ISSN 0706-9413

Pacific Forest Research Centre

Environment Canada | Environnement Canada
Forestry Service | Service des Forêts

# The PFRC Aerial Ignition System MARK II

Part I - Development and Description

Part II - Operational Manual

G.R. Lait and S.J. Muraro

Victoria, B.C.

## ABSTRACT

A potassium permanganate-ethylene glycol incendiary device developed in Australia has been modified for use in an ignition system appropriate to Canadian use. Part I provides background information and a description for the incendiary device and dispenser. Part II details installation and operational procedures for the system.

## RÉSUMÉ

Un dispositif incendiaire contenant du permanganate et de l'éthylene glycol, qui a été mis au point en Astralie, a été modifié pour en faire un allumeur d'usage canadien. Dans la première partie de l'article, le lecteur trouvera l'information de base ainsi qu'une description du dispositif incendiaire et de son appareil distributeur. La seconde partie définit le processus d'installation et de fonctionnement de l'appareil.


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PART I

# DEVELOPMENT AND DESCRIPTION

## I - 1.0 INTRODUCTION

Aerial Ignition systems used for land management purposes utilize one of three types of incendiaries: burning hydrocarbons, launched or free-dropped pyrotechnical devices, and those that utilize an exothermic chemical reaction. The first is generally used for ignition of a continuous line of fire where forest cover does not impede ignition. The others are point ignition devices that allow manipulation of fire behavior and are suitable for use in the open or where penetration of a forest canopy is necessary. Chemical incendiaries used for wildland management are presently limited to the relatively stable potassium permanganate-ethylene glycol type.

The potassium permanganate-ethylene glycol incendiaries were first developed and used in Australia for underburning large tracts of Jarrah forests for hazard abatement (Baxter et al. 1966; Packham and Peet 1967). Later these incendiaries and other air-borne devices were used for suppression burning in Australia (Hodgson and Cheney 1970), Canada (Lait and Taylor 1972) and the United States (Lott 1973). In North America, aerial ignition has been used for prescribed burns for post logging treatment (Fielder 1975), vegetation manipulation for habitat (Leege and Fultz 1972) and fuels management (Sackett 1975).

## I - 2.0 THE PFRC AERIAL IGNITION SYSTEM

This ignition system consists of a chemical ignition device, the priming and dispensing mechanism, the dispenser operator and the pilot and aircraft. Development has been oriented toward improving the automated handling characteristics of the ignition device and to improving the safety, speed and reliability of the priming and dispensing equipment.

Although the system described here was developed at the Pacific Forest Research Centre, it incorporates ideas and techniques from many sources.

### I - 2.1 The Aid (Aerial Ignition Device)

The first operational Canadian adaptation of the Australian igni-

tion device utilized pharmaceutical vials to contain the potassium permanganate (Lait and Taylor 1972). These vials were satisfactory for manual dispensers but their irregular shape caused malfunctions of faster machines. A spherical container, introduced by the Alberta Department of Lands and Forests, Equipment Development Section, appeared more practical and has been modified for use in the PFRC Dispenser. Tests of styrene spheres at the Pacific Forest Research Centre indicated that a sphere 32 mm (1.25 in) in diameter optimized cost and ignition characteristics. Subsequently an injection type mold was designed and constructed under contract by a Victoria manufacturer. The first production run of spheres was of low impact polystyrene, a brittle material that caused dispenser malfunction. Subsequent tests of both polyethylene and the more malleable high impact polystyrene showed the latter to be much superior. The final product, termed AID (Aerial Ignition Device), consists of approximately 3.0 grams of potassium permanganate contained by two permanently sealed hemispheres of high impact polystyrene.

The rate of a chemical reaction is dependent on the concentration and particle size of the chemicals involved. The high proportion of fines in the commercial grade of potassium permanganate reacts with 1.0 ml of full strength ethylene glycol to produce flaming combustion in about 5 seconds. Water-glycol solutions ranging from 75 to 25 percent glycol were tested to determine concentrations that would provide a time interval of at least 20 seconds. A 50 percent concentration of glycol is advocated as it provides reliable ignition with a time delay of 25 seconds and is easy to measure and mix. Unreliable ignition occurs at concentrations of less than 33 percent glycol. The quantity of glycol solution is not critical within the range of 0.5 to 2.0 ml. Lesser or greater quantities do not ignite or ignite very slowly and cannot be relied on.

Commercial grade ethylene glycol is readily available from chemical supply houses and commercially prepared AIDs are available through a Victoria manufacturer[1/] at a reasonable cost. They are packed and labelled to meet current International Air Transport Association regulations regarding transport of restricted articles. Shipping weight is approximately 7.0 kg per case of 1,000 units containing a net weight of 3.0 kg of $KMnO_4$ per case. This configuration allows a maximum of four cases or 4,000 AIDs to be carried by passenger aircraft under current IATA regulations.

Additional specifications of the AID are provided on page 11 and precautions for shipping, storing and handling potassium permanganate are listed in Appendix III.

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1/ Premo Plastics Engineering Ltd., 863 Viewfield Road, Victoria, B.C., V9A 4V2.

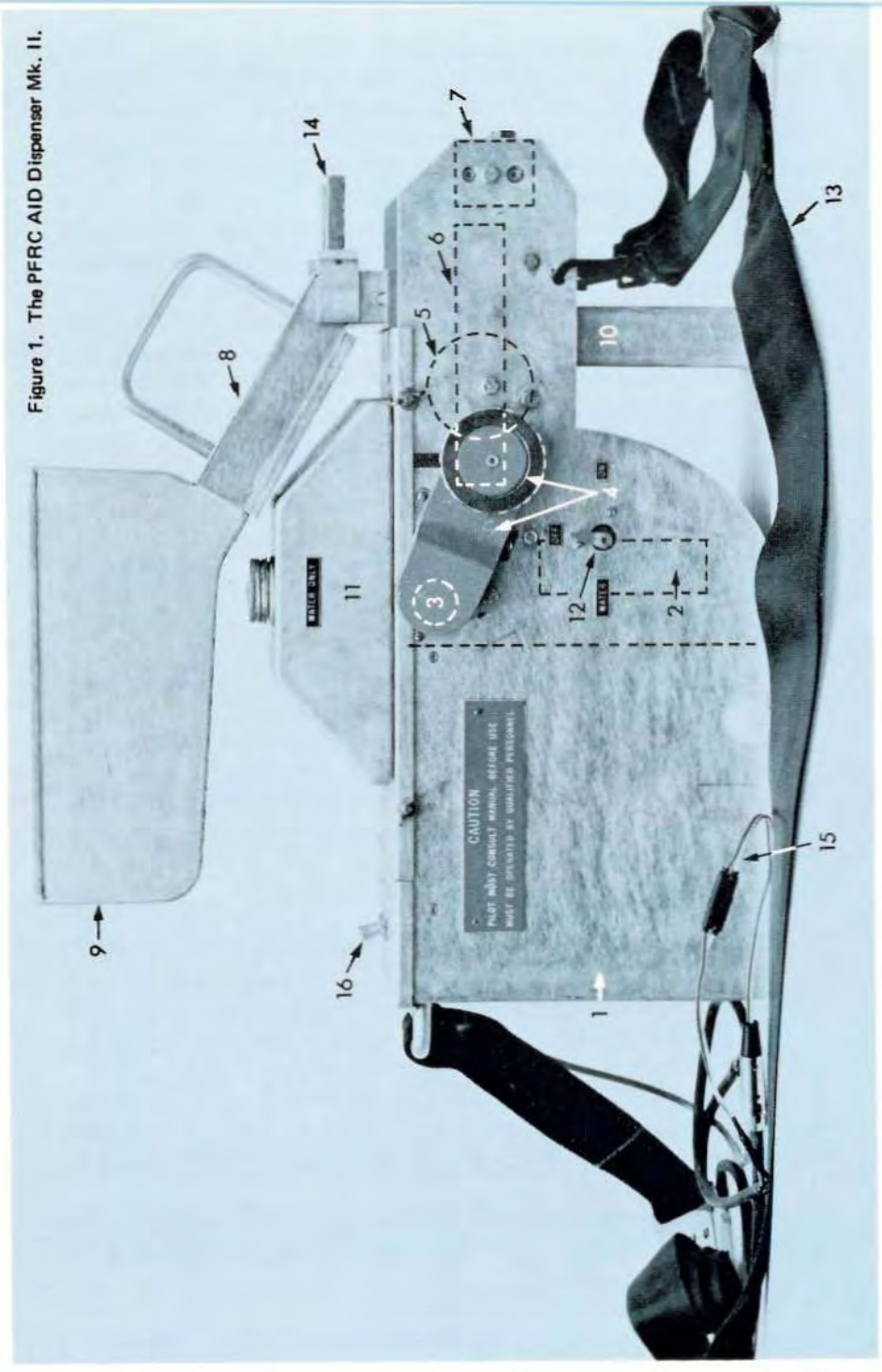


Figure 1. The PFRC AID Dispenser Mk. II.

## I - 2.2 The MKII PFRC Aid Dispenser

The function of the Dispenser is to inject the glycol into the AID, thereby initiating the exothermic reaction, and to expel the primed AIDs from the aircraft. It has been designed to accomplish this with minimum operator manipulation and a high degree of safety and reliability. It is currently accepted for installation in the Bell 206 and in the Hughes 500 type helicopters. The main components shown in Figure 1 are;

(1) glycol storage tank
(2) glycol pump
(3) drive motor
(4) chain drive (under guard) with manual assist
(5) cams
(6) slipper blocks
(7) valve block
(8) AID feed chutes
(9) AID hopper
(10) AID exit chute
(11) water tank
(12) water valve
(13) tie-down straps
(14) AID feed control handles
(15) power cable with break-away connection
(16) motor and pump switches

The main frame of the Dispenser, constructed of welded aluminium, is shaped to the configuration of the rear door sill of the Bell 206 helicopter. Incorporated in the main frame are the power train, glycol reservoir and pump, slipper blocks and injection mechanism. Four AID feed chutes align with each slipper mechanism to provide a supply of AIDs from the 230 capacity AID hopper. Other components of the Dispenser include the tie-down straps, power supply cable and break-away connection and 3.25 litre water reservoir for fire extinguishing. The operational weight with all reservoirs charged is 37 kg (82 lbs.).

Power is supplied to the Dispenser from the aircraft power supply through a quick-disconnect fitting and internal fusing. The switches are series wired so that the drive motor can be operated independently of the pump, but the pump will not operate unless the drive motor is turned on (Figure 2). This allows cycling of unprimed AIDs for testing and enables the Dispenser to be cleared of primed AIDs when shutting down.

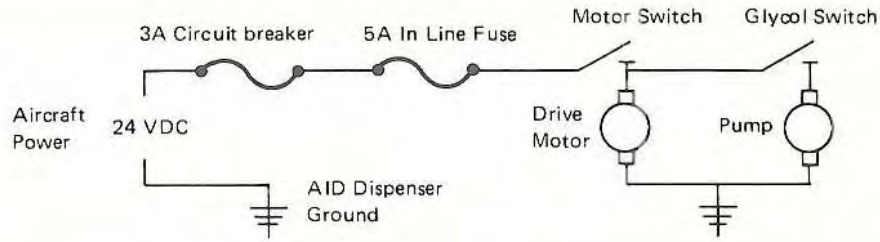


Figure 2. Switch wiring on MKII Dispenser.

The extinguishing system provides water to prevent ignition within the chamber in the event of a malfunction.

The AID feed-chute assembly can be quickly removed to allow access to clear obstructions or to isolate the AID hopper from the priming area. AID feed control levers control the flow of AIDs from the hopper to the slipper blocks. The 10 litre glycol storage tank is fitted with a spillproof cap. The entire Dispenser may be jettisoned in the event of an aircraft emergency by cutting the tie-down strap. A sharp knife must be carried for this purpose.

### 2.2.1 Mode of operation

A 24-volt DC motor, working through a chain drive, rotates four shaft-mounted cams, causing four slipper blocks to move back and forth in a horizontal plane. As a slipper block moves forward (Figure 3-1), its chamber aligns with the AID feed chute. The falling AID is trapped in the chamber (Figure 3-2) and moved forward until it is penetrated by a fixed hollow needle (Figure 3-3). Continued forward motion opens the valve (Figure 3-4) and glycol is pumped into the AID, initiating the exothermic reaction. As cam rotation continues, the direction of travel and the procedure are reversed. The valve is closed (Figure 3-5), the trapped AID is extracted from the needle (Figure 3-6), transported to the exit chute (Figure 3-7) and exits (Figure 3-8). Because each cam is offset 90 degrees on the shaft, each rotation of the shaft causes four AIDs to be primed and ejected. Rotation is 60 rpm, allowing a maximum ejection rate of four AIDs per second. The distance between ignition points may be modified (Table 1) by adjusting the speed of the helicopter or by closing alternate AID feed chutes.

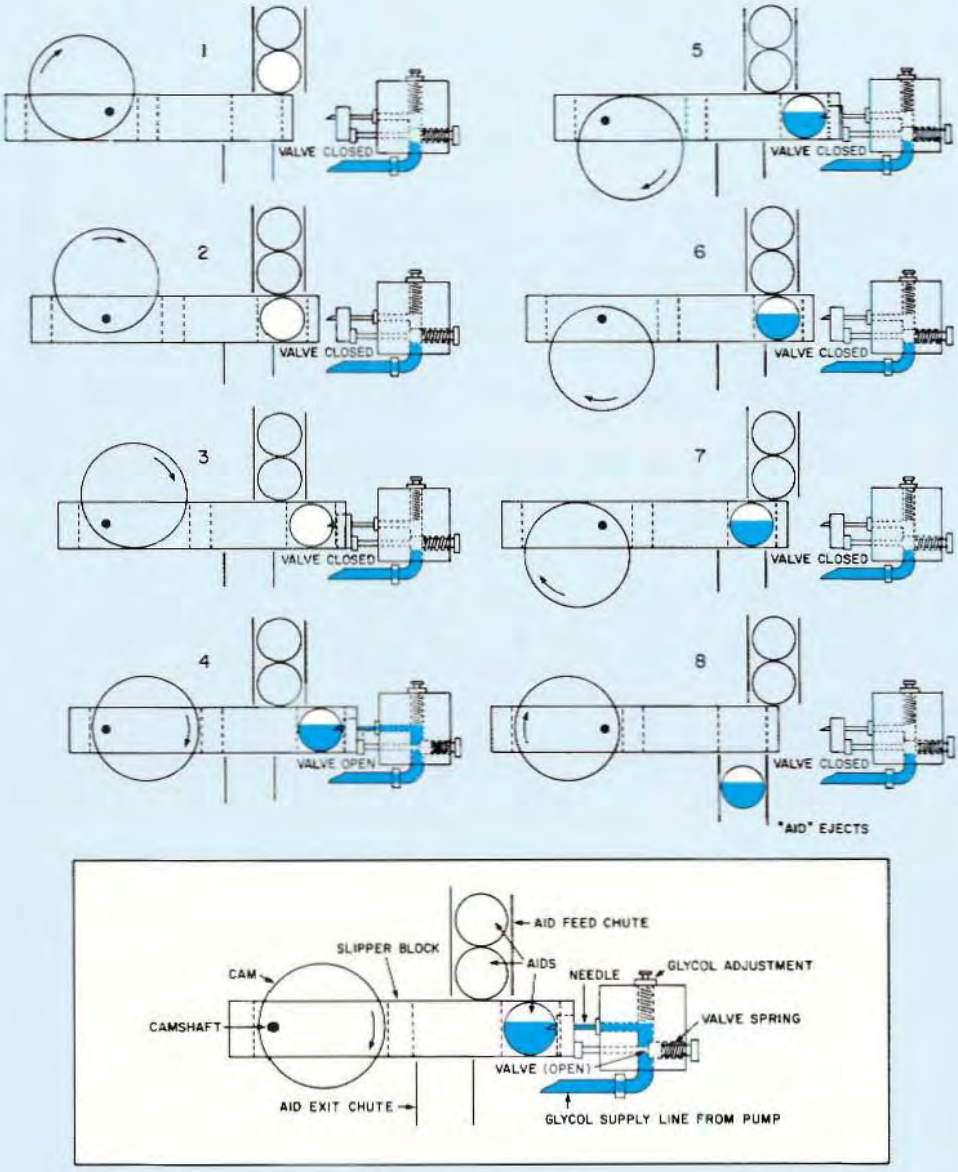


Figure 3. Schematic of slipper and valve block assembly with an eight step sequence of one revolution of a cam.

Table 1

Ignition Spacing as a Function of Ground Speed and Operative AID Feed Chutes

| Camshaft Speed of 60 RPM using | Ground Speed in km/h (MPH) | | | | |
|---|---|---|---|---|---|
| | 16(10) | 32(20) | 48(30) | 64(40) | 80(50) |
| | Approximate Distance Between Ignition Points m(ft) | | | | |
| 1 AID Chute | 5(15) | 9(29) | 13(44) | 18(59) | 22(73) |
| 2 AID Chutes | 2(8) | 5(15) | 7(22) | 9(30) | 11(37) |
| 3 AID Chutes | 2(5) | 3(10) | 5(15) | 6(20) | 7(24) |
| 4 AID Chutes | 1(4) | 2(7) | 3(11) | 4(15) | 5(18) |

## 2.2.2 Specifications for the AID and MKII PFRC Aid Dispenser

AID

| | |
|---|---|
| Material | High Impact Polystyrene |
| mass empty | 2.3 grams |
| mass $KMnO_4$ | 3.0 + 0.3 grams |
| mass total | 5.3 + 0.3 grams |
| diameter | 32 mm |
| wall thickness | 0.76 mm |

AID Dispenser

| | |
|---|---|
| main frame mass, glycol tank empty | 16.6 kg |
| glycol tank full | 26.6 kg |
| hopper and chutes | 6.3 kg |
| volume 50% water-glycol solution | 10 ℓ |
| Overall Dimensions, length | 69 cm |
| height | 55 cm |
| width | 23 cm |
| AID capacity | 230 |
| water tank capacity | 3.2 ℓ |
| approximate operational mass | 37 kg |

| | |
|---|---|
| Power Requirements | 24-28 VDC @ 5A |
| fuse | BUS AGC5 |
| circuit breaker | 3A |

motors, pumps, and other spare parts may be obtained from the manufacturer.

PART II

# OPERATIONAL MANUAL

## FOR THE MKII PFRC AID DISPENSER

These operational instructions were developed through experience gained during trials and consultation with the Ministry of Transport, Pacific Region and apply only to installation and operation in the Bell 206 Jet Ranger type or in the Hughes 500 helicopters.

## II - 1.0 PREPARATION OF DISPENSER AND HELICOPTER

Before installing the Dispenser in the helicopter, the appropriate door must be removed and the cabin cleared of all cushions and other loose articles. Securely fastened extra cartons of AIDs may be carried in the cabin but not extra supplies of ethelyne glycol. Power for the Dispenser must be supplied from the aircraft and lead acid batteries must not be carried in the cabin when the Dispenser is installed.

The Dispenser must be readied for installation at some distance from the helicopter by filling the glycol storage tank with the 50% glycol-water solution and tightly securing the filler cap; close the feed chutes by turning the feed control handles down and fill the hopper with AIDs, but do not attach the hopper until the Dispenser is installed in the helicopter. The water reservoir is filled and the delivery hose is checked for kinks. A metal container for catching AIDs during the preflight test must be obtained and placed near the helicopter.

*CAUTION*

- *The glycol tank must be filled and tightly capped away from the aircraft.*
- *Lead acid batteries must not be carried in the cabin.*
- *The fire extinguisher tank must be filled.*
- *Extra supplies of Glycol must not be carried in the cabin.*
- *A metal container must be on hand.*

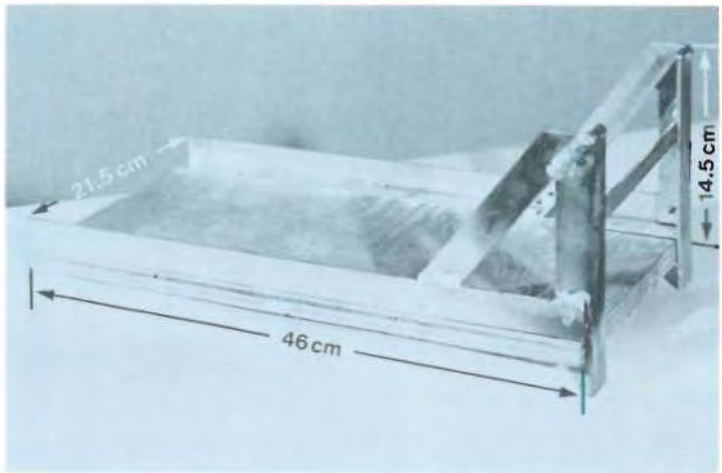


Figure 4. Auxilliary support bracket for Hughes 500; construction is of 1" welded aluminium on a 3/4" plywood base.

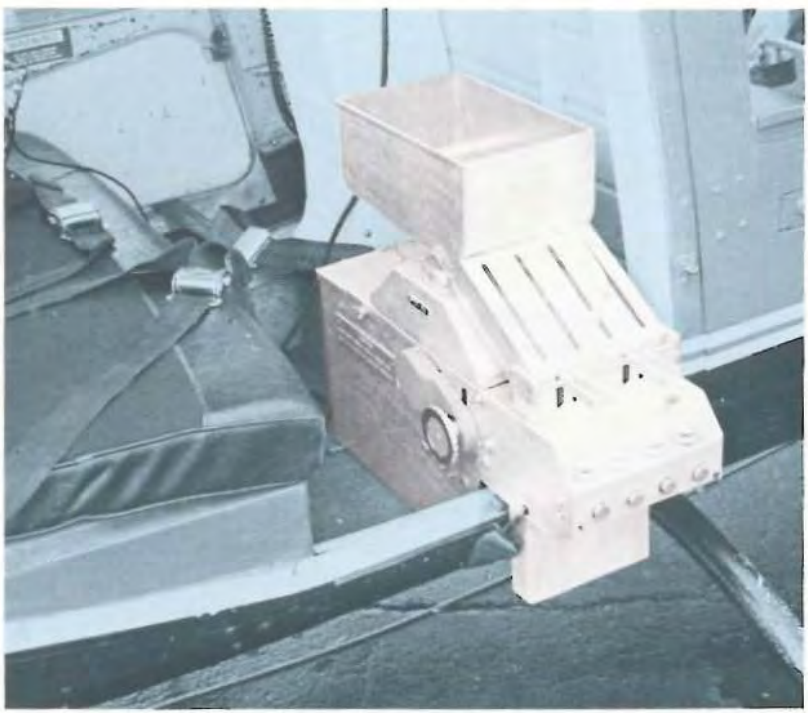

Figure 5. AID Dispenser mounted in a starboard rear door of Bell 206.

Figure 6. Outboard end of tie-down strap under aircraft cabin.


Figure 7. Inboard end of tie-down strap showing jettison label and forward restraint.

## II - 2.0 INSTALLATION OF AID DISPENSER IN THE HELICOPTER

The Dispenser is approved for operation from the right rear door of a Bell 206 Jet Ranger or using the auxiliary support bracket (Figure 4) of a Hughes 500. The Dispenser is fitted over the doorsill or over the auxiliary support bracket so that the AID exit chute clears the outer fuselage (Figure 5). The clips at the "Y" end of the tie-down strap are snapped to the holes on each side of the outboard end of the Dispenser (Figure 6). The other end of the tie-down strap is passed under the cabin, under the opposite door and fastened to the quick-release buckle on the inboard end of the Dispenser. The rear seat belt closest to the open door is passed around the main tie-down strap to restrain forward motion (Figure 7).

Figure 8. Removal of hopper and feed chute assembly.

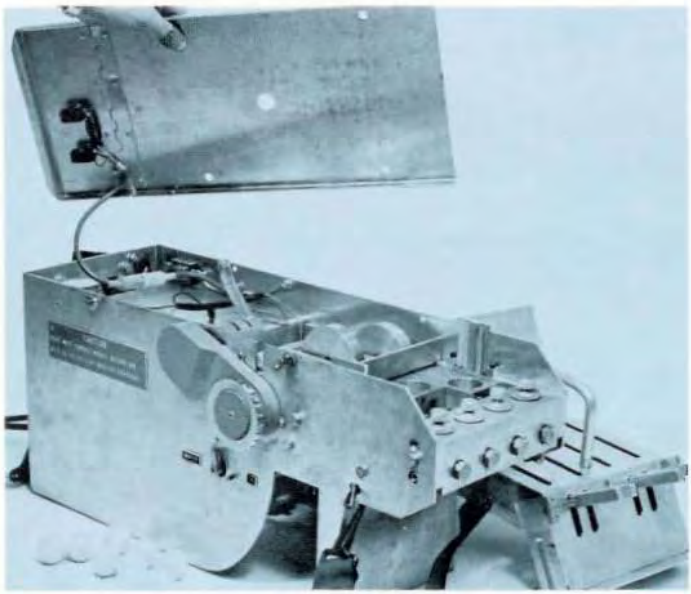

Figure 9. Removal of water tank and top plate takes less than 20 seconds.

Connect the screw-type power supply connector to a compatible utility outlet in the helicopter and connect the in-line break-away connection. **When connecting the helicopter power supply, note that the Dispenser ground is negative.**

> **CAUTION**
>
> *Check that all straps are free of twists, are cinched tight and do not interfere with external fittings under the fuselage, and that the "jettison" label is visible and a knife readily accessible.*

## II - 3.0 PREFLIGHT TEST

> **CAUTION**
>
> *Ignition will be achieved during this test. A container to catch and remove the primed Aids from the vicinity of the aircraft must be provided.*
>
> *Do not conduct this test during fueling operations or where spilled fuels or other combustible material can be ignited.*

A preflight test of the installed system must be conducted to ensure system performance and pilot familiarity. Problems encountered must be remedied prior to take-off. Trouble-shooting aids and a list of the contents of a suggested field service kit are contained in Appendices I and II, respectively.

The test is conducted as follows:

3.1 Show the pilot how the Dispenser has been installed and restrained, that the electrical connections are secure, how the extinguisher is installed and restrained and where supplies and tools are located.

3.2 Start the machine and test its operation as follows:

(1) LIFT AID FEED CONTROL HANDLES. Ensure free movement of AIDs in chutes and that chutes are filled.

(2) TURN ON MOTOR (Figure 10). A slight manual assist may be required to overcome inertia. Ensure free movement of slippers and a steady progression of AIDs down the chutes. The dispensed AIDs will not be primed.

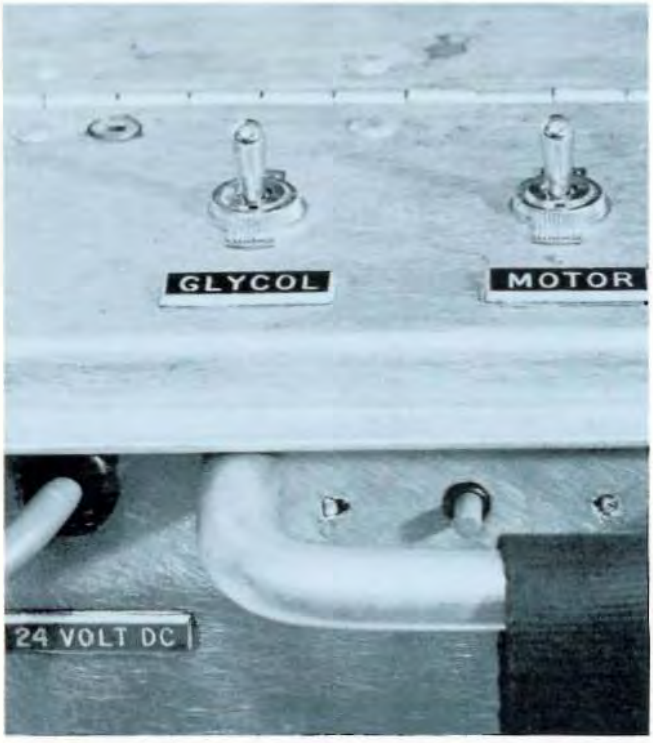


Figure 10. Motor and pump control switches and circuit breaker under handle.

(3) TURN ON GLYCOL PUMP (Figure 10). Run a few AIDs through, then stop the Dispenser as directed below. The dispensed AIDs are primed with glycol and must be removed from the vicinity in the metal container. Check ignition time; if less than 20 seconds, refer to Trouble Shooting Section. Check for glycol system leaks.

**3.3 TO STOP THE DISPENSER**

(1) LOWER AID FEED CONTROL HANDLES
(2) TURN OFF GLYCOL PUMP
(3) WAIT 5 SECONDS THEN TURN OFF MOTOR
(4) REMOVE AID HOPPER AND FEED CHUTE ASSEMBLY

3.4 Operate the fire extinguisher. Turn the water on and ensure that it flows freely.

3.5 Operate in-aircraft and aircraft-to-ground communication systems.

**CAUTION**

*The preflight test must have ensured the following:*

*(1) installation as instructed with restraints in place*
*(2) mechanical operation satisfactory*
*(3) extinguishing system filled and operational*
*(4) glycol reservoir filled and tightly capped*
*(5) 20-second ignition delay achieved*
*(6) in-aircraft and aircraft-to-ground communications operable*
*(7) pilot has been briefed and agrees that all is in order*

# II - 4.0 OPERATIONAL PROCEDURES AND RESTRICTIONS

## II - 4.1 Pilot Instruction

In addition to the familiarization received during the preflight test, the pilot must be provided with specific instructions regarding destination, objective and general procedures. The pilot must also be informed or reminded of the appropriate air regulations and restrictions governing use of the PFRC Aerial Ignition System in accord with the Air Carriers Operators Certificate and in conformance to carriage of restricted materials.

- Flight is restricted to visual flight rules.
- The pilot must be satisfied that the appropriate Crown or Commercial agencies responsible for the protection of the dropping areas have approved the operation.
- The maximum speed of either the Bell 206 or the Hughes 500 shall be less than 50 m.p.h. while the dropping operation is in progress.

A flying height of 300 feet provides good overall visibility of ground conditions, and a safety margin for aircraft emergency procedures without sacrificing ignition accuracy. Violent maneuvres must be avoided to prevent disruption of the ignition pattern.

The manufacturer's Handbook states that the air speed of the Bell 206 Jet Ranger with either aft door removed is restricted to 100 m.p.h. or less and rate of climb is reduced by 350 ft/minute.

## II - 4.2 Inflight Operation

The AID hopper and feed chutes must be dismounted from the main frame and personal seat belts must be fastened enroute to and from the operational area. Upon arrival at the target zone, final instructions regarding the precise ignition pattern referenced to ground features are provided and a practice run is made. Dispenser is readied for operation by mounting the AID hopper and feed-chute assembly to the main frame.

Hovering over the starting point will allow time for the Dispenser to be turned on and develop sufficient glycol pressure to ensure ignition of the first few AIDs, thus avoiding gaps in the ignition line.

When the end of the ignition line is reached, a 3- to 4-second hover will avoid ignition beyond the desired area. Ignition density may be manipulated by varying the aircraft speed or by closing off the desired number of AID chutes. Alternate chutes should be blocked to maintain equal time intervals between AIDs as shown in Table I. Operational malfunctions are reduced if an uninterrupted flow of AIDs is maintained.

## II - 4.3 Operational Malfunctions

Occasionally an AID or fragment of AID will jam on entry or otherwise prevent movement of a slipper block, causing the Dispenser to stall. This occurs most frequently when resistance is greatest at the time of start. Immediately turn off the motor to prevent damage. Pull the manual assist outward to disengage the motor and rotate forward and backward, then restart the motor. In anticipation of this action, one hand should remain on the manual assist until the Dispenser is functioning smoothly. This problem is minimized if starting instructions are followed.

Interruption of operation caused by an obstruction, power or motor failure will result in a primed AID remaining within the Dispenser. If this occurs:

(1) Turn down AID Feed Control handles.
(2) Turn off Motor.
(3) Pull Manual Assist outward and rotate forward then backward. If Obstruction clears Turn on Motor.

IF PROBLEM PERSISTS

(4) Turn water on and leave on.
(5) Remove Hopper and Feed chutes.
(6) Clear all chambers.
(7) Reset circuit breaker if tripped.

**CAUTION**

*Do not remove the AID feed chute while the Dispenser is operating.*

Emergency repairs may be done at a convenient landing spot, using the trouble-shooting guide (Appendix I), if the required tools and spare parts are available (Appendix II).

In the event of an aircraft emergency, the Dispenser and all items must be jettisoned, unless the emergency occurs over a built-up area.

**NOTE**

*To jettison, cut the restraining belt with the knife as indicated, grasp Dispenser by handle and tip clear of aircraft. Clear aircraft of knife and other loose articles.*

## II - 5.0 MAINTENANCE AND REPAIR

As soon as possible after operations are completed, the Dispenser must be dismantled and cleaned thoroughly. Needles should be removed and checked for blockage and sharpness. All metal surfaces should be cleaned and surfaced with a light oil. When extended storage is anticipated, the glycol tank and pump should be thoroughly flushed and the valve block cleaned and oiled. A 3/8 inch box-end wrench is used to remove the needles to prevent damage to the valve stems.

## 6.0 REFERENCES

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## 7.0 APPENDIX I – Trouble Shooting the MKII PFRC Aid Dispenser

(1) AIDs do not move freely in chutes:

(1) Check AID feed control handles
(2) Check chutes for obstructions
(3) Check alignment of AID chutes with main frame.

(2) Drive motor does not start:

(1) Check Dispenser circuit breaker.
(2) Check Dispenser motor switch, quick disconnect, aircraft power supply connection, aircraft main switch and fuse.
(3) Turn on pump; if pump starts, motor or motor connections are faulty.
(4) Remove cover and check inline fuse in Dispenser (replacement fuses are supplied).
(5) Check wiring to motor (Figure 2); repair wiring or replace motor.

(3) Motor starts but Dispenser jams:

(1) Turn off motor switch and rotate manual assist wheel back and forth and switch on motor.
(2) If problem persists, close AID control, remove chute assembly and check chambers for AID fragment.
(3) Check for damaged needle, replace, use 3/8 box-end wrench to prevent damage.

(4) Glycol pump does not start:

(1) Check glycol pump wiring (Figure 2); repair wiring or replace pump.

(5) Incorrect amount of glycol:

(1) Check glycol level in tank and pump operation.
(2) Open or close glycol adjustment valves on top of valve blocks; do not overclose.
(3) Check needles for blockage, remove, clean, replace.
(4) If problem persists, remove coupling to valve block and check for flow.

(5) Replace pump or pump diaphragm or clear valve block and supply line.

(6) Leakage of glycol:

(1) Check couplings for tightness.
(2) Check valve stems and springs for obstructions in valve block.
(3) Replace "O" rings on valve stems.

(7) AIDs do not ignite:

(1) Check fluid level in glycol tank.
(2) Taking precautions against delayed ignition, examine AIDs.
(3) Contents of primed AIDs appear only partially wetted or dry, insufficient glycol (see Section 5).
(4) Contents of primed AIDs are soupy or definitely liquid, excess of glycol (see Section 5).
(5) Consistency of contents satisfactory, check glycol concentration (see page 2 regarding glycol concentration).

(8) AIDs ignite in less than 20 seconds:

(1) Check glycol concentration, (see page 2 regarding glycol concentration) dilute and test.

(9) Water system does not function:

(1) Check reservoir.
(2) Check stopcock and line for kinks or blockage.
(3) Check water ports in valve blocks.

## 8.0 APPENDIX II - Suggested Field Service Tools and Supplies

(1) Small 3" slot screw driver.
(2) Medium 5" slot screw driver.
(3) No. 2 Robertson screw driver.
(4) Set of Allen wrenches.
(5) Box-end 3/8" wrench for removing needles.
(6) 7/16" wrench for chain drive removal or adjustment.
(7) 11/16" wrench for removing valve spring plugs.
(8) Small smooth file for emergency touch-up to the needles.
(9) Small can of light machine oil to lubricate slipper assembly.
(10) A stiff piece of wire small enough to fit inside the needle and clean out any particles that may become lodged inside.

### SUGGESTED SPARE PARTS

(1) Fuses 5A, 1 spare fuse is located under back cover.
(2) Needles.
(3) Valve springs.
(4) Drive chain links.
(5) Spare drive motor. 24-28 volt D.C.
(6) Electric fuel pump (negative ground 12 or 24 VDC).
(7) 3A Circuit breaker.
(8) "0" rings for valve stems.

Spare parts are available from manufacturer.

## 9.0 APPENDIX III - Precautions for Shipping and Storing Potassium Permanganate

1. Shipments of potassium permanganate on commercial airlines must conform to the following International Air Transport Association restrictions.

(a) For passenger aircraft - Packing note 500 states:

"Oxidizing materials referenced to this packing note may be carried in quantities of not more than 0.5 kg (1 lb.) net weight in earthenware, glass, metal or compatible plastic inner receptacles, suitably cushioned with material which will not react with the contents and which will prevent breakage or leakage, and packed in strong wooden, fibreboard or other equally strong outer packaging. The maximum that may be packed in any one package is 12 kilograms (25 lbs.)."

(b) For cargo aircraft - Packing note 502 states:

"Oxidizing materials, except those referred to in other packaging notes, may be carried up to the maximum quantities of 45 kg (100 lbs.) when packed as follows: T3C steel barrel or drums, lined; T30 steel barrels or drums; T4A, T4B or T4C wooden boxes with inside containers or T4D, wooden barrels or drums lined to prevent leakage or wetting."

(c) Restrictions to shipment by other means of transport should be determined by inquiry.

2. Other dangerous compounds that must be isolated from potassium permanganate during shipping and storage are:[2/]

| | | |
|---|---|---|
| arsenic or antimony | - | metals ignite when ground together |
| glycerol | - | may produce an explosion |
| phosphorous | - | explodes when ground together |
| sulphur | - | may explode if heated together |
| sulphuric acid | - | varying degrees of explosion dependent on concentration |
| hydrogen peroxide | - | varying degrees of explosion dependent on concentration |

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2/ Manual of Hazardous Chemical Reactions, 4th Edition, NFPA No. 491 M.

| | | |
|---|---|---|
| aluminum carbide | - | reduction with incandescence |
| titanium | - | explosion when heated |
| hydrogen trisulphide | - | trisulphide ignites |
| ethylene glycol | - | ignites |

AIDs or bulk potassium permanganate must be stored remotely from the above chemicals, in sealed containers elevated above the ground to prevent container deterioration and leakage.

3. Personnel handling potassium permanganate must be equipped with face masks and must work in well-ventilated areas. The compound is highly toxic by ingestion or inhalation and is a strong irritant to tissue.

4. Potassium permanganate is a strong oxidizer and therefore should be stored in a cool, dry place, away from heaters, hot air ducts or hot water conductors, and isolated from liquids having a low-flash point.

5. Split potassium permanganate should be disposed of immediately to prevent possible reactions with subsequently spilled materials.

Environment Canada
Canadian Forestry Service
Pacific Forest Research Centre
506 West Burnside Road
Victoria, B.C. V8Z 1M5

BC-X-167 Revised April, 1979