United Nations
International Strategy for Disaster Reduction

International Fire Aviation Working Group – Practice Guide

Specialist Operations

SO 6.2 - Firebombing

This voluntary Practice Guide forms part of a series in the International Fire Aviation Guidelines.

1. Purpose

1.1. To provide guidance to Fire Agencies and Aircraft Operators regarding safe and effective conduct of firebombing operations.

1.2. To provide guidance regarding consistent terminology that could be used as a basis for communications during firebombing operations.

2. Application

2.1. Fire Agencies that manage and use aircraft.

2.2. Aircraft Operators engaged fire management activities.

2.3. Aircraft Operators providing aircraft under bi-lateral or multi-lateral resource sharing agreements.

3. General Safety Considerations

3.1. Firebombing exposes aircraft and crew to a greater range of potential hazards than many other airborne tasks.

3.2. Firebombing requires a high level of diligence and attention to detail to ensure it's conducted safely and effectively, and to ensure that the required outcomes are achieved without unnecessary risk or expense.

3.3. The Aircraft Operator and the Fire Agency must have appropriate standards, systems and procedures in place to reduce the additional risks associated with firebombing.

3.4. Pilots and Fire Agency personnel should be careful to avoid allowing the perceived urgency of the situation that can sometimes lead to a compromise of the aircraft's safety.

4. Pilot Requirements

4.1. The Aircraft Operator and Fire Agency shall ensure and verify that all Pilots engaged in firebombing and air attack operations hold the necessary license, qualification or certification and that they are current, rated and competent in the relevant aircraft type and task.

4.2. Where required by contractual or similar arrangements, pilots must also meet the standards required by the Fire Agency and Jurisdiction.

4.3. In addition to flying skills and knowledge, firebombing pilots should be additionally trained and certified and current in:

- underwater escape from aircraft (for scooping, bucketing or self-filling aircraft);
- low-level obstacle identification and avoidance;
- low visibility situation recognition, avoidance and recovery;
- fire behaviour and fire control tactics;
- incident management organisation and communications;
- fire traffic patterns and communications;

4.4. The Pilot in Command of a bucket equipped firebombing helicopter shall have an endorsement for sling load operations on aircraft type.

4.5. The Pilot in Command of an aircraft conducting Air Attack Supervisor flights shall have a low flying approval for the particular task undertaken.

5. Pre-flight Checks

5.1. In addition to normal pre-flight preparation and mission planning procedures, prior to commencing firebombing operations, pilots should complete an operational risk assessment.

5.2. Prior to commencing any firebombing operations, pilots must ensure that they receive a briefing from the Fire Agency that includes the objectives of the mission, as well as all other relevant operational information.

5.3. All helicopter flights during agency firebombing operations involving agency personnel shall be conducted with the doors on and securely closed.

5.4. All helicopters conducting agency firebombing operations are to be fitted with a wire strike protection system, where an approved system is available for the helicopter type being operated.

6. Operational Procedures

6.1. Firebombing operations shall only be conducted under day Visual Flight Rules (VFR). Firebombing operations shall not be conducted prior to first light or after last light.

6.2. Once firebombing aircraft have been deployed, the Incident Controller must ensure a Air Operations Unit is established. Only authorised personnel shall be primary holders of Air Operations Unit positions.

6.3. All Agency firebombing aircraft operating on any bushfire shall operate under the authority of the Incident Controller who may delegate responsibility for supervision.

6.4. Agency firebombing operations shall comply with the communications and flight following requirements of:

- Flight Following and SAR Initiation Procedures; and
- Management of Aircraft at Incidents.

6.5. Aircraft conducting Agency firebombing operations on bushfires should be supervised by an authorised Agency Air Attack Supervisor.

6.6. The Incident Controller may authorise firebombing to be conducted without direct supervision of an Air Attack Supervisor in circumstances where:

- an authorised Air Attack Supervisor is not immediately available; and
- fire control objectives would be adversely compromised if firebombing was delayed until an authorised Air Attack Supervisor was available; and
- the Incident Controller has ensured that systems and procedures are in place to ensure the safety of ground and airborne personnel; and
- the Incident Controller has taken reasonable steps to ensure that any environmental risks, particularly any risk to streams, watercourses or other key environmental assets, are assessed and appropriately managed.
- only firebombing aircraft fitted with an operating siren capability may be used without an Air Attack Supervisor.

6.7. Firebombing operations undertaken for training or simulation shall be supervised by an authorised Air Attack Supervisor. The appropriate Agency Manager may authorise firebombing to be conducted for training, simulation or testing provided that:

- systems and procedures are in place to ensure the safety of ground and airborne personnel; and
- any environmental risks, particularly any risk to streams, watercourses or other key environmental assets, are assessed and appropriately managed.

6.8. Helicopter firebombing operations shall comply with the requirements of practice guides related to Helicopter out landings and Low Level Operations.

6.9. All Air Attack Supervisors conducting firebombing operations should:

- complete and submit an Operational Report for each incident per day of operation
- record the location and quantity of all water used by firebombing helicopters, for essential water replacement.

6.10. The Agencies shall only use approved aerial suppressants, water enhancer or chemical retardants.

6.11. The minimum personal protective clothing and equipment to be worn by Agency personnel conducting any phase of a firebombing operation shall comply with the requirements specified in the relevant Practice Guide.

7. Firebombing strategies

7.1. The following strategies should be employed when utilising aircraft for bombing with water surfactants or retardants:

- Air operations need to be fully integrated with ground operations and the IMT.
- Firebombing rarely fully extinguishes fires.
- Firebombing operations should always be supported by ground crews.
- Firebombing is most effective early in the day when fire activity is lowest.
- Always use natural or constructed fire advantages.
- It is important to continually monitor the effectiveness of the firebombing operation. If it is not productive, has a poor chance of success or is unsafe, it should be stood down to consider other strategies.
- The most appropriate aircraft available should be allocated for the task.

8. Firebombing Tactics

8.1. Prior to the commencement of firebombing operations, the following points should be considered:

- established circuit patterns in consultation amongst the pilots and any air traffic control authorities
- should a lead pilot be appointed
- recommendations made by the Air Attack Supervisor
- wind direction (often different in valleys and drainages), wind strength and its relation to orography causing down-draughts and up-draughts
- visibility limitation caused by sun angle, haze and smoke
- terrain, surface and slope
- elevation
- slope of target areas
- aircraft performance limitations due to turbulence, temperature and density altitude
- hazards such as wires, obstructions and turbulence
- fire activity, intensity, movement and spotting
- location of ground personnel in the area
- location of emergency landing areas.

8.2. Firebombing pilots should ensure that they have received directions from the Agency Air Attack Supervisor or obtained a briefing regarding the following information:

- firebombing objectives and requirements;
- target area;
- details of local terrain;
- general conditions;
- wires and other hazards;
- fire line elevation (including QNH or source of QNH).

8.3. When approaching the fire area for the first firebombing operation, or prior to any other procedures being established, if practical firebombing aircraft should first approach the drop zone from a relatively high level high and check for hazards, obstacles and escape routes in case of engine failure or excessive down draughts.

8.4. Pilots and Air Attack Supervisors must collaborate to ensure the safety of persons on the ground in the firebombing target area. Measures include:

- obtain radio confirmation that the drop zone is clear of personnel;
- visually check the area for signs of personnel;
- if available, activate lights, siren or other warning devices.

8.5. While the use of strategic water bucketing may be appropriate when closely directed by ground crews, unsupported helicopter mop-up operations are generally ineffective and should be discouraged.

9. Safety of Ground Personnel

9.1. The Air Attack Supervisor or Incident Controller shall inform firebombing pilots of the presence of personnel on the fire ground or in a drop zone and clearly identify their location on the ground.

9.2. Ground personnel must ensure they are clear of firebombing drop zones and follow prescribed firebombing safety procedures where required.

9.3. The Air Attack Supervisor or Incident Controller must ensure ground personnel are warned by radio of incoming drops from firebombing aircraft and ensure ground personnel are clear before allowing a firebombing operation to proceed.

9.4. Firebombing pilots shall drop loads in a manner which does not compromise the safety of ground personnel.

9.5. The Pilot in Command of any firebombing aircraft with a siren capability shall, where practical, activate the siren prior to and during the release of any load to warn ground personnel of incoming drops.

9.6. Firebombing aircraft not equipped with a siren capability shall only conduct firebombing operations under the direct supervision of an authorised Agency Air Attack Supervisor.

9.7. Agency persons supporting and working around firebombing aircraft at an airbase shall be briefed on the relevant Agency ground safety procedures

10. Safety of Airborne Personnel

10.1. The Air Attack Supervisor or firebombing pilot shall stand down firebombing aircraft or suspend firebombing operations should the safety of air or ground personnel be compromised by continuing the operation. The Air Attack Supervisor shall immediately advise the Operations Officer of any stand down or suspension.

10.2. The Air Attack Supervisor or firebombing pilot shall recommend the stand down of firebombing aircraft or suspension of firebombing operations should:

- the objective is achieved; *or*
- operations are ineffective.

10.3. Sterile cockpit protocols shall be adopted during firebombing and associated air attack supervisor operations.

10.4. Helicopter pilots, aircrew and pilots of fixed wing firebombing aircraft with scooping capability, shall wear an approved personal emergency flotation device when conducting firebombing operations.

10.5. All helicopter out landings required during firebombing operations for the pickup of Agency fire ground personnel shall be conducted as per IAOP FO 2.02.

11. Communications

11.1. Quality communications is vital to safe, effective and efficient firebombing operations.

11.2. The Fire Agency must have in place procedures to ensure clear unambiguous communications between firebombing aircraft, supervisors and ground personnel regarding firebombing operations. These procedures should include standard firebombing terminology, phraseology and definitions

11.3. Pilots must communicate on the nominated frequency to maintain separation from other aircraft as required and should establish a pattern were possible to reduce the need for radio calls. The nature of broadcasts required will depend on the number of aircraft on site, terrain and other conditions. The following radio calls are recommended as a minimum:

- departing water – helicopters and fixed-wing scooping aircraft only;
- final for drop;
- drop zone clear;
- on “dip” – helicopters only.

11.4. Procedures must be in place to ensure that all aircraft are referencing altitude information using a common and appropriate QNH.

11.5. Where GPS/GLONASS positions are used in communications to ensure aircraft separation, procedures must be in place to ensure that all aircraft are using either common map datums.

12. Retardants, surfactants and gels

12.1. Use of straight water in firebombing operations should only be considered where large volumes are available with rapid turnarounds, or when environmental constraints need to be considered.

12.2. Foam surfactants significantly increase the effectiveness of firebombing operations, and should be used whenever possible.

12.3. Retardants are very effective over longer periods of time, but are expensive, require specialist mixing and loading equipment and require significant logistical support. Retardants may not be appropriate in some habitats and are less effective for forest fuel types. The red colour of retardant is for higher visibility over the drop zone and is designed to fade with exposure to sunlight.

12.4. Gels can either be used to suppress fires quickly or to provide a gelled water barrier to prevent the spread of fires. With the addition of red or blue colourants gels can be seen by pilots at altitudes of 2500 feet or more.

12.5. Retardants, surfactants and gels can have environmental impacts, particularly if use is considered near watercourses, wetlands or threatened species habitats.

13. Impacts of distance, elevation and atmospheric conditions

13.1. Firebombing effectiveness decreases with increased distance to the fire, as well as with increased elevation and warmer atmospheric conditions.

13.2. Aircraft are less efficient at higher elevations and may not be able to carry full loads.

13.3. Hotter weather conditions also reduce aircraft efficiency and strong winds reduce manoeuvrability and accuracy.

13.4. Poor visibility due to smoke and inversions can also compromise operations.

13.5. Aircraft turnaround times can be minimised by staging aircraft closer to operations and establishing temporary water points using buoy walls and portable pumps.

14. Environmental Considerations

14.1. Care must be taken to consider the environmental implications of usage of chemical retardants, water enhancers and firefighting foams in possible environmentally sensitive areas including organic farms.

14.2. The dropping of retardants in declared water supply catchment areas should be avoided where possible.

14.3. If firebombing with retardant in environmentally sensitive areas and water supply catchments, is deemed and approved as a necessary strategy by the Incident Controller, the Air Attack Supervisor and Operations Officer should consider locating retardant loads in favourable terrain i.e. avoiding steep slopes and areas of impermeable soils near watercourses or storages. Care must be taken at retardant mixing bases to prevent spills and contamination of water courses and supplies during mixing, loading or wash down. Temporary bunding may need to be erected to ensure retention of leaks.

14.4. Agency firebombing aircraft must avoid overflying water supplies when departing an air base, if loaded with chemical retardants and aerial suppressants.

14.5. The dropping of chemical retardants, suppressants or salt water in water catchments or environmentally sensitive areas should be avoided where possible.

14.6. Pilots must comply, except where it is unsafe to do so, with relevant directions from the Fire Agency regarding exclusion zones where firebombing must not be conducted for environmental reasons.

14.7. The dropping of chemical retardants, suppressants or salt water in water catchments or environmentally sensitive areas should be avoided where possible.

14.8. Pilots must comply, except where it is unsafe to do so, with relevant directions from the Fire Agency regarding exclusion zones where firebombing must not be conducted for environmental reasons.

14.9. Procedures should be in place to ensure a suitable chemical-free buffer is maintained around watercourses or other environmentally sensitive areas.

14.10. Procedures should be in place to avoid repeated drops of salt water at locations where this may have adverse environmental effects.

14.11. Procedures should be in place to ensure that pilots are made aware of known areas of unexploded ordinance (UXO) and avoid flying over, or firebombing, fires in UXO areas.

14.12. Environment protection procedures must allow pilots and supervisors flexibility to continue dropping in sensitive or protected areas when directed by the incident management organisation or where life is at risk.

Attachment 1 – Firebombing 101

1. Fundamental Principals

1.1. Firebombing normally involves the dropping or spraying from an aircraft of fire water, suppressant or retardant on to a fire, or into the expected path of a fire, in order to assist with controlling or managing the fire.

1.2. Firebombing may involve a wide range of aircraft types

- single engine air tankers (SEAT/s)
- multi engine air tankers (MEAT/s)
- very large air tankers (VLAT/s)
- underslung bucket equipped helicopters
- belly tank equipped helicopters
- large heavy multi-engine jet aeroplanes
- helicopters ranging from light to heavy
- Turbine and piston engines using different fuel types (Jet-A1 / AVGAS)
- un-crewed or remotely piloted aerial vehicles

1.3. There are various approaches to filling or loading

- self-filing, such as fixed-wing scooping aircraft or hover-fill or snorkel-fill helicopters
- ground-filling with relay tanks
- roll-on, such as frangible cardboard boxes of suppressant on pallets.

1.4. There are a variety of different suppression mediums

- fire retardant, usually in a suspension or slurry form (eg Phoschek)
- water (fresh water or salt water);
- water with an added wetting agent;
- foam (water with an added surfactant foaming agent);
- water with an added agent that enhances drop characteristics and water retention properties (sometimes referred to as “gel”);

1.5. Firebombing involves a wide range of dispensing systems

- fixed tank with various opening and drop door configurations;
- gravity or pressurised flow;
- roll-on roll off systems;
- underslung bucket (helicopters) or tanks;
- various valve and drop configurations;
- long-line or short-line;

1.6. Firebombing may be conducted for a variety of tactical purposes:

- direct suppression,
- Reducing Flame Heights and Rate of Spread (ROS)
- assistance to firefighters on the ground,
- property and asset protection;
- emergency safety of firefighters on the ground
- “buying time” for another tactic (i.e. slowing the fire until another method of suppression can be employed);

1.7. Firebombing may be conducted using a variety of methods

- direct attack (drops on or immediately adjacent to fire edge)

- parallel, or flanking, attack (generally parallel to the fire perimeter, anticipating lateral fire spread)
- indirect attack (pre-treatment of fire fuels which are a distance from the main fire. This may include establishment of safety zones or reinforcement of other control or containment lines such as ridgelines, roads, or areas of light/sparse fuels.)

1.8. The limitations of any initial attack using aircraft include but are not limited to

- the number and type of firebombing aircraft dispatched to the incident
- absence of air attack supervision
- clear and concise communication with ground resources
- weather conditions at the dispatch location, encountered on route and the incident,
- visibility within the area of operation,
- the localised weather conditions generated by the fire, up drafts and down drafts,
- the physical terrain
- the intensity and rate of spread of the fire and the absence of follow up by ground resources.

1.9. At times a single firebombing aircraft has had limited effectiveness when the fire has a high rate of spread that has eclipsed the line construction rate for the respective aircraft.. The use of multiple firebombing aircraft has demonstrated to be efficient when supporting suppression operations and fire line construction.

1.10. Turns around times are not calculated on linear distance exclusively. Turn-around times are affected by

- ferry speed of the respective firebombing aircraft loaded and unloaded,
- ferry flight time from the filling point to the general area of the drop
- reloading process ground filling (including taxi procedures) or hover fill,
- operational circuit procedures and manoeuvring in the fire area and
- effectiveness of air attack supervision and communications.

1.11. SEAT/s can be most effective during initial attack operations if used as a quick response resource. Operating multiple SEAT/s together can be very effective.

1.12. SEAT/s can be used to knock down small fires until ground resources arrive and can be effective in lighter, shorter fuels and open canopy.

1.13. Because of the volume carried by SEAT/s they have the ability to produce longer line with standard drops up to > 110 meters. Greater lengths can be achieved with restricted drops and reduced coverage levels.

1.14. Aircraft velocity, drop height, tank system flow rate and drop volume, aircraft attitude, wind conditions and fuel arrangement will affect the ground pattern or footprint of the drop.

1.15. Helicopters become efficient in confined air space and in steep and dissected terrain. They have the ability to drop directly onto smaller and numerous sections of fire with a measured partial drop.

1.16. The use of helicopters can allow for low speed delivery of drops with an increased accuracy.

1.17. Helicopters have the ability to operate in low visibility situations with smoke and a low ceiling where fixed wing aircraft cannot fly where direct attack is required.

1.18. Drops generally will be made directly on the fire line, at the head of fires with short flame lengths, or on the flanks working toward the head on fires with longer flame lengths.

1.19. Caution should be used when performing hover drops to avoid rotor down wash fanning the fire.

1.20. With a reduced forward flight speed a helicopter can deliver a salvo drop (< 35 metres), with a accelerated forward flight speed it can deliver an elongated drop(< 70 metres).

1.21. Firebombing often exposes the aircraft and crew to a range of hazards that are more acute tan in other aerial operations. These may include, for example:

- aircraft operating at or near the limits of their performance envelope;
- high temperatures and high density altitudes;
- aircraft operating in close proximity to terrain;
- reduced visibility;
- hazardous meteorological conditions, including strong winds, turbulence and pronounced wind-shear;
- large, rapid changes in aircraft weight;
- multiple aircraft operating in close proximity.

1.22. Terrain may limit fire bombing run directions and the availability of safe exit paths for both fixed and rotary wing fire bombers.

1.23. The influence and dominance of prevailing winds will impact on flight operations, especially under rising terrain flying conditions. Prevailing winds will limit the ability of firebombing aircraft to manoeuvre in rising terrain, including the accuracy of drops. Strong wind conditions and significant wind changes including cross winds may render drops ineffective.

1.24. Because of the rapid rate of spread associated with grassland fires the smoke column and smoke dispersal plume that occurs can occupy a large area. The smoke can occupy an area which includes the total area of the fire, a significant area of the flank perimeters and an area similar to the fire size over the head fire extending in the direction of spread. As a result visibility and access for aircraft can be significantly reduced and the smoke has the potential to obscure hazards and assets including ground resources in the fire area restricting the ability to deliver firebombing drops.

1.25. The presence of obstructions- power lines, tall trees, stags/snags, towers or proximity to built-up areas may restrict the potential for effective low level work for firebombing aircraft. The presence of rising ground poses a risk for firebombing aircraft as well.

1.26. Bushfires and grass fires in proximity to large bodies of surface water will have additional risks with the presence of large birds.

1.27. Given the huge range of variables involved in firebombing, the operation must be carefully managed and tailored according to the circumstances at the time to ensure that the objectives of any mission are achieved.

1.28. To ensure the safety of Aircrew and persons on the ground, firebombing operations require a high level of diligence and very close attention to the management of the risks involved.

1.29. Fire intensity is a key factor in determining the effectiveness of a fire bombing operation. Once fire intensities exceed a moderate threshold, aerial firebombing is unlikely to retard fire advance.

1.30. Under extreme weather conditions, increased fire intensity and reduced aircraft performance will further limit effectiveness. Operations need to be continually monitored for effectiveness and promptly called off if not proving successful, or if safety is compromised.

1.31. The experience of many Fire Agencies over many years has demonstrated that in order for firebombing to be conducted safely, effectively and efficiently:

- firebombing operations must have clear objectives, aligned with the overall Incident Action Plan;
- firebombing must be closely integrated with control activities of ground firefighters;
- it is most important to select the appropriate aircraft and aircraft configuration) for the task – in some circumstances one type of aircraft will be effective, another type will not, whereas in slightly different circumstances the reverse may apply;
- it is most important to select the appropriate suppression medium (suppressant or retardant);
- the Fire Agency must supply competent tactical supervision to the firebombing activity, with high quality communications to all aircraft involved;
- Aircrews must be trained and experienced in firebombing, and must have an understanding of fire behaviour;

1.32. It has often been demonstrated that firebombing is most effective at the early stages of a fire, or at times of the day when the fire intensity is reduced.

1.33. A common failure is initiating or continuing the firebombing operation when it is no longer safe, appropriate or effective. Circumstances may include, for example:

- the firebombing operation is not complementary to the Incident Action Plan (for example it may be more desirable to allow an area to burn out to established boundaries such as a road);

- a more effective, lower cost more lower risk tactic is available to achieve the desired objectives;
- the firebombing is ineffective (e.g. due to fire intensity);
- the objectives have been achieved;
- the flying or terrain conditions expose the aircraft or crew to an inappropriate level of risk;

1.34. Firebombing should never be solely relied upon to ensure the safety of ground firefighters or ground personnel.

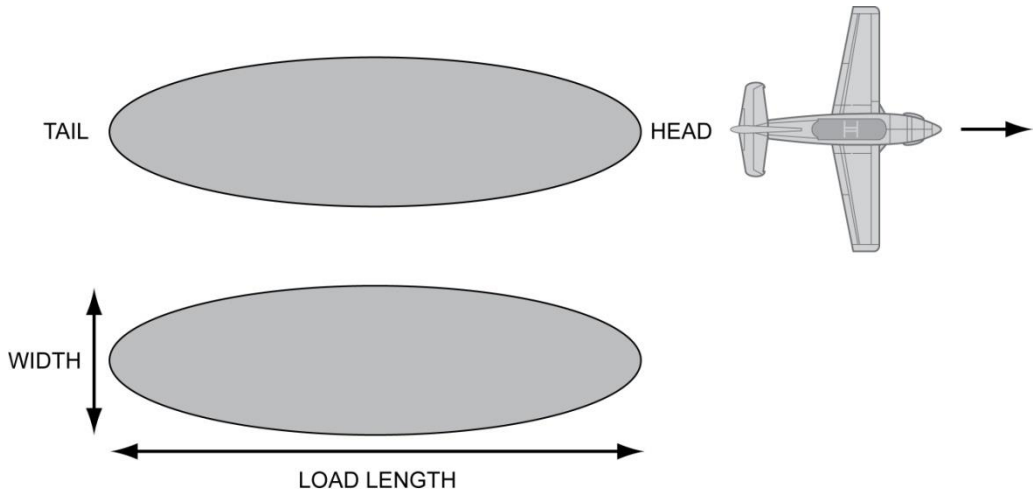
Attachment 2 - Glossary of firebombing terms

Accuracy	The accuracy of the drop as assessed by the Air Attack Supervisor.
Anchor point	An advantageous location, generally of mineral earth, from which a fireline can be constructed.
Drop length	Effective distance actually covered on the ground by a single drop.
Drift	Indication that wind conditions exist of sufficient velocity to significantly affect load placement and that a correction factor must be allowed for.
Dummy run	A simulated bombing run made on a target.
Early	Advice that the drop is to be, or was, dropped short of the designated point.
Extend	An instruction to tag on and extend the line in the required direction.
Firebombing drop zone	Area around a fire bombing target where the impact of a dropped load or turbulence from a low flying aircraft may break or dislodge material from trees.
Gap	A weak or missed area in a retardant/foam line.
Half-on – half-off	A drop made parallel to a specific reference with half the load covering the reference and half outside.
High drop	An instruction to make the drop higher than normal above the target.
Hold	An instruction to hold the load and await further advice.
Load width	Width actually covered on the ground by a load.
Late	Advice that the load is to be, or was triggered beyond, the designated point.
Parallel drop	An instruction to place a load beside and touching a specific reference.
Recce	A pass over the target by the firebombing aircraft or supervision aircraft to assess conditions.
Reload	An instruction to the firebombing aircraft to return to a designated base or filling site and reload and return to the fire.
Restricted drop	A technique whereby the firebombing door is partially opened, restricting the flow rate of the load through the door, and thus forming a longer, narrower drop.
Return and stay	An instruction to the firebombing aircraft to return to base and await instructions.
Rising ground	Indicates that ground ahead of, or beside, the target is higher than the target itself.
Roll-up (to/onto)	Connecting the head end of a load to a given point.
Salvo	The entire load is dropped as one drop with maximum door opening.
Single door	A technique whereby a firebombing aircraft with multiple drop doors opens only one door at a target.
Split load	A technique whereby the firebombing door is opened, releasing part of the load, and then closed, retaining part of the load for a second drop.

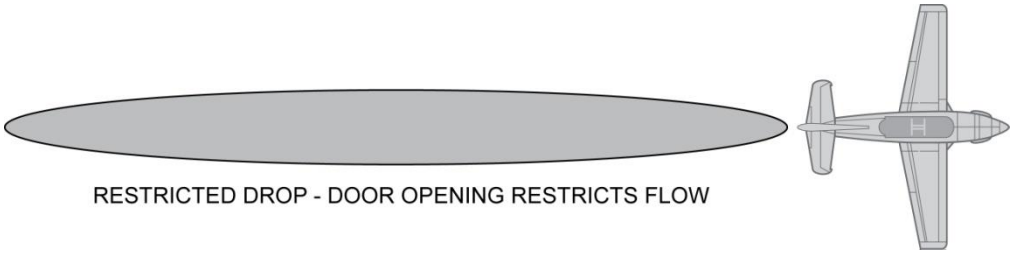
String drop	On multi-door tank systems, a specified number of doors opened in succession to give an extended pattern on the ground.
Tail end of load	The aft end of the load on the ground.
Tag-on	Connecting the tail end of the load to a given point.

Attachment 3 - Firebombing drop patterns

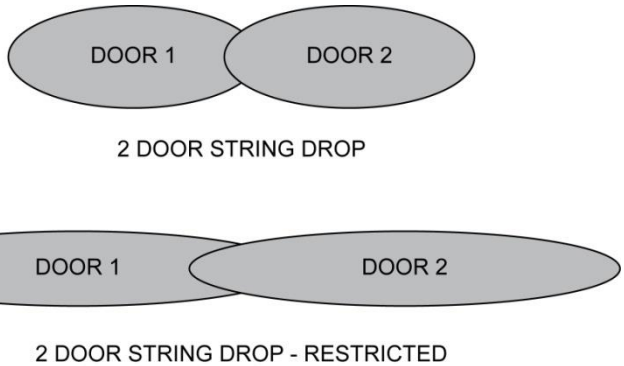
a. Simple drop pattern:



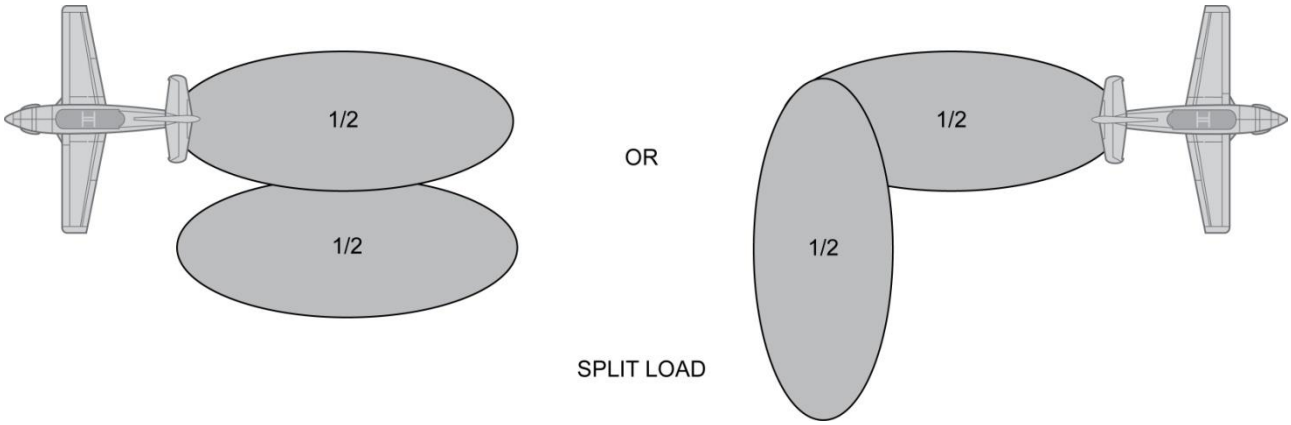
b. ‘Restricted door’ drop pattern:



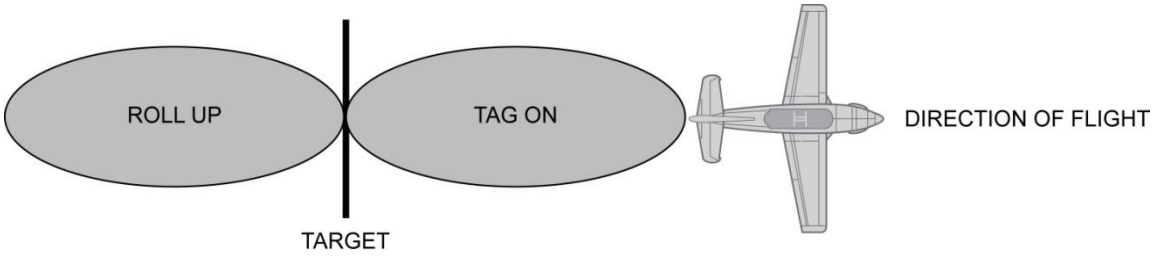
c. Two door string drop and restricted two door string drop



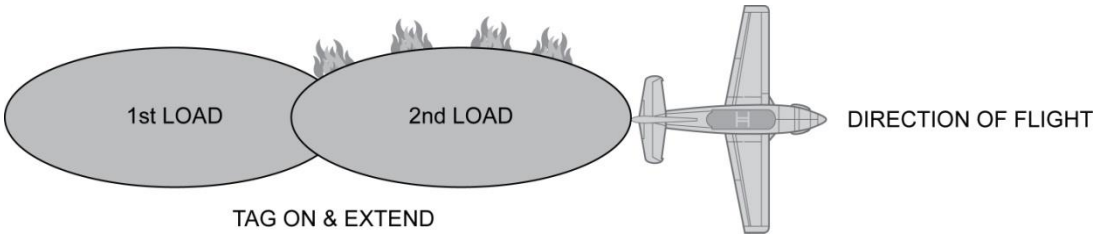
d. Spilt load drop patterns:



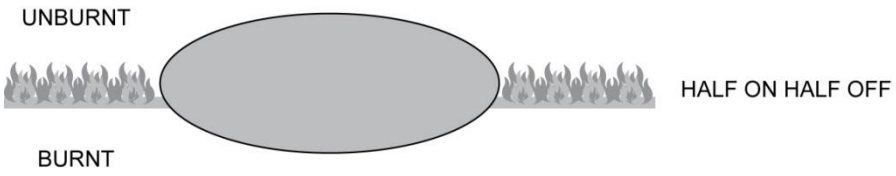
e. ‘Rolling up to’ vs. ‘Tagging onto’ a target or reference:



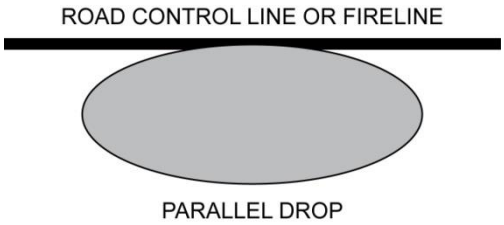
f. ‘Tag on and extend’ drop pattern:



g. ‘Half-on – half-off’ drop pattern:

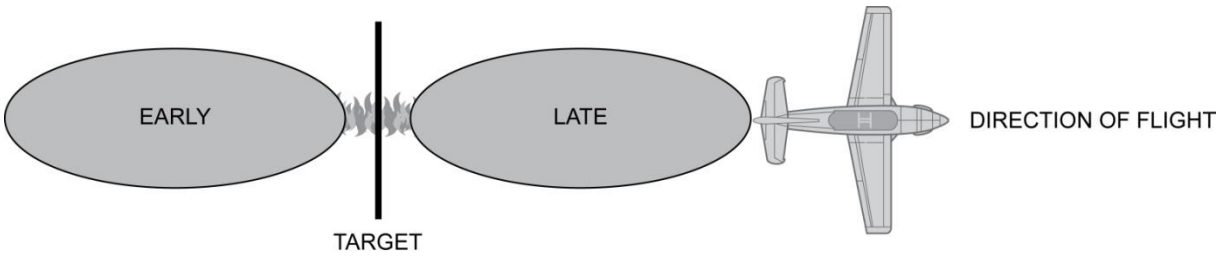


h. ‘Parallel drop’ drop pattern:



Firebombing drop assessment terminology

a. ‘Early’ and ‘late’ drops



b. ‘Gap’ in drop pattern:

c. ‘Missed’ and ‘late’ drops: