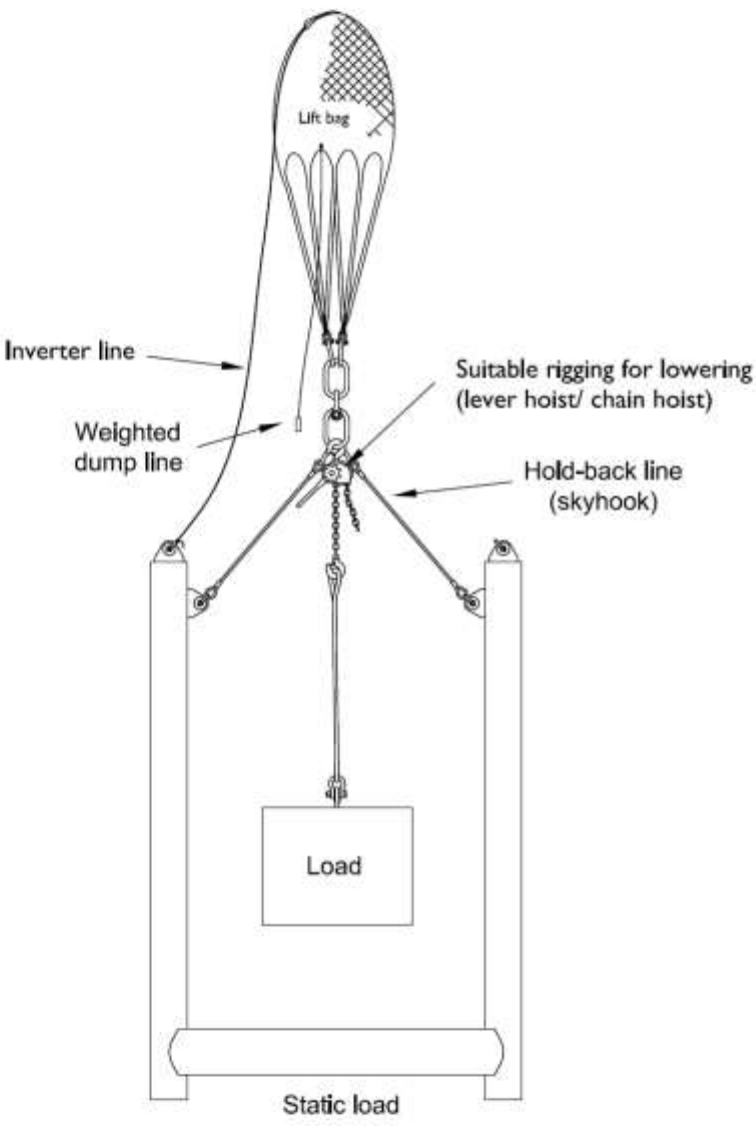


Figure 6 – Lower load into manifold/tree base – static

Lower Load into Manifold/Tree Base – Dynamic

- In this example the inverter line is secured to the load and the hold-back rigging is secured to a suitable fixed point.
- This dynamic lift involves moving the load vertically and horizontally.
- The difference between this type of lift and a static lift is that a dynamic lift is used to move a neutrally buoyant air lift bag and load.

In this configuration any lift bag rigging failure would result in the load and bag being grounded.

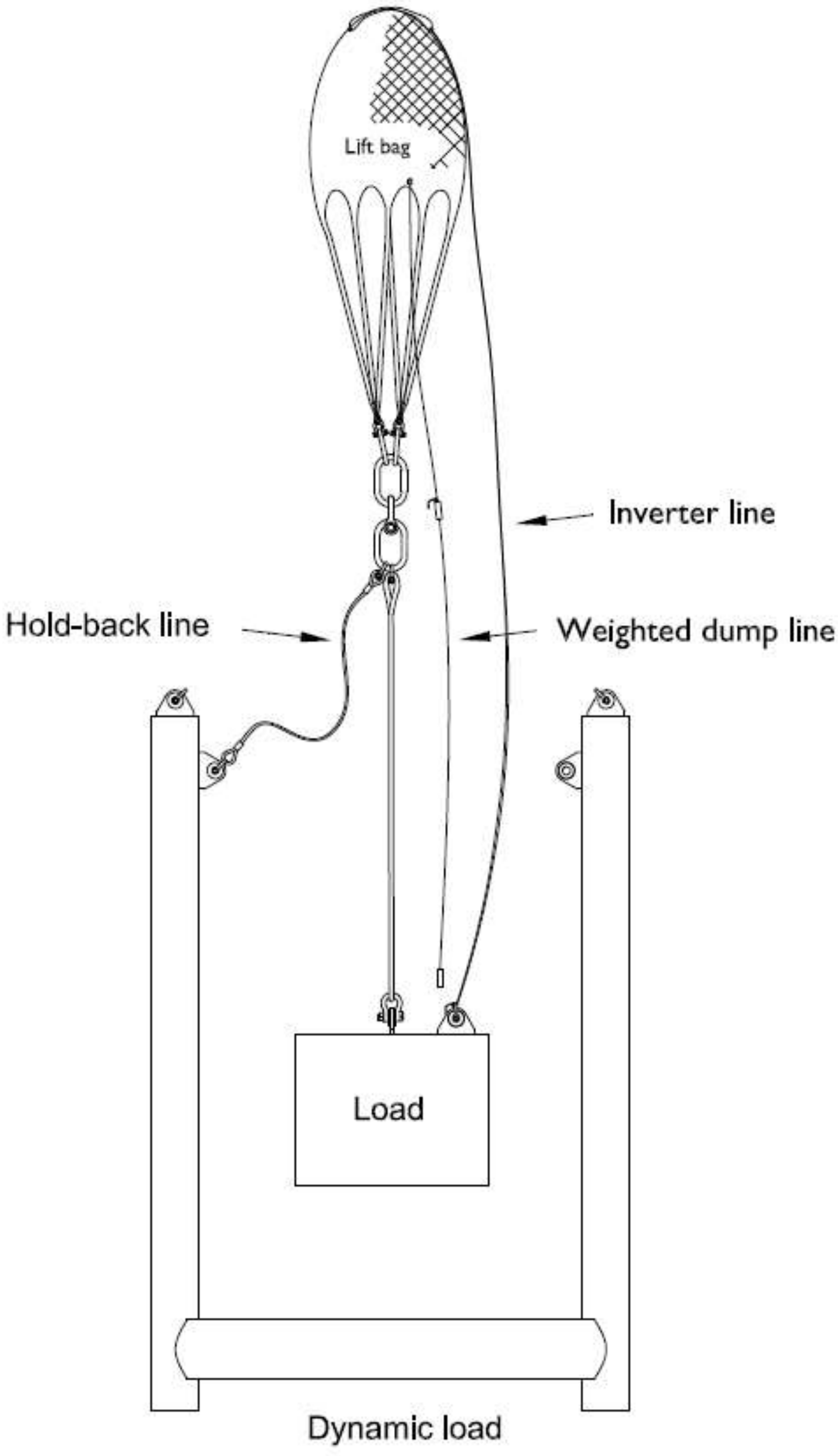


Figure 7 – Lower load into manifold/tree base – dynamic

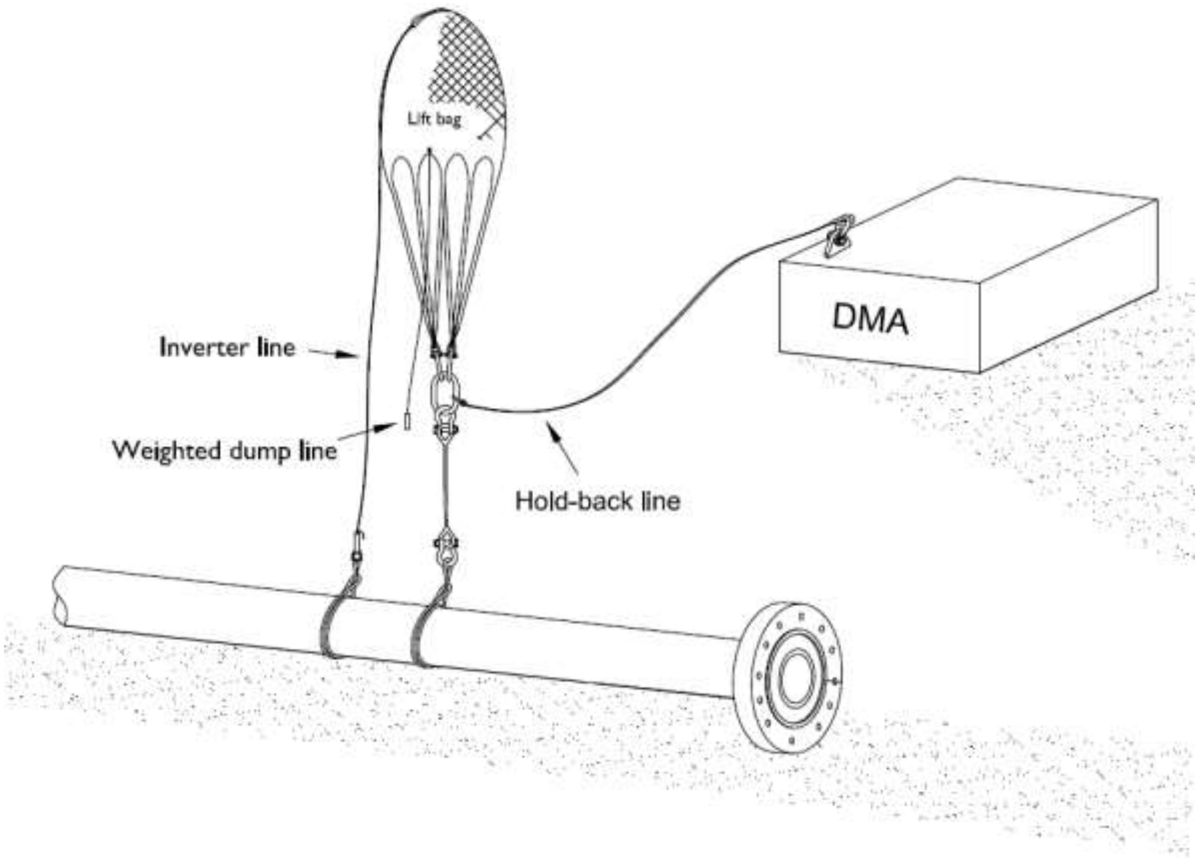


Figure 8 – Single airbag lift – dynamic

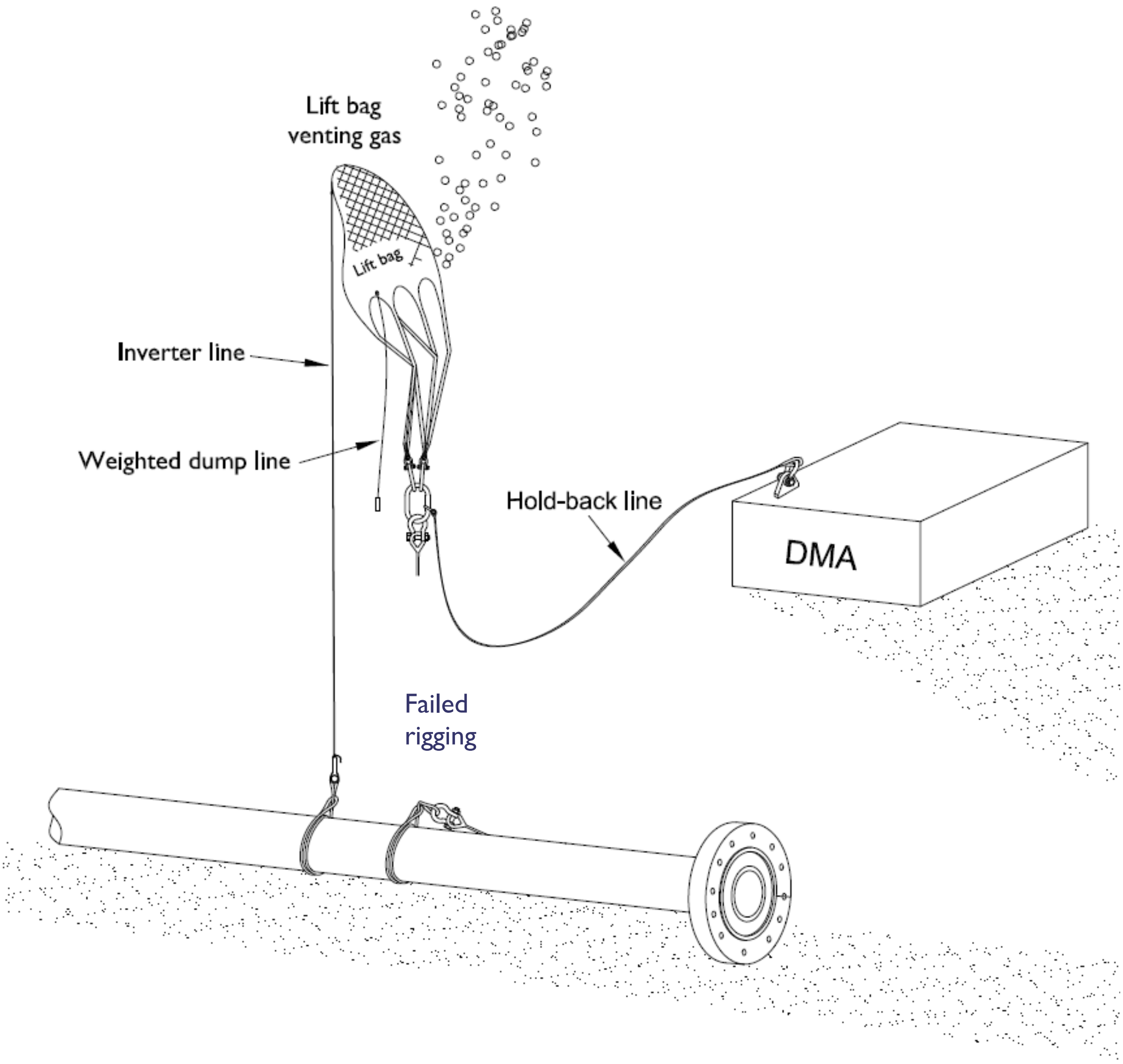


Figure 9 – Single airbag lift – consequences of rigging failure between the bag and the load

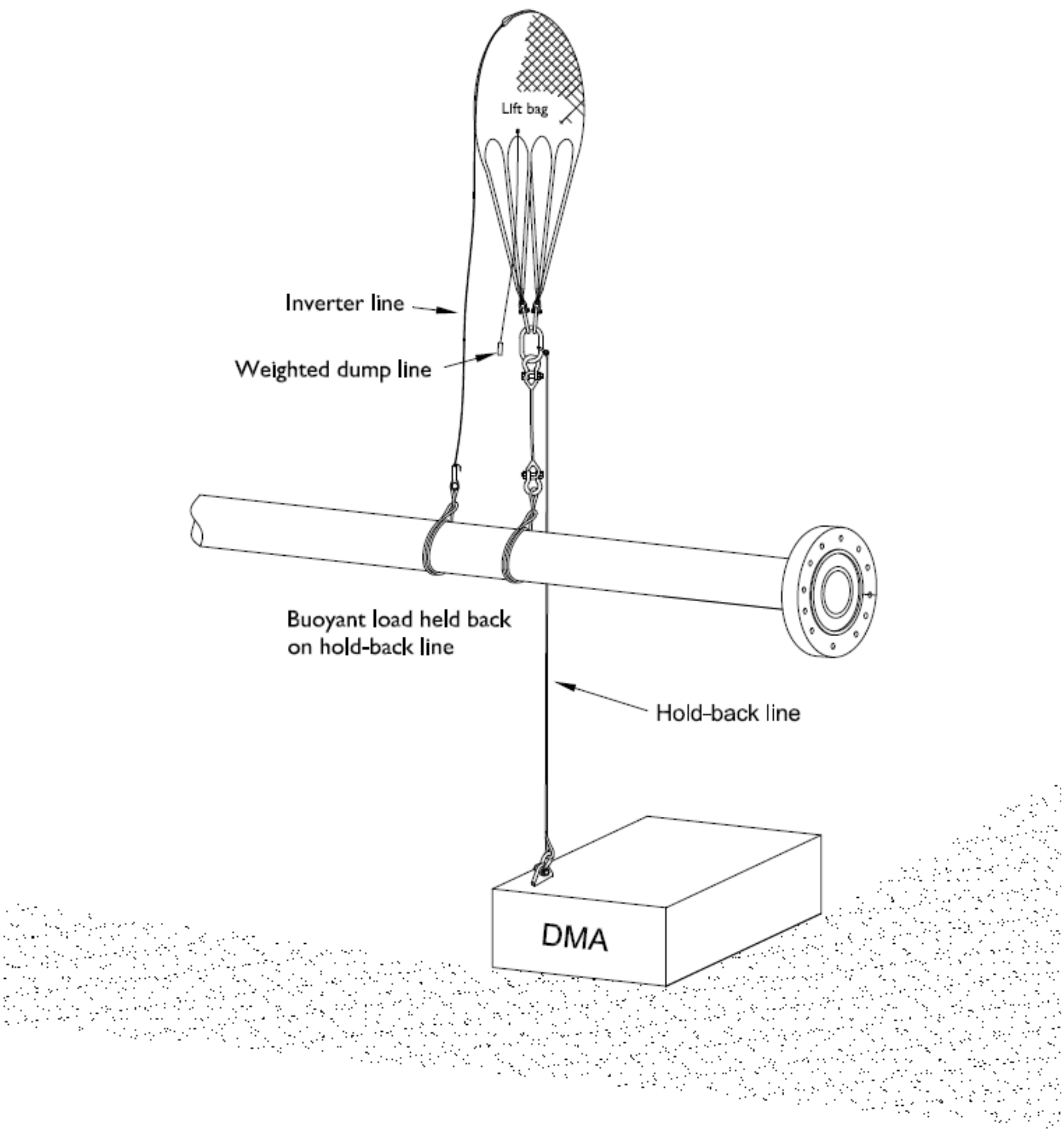


Figure 10 – Single airbag lift – consequences of uncontrolled ascent of the bag and the load

Note: It is recommended that any loss of control situation on a lift should result in a HOLD being placed on operations until the deflation sequence has been risk assessed to ensure that divers and equipment assets are protected as the load and bag comes down.

Multiple Airbag Lift – Dynamic

- In this example the inverter lines are secured to the load and the hold-back rigging is secured to suitable fixed points (DMAs).
- It is advisable to fit hold-back rigging at either end of the spool. If there is sufficient strength in existing hold-back lines, they do not need to be applied to every DMA.
- Positional/alignment devices, such as tirfors and lever hoists, are not suitable substitutes for hold-backs.
- The weight of any alignment rigging only DMAs should be excluded from the calculation. Only DMAs with hold-back lines should be included.
- It may be prudent to include a suitable factor of safety as part of the lift planning process when calculating the necessary in-water weight of the DMAs and load (spool) combined.

In this configuration any lift bag rigging failure would result in the load and bag being grounded. Any uncontrolled ascent of the lift bags and load would be restrained by the hold-back lines.

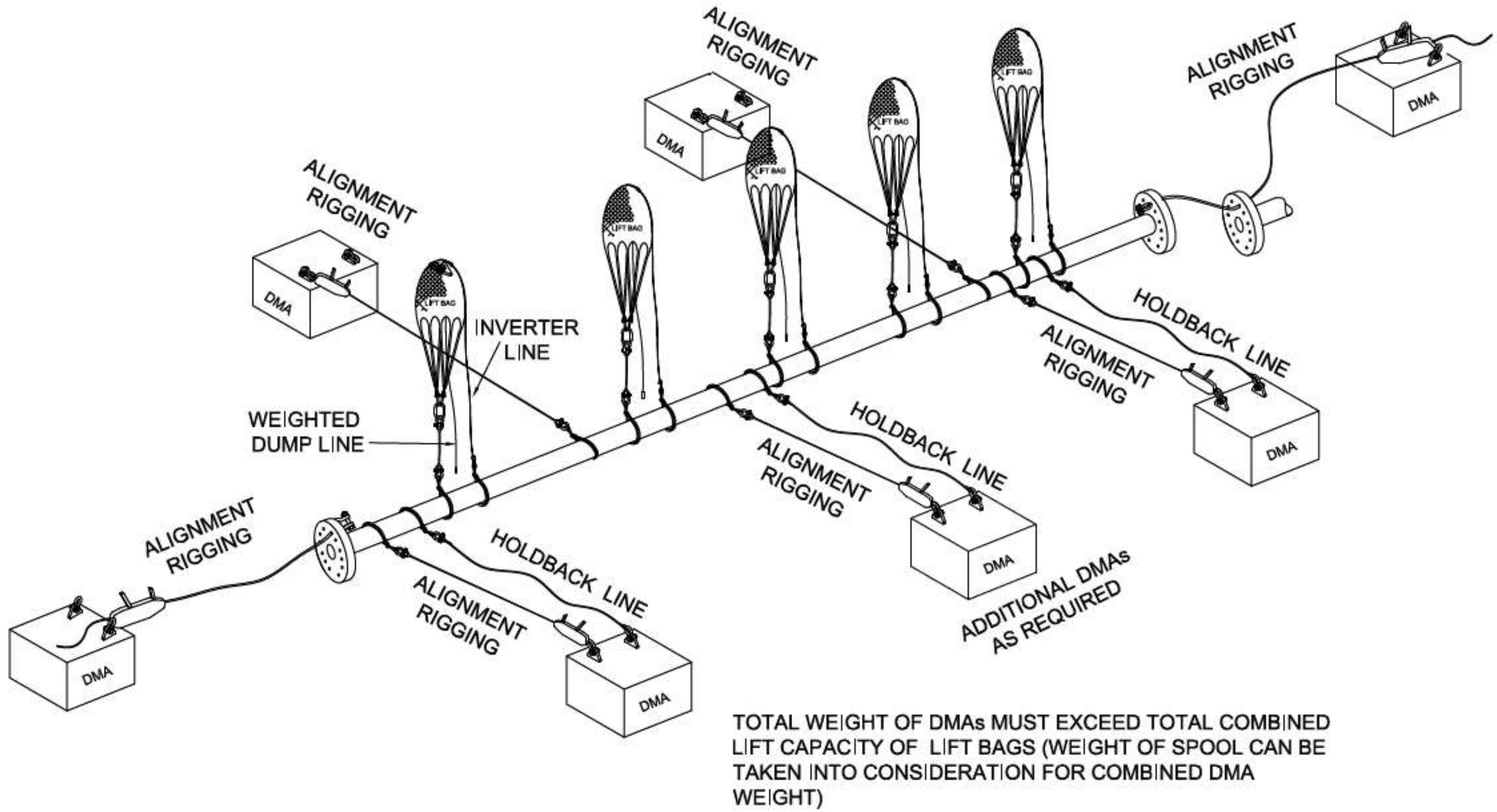
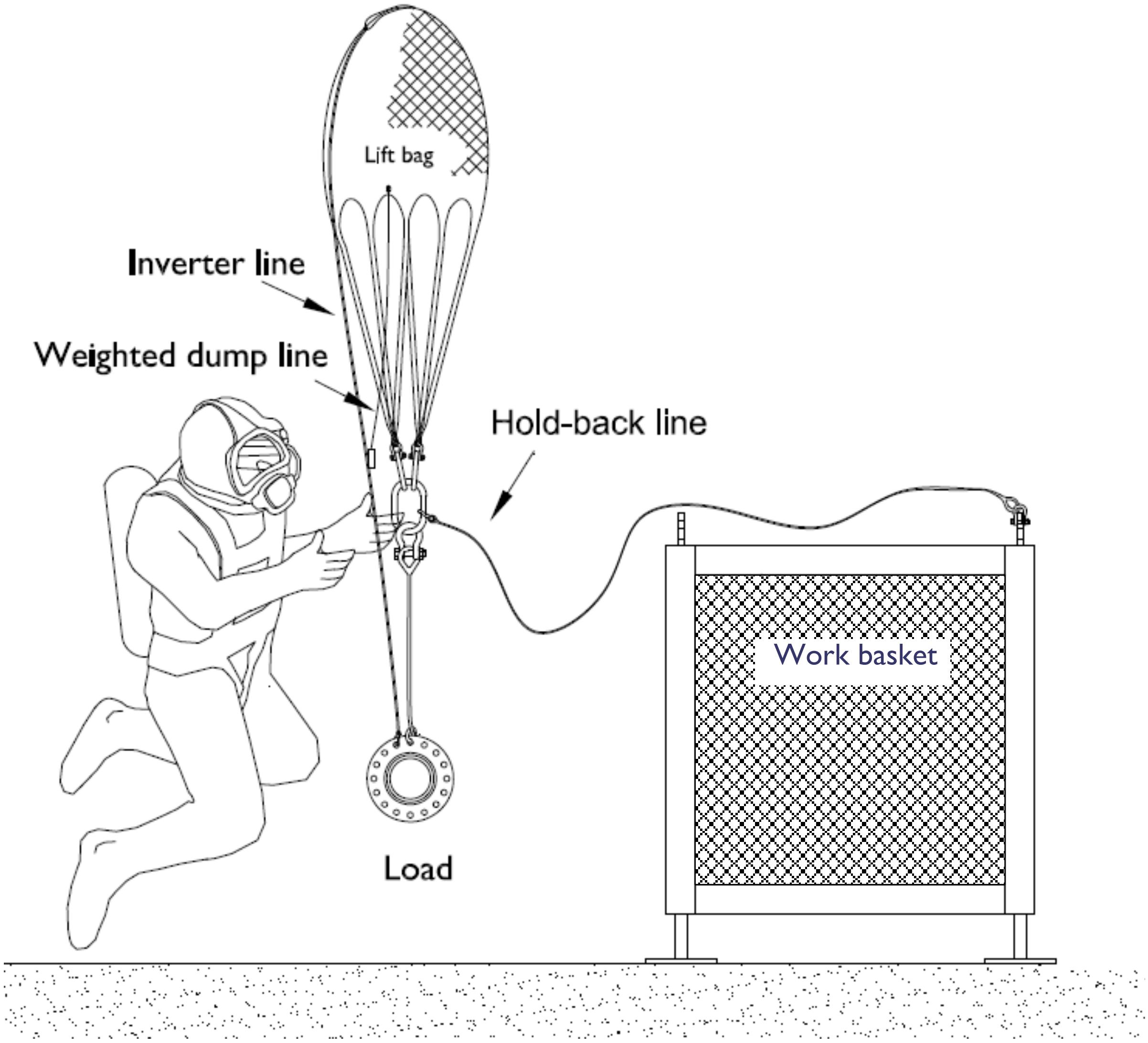


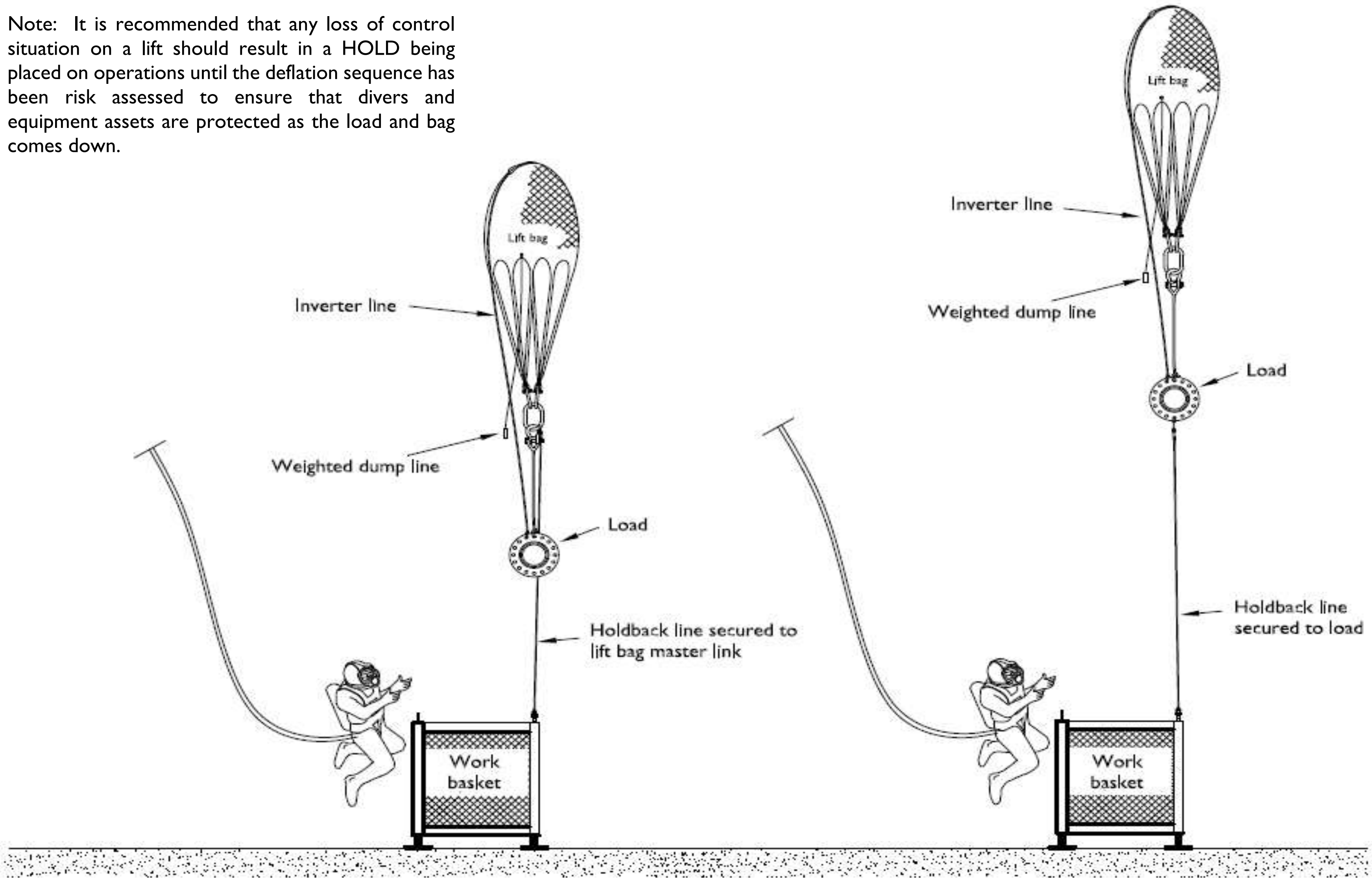
Figure 11 – Multiple airbag lift – dynamic



The weight of the empty work basket combined with the load must exceed the lift capacity of the lift bag. It may be prudent to include a suitable factor of safety as part of the lift planning process when calculating the necessary in-water weight of the empty work basket and load combined.

Figure 12 – Moving equipment to/from a work basket manual lifting aid – dynamic

Note: It is recommended that any loss of control situation on a lift should result in a HOLD being placed on operations until the deflation sequence has been risk assessed to ensure that divers and equipment assets are protected as the load and bag comes down.

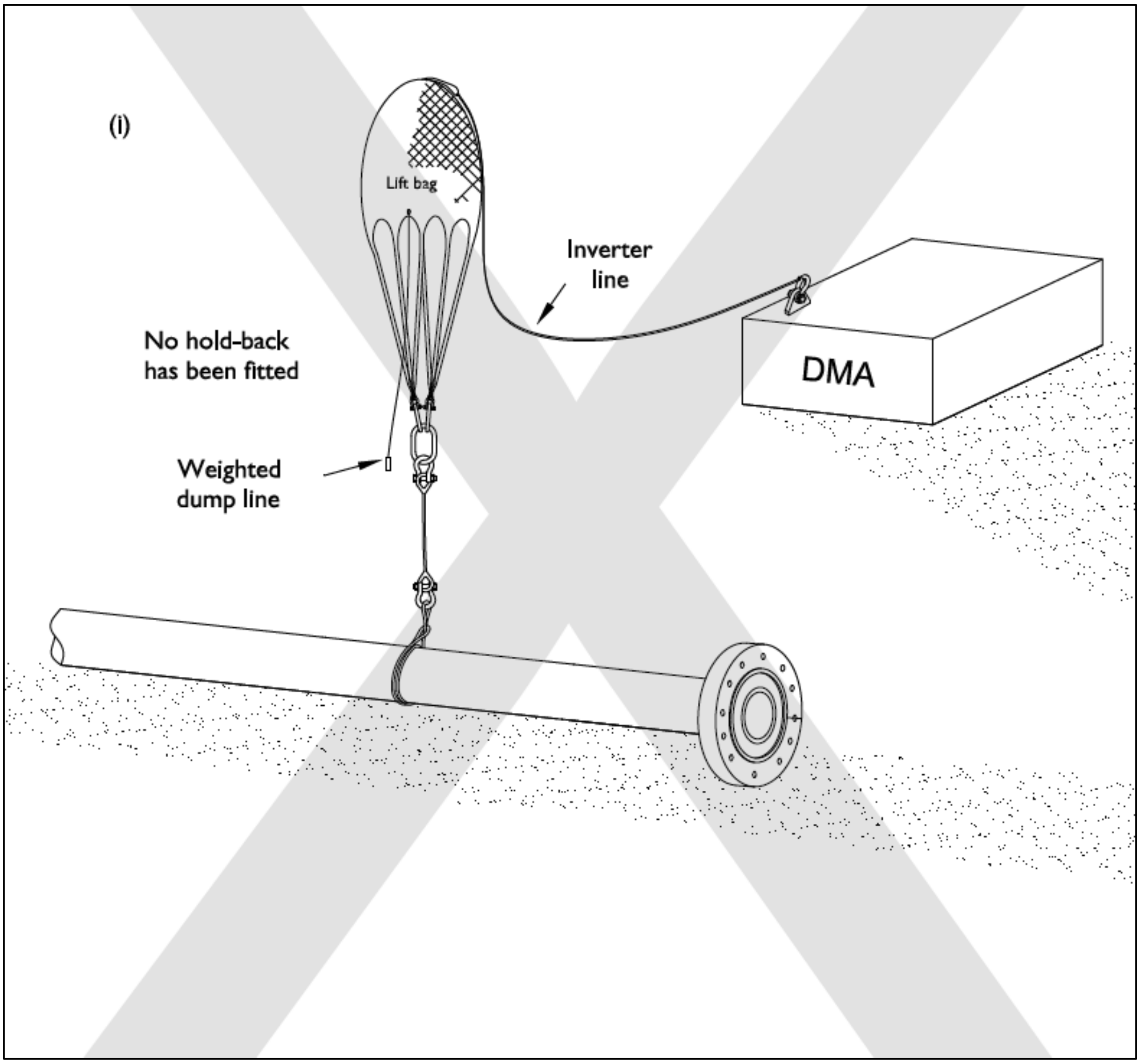


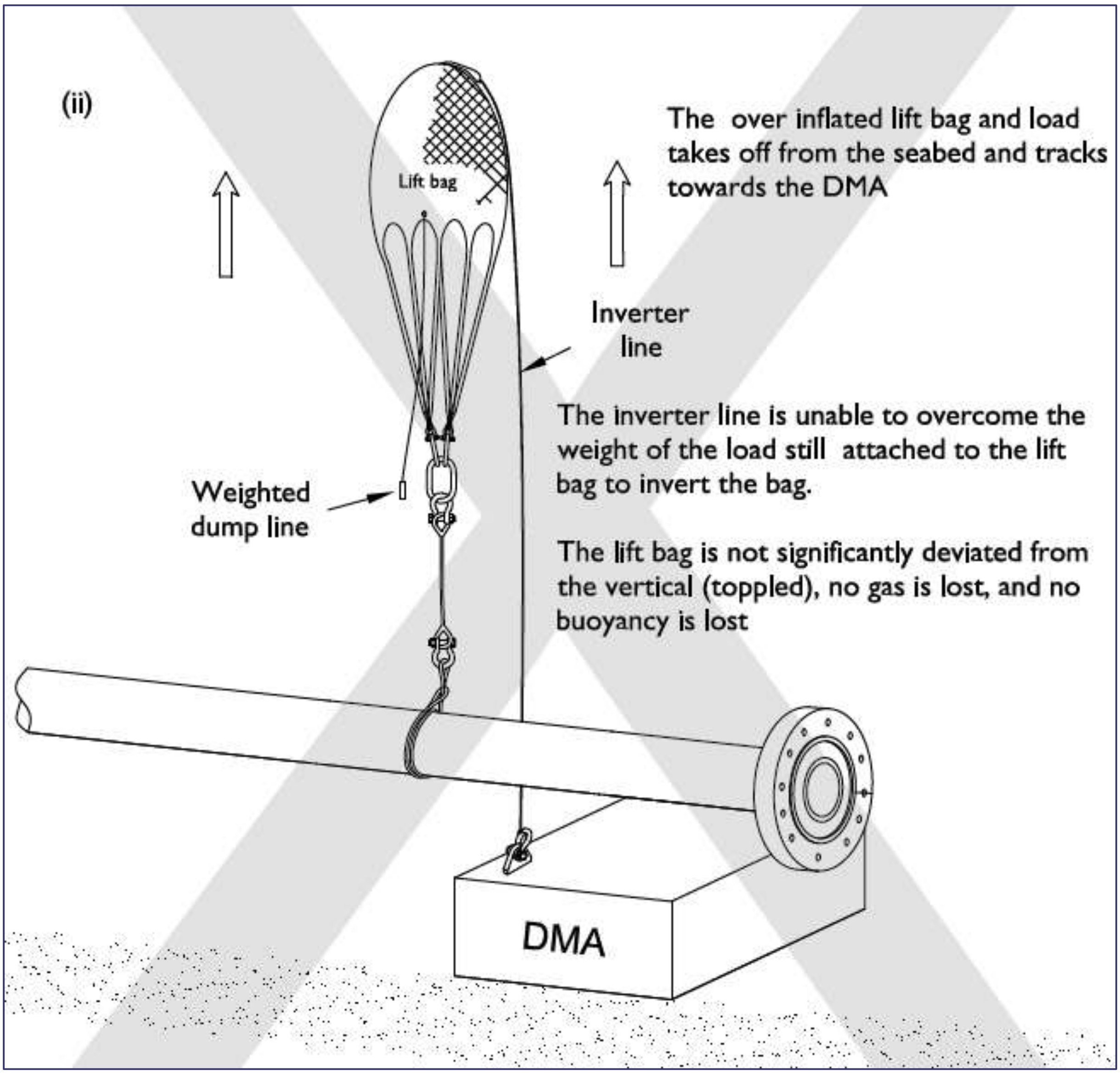
Depending on excursion limits and other factors it may be advantageous to connect the holdback to the lift bag master link rather than to the load itself in the event of a loss of control in lift bag and load buoyancy.

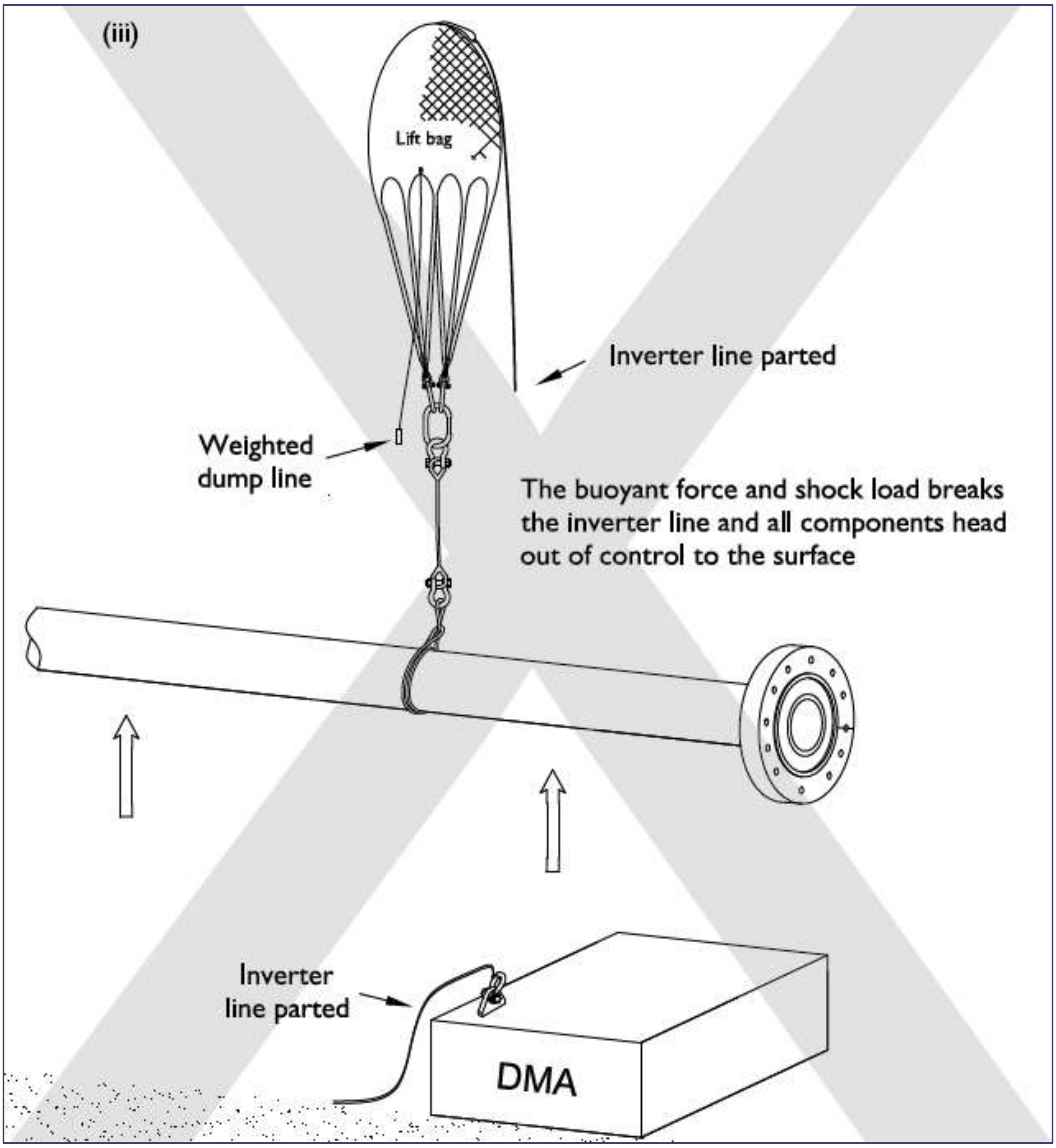
Figure 13 – Consequences of uncontrolled ascent of the bag and the load – work basket manual lifting aid

Incorrect Use of an Inverter Line (Possible Scenarios)

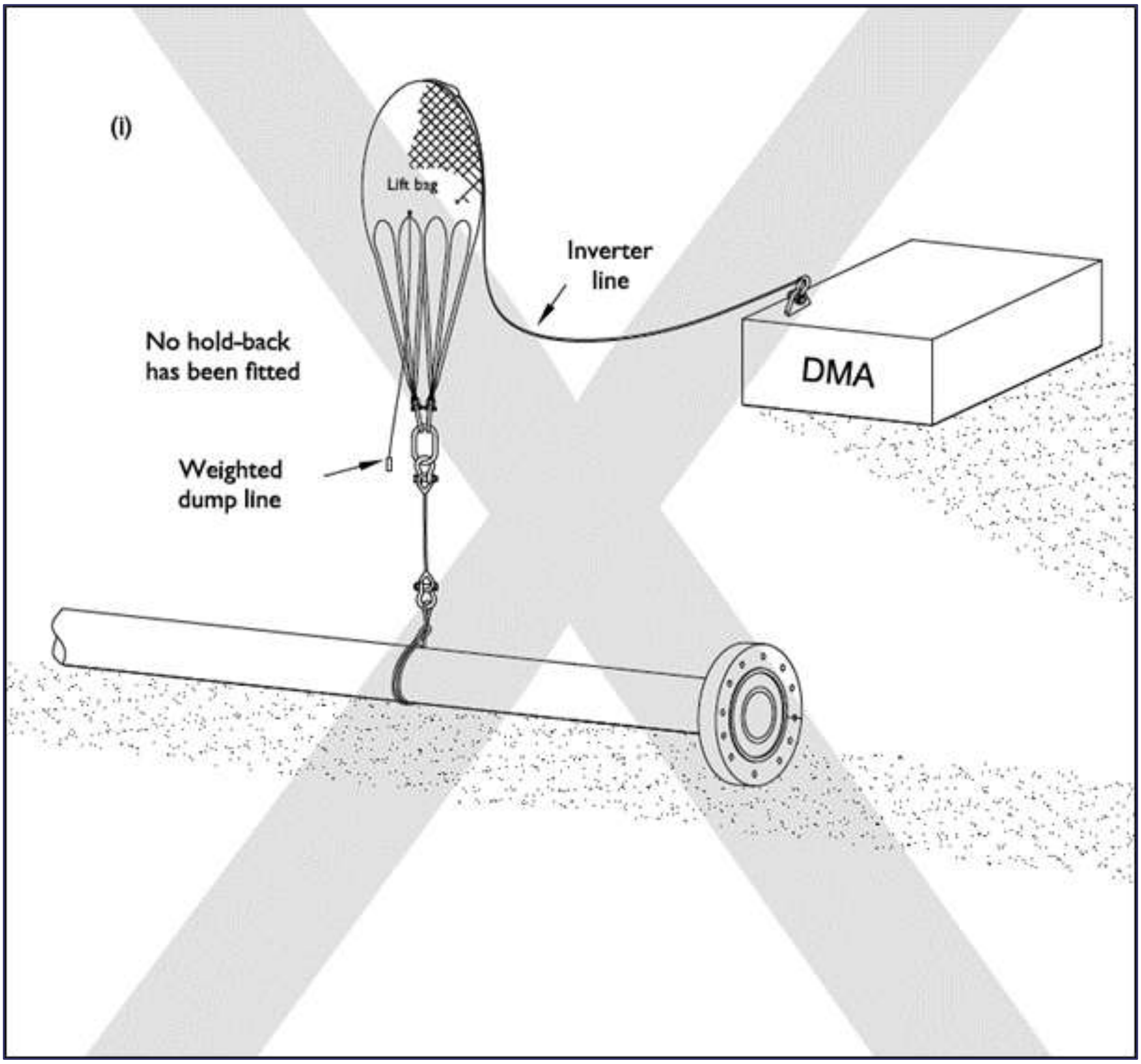
Scenario 1



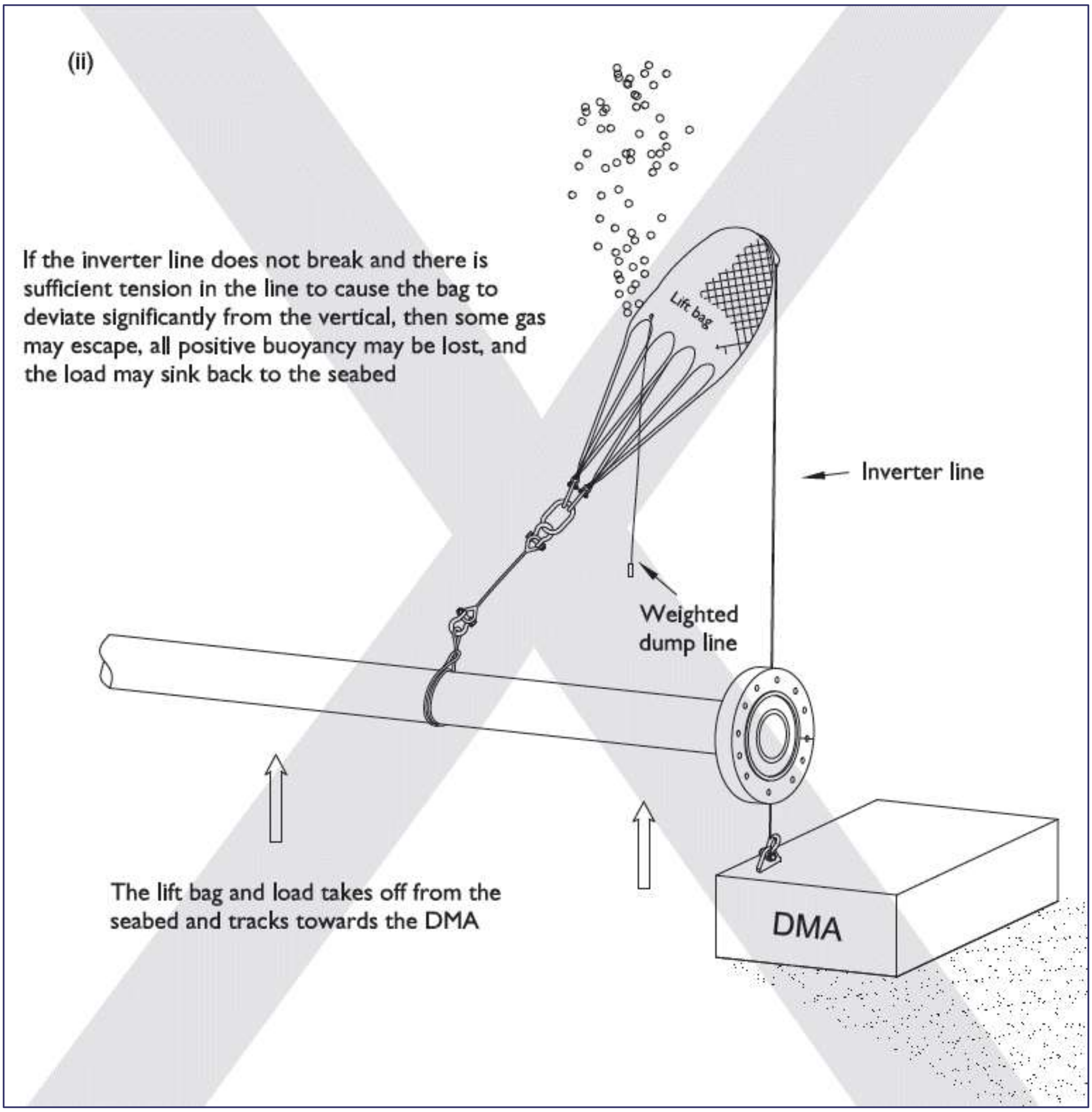

(ii)
Lift bag
The over inflated lift bag and load takes off from the seabed and tracks towards the DMA
Inverter line
The inverter line is unable to overcome the weight of the load still attached to the lift bag to invert the bag.
Weighted dump line
The lift bag is not significantly deviated from the vertical (toppled), no gas is lost, and no buoyancy is lost
DMA

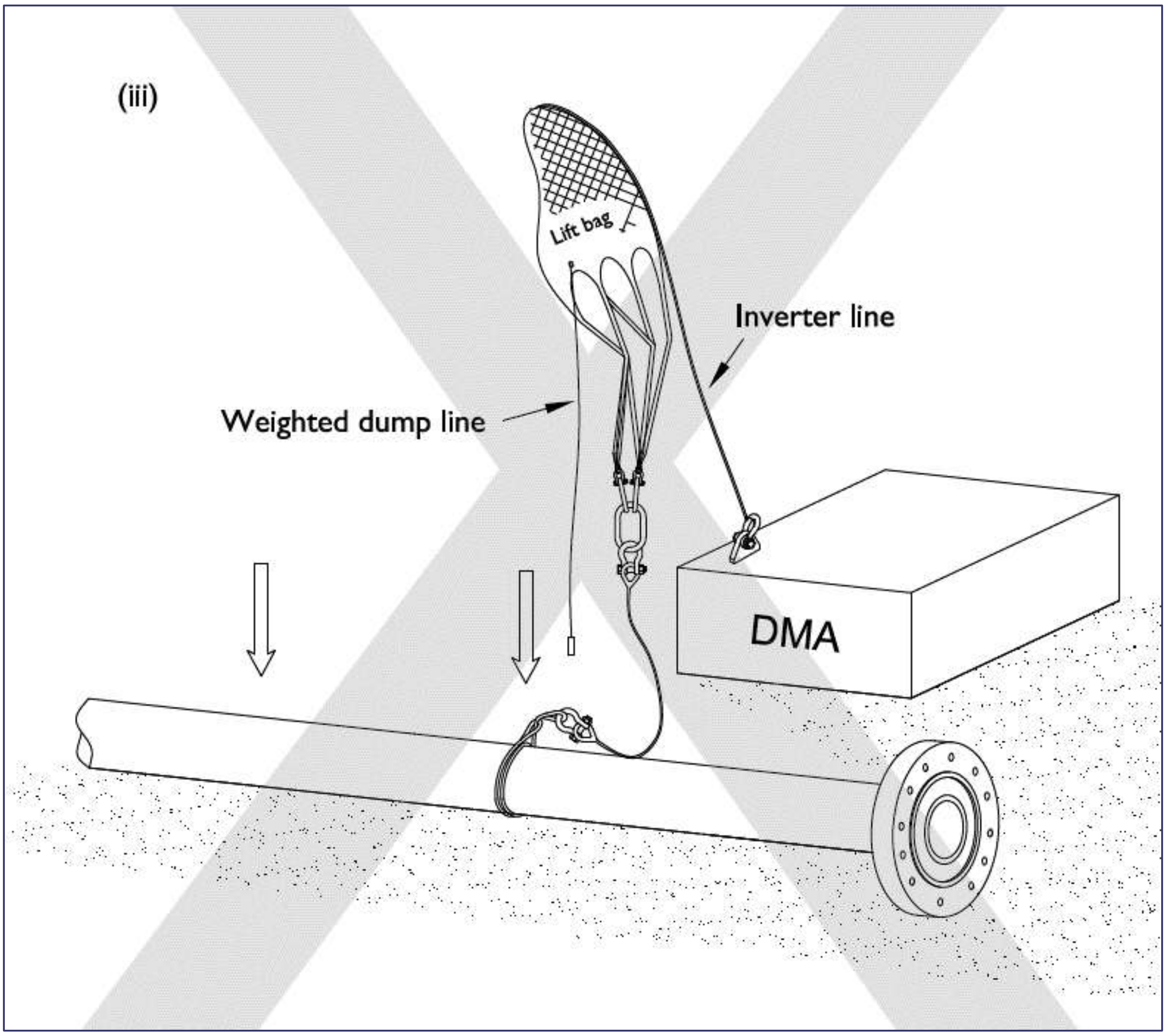

(iii)
Lift bag
Inverter line parted
Weighted dump line
The buoyant force and shock load breaks the inverter line and all components head out of control to the surface
Inverter line parted
DMA

Scenario 2



(i)
Lift bag
Inverter
line
No hold-back
has been fitted
DMA
Weighted
dump line


(ii)
If the inverter line does not break and there is sufficient tension in the line to cause the bag to deviate significantly from the vertical, then some gas may escape, all positive buoyancy may be lost, and the load may sink back to the seabed
Lift bag
Inverter line
Weighted dump line
The lift bag and load takes off from the seabed and tracks towards the DMA
DMA


(iii)
Lift bag
Inverter line
Weighted dump line
DMA