FOREST FIRE MANAGEMENT IN CANADA

Part 1 - Organization

Part 2 - Suppression Equipment, Products, and Systems

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PART I

ORGANIZATION

Canada is a large country with abundant natural resources. The total area of Canada is 9,922,000 km² of which 4,364,000 km² is forested (inventoried and non-inventoried). These forests represent Canada's leading resource industry and this fact has resulted in forest fire management becoming a high priority with increasingly sophisticated systems and techniques.

During the past twenty years (1966-85) the number of wildfires have averaged 8775 with an average annual burned area of 1 533 000 ha (Ramsey and Higgins 1986). The worst fire seasons in recent memory were in 1980 and 1981. The record fire season of 1981 resulted in 10 145 fires burning 5.4 million ha of both productive and non-productive forested land with suppression costs of $230 million. Annually, large wildfires (over 200 ha in size) account for only three per cent of the total number of fires reported but contribute to over 90 per cent of the total area burned. However, over 90 per cent of these large fires are caused by lightning and are generally located in remote areas where limited or no suppression action is undertaken. Canada's northern areas are covered with coniferous forest types which, because of their nature, permit unlimited spread of fire with limited suppression action being taken.

The 1986 fire season in Canada has yielded a total of 6363 fires as of August 27/86 with the area burned standing at 938 488 ha to date (CIFFC).

PROVINCIAL/TERRITORIAL ORGANIZATION

The Canadian Forestry Service (CFS), for many years, has supported strong research and development programs in forest fire management, in direct support of provincial forest fire activities. In Canada, the management and protection of forested lands are the responsibility of the individual provinces and territories. Each province and territory has developed its own fire management organization and strategies to meet specific individual objectives. The existing organizational structure of most fire management systems in Canada typically has three components: (1) a provincial/ territorial headquarters, (2) regional service and coordinating centres, and (3) district operational centres. The larger provinces have regions spanning from 5 to 15 million ha and these are then divided into three to six districts.

Each component of the organizational structure has specific roles. The roles of the small headquarters group for each province/territory is to set general policy, to plan, prepare budgets, and to service requests for additional resources. The roles of the regional centre are to implement policy, to plan regionally, and to provide support services to the districts. It is then the role of each district within the region to plan and operate its own presuppression and fire control facility (Kourtz 1984).

"Centralized fire management" is the phrase commonly used to describe the alternative organizational structure presently used by the Ontario Ministry of Natural Resources and the Québec Société de Conservation de l'Outaouais consisting of only two levels, provincial and regional. A provincial fire centre, in addition to the roles currently played by the headquarters group, now becomes an aggressive participant in the day-to-day fire management operations. It is responsible for anticipating and supplying the resources needed by the regional centres on a daily basis. The regional centre lies at the heart of the new organization and is responsible for meeting the complete fire management needs within its jurisdiction. These needs

obviously require district input during the annual planning stages. Unlike the current structure, however, the district plays, at most, a support role in day-to-day fire control activities (Kourtz 1985).

Key to the success of centralized fire control is the province-wide mobility of fire control personnel, equipment, and aircraft. These no longer are tied to specific locations, but are easily transferable thus avoiding inefficient and expensive duplication. This centralized system has lower manpower and training requirements and these fewer resources should prove more efficient (Kourtz 1985).

In 1984, the province of Ontario, Ontario Ministry of Natural Resources (OMNR) introduced a centralized fire management command and control system. Mr. Reidar Vollebekk, Fire Operations Officer for the Aviation and Fire Management Centre of OMNR and a guest speaker at this meeting will elaborate on OMNR's fire management system.

There are many national oriented organizations that provide invaluable assistance to the provincial fire management organizations. These are described in the following paragraphs under the name of each organization.

Canadian Forestry Service

The Canadian Forestry Service (CFS) is the principal source of federal expertise in forestry. The general objective of the CFS is to promote the wise management and use of Canada's forest resources for the economic, social, and environmental benefit of Canadians.

The Canadian Forestry Service is comprised of a headquarters unit in Ottawa, Ontario, six forestry centres, and two national institutes. The forestry centres are responsive to regional priorities and maintain close liaison with the respective provincial and territorial government forestry departments and other clients. They also participate in and frequently lead national programs. The two national institutes provide the focus for programs of national scope. At the present time the regionally situated Pacific Forestry Centre, Northern Forestry Centre, the Great Lakes Forestry Centre, and the Petawawa National Forestry Institute undertake active fire research programs to assist the operational fire management agencies with research needs.

The Petawawa National Forestry Institute, at which I undertake studies in fire equipment, materials, and methods, carries out several forest fire research studies within the Institute's Forest Management Systems program. These studies are outlined as follows:

PROJECT PI-4 C.E. Van Wagner

Fire Behavior and Effects

Objectives: To expand the Canadian Forest Fire Danger Rating System to yield quantitative estimates of fire behavior; to explain and model the ecological role of fire in the boreal forest and its effect on timber supply; to develop the effective use of prescribed fire in managing white and red pine.

PROJECT PI-5 G.S. Ramsey

Fire Equipment, Materials, and Methods - Development, Standards, and Evaluation

Objectives: To give direction to agencies and industry in the standardization of forest fire control methods, equipment, and materials; to assist in the development of new forest fire fighting equipment; to promote technology transfer and information exchange among Canadian forest fire management agencies; and, to compile national statistics on forest fires.

PROJECT PI-6 P.H. Kourtz

Fire Management Systems

Objectives: To research, develop, and integrate appropriate new decision-making, computer, and remote sensing technology into the daily operations of Canadian fire management agencies; to apply centralized command and control concepts developed by the military and modern city fire departments to the Canadian forest fire situation.

PROJECT PI-7 E. Stechishen

Fire Suppression Systems

Objectives: To evaluate and report on the effectiveness and cost benefits of ground and aerial forest fire suppression systems proposed for use, and those currently used by Canadian forest fire management agencies.

PROJECT PI-8 J.B. Harrington

Forest Meteorology

Objectives: To use state-of-the-art meteorological technology in the solution of forestry problems; particularly those related to fire and forest renewal.

Canadian Committee on Forest Fire Management (CCFFM)

The Canadian Committee on Forest Fire Management functions under the direction of the National Research Council of Canada. The committee serves as a national advisory body for the advancement of research into forest fire problems and for development of improved fire control practices and inter-agency cooperation in Canada.

Membership includes the director of forest fire management from each province/territory, as well as representation from each of the following organizations: National Parks, Canadian Forest Industries, Canadian Forestry schools, Canadian Forestry Association, Canadian Interagency Forest Fire Centre, and the Canadian Forestry Service.

An important function of the CCFFM is to provide a national forum for the entire fire management community. It is the focal point for the exchange of information and for discussion of fire management matters of

mutual concern. Much of this is accomplished through several subcommittees which focus on specific subject areas.

One subcommittee, the Forest Fire Equipment Subcommittee, focuses on the transfer of technology among agencies, the development of national equipment/product specifications, the identification of and the development of needed equipment or products, the identification and solving of equipment/products problems, etc. This subcommittee organizes national equipment workshops from time to time and publishes a periodical called "Smoke Signals" which concentrates on new developments in the field of forest fire suppression equipment, products, and techniques.

The Canadian Committee on Forest Fire Management has been instrumental in initiating the development of the Canadiar CL-215 Water Bomber, the establishment of the Canadian Interagency Forest Fire Centre, the Canada/United States mutual aid sharing agreement and many other equally important accomplishments.

Canadian Interagency Forest Fire Centre

In Canada there is a marked variation in fire season severity from year to year as well as from one geographical region to another. These variations, on occasion, have severely overextended the resources (manpower and equipment) of individual provincial or territorial forest fire management agencies to the degree where effective fire control is limited. In 1980, following the country's record fire season, several provinces made presentations to the Canadian Council of Resource and Environment Ministers (CCREM) regarding their distress with the forest fire management system in Canada. The result was the establishment of the Canadian Interagency Forest Fire Centre (CIFFC) in 1982.

The Centre is responsible for gathering and disseminating fire management information from and to the provinces and territories. As well, the Fire Centre identifies resources such as helicopters, airtankers, equipment, and personnel which can be shared in time of need. Although CIFFC does not participate in actual fire management operations, it does act as a coordinator for each fire management agency in the country. Each member agency - ten provinces, CFS, Parks Canada, the Yukon, and the Northwest Territories - has identified resources it is prepared to share. An agreement states how resources will be made available, what costs will be involved, and the conditions for their return. An Airtanker Cooperative Supply Agreement has been signed which has resulted in the purchase of the Canadair CL-215 Airtanker and the development of a National Airtanker Fleet which will allow this costly equipment to be made available to all member agencies. In addition, the Canada/United States Reciprocal Forest Fire Fighting Arrangement has been established for the purpose of resource sharing between the two countries. The Fire Centre is funded by the federal and provincial governments. Plans for the future include: a) national training program for forest fire management, b) National Equipment Management System as well as standardized aircraft communication networks, c) regional equipment caches.

Maniwaki Technology Transfer Centre (MTTC)

In June 1986 the Maniwaki Technology Transfer Centre was opened through the combined efforts of the federal government and the Quebec provincial government, and the Quebec Société de Conservation de l'Outaouais at Maniwaki, Québec. The Centre was established to assist the transfer of technology developed by the Canadian Forestry Service at the Petawawa National Forestry Institute primarily in the field of computerized fire management techniques to interested fire management agencies within Canada and other countries. Visitors from Argentina and Chili have visited the Centre this summer.

Computerized fire management decision support systems presently utilized at MTTC and developed at PNFI include:

(a) Fire Weather

- 24 weather stations
- Atmospheric Environment Services forecasts
- fire weather indices
- cumulated rainfall
- fire severity

(b) Lightning Location

- real-time capture
- archiving
- map displays

(c) Radar Precipitation

- rainfall rate capture
- rainfall cumulation
- Fire Weather Index (FWI) integration

(d) Daily Fire Prediction

- man-caused
- past lightning
- forecast lightning

(e) Daily Aerial Detection Planning

- patrol frequency
- location and time
- patrol routes
- number of aircraft required

(f) Fire Behaviour

- rate-of-spread
- fire growth model

(g) Resource Allocation

- water bomber transfer
- aircraft location

(h) Fuel Terrain Support

- fuel map scales
- terrain profiles
- fuel and terrain combined
- map

(i) Administration Services

- fire payroll
- office support

PART II

Equipment, Products, and Systems

Due to a significant variance of geographical conditions within the boundaries of Canada a wide range of forest fire suppression techniques, equipment, and products have been developed. Much of the equipment developed has been designed for rapid initial attack and thereby transportable by either helicopter or fixed wing aircraft. Due to the general inaccessibility to the majority of wildfires equipment portability is a necessity.

Fire management organizations have over the years worked in close cooperation with equipment and product developers as well as with fire research organizations such as the Canadian Forestry Service to ensure the development of the most efficient equipment, products, or systems for the job-at-hand. This section will focus on some of Canada's equipment, products, and systems which may have application in other parts of the world.

Canadian Forest Fire Danger Rating System (CFFDRS)

An integral part of each forest fire management agency fire management program in Canada is the application of the Canadian Forest Fire Danger Rating System (e.g. detection routing and frequency, resource placement, etc.). The system is comprised of two components, the Canadian Forest Fire Weather Index (FWI) System and the Fire Behaviour Index (FBI). The FWI System which has been in operational use across Canada since 1971 is the "backbone" of the CFFDRS and provides numerical ratings of relative wildland fire potential. The FWI System is based solely on the effect of past and current weather on fuel flammability, thus providing a uniform method of evaluating fire weather severity across Canada (Alexander 1982). The six standard components of the FWI System are described below.

Fine Fuel Moisture Code (FFMC)

A numerical rating of the moisture content of litter and other cured fine fuels. This code is an indicator of the relative ease of ignition and flammability of fine fuel.

Duff Moisture Code (DMC)

A numerical rating of the average moisture content of loosely compacted organic layers of moderate depth. This code gives an indication of fuel consumption in moderate duff layers and medium-size woody material.

Drought Code (DC)

A numerical rating of the average moisture content of deep, compact, organic layers. This code is a useful indicator of seasonal drought effects on forest fuels, and amount of smouldering in deep duff layers and large logs.

Initial Spread Index (ISI)

A numerical rating of the expected rate of fire spread. It combines the effects of wind and FFMC on rate of spread without the influence of variable quantities of fuel.

Buildup Index (BUI)

A numerical rating of the total amount of fuel available for combustion that combines DMC and DC.

Fire Weather Index (FWI)

A numerical rating of fire intensity that combines ISI and BUI. It is suitable as a general index of fire danger throughout the forested areas of Canada.

The second subsystem of CFFDRS is the Fire Behaviour Index (FBI). The FBI is a numerical rating of expected fire behaviour in a specific fuel type based on the FWI System components and topographic considerations, which provides an absolute quantitative measure of one or more fire behaviour characteristics (generally in addition to rate of spread). The development of FBI's represents an on-going research program of Canadian Forestry Service staff. The FBI's are intended to be guides for both wildfire and prescribed fire management (Alexander 1982).

Much of the work on the development of CFFDRS has been undertaken by C.E. Van Wagner, Petawawa National Forestry Institute and researchers of the other CFS Regional Research Centres.

Fire Management Systems

Dr. Peter Kourtz and his fire management group have developed the computerized fire management decision support systems presently utilized by the Société de Conservation de l'Outaouais at the Maniwaki Technology Transfer Centre and by several other provincial fire management organizations. The systems assist the fire managers with daily decision making requirements. For example, the Fire Prediction Model which utilizes and assimilates daily FWI information, past fire history, lightning location, and weather radar can be used to assist in aerial detection routing and frequency, and aid in the daily movement of resources (personnel and equipment) to strategic locations.

Another system under active development is Fire Growth Model. This system utilizes enhanced Landsat imagery to provide a fuel type database for each 50-meter square of terrain, weather data, and aspect and slope data to predict the spread or growth of a fire. By applying various suppression methods to the model a fire manager in the future will know how best to suppress the fire with the available resources at hand.

The use of Artificial Intelligence is being investigated for use in forest fire management. Two subsystems of artificial intelligence are presently of interest, namely expert systems and natural language processing. Expert systems permit the encoding of human knowledge in the form of facts and rules related to a specific task. This knowledge can then be used by the expert program to automatically analyze a situation and recommend a solution as if a human expert were present (Kourtz 1986). Presently an expert system is being developed to dispatch airtankers and helicopter-transported fire crews to newly reported fires.

Natural Language processing involves human - computer communication. Human voice communication can take place between the computer and the individual asking the questions.

AERIAL OPERATIONS

Forest Fire Retardants

Amphibious skimmer and landbased airtankers are used extensively throughout Canada on forest fire suppression operations. The 7-year period 1978-1984, an annual average of 150 million litres of water and long term retardant combined were delivered to fire operations by fixed wing aircraft. Twenty million litres of the annual average total was long term retardant. Helitanker operations contributed an annual average of 700 thousand litres of long term retardant (Murray 1986).

The land based airtankers are utilized primarily in western Canada and the Territories where suitable water-sources for use by the skimmer type airtanker are limited. The landbased aircraft generally use long-term retardants in conjunction with their suppression activities.

A long-term retardant contains a chemical salt, such as ammonium sulphate or ammonium phosphate, which inhibits the combustion process and thereby slowing or retarding the rate of spread of the fire. These chemicals are capable of holding the fire for much longer periods of time than would be the case with untreated water. This is necessary due to the longer turn around time normally associated with this type of operation.

Permanent retardant mixing bases have been established in strategic locations throughout Western Canada. The retardant chemicals primarily utilized at these bases are Fire-Trol (Chemonics Industries (Canada) Ltd. and Phos-Chek (Monsanto Canada Inc.). In eastern Canada only the province of New Brunswick utilizes land-based aircraft. The province utilizes both short term and long term retardants. A short term retardant is a water thickener which relies almost entirely on its water holding capacity and cooling ability for its effectiveness.

A considerable portion of Canada is covered with numerous lakes and rivers suitable for the operation of the amphibious skimmer-type airtankers. The aircraft skims over a suitable water source with probes lowered into the water. On board tanks or integral float tanks are filled in seconds. Due to a normally rapid turnaround time untreated water is applied directly on to the fire as a long term holding action is not a critical factor since many loads can be dropped in a short period of time.

Fire Fighting Foam

To increase the line holding capability of water used with skimmer airtankers, foam concentrates have been successfully utilized. Mixed in solution at 1% or less, a thick medium expansion foam is produced when dumped from an airtanker. The foam which is a blend of surfactants reduces surface tension of water thus providing good penetration into the fuel and retards evaporation by blanketing the fuel for a reasonable period of time. Also, through controlled drainage, foam may extend the effectiveness of a given

quantity of water substantially. The foam concentrate readily mixes with water and can be used in conjunction with existing water application systems (airtankers, helicopter helibuckets and belly tanks, tanker vehicles, and power pumps and hose). In the 1985 fire season the Province of British Columbia used substantial quantities of foam (Silv-Ex) as did France and Spain in conjunction with their Canadair CL-215 Airtanker operations. Foam concentrate metering systems were installed in aircraft of those countries. Early indications are that foam does increase the effectiveness of water, however, much more evaluation and research remains to be undertaken.

Skimmer Airtankers

The types of skimmer airtankers presently on forest fire duty in Canada include the Otter (1045 ℓ), Twin Otter (1818 ℓ), Martin Mars (27 000 ℓ), PBY Canso (3637 ℓ), and Canadair CL-215 (5350 ℓ). Although many converted military PBY Canso's remain active on fire operations across Canada today, the Canadair CL-215 airtanker was developed to replace that aircraft. The CL-215 is the only aircraft that was designed specifically for use on forest fire operations. Over the years it has proven extremely effective and now will be used to form Canada's National Airtanker Fleet.

The Canadair CL-215 is a twin engined multipurpose amphibious aircraft which can also be utilized in land based operations. Twin drop doors allow flexibility in drop pattern from a salvo, string, or single tank drop of water, retardant, or foam. It can also be used as a transport or aerial spray aircraft.

The Quebec Government presently has the largest complement of CL-215s with 15. In 1988 the Province will have 19 CL-215 airtankers with 2 designated for use in the National Fleet. Most other Canadian provinces will have this aircraft type in service by 1988. Other countries presently utilizing the Canadair CL-215 include: France, Spain, Greece, Yugoslavia, Venezuela, and Thailand.

Presently there are 28 aircraft operating in Canada with the number increasing to 49 in 1988. Eleven aircraft have been designated for use as the National Airtanker Fleet and these aircraft will be managed by the Canadian Interagency Forest Fire Centre.

The PBY Canso Airtanker remains the workhorse in many areas of Canada. Significant numbers are available on a contract basis from several private aviation firms and others remain active in provincial air fleets.

Land Based Airtankers

A variety of military, cargo, and agricultural aircraft have been successfully converted for use as land based airtankers in Canada. The types in service include: Douglas DC-6 (10 900 ℓ), Douglas A-26 (4100 ℓ), Douglas B-25 (4300 ℓ), Douglas B-26 (4100 ℓ), Tracker (3400 ℓ), Fire Cat (3300 ℓ), and Dromader M-18 (1640 ℓ). The Dromader M-18, an agricultural spray aircraft, is utilized as a water bombing airtanker in the eastern province of New Brunswick.

The latest development in land-based aircraft is the conversion and demonstration of the Fôkker F27 by Conair Aviation Ltd. this summer. The new airtanker is powered by twin turbo-prop engines and has a retardant holding capacity of 6365 litres. The twelve drop doors are computer controlled (0.01 to 0.99 sec). This airtanker will be assessed over a trial period before additional aircraft are converted. There are 800 F-27s in existance worldwide of which 200 are suitable for conversion. Also the F-27 can be readily (within minutes) converted into a cargo aircraft.

Helicopters

Helicopter usage on fire operations in Canada has become indispensable and these versatile machines are employed in a multitude of ways. They include the transport of personnel and equipment, water bucketing (helibucket), and water bombing (belly tanks), fire surveillance (visual and with infra red) and patrol, equipment retrieval (cargo net), aerial ignition, (AID machine, and helitorch), etc. Helicopter types utilized are: Bell 206 and 206L-1, Bell 205 and 212, Hughes 500, Astar 350, Sikorsky-S55T, and S58T, and others.

Several major systems used in forest fire operations (wildfire and prescribed burn) have been developed for use with helicopters:

Helibucket

The latest development in helibuckets is the "Bambi Bucket" designed and manufactured by SEI Industries Ltd., British Columbia. This bucket type is rapidly replacing, in Canada, the fiberglas open-topped helibucket which is sling loaded beneath a helicopter. The device is frameless and collapsible and fits readily into the helicopter cargo compartment. Manufactured in two sizes, the 400 kg bucket is suitable for use with Bell 206 or Hughes 500 helicopters and the 1600 kg bucket is designed for a helicopter with a lifting capacity of the Bell 205 and 212. An all-fabric dump valve releases the water by everting itself and produces a concentrated drop pattern. Water capacity can be regulated by varying the speed the bucket is lifted from the water.

Good quality foam can be produced using a helicopter bucket system. A 1% or less foam solution is used to produce foam when dropped from a high hover or with a foreward speed of 45-50 knots.

Helitanker Belly Tanks

Conair have developed a belly tank system which mounts on the bottom side of a Bell 205 or 212 helicopter. The twin 680 litre compartments can be filled in less than one minute using a suction hose complete with submersible electric pump while the machine hovers over a water source. The tank drop doors can be activated to produce a salvo, string, or single door drop. In conjunction with a foam trial the helicopter produced a good quality foam line 180 m by 6 m. The primary advantage of a fixed-tank helicopter is that it can drop accurately at higher airspeeds, thus minimizing the dangers of rotor downwash (Chandler et al. 1983).

Aerial Ignition Systems

Ignition of forest fuels from the air using specialized aerial ignition systems (AID machine and helitorch) for both prescribed burn and wildfire operations are regularly used by fire management officers. The two devices utilized are:

Aerial Ignition Device - AID Machine

The AID machine has been designed to eject an incendiary device (AID) resembling a "ping pong" ball at regular predetermined intervals. Each polystyrene plastic ball contains a quantity of potasium permanganate and when injected with ethylene glycol as it is dropped from the machine an exothermic reaction causes the AID to burst into flame following a delay of approximately 20 seconds. Ignition patterns can be varied as desired.

The Premo MK III Aerial Ignition Device dispenser is the most versatile AID machine utilized in North America. It is a third generation version of the first such device developed and manufactured in Canada, the Pacific Forest Research Centre (PFRC) Mark I. The MK III can eject several incendiary balls per second. The ignition pattern is accomplished by regulating the speed of the helicopter and/or rate the balls are dispensed. The device is well suited to ignite forest fuels in most conditions.

Helitorch

In Canada the helitorch is recognized as a most effective and efficient tool used for igniting forest fuels both for prescribed burn operations and backfiring operations associated with the control of wildfire. The helitorch has evolved from the flying drop torch which was developed by Canadian Forestry Service researchers, John Muraro and Gary Lait in 1971.

The helitorch can be flown over the target area at any safe high (greater than 60 m if desired) and effectively ignite the fuels below by dropping globs of ignited gelled hydrocarbon fuel (normally gasoline). These globs land on and cover the fuel and thereby provide an intense ignition source for several minutes. Continuous lines of fire can be established rapidly depending upon the speed of the helicopter and the ignition pattern desired. Techniques for use developed in Canada have proved successful in controlling intense fast moving crown fires as well as improving the efficiency by which prescribed burn operations are undertaken.

The helitorch which is slung beneath a helicopter is comprised of a fuel reservoir (200 ℓ fuel drum), a propane igniter, and a pump. Several of the hydrocarbon fuels can be utilized, however, gasoline has proven to be the most efficient. The fuel is mixed with one of the commercially available hydrocarbon gelling agents (aluminum soap). At this time in Canada, the product "Sure Fire" (Calford 760) is replacing the long used product Alumagel because of superior gelling qualities and lesser quantities required (1.8 kg per 4.5 ℓ). Control of the operation of the helitorch is maintained by the pilot within the helicopter. Elaborate mixing and operation procedures for use have been established by the agencies.

The most popular helitorch type used in Canada incorporates what is referred to as the "hockey stick" design. In this type, the fuel reservoir is attached below the helitorch frame thus allowing for the exchange of fuel drums while the helicopter remains in a hover. Forest Industries Flying Tankers and Okanagan Helicopters both of British Columbia have developed two of the most efficient "hockey stick" type helitorches. The other helitorch system which is widely used is the Simplex Helitorch.

The "Terra Torch" a system developed for ground ignition operations (windrow burning, prescribed burns, etc.) was designed and developed at the Boise Interagency Fire Center by United States Bureau of Land Management. The system operates on the same principle as the helitorch and can pump through the air ignited gelled fuel for distances in excess of 30 metres to a target area. It can be operated directly from the vehicle (½ ton pickup) transporting the system or by an operator on foot along the roadside using an appropriate hose line. Two Canadian companies, Chemonics Industries (Canada) Ltd. and MacMillan Bloedel Ltd. have developed systems modelled after the "Terra Torch." The use of this type of ignition device is becoming widespread.

Rapattack and Helitack

Helicopters, because of their versatility, hoverability, and ability to land in confined spaces are being increasingly utilized to transport initial attack or helitack crews to fires. The helitack crew is deposited on the ground close to where initial suppression action is to commence (hand tools, power pumps, etc.).

A refinement to the helitack operation has been accomplished by the British Columbia Forest Service whereby an initial attack crew is rappelled from the helicopter (up to 60 m) to a location near the fire below. This rappel attack system known as Rapattack gets equipment and Rapattack crews to remote lightning fires often in some of the most rugged and inaccessible terrain in Canada.

The Rapattack system employs a variety of equipment and techniques by which to meet the objective of extinguishing a wildfire or holding it until additional equipment and manpower can be obtained. The following are some of the components included in Rapattack.

Rapattack Crew

The highly trained rapattack crew consists of a pilot, a spotter, and three rappellers. The crew normally operates from a Bell 205A-1 helicopter or can operate from a Bell 206L-1 with a smaller crew size. Equipment for Rapattack includes a rope attachment point on the helicopter, a 70 to 80 meter continuous fiber nylon rope and a device (Sky Genie Descent Device) by which the rappeller controls decent on the rope. Special clothing and equipment include a helmet (motorcycle type for descent and hard hat for control operations), heavy gloves, a jumpsuit, and reinforced boots. Initial attack equipment such as hand tools, chainsaws, pumps/hose, etc, are rappelled to the ground with the descent being controlled from within the helicopter.

Self-Loading and Off-Loading System

The Self-Loading and Off-Loading System was developed by Conair Aviation Ltd. in cooperation with the British Columbia Forest Service for use with the Bell 205/Belly Tank Helitanker. The system permits self loading through the automatic deployment of a probe loader (suction hose and submersible pump) and off loading to a ground reservoir. While hovering a length of standard 38 mm lined forestry hose coupled to an hydraulic pump mounted at the rear of the belly tank is dropped to the ground. Water is then pumped from one of the 680 litre compartments to the reservoir below. The time required is approximately two minutes. The second compartment (680 ℓ) is dumped where needed.

Several specialized reservoirs have been developed for use with the system. They have been designed for ease of packaging and securing on step slopes. (Rapattack 300 by Fireflex).

Rappel Relay Tank System

The Rappel Relay Tank System consists of a water reservoir (relay tank) a low volume high pressure pump (Shindaiwa) and a supply of small diameter discharge hose (16 mm Niedner Econoflo). A variety of relay tanks are utilized which can be positioned adjacent to the fire for immediate use.

The Rapattack 300 relay tank holds 1365 ℓ of water and is constructed from a highly visible orange coloured puncture resistant PVC coated polyester material. It is spherical in shape when filled with water and has a 100 mm inlet and a 38 mm outlet with a shutoff valve. The tanks are equipped with six tie-down rings for anchoring to steep slopes. The same tank is in helicopterable version for use with a Bell 212 or equivalent and can be transported full. Another helicopterable relay tank utilized by Rapattack is the Stilwell Fire Flyer (Fireflex). This 270 ℓ capacity tank is equipped with a lift ring for slinging beneath a Bell 206 helicopter.

Rapattack crews effectively use the Self-Loading and Off-Loading System on 90 per cent of the fires they action. The use of small diameter hose and the lightweight (5.8 kg) portable Shindaiwa pumps provides for the economical use of water where natural water sources are absent.

GROUND OPERATIONS

Water Delivery System

The use of lightweight high pressure portable centrifugal pumps and forestry fire hose is the mainstay of most fire suppression operations in Canada today. These pumps, used singly or in tandem and in a variety of configurations provide water to the fire over long distances. The "portable" pump first developed in Canada in 1916 (Fairbanks Morse) has evolved to the present day, high performance Wajax Mark 3 portable centrifugal pump. This pump type is presently used universally throughout the country and has recently been designated as the National Standard for purposes of resource sharing. The multistage centrifugal pump weighs 26 kg and is capable of attaining shutoff pressures in excess of 2000 kPa (300 psi). This pump type and others like it are routinely joined in tandem for the purpose of

increasing the working nozzle pressure where losses due to friction in the 38 mm (1½") forestry hose and elevation must be overcome. Dependant upon application, several other Canadian developed or manufactured pump types are also commonly used in suppression activities. These include the Gorman-Rupp Backpak, Wajax Mark 75, Wajax Mark 26, and a variety of low pressure volume pumps.

Forest fire hose development in Canada has progressed with strong input from user agencies. This input plus well defined specifications for the various hose types has resulted in the manufactures of very dependable hose. The hose utilized is 38 mm (1½") in diameter and is coupled in 30 m (100 ft) lengths. Depending upon type and material utilized in construction, hose weighs between 5 kg (11 lbs) and 7 kg (15 lbs) and is designed to withstand a burst pressure of 4100 kPa (600 psi), a pressure which may be closely attained by two Wajax Mark 3s pumping in tandem. Of the three hose types used in Canada, lined, unlined, and percolating lined, the percolating lined is the most widely used hose type. This type is manufactured with a light inner liner to reduce friction loss and allows a controlled amount of water to escape to the outer cotton/synthetic or all synthetic fibre jacket. The outer jacket remains wet while the hose is under pressure and protects against failure if the hose should come in contact with burning material. The cotton/synthetic percolating hose has superior heat resistance qualities when compared with the all-synthetic type.

Presently there are 4.5 - 6.0 million metres (15 - 20 million ft) of hose on inventory in Canada. This hose is provided by three primary manufacturers, Angus Fire Armour, Niedner Ltd. (Wajax), and National Fire Hose.

Hose recycling is a major undertaking by all fire management agencies and most have established centres where both pumps, hose, and other equipment can be serviced after use. At these centres hose is cleaned, tested, dried, rolled or folded, and repackaged. If the hose has a rupture(s) or break the length may be patched, spliced, or culled. Splicing techniques developed at the OMNR Thunder Bay Service Centre have substantially reduced the quantity of hose annually culled. Following drying, the hose is normally centre rolled or centre folded for use around a fire's perimeter or end rolled or folded for use when laying hose between the water source and the fire. Fire hose lengths are placed into specially designed backpacking hose carrying packs.

Two 38 mm forestry hose coupling types are currently utilized in Canada, a standard threaded brass coupling and an external lug forged or cast aluminum coupling. Due to the increased sharing of equipment, all agencies have agreed to adopt the external lug coupling type as the National Standard in order to ensure the ready interchange of hose.

A wide variety of accessories have been developed for use in conjunction with the pump/hose system. They include specialized couplings (tandem, reverse, etc.) and valves (wyes and siameses), water thieves, hose stranglers and patches, nozzles (straight stream, combination, etc.), check valves, etc.

Systems have been developed to enhance the efficiency of the pump/hose water delivery system. The use of sprinklers and forest fire fighting foams are new tools being utilized by fire suppression crews.

The sprinkler system is now widely used throughout Canada for wildfire and prescribed burn operations as well as for the protection of personal property threatened by a forest fire. One of the most efficient systems developed is the Ontario Sprinkler System. It is comprised of sprinkler head (Rainbird 70 EW) coupled to a 4.5 m (15 ft) length of garden-type hose (Econoflo) which in turn is attached to a water thief positioned between each 30 m (100 ft) length of hose. The 4.5 m (15 ft) length of small diameter hose permits positioning the sprinkler in the most advantageous location and the water thief allows for the regulation of pressure. Properly regulated each sprinkler head has a reach of in excess of 15 m (50 ft). The number of heads which can be utilized at one time is dependent upon the pump(s) used and the configuration of the pump/hose setup.

A sprinkler line can be set up and activated well in advance of the ignition of a prescribed burn or used to establish a control line on a wildfire operation from which to burn out. Sprinklers can be setup and operated unattended to protect buildings or other property where there is a risk from wildfire. The system will function until the pump runs out of fuel.

Although forest fire fighting foam has been used experimentally during the past several years, in Canada, only during the past two years has this new product been used operationally. It is readily utilized with existing ground pumping systems. It can be pumped as a premix from a tanker vehicle or can be introduced into the hose line with an inline eductor or with a metering valve located at the suction side of the pump. Normally mixed at 1% or less the foam concentrate/water solution is pumped through the hose line and aerated with a specially designed aerating foam nozzle. The full benefits to be derived from using fire fighting foam on ground operations remains to be determined.

Nozzle Crew Organization

Nozzle crew organization has become very efficient with systematic methods for adding lengths of hose while progressing along the perimeter of a fire or during a back pass where hose is deleted while fortifying the control line. Ideally a nozzle crew is comprised of 4 crew members (one nozzle man, two hose handlers, and one hose layer) each with a specific task.

Tanker Vehicles and Other Heavy Equipment

Tanker vehicle use in Canada for the most part is limited. All provinces utilize water tankers to some degree with only the Province of Nova Scotia maintaining an actual tanker fleet. The Province has designed and fabricated two models, a four wheeled drive 1500 ℓ capacity tanker and a larger 3500 ℓ unit. Nova Scotia has also developed a forewarder tank complete with pumping system for use on forwarder trucks used in woods operations. These tanks which can readily be hoisted onto the bed of the forewarder, are prepositioned at most woods operations throughout the Province. A variety of slip on tanks are also used.

Skidder tanks complete with pumping system are fabricated and used by several provinces. These 1400 ℓ capacity units can quickly be secured to the machine by using the skidder winch.

Bulldozers of all sizes are routinely used on fire operations where access is available.

Fire Camp Setup

Fire camp setup is an important consideration on many fires in Canada. A variety of equipment has been specifically designed for camp use both for personnel needs and fire service requirements.

Where adequate road access is available, kitchen trailers are coming into greater usage. These units have refrigerator/freezer facilities, generating system as well as the normal cooking facilities. Equipment caches trailers have been developed and stocked to service large fire operations.

Several companies including Project Shelter Ltd. and Fireflex have designed and manufactured a variety of tent models specific to the needs of fire operations. Tents and shelters are designed to accommodate various crew sizes, to be utilized as command centres, and to be used for storage, equipment, repair, etc. Large modular military tents are also used for a number of purposes such as kitchen and eating facilities, etc.

Portable shower units complete with hot water demand heaters are replacing the traditional fire hose nozzle and pump setup.

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Fire Suppression		
Simmonds, Brent L. Manager	Simmonds Enterprises Ltd. P.O. Box 2583 Hinton, Alberta T0E 1C0	403-865-2141 403-865-2550
Fire Bomber Aircraft		
	Air Spray (1967) Limited	
(16 Douglas B-26 fire bombing aircraft and 6 Cessna 310 birddog aircraft)		
Hamilton, D.T. Manager	Air Spray (1967) Ltd. No. 9 Hanger Edmonton Industrial Airport Edmonton, Alberta T5G 2Z3	403-453-1737 403-483-5440 (night)
	Athabaska Airways Limited	
(Twin Otters-floats and wheels, single engine Otter and Beaver, Jet Rangers and Sikorsky-S55T's and Sikorsky S58T with helibuckets)		
Glass, Floyd R. President	Athabaska Airways Ltd. P.O. Box 100 Prince Albert, Saskatchewan S6V 5R4	306-764-1404 Telex: 074-29219 Res.: 306-922-8325
	Avalon Aviation/Georgian Bay Airways	
(Divisions of Powell Corporation)		
(Aerial Fire Suppression)		
(8 PBY Canso Waterbombers, 1 amphibious Cessna 185 birddog aircraft, 13 Piper Aztec detection aircraft)		
Powell, Bruce D. General Manager	Avalon Aviation 55 Great North Road Parry Sound, Ontario P2A 2N9	705-378-2414 Telex: 068-75753 Res.: 705-746-8884 or 705-746-4111

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(Manufacturer of the Canadair CL-215)

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Conair Aviation Limited

(Aerial Fire Control - fixed and rotary wing aircraft, birddog aircraft, aircraft modification to firefighting configuration, retardant delivery system design and manufacture, infrared fire detection)

(Firefighting aircraft Conair Firecat, Douglas A-26, Douglas DC-6, Bell 205 and 212 helitankers (refer Frontier Helicopters Ltd.))

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Forest Industries Flying Tankers Limited

(Aerial Fire Control and Forest Management)

(Martin Mars Waterbombers, G-21 Goose Birddog, Bell 206L-1 Helicopters)

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Frontier Helicopters Ltd.

(Subsidiary of Conair Aviation)

(Bell 205 and 212 helitankers (with fixed retardant delivery systems), and rappel capabilities. Bell 206s and AStar 305s also available.)

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The Flying Fireman Limited

(Aerial Fire Control and Forest Protection Services)

(PBY Canso & PBY Super Canso Waterbombers and Cessna 337 birddog aircraft)

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Fire Retardants

3M Canada Inc.

(Forestry Fire Foam)

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Angus Fire Armour Ltd.

(Forestry fire foam - "Surefire")

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Monsanto Canada Inc.		
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Wormald CDN		
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Fireflex Manufacturing Ltd.

(collapsible helicopter tanks and portable water storage tanks, fuel tanks, hose drying towers, back tanks, SUREFIRE gelling agent)

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Fleck Bros. Ltd.

(Hale forestry fire pumps and related equipment)

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Gorman-Rupp of Canada Limited

(Forest fire control pumps)

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Hale Fire Pump Company

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Langridge-Marshall

(Shelters, sleeping bags, etc.)

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(Materials for patching and splicing forestry fire hose - cement, patching fabric and cleaner)

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Sei Industries Ltd.

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